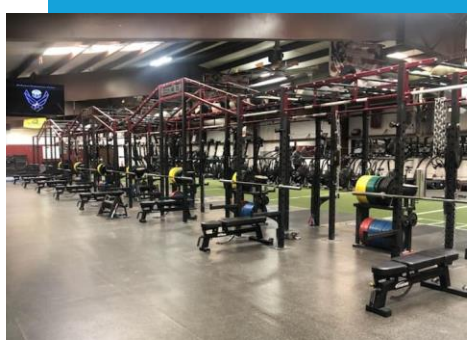
FTFA 23-VH59
D51 Hangar Conversion, Human Performance Center
Eglin AFB, FL

Specifications
Volume 2 of 2



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ADVANCING THE HEALTH AND WELLNESS OF NAVY EOD

23 May 2024

Final Submittal

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VOLUME 1 OF 2

STATE OF ALABAMA
KIMBERLY E. HARDEN
3186
5/29/2024
REGISTERED ARCHITECT

LOUIS JOSEPH DEREUIL
CERTIFICATE
No. 54319
STATE OF
FLORIDA
REGISTERED ENGINEER
5-29-2024
Structural

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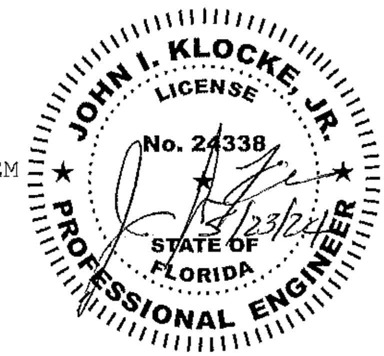

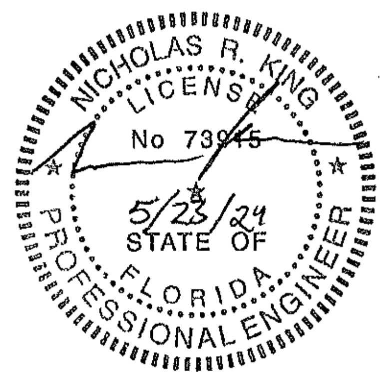

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SECTION 22 00 00

PLUMBING, GENERAL PURPOSE
11/15, CHG 4: 05/21

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AIR-CONDITIONING, HEATING AND REFRIGERATION INSTITUTE (AHRI)

AHRI 1010 (2002) Self-Contained, Mechanically Refrigerated Drinking-Water Coolers

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI Z21.10.3/CSA 4.3 (2019) Gas-Fired Water Heaters Vol.III, Storage Water Heaters With Input Ratings Above 75,000 Btu Per Hour, Circulating and Instantaneous

ANSI Z21.22/CSA 4.4 (2015; R 2020) Relief Valves for Hot Water Supply Systems

AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS (ASHRAE)

ASHRAE 146 (2020) Method of Testing and Rating Pool Heaters

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME A112.1.2 (2012; R 2017; R 2022) Air Gaps in Plumbing Systems (For Plumbing Fixtures and Water-Connected Receptors)

ASME A112.6.1M (1997; R 2017) Floor Affixed Supports for Off-the-Floor Plumbing Fixtures for Public Use

ASME A112.6.3 (2019) Standard for Floor and Trench Drains

ASME A112.19.2/CSA B45.1 (2018; ERTA 2018) Standard for Vitreous China Plumbing Fixtures and Hydraulic Requirements for Water Closets and Urinals

ASME A112.19.3/CSA B45.4 (2022) Stainless Steel Plumbing Fixtures

ASME A112.36.2M (1991; R 2017) Cleanouts

ASME B1.20.1 (2013; R 2018) Pipe Threads, General Purpose (Inch)

ASME B16.4 (2021) Gray Iron Threaded Fittings;

	Classes 125 and 250
ASME B16.5	(2020) Pipe Flanges and Flanged Fittings NPS 1/2 Through NPS 24 Metric/Inch Standard
ASME B16.12	(2019) Cast Iron Threaded Drainage Fittings
ASME B16.15	(2018) Cast Copper Alloy Threaded Fittings Classes 125 and 250
ASME B16.18	(2021) Cast Copper Alloy Solder Joint Pressure Fittings
ASME B16.21	(2021) Nonmetallic Flat Gaskets for Pipe Flanges
ASME B16.24	(2022) Cast Copper Alloy Pipe Flanges, Flanged Fittings, and Valves Classes 150, 300, 600, 900, 1500, and 2500
ASME B16.34	(2021) Valves - Flanged, Threaded and Welding End
ASME B16.50	(2021) Wrought Copper and Copper Alloy Braze-Joint Pressure Fittings
ASME B16.51	(2013) Copper and Copper Alloy Press-Connect Pressure Fittings
ASME B31.1	(2022) Power Piping
ASME B31.5	(2022) Refrigeration Piping and Heat Transfer Components
ASME B40.100	(2022) Pressure Gauges and Gauge Attachments
ASME BPVC SEC IV	(2017) BPVC Section IV-Rules for Construction of Heating Boilers
ASME BPVC SEC IX	(2017; Errata 2018) BPVC Section IX-Welding, Brazing and Fusing Qualifications

AMERICAN SOCIETY OF SANITARY ENGINEERING (ASSE)

ASSE 1010	(2021) Performance Requirements for Water Hammer Arresters
ASSE 1013	(2021) Performance Requirements for Reduced Pressure Principle Backflow Prevention Assemblies
ASSE 1018	(2023) Performance Requirements for Trap Seal Primer Valves - Potable Water Supplied (ANSI Approved 2002
ASSE 1019	(2011; R 2016) Performance Requirements for Wall Hydrant with Backflow Protection

and Freeze Resistance

AMERICAN WATER WORKS ASSOCIATION (AWWA)

AWWA B300	(2018) Hypochlorites
AWWA B301	(2018) Liquid Chlorine
AWWA C651	(2014) Standard for Disinfecting Water Mains
AWWA C652	(2019) Disinfection of Water-Storage Facilities

AMERICAN WELDING SOCIETY (AWS)

AWS A5.8/A5.8M	(2019) Specification for Filler Metals for Brazing and Braze Welding
AWS B2.2/B2.2M	(2016) Specification for Brazing Procedure and Performance Qualification

ASTM INTERNATIONAL (ASTM)

ASTM A53/A53M	(2022) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM A105/A105M	(2021) Standard Specification for Carbon Steel Forgings for Piping Applications
ASTM A193/A193M	(2023) Standard Specification for Alloy-Steel and Stainless Steel Bolting Materials for High-Temperature Service and Other Special Purpose Applications
ASTM A515/A515M	(2017; R2022) Standard Specification for Pressure Vessel Plates, Carbon Steel, for Intermediate- and Higher-Temperature Service
ASTM A516/A516M	(2017) Standard Specification for Pressure Vessel Plates, Carbon Steel, for Moderate- and Lower-Temperature Service
ASTM A733	(2016; R 2022) Standard Specification for Welded and Seamless Carbon Steel and Austenitic Stainless Steel Pipe Nipples
ASTM B32	(2020) Standard Specification for Solder Metal
ASTM B42	(2020) Standard Specification for Seamless Copper Pipe, Standard Sizes
ASTM B88	(2022) Standard Specification for Seamless Copper Water Tube
ASTM B88M	(2020) Standard Specification for Seamless

	Copper Water Tube (Metric)
ASTM B306	(2020) Standard Specification for Copper Drainage Tube (DWV)
ASTM B370	(2022) Standard Specification for Copper Sheet and Strip for Building Construction
ASTM B813	(2016) Standard Specification for Liquid and Paste Fluxes for Soldering of Copper and Copper Alloy Tube
ASTM B828	(2016) Standard Practice for Making Capillary Joints by Soldering of Copper and Copper Alloy Tube and Fittings
ASTM C920	(2018) Standard Specification for Elastomeric Joint Sealants
ASTM D638	(2014) Standard Test Method for Tensile Properties of Plastics
ASTM D1004	(2013) Initial Tear Resistance of Plastic Film and Sheeting
ASTM D1785	(2015; E 2018) Standard Specification for Poly(Vinyl Chloride) (PVC), Plastic Pipe, Schedules 40, 80, and 120
ASTM D2241	(2015) Standard Specification for Poly(Vinyl Chloride) (PVC) Pressure-Rated Pipe (SDR Series)
ASTM D2464	(2015) Standard Specification for Threaded Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80
ASTM D2466	(2017) Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 40
ASTM D2467	(2015) Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80
ASTM D2564	(2020) Standard Specification for Solvent Cements for Poly(Vinyl Chloride) (PVC) Plastic Piping Systems
ASTM D2665	(2014) Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Drain, Waste, and Vent Pipe and Fittings
ASTM D2672	(2014) Joints for IPS PVC Pipe Using Solvent Cement
ASTM D2822/D2822M	(2005; R 2011; E 2011) Standard Specification for Asphalt Roof Cement, Asbestos-Containing

ASTM D2855	(2015) Standard Practice for Making Solvent-Cemented Joints with Poly(Vinyl Chloride) (PVC) Pipe and Fittings
ASTM D3139	(2019) Joints for Plastic Pressure Pipes Using Flexible Elastomeric Seals
ASTM D3212	(2020) Standard Specification for Joints for Drain and Sewer Plastic Pipes Using Flexible Elastomeric Seals
ASTM D3311	(2017) Standard Specification for Drain, Waste, and Vent (DWV) Plastic Fittings Patterns
ASTM D4551	(2017) Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Flexible Concealed Water-Containment Membrane
ASTM E1	(2014) Standard Specification for ASTM Liquid-in-Glass Thermometers
ASTM E96/E96M	(2022a) Standard Test Methods for Gravimetric Determination of Water Vapor Transmission Rate of Materials
ASTM F409	(2022) Standard Specification for Thermoplastic Accessible and Replaceable Plastic Tube and Tubular Fittings
ASTM F477	(2014; R 2021) Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe
ASTM F891	(2016) Standard Specification for Coextruded Poly (Vinyl Chloride) (PVC) Plastic Pipe with a Cellular Core
ASTM F1760	(2016; R 2020) Standard Specification for Coextruded Poly(Vinyl Chloride) (PVC) Non-Pressure Plastic Pipe Having Reprocessed-Recycled Content

COPPER DEVELOPMENT ASSOCIATION (CDA)

CDA A4015	(2016; 14/17) Copper Tube Handbook

INTERNATIONAL ASSOCIATION OF PLUMBING AND MECHANICAL OFFICIALS (IAPMO)

IAPMO PS 117	(2005b) Press Type Or Plain End Rub Gasketed W/ Nail CU & CU Alloy Fittings 4 Install On CU Tubing

INTERNATIONAL CODE COUNCIL (ICC)

ICC A117.1	(2017) Standard And Commentary Accessible

	and Usable Buildings and Facilities
ICC IPC	(2021) International Plumbing Code

MANUFACTURERS STANDARDIZATION SOCIETY OF THE VALVE AND FITTINGS INDUSTRY (MSS)

MSS SP-25	(2018) Standard Marking System for Valves, Fittings, Flanges and Unions
MSS SP-58	(2018) Pipe Hangers and Supports - Materials, Design and Manufacture, Selection, Application, and Installation
MSS SP-72	(2010a) Ball Valves with Flanged or Butt-Welding Ends for General Service
MSS SP-78	(2011) Cast Iron Plug Valves, Flanged and Threaded Ends
MSS SP-80	(2019) Bronze Gate, Globe, Angle and Check Valves
MSS SP-110	(2010) Ball Valves Threaded, Socket-Welding, Solder Joint, Grooved and Flared Ends

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 90A	(2021) Standard for the Installation of Air Conditioning and Ventilating Systems

NSF INTERNATIONAL (NSF)

NSF 372	(2016) Drinking Water System Components - Lead Content
NSF/ANSI 14	(2022) Plastics Piping System Components and Related Materials
NSF/ANSI 61	(2022) Drinking Water System Components - Health Effects

PLASTIC PIPE AND FITTINGS ASSOCIATION (PPFA)

PPFA Fire Man	(2016) Firestopping: Plastic Pipe in Fire Resistive Construction

PLUMBING AND DRAINAGE INSTITUTE (PDI)

PDI WH 201	(2010) Water Hammer Arresters Standard

SOCIETY OF AUTOMOTIVE ENGINEERS INTERNATIONAL (SAE)

SAE J1508	(2023) Hose Clamp Specifications

U.S. DEPARTMENT OF ENERGY (DOE)

Energy Star	(1992; R 2006) Energy Star Energy

Efficiency Labeling System (FEMP)

U.S. ENVIRONMENTAL PROTECTION AGENCY (EPA)

PL 93-523	(1974; A 1999) Safe Drinking Water Act

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

10 CFR 430	Energy Conservation Program for Consumer Products
40 CFR 141.80	National Primary Drinking Water Regulations; Control of Lead and Copper; General Requirements

UNDERWRITERS LABORATORIES (UL)

UL 174	(2004; Reprint Dec 2021) UL Standard for Safety Household Electric Storage Tank Water Heaters

1.2 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Backflow Prevention Assemblies; G,

Shower Faucets; G

Fixtures

List of installed fixtures with manufacturer, model, and flow rate.

Flush Valve Water Closets

Countertop Lavatories

Kitchen Sinks

Drinking-Water Coolers; G

Water Heaters; G

Welding

A copy of qualified procedures and a list of names and identification symbols of qualified welders and welding operators.

Plumbing System

SD-06 Test Reports

Tests, Flushing and Disinfection

Test reports in booklet form showing all field tests performed to adjust each component and all field tests performed to prove compliance with the specified performance criteria, completion and testing of the installed system. Each test report shall indicate the final position of controls.

Test of Backflow Prevention Assemblies; G.

Certification of proper operation shall be as accomplished in accordance with state regulations by an individual certified by the state to perform such tests. If no state requirement exists, the Contractor shall have the manufacturer's representative test the device, to ensure the unit is properly installed and performing as intended. The Contractor shall provide written documentation of the tests performed and signed by the individual performing the tests.

SD-07 Certificates

Materials and Equipment

Bolts

Written certification by the bolt manufacturer that the bolts furnished comply with the specified requirements.

SD-10 Operation and Maintenance Data

Plumbing System; G

Submit in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA.

1.3 STANDARD PRODUCTS

Specified materials and equipment shall be standard products of a manufacturer regularly engaged in the manufacture of such products. Specified equipment shall essentially duplicate equipment that has performed satisfactorily at least two years prior to bid opening. Standard products shall have been in satisfactory commercial or industrial use for 2 years prior to bid opening. The 2-year use shall include applications of equipment and materials under similar circumstances and of similar size. The product shall have been for sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 2 year period.

1.3.1 Alternative Qualifications

Products having less than a two-year field service record will be acceptable if a certified record of satisfactory field operation for not less than 6000 hours, exclusive of the manufacturer's factory or laboratory tests, can be shown.

1.3.2 Service Support

The equipment items shall be supported by service organizations. Submit a certified list of qualified permanent service organizations for support of the equipment which includes their addresses and qualifications. These service organizations shall be reasonably convenient to the equipment installation and able to render satisfactory service to the equipment on a regular and emergency basis during the warranty period of the contract.

1.3.3 Manufacturer's Nameplate

Each item of equipment shall have a nameplate bearing the manufacturer's name, address, model number, and serial number securely affixed in a conspicuous place; the nameplate of the distributing agent will not be acceptable.

1.3.4 Modification of References

In each of the publications referred to herein, consider the advisory provisions to be mandatory, as though the word, "shall" had been substituted for "should" wherever it appears. Interpret references in these publications to the "authority having jurisdiction", or words of similar meaning, to mean the Contracting Officer.

1.3.4.1 Definitions

For the International Code Council (ICC) Codes referenced in the contract documents, advisory provisions shall be considered mandatory, the word "should" shall be interpreted as "shall." Reference to the "code official" shall be interpreted to mean the "Contracting Officer." For Navy owned property, references to the "owner" shall be interpreted to mean the "Contracting Officer." For leased facilities, references to the "owner" shall be interpreted to mean the "lessor." References to the "permit holder" shall be interpreted to mean the "Contractor."

1.3.4.2 Administrative Interpretations

For ICC Codes referenced in the contract documents, the provisions of Chapter 1, "Administrator," do not apply. These administrative requirements are covered by the applicable Federal Acquisition Regulations (FAR) included in this contract and by the authority granted to the Officer in Charge of Construction to administer the construction of this project. References in the ICC Codes to sections of Chapter 1, shall be applied appropriately by the Contracting Officer as authorized by his administrative cognizance and the FAR.

1.4 DELIVERY, STORAGE, AND HANDLING

Handle, store, and protect equipment and materials to prevent damage before and during installation in accordance with the manufacturer's recommendations, and as approved by the Contracting Officer. Replace damaged or defective items.

1.5 PERFORMANCE REQUIREMENTS

1.5.1 Welding

Piping shall be welded in accordance with qualified procedures using performance-qualified welders and welding operators. Procedures and welders shall be qualified in accordance with ASME BPVC SEC IX. Welding procedures qualified by others, and welders and welding operators qualified by another employer, may be accepted as permitted by ASME B31.1. The Contracting Officer shall be notified 24 hours in advance of tests, and the tests shall be performed at the work site if practicable. Welders or welding operators shall apply their assigned symbols near each weld they make as a permanent record.

1.6 REGULATORY REQUIREMENTS

Unless otherwise required herein, plumbing work shall be in accordance with ICC IPC.

1.7 PROJECT/SITE CONDITIONS

The Contractor shall become familiar with details of the work, verify dimensions in the field, and advise the Contracting Officer of any discrepancy before performing any work.

1.8 INSTRUCTION TO GOVERNMENT PERSONNEL

When specified in other sections, furnish the services of competent instructors to give full instruction to the designated Government personnel in the adjustment, operation, and maintenance, including pertinent safety requirements, of the specified equipment or system. Instructors shall be thoroughly familiar with all parts of the installation and shall be trained in operating theory as well as practical operation and maintenance work.

Instruction shall be given during the first regular work week after the equipment or system has been accepted and turned over to the Government for regular operation. The number of man-days (8 hours per day) of instruction furnished shall be as specified in the individual section. When more than 4 man-days of instruction are specified, use approximately half of the time for classroom instruction. Use other time for instruction with the equipment or system.

When significant changes or modifications in the equipment or system are made under the terms of the contract, provide additional instruction to acquaint the operating personnel with the changes or modifications.

1.9 ACCESSIBILITY OF EQUIPMENT

Install all work so that parts requiring periodic inspection, operation, maintenance, and repair are readily accessible. Install concealed valves, expansion joints, controls, dampers, and equipment requiring access, in locations freely accessible through access doors.

PART 2 PRODUCTS

2.1 MATERIALS

Materials for various services shall be in accordance with TABLES I and II. Pipe schedules shall be selected based on service requirements. Pipe fittings shall be compatible with the applicable pipe materials. Plastic pipe, fittings, and solvent cement shall meet NSF/ANSI 14 and shall be NSF listed for the service intended. Plastic pipe, fittings, and solvent cement used for potable hot and cold water service shall bear the NSF seal "NSF-PW." Pipe threads (except dry seal) shall conform to ASME B1.20.1. Material or equipment containing a weighted average of greater than 0.25 percent lead shall not be used in any potable water system intended for human consumption, and shall be certified in accordance with NSF/ANSI 61, Annex G or NSF 372. In line devices such as water meters, building valves, check valves, meter stops, valves, fittings and back flow preventers shall comply with PL 93-523 and NSF/ANSI 61, Section 8. End point devices such as drinking water fountains, lavatory faucets, kitchen and bar faucets, residential ice makers, supply stops and end point control valves used to dispense water for drinking must meet the requirements of NSF/ANSI 61, Section 9. Hubless cast-iron soil pipe shall not be installed underground, under concrete floor slabs, or in crawl spaces below kitchen floors. Plastic pipe shall not be installed in air plenums. Plastic pipe shall not be installed in a pressure piping system in buildings greater than three stories including any basement levels.

2.1.1 Pipe Joint Materials

Grooved pipe and hubless cast-iron soil pipe shall not be used underground. Solder containing lead shall not be used with copper pipe. Joints and gasket materials shall conform to the following:

d. Flange Gaskets: Gaskets shall be made of non-asbestos material in accordance with ASME B16.21. Gaskets shall be flat, 1/16 inch thick, and contain Aramid fibers bonded with Styrene Butadiene Rubber (SBR) or Nitro Butadiene Rubber (NBR). Gaskets shall be the full face or self centering flat ring type. Gaskets used for hydrocarbon service shall be bonded with NBR.

e. Brazing Material: Brazing material shall conform to AWS A5.8/A5.8M, BCuP-5.

f. Brazing Flux: Flux shall be in paste or liquid form appropriate for use with brazing material. Flux shall be as follows: lead-free; have a 100 percent flushable residue; contain slightly acidic reagents; contain potassium borides; and contain fluorides.

g. Solder Material: Solder metal shall conform to ASTM B32.

h. Solder Flux: Flux shall be liquid form, non-corrosive, and conform to ASTM B813, Standard Test 1.

i. PTFE Tape: PTFE Tape, for use with Threaded Metal or Plastic Pipe.

l. Flexible Elastomeric Seals: ASTM D3139, ASTM D3212 or ASTM F477.

p. Plastic Solvent Cement for PVC Plastic Pipe: ASTM D2564 and ASTM D2855.

r. Flanged fittings including, but not limited to, flanges, bolts, nuts and bolt patterns shall be in accordance with ASME B16.5 class 150 and shall have the manufacturer's trademark affixed in accordance with MSS SP-25. Flange material shall conform to ASTM A105/A105M. Blind flange material shall conform to ASTM A516/A516M cold service and ASTM A515/A515M for hot service. Bolts shall be high strength or intermediate strength with material conforming to ASTM A193/A193M.

t. Press fittings for Copper Pipe and Tube: Copper press fittings shall conform to the material and sizing requirements of ASME B16.51 and performance criteria of IAPMO PS 117. Sealing elements for copper press fittings shall be EPDM, FKM or HNBR. Sealing elements shall be factory installed or an alternative supplied fitting manufacturer. Sealing element shall be selected based on manufacturer's approved application guidelines.

u. Copper tubing shall conform to ASTM B88, Type K, L or M.

2.1.2 Miscellaneous Materials

Miscellaneous materials shall conform to the following:

a. Water Hammer Arrester: PDI WH 201. Water hammer arrester shall be piston type.

b. Copper, Sheet and Strip for Building Construction: ASTM B370.

c. Asphalt Roof Cement: ASTM D2822/D2822M.

d. Hose Clamps: SAE J1508.

e. Supports for Off-The-Floor Plumbing Fixtures: ASME A112.6.1M.

f. Metallic Cleanouts: ASME A112.36.2M.

g. Plumbing Fixture Setting Compound: A preformed flexible ring seal molded from hydrocarbon wax material. The seal material shall be nonvolatile nonasphaltic and contain germicide and provide watertight, gastight, odorproof and verminproof properties.

i. Hypochlorites: AWWA B300.

j. Liquid Chlorine: AWWA B301.

k. Gauges - Pressure and Vacuum Indicating Dial Type - Elastic Element: ASME B40.100.

l. Thermometers: ASTM E1. Mercury shall not be used in thermometers.

2.1.3 Pipe Insulation Material

Insulation shall be as specified in Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS.

2.2 PIPE HANGERS, INSERTS, AND SUPPORTS

Pipe hangers, inserts, and supports shall conform to MSS SP-58.

2.3 VALVES

Valves shall be provided on supplies to equipment and fixtures. Valves 2-1/2 inches and smaller shall be bronze with threaded bodies for pipe and solder-type connections for tubing. Valves 3 inches and larger shall have flanged iron bodies and bronze trim. Pressure ratings shall be based upon the application. Grooved end valves may be provided if the manufacturer certifies that the valves meet the performance requirements of applicable MSS standard. Valves shall conform to the following standards:

Description	Standard
Ball Valves with Flanged Butt-Welding Ends for General Service	MSS SP-72

Ball Valves Threaded, Socket-Welding, Solder Joint, Grooved and Flared Ends	MSS SP-110
Cast-Iron Plug Valves, Flanged and Threaded Ends	MSS SP-78
Bronze Gate, Globe, Angle, and Check Valves	MSS SP-80
Steel Valves, Socket Welding and Threaded Ends	ASME B16.34
Vacuum Relief Valves	ANSI Z21.22/CSA 4.4
Water Heater Drain Valves	ASME BPVC SEC IV, Part HLW-810: Requirements for Potable-Water Heaters Bottom Drain Valve
Trap Seal Primer Valves	ASSE 1018
Temperature and Pressure Relief Valves for Hot Water Supply Systems	ANSI Z21.22/CSA 4.4

2.3.1 Wall Hydrants (Frostproof)

ASSE 1019 with vacuum-breaker backflow preventer shall have a nickel-brass or nickel-bronze wall plate or flange with nozzle and detachable key handle. A brass or bronze operating rod shall be provided within a galvanized iron casing of sufficient length to extend through the wall so that the valve is inside the building, and the portion of the hydrant between the outlet and valve is self-draining. A brass or bronze valve with coupling and union elbow having metal-to-metal seat shall be provided. Valve rod and seat washer shall be removable through the face of the hydrant. The hydrant shall have 3/4 inch exposed hose thread on spout and 3/4 inch male pipe thread on inlet.

2.3.2 Relief Valves

Water heaters shall have a combination pressure and temperature (P&T) relief valve. The pressure relief element of a P&T relief valve shall have adequate capacity to prevent excessive pressure buildup in the system when the system is operating at the maximum rate of heat input. The temperature element of a P&T relief valve shall have a relieving capacity which is at least equal to the total input of the heaters when operating at their maximum capacity. Relief valves shall be rated according to ANSI Z21.22/CSA 4.4. The discharge pipe from the relief valve shall be the size of the valve outlet.

2.3.3 Thermostatic Mixing Valves

Provide thermostatic mixing valve for lavatory faucets. Mixing valves, thermostatic type, pressure-balanced or combination thermostatic and pressure-balanced shall be line size and shall be constructed with rough or finish bodies either with or without plating. Each valve shall be constructed to control the mixing of hot and cold water and to deliver water at a desired temperature regardless of pressure or input temperature changes. The control element shall be of an approved type. The body shall be of heavy cast bronze, and interior parts shall be brass, bronze, corrosion-resisting steel or copper. The valve shall be equipped with necessary stops, check valves, unions, and sediment strainers on the inlets. Mixing valves shall maintain water temperature within 5 degrees F of any setting.

2.4 FIXTURES

Water closet replacements in major renovations may have a flush valve of up to 1.6 GPF to accommodate existing plumbing capacity. Fixtures for use by the physically handicapped shall be in accordance with ICC A117.1. Vitreous China, nonabsorbent, hard-burned, and vitrified throughout the body shall be provided. Porcelain enameled ware shall have specially selected, clear white, acid-resisting enamel coating evenly applied on surfaces. No fixture will be accepted that shows cracks, crazes, blisters, thin spots, or other flaws. Fixtures shall be equipped with appurtenances such as traps, faucets, stop valves, and drain fittings. Each fixture and piece of equipment requiring connections to the drainage system, except grease interceptors, shall be equipped with a trap. Brass expansion or toggle bolts capped with acorn nuts shall be provided for supports, and polished chromium-plated pipe, valves, and fittings shall be provided where exposed to view. Fixtures with the supply discharge below the rim shall be equipped with backflow preventers. Internal parts of flush valves and flushometer valves, shower mixing valves, shower head face plates, pop-up stoppers of lavatory waste drains, and pop-up stoppers and overflow tees and shoes of bathtub waste drains shall be copper alloy with all visible surfaces chrome plated. Plastic in contact with hot water shall be suitable for 180 degrees F water temperature.

2.4.1 Lavatories

Vitreous china lavatories shall be under-mount to counter. Provide WaterSense labeled faucet with a maximum flow rate of 0.5 gpm at a flowing pressure of 60 psi.

2.4.2 Flush Valve Water Closets

ASME A112.19.2/CSA B45.1, white vitreous china, siphon jet, elongated bowl, floor-mounted, floor outlet. Top of toilet seat height above floor shall be 14 to 15 inches, except 17 to 19 inches for wheelchair water closets. Provide wax bowl ring including plastic sleeve. Provide white solid plastic elongated open-front seat.

Water flushing volume of the water closet and flush valve combination shall not exceed 1.28 gallons per flush. Water closets must meet the EPA WaterSense product definition specified in http://www.epa.gov/watersense/partners/product_program_specs.html and must be EPA WaterSense labeled products.

Provide large diameter flush valve including angle control-stop valve, vacuum breaker, tail pieces, slip nuts, and wall plates; exposed to view components shall be chromium-plated or polished stainless steel. Flush valves shall be nonhold-open type. Mount flush valves not less than 11 inches above the fixture. Mounted height of flush valve shall not interfere with the hand rail in ADA stalls.

2.4.3 Countertop Lavatories

ASME A112.19.2/CSA B45.1, white vitreous china, ,self-rimming, minimum dimensions of 19 inches wide by 17 inches front to rear, with supply openings for use with top mounted centerset faucets. Furnish template and mounting kit by lavatory manufacturer. Provide aerator with faucet. Provide lavatory faucets and accessories meeting the flow rate and product requirements of the paragraph LAVATORIES. Mount counter with the top surface 34 inches above floor and with 29 inches minimum clearance from bottom of the counter face to floor. Provide top mounted washerless centerset lavatory faucets.

2.4.4 Kitchen Sinks

ASME A112.19.3/CSA B45.4, 20 gage stainless steel under mount with minimum dimensions of 33 inches wide by 21 inches front to rear, two compartments, with undersides fully sound deadened, with supply openings for use with top mounted washerless sink faucets with hose spray, and with 3.5 inch drain outlet. Water flow rate shall not exceed 2.2 gpm when measured at a flowing water pressure of 60 psi. Provide stainless steel drain outlets and stainless steel cup strainers. Provide separate 1.5 inch P-trap and drain piping to vertical vent piping from each compartment. Provide top mounted washerless sink faucets with hose spray.

2.4.5 Drinking-Water Coolers

AHRI 1010 with more than a single thickness of metal between the potable water and the refrigerant in the heat exchanger, wall-hung, bubbler style, air-cooled condensing unit, 4.75 gph minimum capacity, stainless steel splash receptor and basin, and stainless steel cabinet. Bubblers shall be controlled by push levers or push bars, front mounted or side mounted near the front edge of the cabinet. Bubbler spouts shall be mounted at maximum of 36 inches above floor and at front of unit basin. Spouts shall direct water flow at least 4 inches above unit basin and trajectory parallel or nearly parallel to the front of unit. Provide ASME A112.6.1M concealed steel pipe chair carriers. Provide electric water cooler that is Energy Star labeled.

2.4.6 Wheelchair Drinking Water cooler

AHRI 1010, wall-mounted bubbler style with ASME A112.6.1M concealed chair carrier, air-cooled condensing unit, 4.75 gph minimum capacity, stainless steel splash receptor, and all stainless steel cabinet, with 27 inch minimum knee clearance from front bottom of unit to floor and 36 inch maximum spout height above floor and bottle filler. Bubblers shall also be controlled by push levers, by push bars, or touch pads one on each side or one on front and both sides of the cabinet. Provide electric water cooler that is Energy Star labeled.

2.5 BACKFLOW PREVENTERS

Backflow prevention devices must be approved by the State or local regulatory agencies. If there is no State or local regulatory agency requirements, the backflow prevention devices must be listed by the Foundation for Cross-Connection Control & Hydraulic Research, or any other approved testing laboratory having equivalent capabilities for both laboratory and field evaluation of backflow prevention devices and assemblies.

Reduced pressure principle assemblies shall be meet the above requirements.

Reduced pressure principle backflow preventers shall conform to ASSE 1013. Air gaps in plumbing systems shall conform to ASME A112.1.2.

2.6 DRAINS

2.6.1 Floor and Shower Drains

Floor and shower drains shall consist of a galvanized body, integral seepage pan, and adjustable perforated or slotted chromium-plated bronze, nickel-bronze, or nickel-brass strainer, consisting of grate and threaded collar. Floor drains shall be cast iron except where metallic waterproofing membrane is installed. Drains shall be of double drainage pattern for embedding in the floor construction. The seepage pan shall have weep holes or channels for drainage to the drainpipe. The strainer shall be adjustable to floor thickness. A clamping device for attaching flashing or waterproofing membrane to the seepage pan without damaging the flashing or waterproofing membrane shall be provided when required. Drains shall be provided with threaded connection. Floor and shower drains shall conform to ASME A112.6.3. Provide drain with trap primer connection, trap primer, and connection piping. Primer shall meet ASSE 1018.

2.6.1.1 Drains

Drains installed in connection with waterproofed floors or shower pans shall be equipped with bolted-type device to securely clamp flashing.

2.6.2 Shower Faucets and Drain Fittings

Provide single control pressure equalizing shower faucets with body mounted from behind the wall with threaded connections. Provide ball joint self-cleaning shower heads. Provide WaterSense labeled showerhead with a maximum flow rate of (1.75 gpm). Provide tubing mounted from behind the wall between bathtub faucets and shower heads and bathtub diverter spouts. Provide separate angle valves with union connections in each supply to faucet. Provide shower valve with ball type control handle.

2.7 SHOWER PAN

Shower pan may be copper, or nonmetallic material.

2.7.1 Sheet Copper

Sheet copper shall be 16 ounce weight.

2.7.2 Plasticized Polyvinyl Chloride Shower Pan Material

Material shall be sheet form. The material shall be 0.040 inch minimum thickness of plasticized polyvinyl chloride or chlorinated polyethylene and shall be in accordance with ASTM D4551.

2.7.3 Nonplasticized Polyvinyl Chloride (PVC) Shower Pan Material

Material shall consist of a plastic waterproofing membrane in sheet form.

The material shall be 0.040 inch minimum thickness of nonplasticized PVC and shall have the following minimum properties:

a. or ASTM D638:

Ultimate Tensile Strength:	2600 psi
Ultimate Elongation:	398 percent
100 Percent Modulus:	445 psi

b. ASTM D1004:

Tear Strength:	300 pounds per inch

c. ASTM E96/E96M:

Permeance:	0.008 perms

d. Other Properties:

Specific Gravity:	1.29
PVC Solvent:	Weldable
Cold Crack:	minus 53 degrees F
Dimensional stability	212 degrees F minus 2.5 percent
Hardness, Shore A:	89

2.8 TRAPS

Unless otherwise specified, traps shall be plastic per ASTM F409 or copper-alloy adjustable tube type with slip joint inlet and swivel. Traps shall be without a cleanout. Provide traps with removable access panels for easy clean-out at sinks and lavatories. Tubes shall be copper alloy with walls not less than 0.032 inch thick within commercial tolerances, except on the outside of bends where the thickness may be reduced slightly in manufacture by usual commercial methods. Inlets shall have rubber washer and copper alloy nuts for slip joints above the discharge level. Swivel joints shall be below the discharge level and shall be of metal-to-metal or metal-to-plastic type as required for the application. Nuts shall have flats for wrench grip. Outlets shall have internal pipe thread, except that when required for the application, the outlets shall have sockets for solder-joint connections. The depth of the water seal shall be not less than 2 inches. The interior diameter shall be not more than 1/8 inch over or under the nominal size, and interior surfaces shall be reasonably smooth throughout. A copper alloy "P" trap assembly consisting of an adjustable "P" trap and threaded trap wall nipple with cast brass wall flange shall be provided for lavatories. The assembly shall be a standard manufactured unit and may have a rubber-gasketed swivel joint.

2.9 INTERCEPTORS

2.9.1 Sand Interceptors

Sand interceptor of the size indicated shall be of reinforced concrete, or equivalent capacity commercially available steel sand interceptor with manufacturer's standard checker-plate cover, and shall be installed floor mounted. Steel sand interceptor shall be installed in accordance with manufacturer's recommendations and shall be coated to resist corrosion as recommended by the manufacturer.

2.10 WATER HEATERS

Water heater types and capacities shall be as indicated. Each water heater shall have replaceable anodes. Each primary water heater shall have controls with an adjustable range that includes 90 to 160 degrees F. The thermal efficiencies and standby heat losses shall conform to TABLE III in PART 3 of this Section for each type of water heater specified. Plastic materials polyetherimide (PEI) and polyethersulfone (PES) are forbidden to be used for vent piping of combustion gases. A factory pre-charged expansion tank shall be installed on the cold water supply to each water heater. Expansion tanks shall be specifically designed for use on potable water systems and shall be rated for 200 degrees F water temperature and 150 psi working pressure. The expansion tank size and acceptance volume shall be as indicated.

2.10.1 Automatic Storage Type

2.10.1.1 Electric Type

Electric type water heaters shall conform to UL 174 with dual heating elements. Each element shall be 4.5 KW. The elements shall be wired so that only one element can operate at a time.

2.11 MISCELLANEOUS PIPING ITEMS

2.11.1 Escutcheon Plates

Provide one piece or split hinge metal plates for piping entering floors, walls, and ceilings in exposed spaces. Provide chromium-plated on copper alloy plates or polished stainless steel finish in finished spaces. Provide paint finish on plates in unfinished spaces.

2.11.2 Pipe Sleeves

Provide where piping passes entirely through walls, ceilings, roofs, and floors. Sleeves are not required where drain, waste, and vent (DWV) piping passes through concrete floor slabs located on grade, except where penetrating a membrane waterproof floor.

2.11.2.1 Sleeves in Masonry and Concrete

Provide steel pipe sleeves or schedule 40 PVC plastic pipe sleeves. Sleeves are not required where drain, waste, and vent (DWV) piping passes through concrete floor slabs located on grade. Core drilling of masonry and concrete may be provided in lieu of pipe sleeves when cavities in the core-drilled hole are completely grouted smooth.

2.11.2.2 Sleeves Not in Masonry and Concrete

Provide 26 gage galvanized steel sheet or PVC plastic pipe sleeves.

2.11.3 Pipe Hangers (Supports)

Provide MSS SP-58 Type 1 with adjustable type steel support rods, except as specified or indicated otherwise. Attach to steel joists with Type 19 or 23 clamps and retaining straps. Attach to Steel W or S beams with Type 21, 28, 29, or 30 clamps. Attach to steel angles and vertical web steel channels with Type 20 clamp with beam clamp channel adapter. Attach to horizontal web steel channel and wood with drilled hole on centerline and double nut and washer. Attach to concrete with Type 18 insert or drilled expansion anchor. Provide Type 40 insulation protection shield for insulated piping.

PART 3 EXECUTION

3.1 GENERAL INSTALLATION REQUIREMENTS

Piping located in air plenums shall conform to NFPA 90A requirements. Piping located in shafts that constitute air ducts or that enclose air ducts shall be noncombustible in accordance with NFPA 90A. Installation of plastic pipe where in compliance with NFPA may be installed in accordance with PPFA Fire Man. The plumbing system shall be installed complete with necessary fixtures, fittings, traps, valves, and accessories. Water and drainage piping shall be extended 5 feet outside the building, unless otherwise indicated. A full port ball valve and drain shall be installed on the water service line inside the building approximately 6 inches above the floor from point of entry. Piping shall be connected to the exterior service lines or capped or plugged if the exterior service is not in place. Sewer and water pipes shall be laid in separate trenches, except when otherwise shown. Exterior underground utilities shall be at least 12 inches below the finish grade or as indicated on the drawings. If trenches are closed or the pipes are otherwise covered before being connected to the service lines, the location of the end of each plumbing utility shall be marked with a stake or other acceptable means. Valves shall be installed with control no lower than the valve body.

3.1.1 Water Pipe, Fittings, and Connections

3.1.1.1 Utilities

The piping shall be extended to fixtures, outlets, and equipment. The hot-water and cold-water piping system shall be arranged and installed to permit draining. The supply line to each item of equipment or fixture, except faucets, flush valves, or other control valves which are supplied with integral stops, shall be equipped with a shutoff valve to enable isolation of the item for repair and maintenance without interfering with operation of other equipment or fixtures. Supply piping to fixtures, faucets, hydrants, shower heads, and flushing devices shall be anchored to prevent movement.

3.1.1.2 Cutting and Repairing

The work shall be carefully laid out in advance, and unnecessary cutting of construction shall be avoided. Damage to building, piping, wiring, or equipment as a result of cutting shall be repaired by mechanics skilled in the trade involved.

3.1.1.3 Protection of Fixtures, Materials, and Equipment

Pipe openings shall be closed with caps or plugs during installation. Fixtures and equipment shall be tightly covered and protected against dirt, water, chemicals, and mechanical injury. Upon completion of the work, the fixtures, materials, and equipment shall be thoroughly cleaned, adjusted, and operated. Safety guards shall be provided for exposed rotating equipment.

3.1.1.4 Mains, Branches, and Runouts

Piping shall be installed as indicated. Pipe shall be accurately cut and worked into place without springing or forcing. Structural portions of the building shall not be weakened. Aboveground piping shall run parallel with the lines of the building, unless otherwise indicated. Branch pipes from service lines may be taken from top, bottom, or side of main, using crossover fittings required by structural or installation conditions. Supply pipes, valves, and fittings shall be kept a sufficient distance from other work and other services to permit not less than 1/2 inch between finished covering on the different services. Bare and insulated water lines shall not bear directly against building structural elements so as to transmit sound to the structure or to prevent flexible movement of the lines. Water pipe shall not be buried in or under floors unless specifically indicated or approved. Changes in pipe sizes shall be made with reducing fittings. Use of bushings will not be permitted except for use in situations in which standard factory fabricated components are furnished to accommodate specific accepted installation practice. Change in direction shall be made with fittings, except that bending of pipe 4 inches and smaller will be permitted, provided a pipe bender is used and wide sweep bends are formed. The center-line radius of bends shall be not less than six diameters of the pipe. Bent pipe showing kinks, wrinkles, flattening, or other malformations will not be acceptable.

3.1.1.5 Pipe Drains

Pipe drains indicated shall consist of 3/4 inch hose bibb with renewable seat and full port ball valve ahead of hose bibb. At other low points, 3/4 inch brass plugs or caps shall be provided. Disconnection of the supply piping at the fixture is an acceptable drain.

3.1.1.6 Expansion and Contraction of Piping

Allowance shall be made throughout for expansion and contraction of water pipe. Each hot-water and hot-water circulation riser shall have expansion loops or other provisions such as offsets and changes in direction where indicated and required. Risers shall be securely anchored as required or where indicated to force expansion to loops. Branch connections from risers shall be made with ample swing or offset to avoid undue strain on fittings or short pipe lengths. Horizontal runs of pipe over 50 feet in length shall be anchored to the wall or the supporting construction about midway on the run to force expansion, evenly divided, toward the ends. Sufficient flexibility shall be provided on branch runouts from mains and risers to provide for expansion and contraction of piping. Flexibility shall be provided by installing one or more turns in the line so that piping will spring enough to allow for expansion without straining. If mechanical grooved pipe coupling systems are provided, the deviation from design requirements for expansion and contraction may be allowed pending approval of Contracting Officer.

3.1.1.7 Commercial-Type Water Hammer Arresters

Commercial-type water hammer arresters shall be provided on hot- and cold-water supplies and shall be located as generally indicated, with precise location and sizing to be in accordance with PDI WH 201. Water hammer arresters, where concealed, shall be accessible by means of access doors or removable panels. Commercial-type water hammer arresters shall conform to ASSE 1010. Vertical capped pipe columns will not be permitted.

3.1.2 Joints

Installation of pipe and fittings shall be made in accordance with the manufacturer's recommendations. Mitering of joints for elbows and notching of straight runs of pipe for tees will not be permitted. Joints shall be made up with fittings of compatible material and made for the specific purpose intended.

3.1.2.1 Threaded

Threaded joints shall have American Standard taper pipe threads conforming to ASME B1.20.1. Only male pipe threads shall be coated with graphite or with an approved graphite compound, or with an inert filler and oil, or shall have a polytetrafluoroethylene tape applied.

3.1.2.2 Unions and Flanges

Unions, flanges shall not be concealed in walls, ceilings, or partitions. Unions shall be used on pipe sizes 2-1/2 inches and smaller; flanges shall be used on pipe sizes 3 inches and larger.

3.1.2.3 Copper Tube and Pipe

a. Brazed. Brazed joints shall be made in conformance with AWS B2.2/B2.2M, ASME B16.50, and CDA A4015 with flux and are acceptable for all pipe sizes. Copper to copper joints shall include the use of copper-phosphorus or copper-phosphorus-silver brazing metal without flux. Brazing of dissimilar metals (copper to bronze or brass) shall include the use of flux with either a copper-phosphorus, copper-phosphorus-silver or a silver brazing filler metal.

b. Soldered. Soldered joints shall be made with flux and are only acceptable for piping 2 inches and smaller. Soldered joints shall conform to ASME B31.5 and CDA A4015. Soldered joints shall not be used in compressed air piping between the air compressor and the receiver.

c. Copper Tube Extracted Joint. Mechanically extracted joints shall be made in accordance with ICC IPC.

d. Press connection. Copper press connections shall be made in **strict** accordance with the manufacturer's installation instructions for manufactured rated size. The joints shall be pressed using the tool(s) approved by the manufacturer **of that joint**. Minimum distance between fittings shall be in accordance with the manufacturer's requirements.

3.1.2.4 Plastic Pipe

PVC pipe shall have joints made with solvent cement elastomeric, threading, (threading of Schedule 80 Pipe is allowed only where required for disconnection and inspection; threading of Schedule 40 Pipe is not allowed), or mated flanged.

3.1.2.5 Other Joint Methods

3.1.3 Dissimilar Pipe Materials

Connections between ferrous and non-ferrous copper water pipe shall be made with dielectric unions or flange waterways. Dielectric waterways shall have temperature and pressure rating equal to or greater than that specified for the connecting piping. Waterways shall have metal connections on both ends suited to match connecting piping. Dielectric waterways shall be internally lined with an insulator specifically designed to prevent current flow between dissimilar metals. Dielectric flanges shall meet the performance requirements described herein for dielectric waterways. Connecting joints between plastic and metallic pipe shall be made with transition fitting for the specific purpose.

3.1.4 Pipe Sleeves and Flashing

Pipe sleeves shall be furnished and set in their proper and permanent location.

3.1.4.1 Sleeve Requirements

Unless indicated otherwise, provide pipe sleeves meeting the following requirements:

a. Secure sleeves in position and location during construction. Provide sleeves of sufficient length to pass through entire thickness of walls, ceilings, roofs, and floors.

c. Sleeves shall not be installed in structural members, except where indicated or approved. Rectangular and square openings shall be as detailed. Each sleeve shall extend through its respective floor, or roof, and shall be cut flush with each surface, except for special circumstances. Pipe sleeves passing through floors in wet areas such as mechanical equipment rooms, lavatories, kitchens, and other plumbing fixture areas shall extend a minimum of 4 inches above the finished floor.

d. Unless otherwise indicated, sleeves shall be of a size to provide a minimum of 1/4 inch clearance between bare pipe or insulation and inside of sleeve or between insulation and inside of sleeve. Sleeves in bearing walls and concrete slab on grade floors shall be steel pipe or cast-iron pipe. Sleeves in nonbearing walls or ceilings may be steel pipe, cast-iron pipe, galvanized sheet metal with lock-type longitudinal seam, or plastic.

e. Except as otherwise specified, the annular space between pipe and sleeve, or between jacket over insulation and sleeve, shall be sealed as indicated with sealants conforming to ASTM C920 and with a primer, backstop material and surface preparation as specified in Section 07 92 00 JOINT SEALANTS. The annular space between pipe and sleeve, between bare insulation and sleeve or between jacket over insulation and sleeve shall not be sealed for interior walls which are not designated as fire rated.

3.1.4.2 Flashing Requirements

Pipes passing through roof shall be installed through a 16 ounce copper flashing, each within an integral skirt or flange. Flashing shall be suitably formed, and the skirt or flange shall extend not less than 8 inches from the pipe and shall be set over the roof or floor membrane in a solid coating of bituminous cement. The flashing shall extend up the pipe a minimum of 10 inches. For cleanouts, the flashing shall be turned down into the hub and caulked after placing the ferrule. Pipes passing through pitched roofs shall be flashed, using lead or copper flashing, with an adjustable integral flange of adequate size to extend not less than 8 inches from the pipe in all directions and lapped into the roofing to provide a watertight seal. The annular space between the flashing and the bare pipe or between the flashing and the metal-jacket-covered insulation shall be sealed as indicated. Flashing for dry vents shall be turned down into the pipe to form a waterproof joint. Pipes, up to and including 10 inches in diameter, passing through roof or floor waterproofing membrane may be installed through a cast-iron sleeve with caulking recess, anchor lugs, flashing-clamp device, and pressure ring with brass bolts. Flashing shield shall be fitted into the sleeve clamping device. Pipes passing through wall waterproofing membrane shall be sleeved as described above. A waterproofing clamping flange shall be installed.

3.1.4.3 Waterproofing

Waterproofing at floor-mounted water closets shall be accomplished by forming a flashing guard from soft-tempered sheet copper. The center of the sheet shall be perforated and turned down approximately 1-1/2 inches to fit between the outside diameter of the drainpipe and the inside diameter of the cast-iron or steel pipe sleeve. The turned-down portion of the flashing guard shall be embedded in sealant to a depth of approximately 1-1/2 inches; then the sealant shall be finished off flush to floor level between the flashing guard and drainpipe. The flashing guard of sheet copper shall extend not less than 8 inches from the drainpipe and shall be lapped between the floor membrane in a solid coating of bituminous cement. If cast-iron water closet floor flanges are used, the space between the pipe sleeve and drainpipe shall be sealed with sealant and the flashing guard shall be upturned approximately 1-1/2 inches to fit the outside diameter of the drainpipe and the inside diameter of the water closet floor flange. The upturned portion of the sheet fitted into the floor flange shall be sealed.

3.1.4.4 Pipe Penetrations of Slab on Grade Floors

Where pipes, fixture drains, floor drains, cleanouts or similar items penetrate slab on grade floors, except at penetrations of floors with waterproofing membrane as specified in paragraphs FLASHING REQUIREMENTS and WATERPROOFING, a groove 1/4 to 1/2 inch wide by 1/4 to 3/8 inch deep shall be formed around the pipe, fitting or drain. The groove shall be filled with a sealant as specified in Section 07 92 00 JOINT SEALANTS.

3.1.4.5 Pipe Penetrations

Provide sealants for all pipe penetrations. All pipe penetrations shall be sealed to prevent infiltration of air, insects, and vermin.

3.1.5 Fire Seal

Where pipes pass through fire walls, fire-partitions, fire-rated pipe chase walls or floors above grade, a fire seal shall be provided as specified in Section 07 84 00 FIRESTOPPING.

3.1.6 Supports

3.1.6.1 General

Hangers used to support piping 2 inches and larger shall be fabricated to permit adequate adjustment after erection while still supporting the load. Pipe guides and anchors shall be installed to keep pipes in accurate alignment, to direct the expansion movement, and to prevent buckling, swaying, and undue strain. Piping subjected to vertical movement when operating temperatures exceed ambient temperatures shall be supported by variable spring hangers and supports or by constant support hangers. In the support of multiple pipe runs on a common base member, a clip or clamp shall be used where each pipe crosses the base support member. Spacing of the base support members shall not exceed the hanger and support spacing required for an individual pipe in the multiple pipe run. Threaded sections of rods shall not be formed or bent.

3.1.6.2 Pipe Hangers, Inserts, and Supports

Installation of pipe hangers, inserts and supports shall conform to MSS SP-58 except as modified herein.

a. Types 5, 12, and 26 shall not be used.

b. Type 3 shall not be used on insulated pipe.

c. Type 18 inserts shall be secured to concrete forms before concrete is placed. Continuous inserts which allow more adjustment may be used if they otherwise meet the requirements for type 18 inserts.

d. Type 19 and 23 C-clamps shall be torqued per MSS SP-58 and shall have both locknuts and retaining devices furnished by the manufacturer. Field-fabricated C-clamp bodies or retaining devices are not acceptable.

e. Type 20 attachments used on angles and channels shall be furnished with an added malleable-iron heel plate or adapter.

f. Type 24 may be used only on trapeze hanger systems or on fabricated frames.

g. Type 39 saddles shall be used on insulated pipe 4 inches and larger when the temperature of the medium is 60 degrees F or higher. Type 39 saddles shall be welded to the pipe.

h. Type 40 shields shall:

    (1) Be used on insulated pipe less than 4 inches.

    (2) Be used on insulated pipe 4 inches and larger when the temperature of the medium is 60 degrees F or less.

    (3) Have a high density insert for all pipe sizes. High density inserts shall have a density of 8 pcf or greater.

i. Horizontal pipe supports shall be spaced as specified in MSS SP-58 and a support shall be installed not over 1 foot from the pipe fitting joint at each change in direction of the piping. Pipe supports shall be spaced not over 5 feet apart at valves. Operating temperatures in determining hanger spacing for PVC or CPVC pipe shall be 120 degrees F for PVC and 180 degrees F for CPVC. Horizontal pipe runs shall include allowances for expansion and contraction.

j. Vertical pipe shall be supported at each floor, except at slab-on-grade, at intervals of not more than 15 feet nor more than 8 feet from end of risers, and at vent terminations. Vertical pipe risers shall include allowances for expansion and contraction.

k. Type 35 guides using steel, reinforced polytetrafluoroethylene (PTFE) or graphite slides shall be provided to allow longitudinal pipe movement. Slide materials shall be suitable for the system operating temperatures, atmospheric conditions, and bearing loads encountered. Lateral restraints shall be provided as needed. Where steel slides do not require provisions for lateral restraint the following may be used:

(1) On pipe 4 inches and larger when the temperature of the medium is 60 degrees F or higher, a Type 39 saddle, welded to the pipe, may freely rest on a steel plate.

(2) On pipe less than 4 inches a Type 40 shield, attached to the pipe or insulation, may freely rest on a steel plate.

(3) On pipe 4 inches and larger carrying medium less that 60 degrees F a Type 40 shield, attached to the pipe or insulation, may freely rest on a steel plate.

l. Pipe hangers on horizontal insulated pipe shall be the size of the outside diameter of the insulation. The insulation shall be continuous through the hanger on all pipe sizes and applications.

m. Where there are high system temperatures and welding to piping is not desirable, the type 35 guide shall include a pipe cradle, welded to the guide structure and strapped securely to the pipe. The pipe shall be separated from the slide material by at least 4 inches or by an amount adequate for the insulation, whichever is greater.

n. Hangers and supports for plastic pipe shall not compress, distort, cut or abrade the piping, and shall allow free movement of pipe except where otherwise required in the control of expansion/contraction.

3.1.6.3 Structural Attachments

Attachment to building structure concrete and masonry shall be by cast-in concrete inserts, built-in anchors, or masonry anchor devices. Inserts and anchors shall be applied with a safety factor not less than 5. Supports shall not be attached to metal decking. Supports shall not be attached to the underside of concrete filled floor or concrete roof decks unless approved by the Contracting Officer. Masonry anchors for overhead applications shall be constructed of ferrous materials only.

3.1.7 Welded Installation

Plumbing pipe weldments shall be as indicated. Changes in direction of piping shall be made with welding fittings only; mitering or notching pipe to form elbows and tees or other similar type construction will not be permitted. Branch connection may be made with either welding tees or forged branch outlet fittings. Branch outlet fittings shall be forged, flared for improvement of flow where attached to the run, and reinforced against external strains. Beveling, alignment, heat treatment, and inspection of weld shall conform to ASME B31.1. Weld defects shall be removed and repairs made to the weld, or the weld joints shall be entirely removed and rewelded. After filler metal has been removed from its original package, it shall be protected or stored so that its characteristics or welding properties are not affected. Electrodes that have been wetted or that have lost any of their coating shall not be used.

3.1.8 Pipe Cleanouts

Pipe cleanouts shall be the same size as the pipe except that cleanout plugs larger than 4 inches will not be required. A cleanout installed in connection with cast-iron soil pipe shall consist of a long-sweep 1/4 bend or one or two 1/8 bends extended to the place shown. An extra-heavy cast-brass or cast-iron ferrule with countersunk cast-brass head screw plug shall be caulked into the hub of the fitting and shall be flush with the floor. Cleanouts in connection with other pipe, where indicated, shall be T-pattern, 90-degree branch drainage fittings with cast-brass screw plugs, except plastic plugs shall be installed in plastic pipe. Plugs shall be the same size as the pipe up to and including 4 inches. Cleanout tee branches with screw plug shall be installed at the foot of soil and waste stacks, at the foot of interior downspouts, on each connection to building storm drain where interior downspouts are indicated, and on each building drain outside the building. Cleanout tee branches may be omitted on stacks in single story buildings with slab-on-grade construction or where less than 18 inches of crawl space is provided under the floor. Cleanouts on pipe concealed in partitions shall be provided with chromium plated bronze, nickel bronze, nickel brass or stainless steel flush type access cover plates. Round access covers shall be provided and secured to plugs with securing screw. Square access covers may be provided with matching frames, anchoring lugs and cover screws. Cleanouts in finished walls shall have access covers and frames installed flush with the finished wall. Cleanouts installed in finished floors subject to foot traffic shall be provided with a chrome-plated cast brass, nickel brass, or nickel bronze cover secured to the plug or cover frame and set flush with the finished floor. Heads of fastening screws shall not project above the cover surface. Where cleanouts are provided with adjustable heads, the heads shall be cast iron or plastic.

3.2 WATER HEATERS

3.2.1 Relief Valves

No valves shall be installed between a relief valve and its water heater. The P&T relief valve shall be installed where the valve actuator comes in contact with the hottest water in the heater. Whenever possible, the relief valve shall be installed directly in a tapping in the heater; otherwise, the P&T valve shall be installed in the hot-water outlet piping. A vacuum relief valve shall be provided on the cold water supply line to the water heater and mounted above and within 6 inches above the top of the tank or water heater.

3.2.2 Heat Traps

Piping to and from each water heater shall be routed horizontally and downward a minimum of 2 feet before turning in an upward direction.

3.2.3 Connections to Water Heaters

Connections of metallic pipe to water heaters shall be made with dielectric unions or flanges.

3.2.4 Expansion Tank

A pre-charged expansion tank shall be installed on the cold water supply between the water heater inlet and the cold water supply shut-off valve. The Contractor shall adjust the expansion tank air pressure, as recommended by the tank manufacturer, to match incoming water pressure.

3.3 FIXTURES AND FIXTURE TRIMMINGS

Polished chromium-plated pipe, valves, and fittings shall be provided where exposed to view. Angle stops, straight stops, stops integral with the faucets, or concealed type of lock-shield, and loose-key pattern stops for supplies with threaded, sweat or solvent weld inlets shall be furnished and installed with fixtures. Where connections between copper tubing and faucets are made by rubber compression fittings, a beading tool shall be used to mechanically deform the tubing above the compression fitting. Exposed traps and supply pipes for fixtures and equipment shall be connected to the rough piping systems at the wall, unless otherwise specified under the item. Floor and wall escutcheons shall be as specified. Drain lines and hot water lines of fixtures for handicapped personnel shall be insulated and do not require polished chrome finish. Plumbing fixtures and accessories shall be installed within the space shown.

3.3.1 Fixture Connections

Where space limitations prohibit standard fittings in conjunction with the cast-iron floor flange, special short-radius fittings shall be provided. Connections between earthenware fixtures and flanges on soil pipe shall be made gastight and watertight with a closet-setting compound or neoprene gasket and seal. Use of natural rubber gaskets or putty will not be permitted. Fixtures with outlet flanges shall be set the proper distance from floor or wall to make a first-class joint with the closet-setting compound or gasket and fixture used.

3.3.2 Flushometer Valves

Flushometer valves shall be secured to prevent movement by anchoring the long finished top spud connecting tube to wall adjacent to valve with approved metal bracket. Flushometer valves for water closets shall be installed 39 inches above the floor, except at water closets intended for use by the physically handicapped where flushometer valves shall be mounted at approximately 30 inches above the floor and arranged to avoid interference with grab bars. In addition, for water closets intended for handicap use, the flush valve handle shall be installed on the wide side of the enclosure.

3.3.3 Height of Fixture Rims Above Floor

Lavatories shall be mounted with rim 31 inches above finished floor. Wall-hung drinking fountains and water coolers shall be installed with rim 42 inches above floor. Wall-hung service sinks shall be mounted with rim 28 inches above the floor. Installation of fixtures for use by the physically handicapped shall be in accordance with ICC A117.1.

3.3.4 Shower Bath Outfits

The area around the water supply piping to the mixing valves and behind the escutcheon plate shall be made watertight by caulking or gasketing.

3.3.5 Fixture Supports

Fixture supports for off-the-floor lavatories, urinals, water closets, and other fixtures of similar size, design, and use, shall be of the chair-carrier type. The carrier shall provide the necessary means of mounting the fixture, with a foot or feet to anchor the assembly to the floor slab. Adjustability shall be provided to locate the fixture at the desired height and in proper relation to the wall. Support plates, in lieu of chair carrier, shall be fastened to the wall structure only where it is not possible to anchor a floor-mounted chair carrier to the floor slab.

3.3.5.1 Support for Solid Masonry Construction

Chair carrier shall be anchored to the floor slab. Where a floor-anchored chair carrier cannot be used, a suitable wall plate shall be imbedded in the masonry wall.

3.3.5.2 Support for Concrete-Masonry Wall Construction

Chair carrier shall be anchored to floor slab. Where a floor-anchored chair carrier cannot be used, a suitable wall plate shall be fastened to the concrete wall using through bolts and a back-up plate.

3.3.5.3 Support for Steel Stud Frame Partitions

Chair carrier shall be used. The anchor feet and tubular uprights shall be of the heavy duty design; and feet (bases) shall be steel and welded to a square or rectangular steel tube upright. Wall plates, in lieu of floor-anchored chair carriers, shall be used only if adjoining steel partition studs are suitably reinforced to support a wall plate bolted to these studs.

3.3.5.4 Support for Wood Stud Construction

Where floor is a concrete slab, a floor-anchored chair carrier shall be used. Where entire construction is wood, wood crosspieces shall be installed. Fixture hanger plates, supports, brackets, or mounting lugs shall be fastened with not less than No. 10 wood screws, 1/4 inch thick minimum steel hanger, or toggle bolts with nut. The wood crosspieces shall extend the full width of the fixture and shall be securely supported.

3.3.6 Backflow Prevention Devices

Plumbing fixtures, equipment, and pipe connections shall not cross connect or interconnect between a potable water supply and any source of nonpotable water. Backflow preventers shall be installed where indicated and in accordance with ICC IPC at all other locations necessary to preclude a cross-connect or interconnect between a potable water supply and any nonpotable substance. In addition backflow preventers shall be installed at all locations where the potable water outlet is below the flood level of the equipment, or where the potable water outlet will be located below the level of the nonpotable substance. Backflow preventers shall be located so that no part of the device will be submerged. Backflow preventers shall be of sufficient size to allow unrestricted flow of water to the equipment, and preclude the backflow of any nonpotable substance into the potable water system. Bypass piping shall not be provided around backflow preventers. Access shall be provided for maintenance and testing. Each device shall be a standard commercial unit.

3.3.7 Access Panels

Access panels shall be provided for concealed valves and controls, or any item requiring inspection or maintenance. Access panels shall be of sufficient size and located so that the concealed items may be serviced, maintained, or replaced.

3.3.8 Traps

Each trap shall be placed as near the fixture as possible, and no fixture shall be double-trapped. Traps installed on steel pipe or copper tubing shall be recess-drainage pattern, or brass-tube type. Traps installed on plastic pipe may be plastic conforming to ASTM D3311.

3.3.9 Shower Pans

Before installing shower pan, subfloor shall be free of projections such as nail heads or rough edges of aggregate. Drain shall be a bolt-down, clamping-ring type with weepholes, installed so the lip of the subdrain is flush with subfloor.

3.3.9.1 General

The floor of each individual shower, the shower-area portion of combination shower and drying room, and the entire shower and drying room where the two are not separated by curb or partition, shall be made watertight with a shower pan fabricated in place. The shower pan material shall be cut to size and shape of the area indicated, in one piece to the maximum extent practicable, allowing a minimum of 6 inches for turnup on walls or partitions, and shall be folded over the curb with an approximate return of 1/4 of curb height. The upstands shall be placed behind any wall or partition finish. Subflooring shall be smooth and clean, with nailheads driven flush with surface, and shall be sloped to drain. Shower pans shall be clamped to drains with the drain clamping ring.

3.3.9.2 Metal Shower Pans

When a shower pan of required size cannot be furnished in one piece, metal pieces shall be joined with a flintlock seam and soldered or burned. The corners shall be folded, not cut, and the corner seam shall be soldered or burned. Pans, including upstands, shall be coated on all surfaces with one brush coat of asphalt. Asphalt shall be applied evenly at not less than 1 gallon per 50 square feet. A layer of felt covered with building paper shall be placed between shower pans and wood floors. The joining surfaces of metal pan and drain shall be given a brush coat of asphalt after the pan is connected to the drain.

3.3.9.3 Plasticized Chlorinated Polyethylene Shower Pans

Corners of plasticized chlorinated polyethylene shower pans shall be folded against the upstand by making a pig-ear fold. Hot-air gun or heat lamp shall be used in making corner folds. Each pig-ear corner fold shall be nailed or stapled 1/2 inch from the upper edge to hold it in place. Nails shall be galvanized large-head roofing nails. On metal framing or studs, approved duct tape shall be used to secure pig-ear fold and membrane. Where no backing is provided between the studs, the membrane slack shall be taken up by pleating and stapling or nailing to studding 1/2 inch from upper edge. To adhere the membrane to vertical surfaces, the back of the membrane and the surface to which it will be applied shall be coated with adhesive that becomes dry to the touch in 5 to 10 minutes, after which the membrane shall be pressed into place. Surfaces to be solvent-welded shall be clean. Surfaces to be joined with xylene shall be initially sprayed and vigorously cleaned with a cotton cloth, followed by final coating of xylene and the joining of the surfaces by roller or equivalent means. If ambient or membrane temperatures are below 40 degrees F the membrane and the joint shall be heated prior to application of xylene. Heat may be applied with hot-air gun or heat lamp, taking precautions not to scorch the membrane. Adequate ventilation and wearing of gloves are required when working with xylene. Membrane shall be pressed into position on the drain body, and shall be cut and fit to match so that membrane can be properly clamped and an effective gasket-type seal provided. On wood subflooring, two layers of 15 pound dry felt shall be installed prior to installation of shower pan to ensure a smooth surface for installation.

3.3.9.4 Nonplasticized Polyvinyl Chloride (PVC) Shower Pans

Nonplasticized PVC shall be turned up behind walls or wall surfaces a distance of not less than 6 inches in room areas and 3 inches above curb level in curbed spaces with sufficient material to fold over and fasten to outside face of curb. Corners shall be pig-ear type and folded between pan and studs. Only top 1 inch of upstand shall be nailed to hold in place. Nails shall be galvanized large-head roofing type. Approved duct tape shall be used on metal framing or studs to secure pig-ear fold and membrane. Where no backing is provided between studs, the membrane slack shall be taken up by pleating and stapling or nailing to studding at top inch of upstand. To adhere the membrane to vertical surfaces, the back of the membrane and the surface to which it is to be applied shall be coated with adhesive that becomes dry to the touch in 5 to 10 minutes, after which the membrane shall be pressed into place. Trim for drain shall be exactly the size of drain opening. Bolt holes shall be pierced to accommodate bolts with a tight fit. Adhesive shall be used between pan and subdrain. Clamping ring shall be bolted firmly. A small amount of gravel or porous materials shall be placed at weepholes so that holes remain clear when setting bed is poured. Membrane shall be solvent welded with PVC solvent cement. Surfaces to be solvent welded shall be clean (free of grease and grime). Sheets shall be laid on a flat surface with an overlap of about 2 inches. Top edge shall be folded back and surface primed with a PVC primer. PVC cement shall be applied and surfaces immediately placed together, while still wet. Joint shall be lightly rolled with a paint roller, then as the joint sets shall be rolled firmly but not so hard as to distort the material. In long lengths, about 2 or 3 feet at a time shall be welded. On wood subflooring, two layers of 15 pound felt shall be installed prior to installation of shower pan to ensure a smooth surface installation.

3.4 WATER METER REMOTE READOUT REGISTER

The remote readout register shall be mounted at the location indicated or as directed by the Contracting Officer.

3.5 IDENTIFICATION SYSTEMS

3.5.1 Identification Tags

Identification tags made of brass, engraved laminated plastic, or engraved anodized aluminum, indicating service and valve number shall be installed on valves, except those valves installed on supplies at plumbing fixtures. Tags shall be 1-3/8 inch minimum diameter, and marking shall be stamped or engraved. Indentations shall be black, for reading clarity. Tags shall be attached to valves with No. 12 AWG, copper wire, chrome-plated beaded chain, or plastic straps designed for that purpose.

3.6 ESCUTCHEONS

Escutcheons shall be provided at finished surfaces where bare or insulated piping, exposed to view, passes through floors, walls, or ceilings, except in boiler, utility, or equipment rooms. Escutcheons shall be fastened securely to pipe or pipe covering and shall be satin-finish, corrosion-resisting steel, polished chromium-plated zinc alloy, or polished chromium-plated copper alloy. Escutcheons shall be either one-piece or split-pattern, held in place by internal spring tension or setscrew.

3.7 TESTS, FLUSHING AND DISINFECTION

3.7.1 Plumbing System

The following tests shall be performed on the plumbing system in accordance with ICC IPC, except that the drainage and vent system final test shall include the smoke test.

a. Drainage and Vent Systems Test. The final test shall include a smoke test.

b. Building Sewers Tests.

c. Water Supply Systems Tests.

3.7.1.1 Test of Backflow Prevention Assemblies

Backflow prevention assembly shall be tested using gauges specifically designed for the testing of backflow prevention assemblies.

If the unit fails to meet specified requirements, the unit shall be repaired and retested.

3.7.1.2 Shower Pans

After installation of the pan and finished floor, the drain shall be temporarily plugged below the weep holes. The floor area shall be flooded with water to a minimum depth of 1 inch for a period of 24 hours. Any drop in the water level during test, except for evaporation, will be reason for rejection, repair, and retest.

3.7.2 Defective Work

If inspection or test shows defects, such defective work or material shall be replaced or repaired as necessary and inspection and tests shall be repeated. Repairs to piping shall be made with new materials. Caulking of screwed joints or holes will not be acceptable.

3.7.3 System Flushing

3.7.3.1 During Flushing

Before operational tests or disinfection, potable water piping system shall be flushed with potable water. Sufficient water shall be used to produce a water velocity that is capable of entraining and removing debris in all portions of the piping system. This requires simultaneous operation of all fixtures on a common branch or main in order to produce a flushing velocity of approximately 4 fps through all portions of the piping system. In the event that this is impossible due to size of system, the Contracting Officer (or the designated representative) shall specify the number of fixtures to be operated during flushing. Contractor shall provide adequate personnel to monitor the flushing operation and to ensure that drain lines are unobstructed in order to prevent flooding of the facility. Contractor shall be responsible for any flood damage resulting from flushing of the system. Flushing shall be continued until entrained dirt and other foreign materials have been removed and until discharge water shows no discoloration. All faucets and drinking water fountains, to include any device considered as an end point device by NSF/ANSI 61, Section 9, shall be flushed a minimum of 0.25 gallons per 24 hour period, ten times over a 14 day period.

3.7.3.2 After Flushing

System shall be drained at low points. Strainer screens shall be removed, cleaned, and replaced. After flushing and cleaning, systems shall be prepared for testing by immediately filling water piping with clean, fresh potable water. Any stoppage, discoloration, or other damage to the finish, furnishings, or parts of the building due to the Contractor's failure to properly clean the piping system shall be repaired by the Contractor. When the system flushing is complete, the hot-water system shall be adjusted for uniform circulation. Flushing devices and automatic control systems shall be adjusted for proper operation according to manufacturer's instructions. Flow rates on fixtures must not exceed those stated in PART 2 of this Section. Unless more stringent local requirements exist, lead levels shall not exceed limits established by 40 CFR 141.80 (c)(1). The water supply to the building shall be tested separately to ensure that any lead contamination found during potable water system testing is due to work being performed inside the building.

3.7.4 Operational Test

Upon completion of flushing and prior to disinfection procedures, the Contractor shall subject the plumbing system to operating tests to demonstrate satisfactory installation, connections, adjustments, and functional and operational efficiency. Such operating tests shall cover a period of not less than 8 hours for each system and shall include the following information in a report with conclusion as to the adequacy of the system:

a. Time, date, and duration of test.

b. Water pressures at the most remote and the highest fixtures.

c. Operation of each fixture and fixture trim.

d. Operation of each valve, hydrant, and faucet.

f. Temperature of each domestic hot-water supply.

g. Operation of each floor and roof drain by flooding with water.

h. Operation of each vacuum breaker and backflow preventer.

3.7.5 Disinfection

After all system components are provided and operational tests are complete, the entire domestic hot- and cold-water distribution system shall be disinfected. Before introducing disinfecting chlorination material, entire system shall be flushed with potable water until any entrained dirt and other foreign materials have been removed.

Water chlorination procedure shall be in accordance with AWWA C651 and AWWA C652 as modified and supplemented by this specification. The chlorinating material shall be hypochlorites or liquid chlorine. The chlorinating material shall be fed into the water piping system at a constant rate at a concentration of at least 50 parts per million (ppm). Feed a properly adjusted hypochlorite solution injected into the system with a hypochlorinator, or inject liquid chlorine into the system through a solution-feed chlorinator and booster pump until the entire system is completely filled.

Test the chlorine residual level in the water at 6 hour intervals for a continuous period of 24 hours. If at the end of a 6 hour interval, the chlorine residual has dropped to less than 25 ppm, flush the piping including tanks with potable water, and repeat the above chlorination procedures. During the chlorination period, each valve and faucet shall be opened and closed several times.

After the second 24 hour period, verify that no less than 25 ppm chlorine residual remains in the treated system. The 24 hour chlorination procedure must be repeated until no less than 25 ppm chlorine residual remains in the treated system.

3.8 PERFORMANCE OF WATER HEATING EQUIPMENT

Standard rating condition terms are as follows:

EF = Energy factor, minimum overall efficiency.

ET = Minimum thermal efficiency with 70 degrees F delta T.

SL = Standby loss is maximum (Btu/h) based on a 70 degrees F temperature difference between stored water and ambient requirements.

V = Rated volume in gallons

Q = Nameplate input rate in kW (Btu/h)

3.8.1 Storage Water Heaters

3.8.1.1 Electric

a. Storage capacity of 60 gallons shall have a minimum energy factor (EF) of 0.93 or higher per FEMP requirements.

3.9 TABLES

TABLE I								
PIPE AND FITTING MATERIALS FOR DRAINAGE, WASTE, VENT AND CONDENSATE DRAIN PIPING SYSTEMS								
It #	Pipe and Fitting Materials	SERVICE A	SERVICE B	SERVICE C	SERVICE D	SERVICE E	SERVICE F	SERVICE G
3	Cast iron drainage fittings, threaded, ASME B16.12 for use with Item 10	X		X	X			
4	Cast iron screwed fittings (threaded) ASME B16.4 for use with Item 10				X	X		
10	Steel pipe, seamless galvanized, ASTM A53/A53M, Type S, Grade B	X			X	X		
12	Bronzed flanged fittings, ASME B16.24 for use with Items 11 and 14				X	X		X
13	Cast copper alloy solder joint pressure fittings, ASME B16.18for use with Item 14				X	X		X
14	Seamless copper pipe, ASTM B42						X	X
15	Cast bronze threaded fittings, ASME B16.15				X	X		
16	Copper drainage tube, (DWV), ASTM B306	X*	X	X*	X	X		X
20	Polyvinyl Chloride plastic drain, waste and vent pipe and fittings, ASTM D2665, ASTM F891, (Sch 40) ASTM F1760	X	X	X	X	X	X	X

TABLE I

PIPE AND FITTING MATERIALS FOR DRAINAGE, WASTE, VENT AND CONDENSATE DRAIN PIPING SYSTEMS

It #	Pipe and Fitting Materials	SERVICE A	SERVICE B	SERVICE C	SERVICE D	SERVICE E	SERVICE F	SERVICE G

SERVICE:

A - Underground Building Soil, Waste and Storm Drain
B - Aboveground Soil, Waste, Drain In Buildings
C - Underground Vent
D - Aboveground Vent
E - Interior Rainwater Conductors Aboveground
F - Corrosive Waste And Vent Above And Belowground
G - Condensate Drain Aboveground

* - Hard Temper

TABLE II

PIPE AND FITTING MATERIALS FOR PRESSURE PIPING SYSTEMS

Item #	Pipe and Fitting Materials	SERVICE A	SERVICE B	SERVICE C	SERVICE D
4	Steel pipe:				
	a. Seamless, galvanized, ASTM A53/A53M, Type S, Grade B	X	X	X	X
6	Bronze flanged fittings, ASME B16.24 for use with Items 5 and 7	X	X		X
7	Seamless copper pipe, ASTM B42	X	X		X
9	Cast bronze threaded fittings, ASME B16.15 for use with Items 5 and 7	X	X		X
11	Cast copper alloy solder-joint pressure fittings, ASME B16.18 for use with Item 8	X	X	X	X
25	Polyvinyl chloride (PVC) plastic pipe, Schedules 40, 80, and 120, ASTM D1785	X			X

TABLE II					
PIPE AND FITTING MATERIALS FOR PRESSURE PIPING SYSTEMS					
Item #	Pipe and Fitting Materials	SERVICE A	SERVICE B	SERVICE C	SERVICE D
26	Polyvinyl chloride (PVC) pressure-rated pipe (SDR Series), ASTM D2241	X			X
27	Polyvinyl chloride (PVC) plastic pipe fittings, Schedule 40, ASTM D2466	X			X
28	Socket-type polyvinyl chloride (PVC) plastic pipe fittings, schedule 80, ASTM D2467 for use with Items 26 and 27	X			X
29	Threaded polyvinyl chloride (PVC) plastic pipe fittings, schedule 80, ASTM D2464	X			X
30	Joints for IPS PVC pipe using solvent cement, ASTM D2672	X			X
33	Fittings: brass or bronze; ASME B16.15, and ASME B16.18 ASTM B828	X	X		
36	Nipples, pipe threaded ASTM A733	X	X	X	
38	Press Fittings	X	X		
	SERVICE: A - Cold Water Service Aboveground B - Hot and Cold Water Distribution 180 degrees F Maximum Aboveground C - Compressed Air Lubricated D - Cold Water Service Belowground Indicated types are minimum wall thicknesses. ** - Type L - Hard *** - Type K - Hard temper with brazed joints only or type K-soft temper without joints in or under floors **** - In or under slab floors only brazed joints				

TABLE III

STANDARD RATING CONDITIONS AND MINIMUM PERFORMANCE RATINGS FOR WATER HEATING EQUIPMENT

FUEL	STORAGE CAPACITY GALLONS	INPUT RATING	TEST PROCEDURE	REQUIRED PERFORMANCE
A. STORAGE WATER HEATERS				
Elect.	60 max.		10 CFR 430	EF = 0.93

TERMS:

EF = Energy factor, minimum overall efficiency.
ET = Minimum thermal efficiency with 70 degrees F delta T.
SL = Standby loss is maximum Btu/h based on a 70 degree F temperature difference between stored water and ambient requirements.
V = Rated storage volume in gallons
Q = Nameplate input rate in Btu/h

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SECTION 23 05 93

TESTING, ADJUSTING, AND BALANCING FOR HVAC
11/15

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AIR MOVEMENT AND CONTROL ASSOCIATION INTERNATIONAL, INC. (AMCA)

AMCA 203	(1990; R 2011) Field Performance Measurements of Fan Systems

AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS (ASHRAE)

ASHRAE 62.1	(2022) Ventilation for Acceptable Indoor Air Quality

ASSOCIATED AIR BALANCE COUNCIL (AABC)

AABC MN-1	(2002; 6th ed) National Standards for Total System Balance
AABC MN-4	(1996) Test and Balance Procedures

NATIONAL ENVIRONMENTAL BALANCING BUREAU (NEBB)

NEBB MASV	(2006) Procedural Standards for Measurements and Assessment of Sound and Vibration
NEBB PROCEDURAL STANDARDS	(2015) Procedural Standards for TAB (Testing, Adjusting and Balancing) Environmental Systems

SHEET METAL AND AIR CONDITIONING CONTRACTORS' NATIONAL ASSOCIATION (SMACNA)

SMACNA 1780	(2002) HVAC Systems - Testing, Adjusting and Balancing, 3rd Edition
SMACNA 1858	(2004) HVAC Sound And Vibration Manual - First Edition
SMACNA 1972 CD	(2012) HVAC Air Duct Leakage Test Manual - 2nd Edition

1.2 DEFINITIONS

a. AABC: Associated Air Balance Council

b. COTR: Contracting Officer's Technical Representative

c. DALT: Duct air leakage test

d. DALT'd: Duct air leakage tested

e. HVAC: Heating, ventilating, and air conditioning; or heating, ventilating, and cooling

f. NEBB: National Environmental Balancing Bureau

g. Out-of-tolerance data: Pertains only to field acceptance testing of Final DALT or TAB report. When applied to DALT work, this phase means "a leakage rate measured during DALT field acceptance testing which exceeds the leakage rate allowed by SMACNA Leak Test Manual for an indicated duct construction and sealant class." When applied to TAB work this phase means "a measurement taken during TAB field acceptance testing which does not fall within the range of plus 5 to minus 5 percent of the original measurement reported on the TAB Report for a specific parameter."

h. Season of maximum heating load: The time of year when the outdoor temperature at the project site remains within plus or minus 30 degrees Fahrenheit of the project site's winter outdoor design temperature, throughout the period of TAB data recording.

i. Season of maximum cooling load: The time of year when the outdoor temperature at the project site remains within plus or minus 5 degrees Fahrenheit of the project site's summer outdoor design temperature, throughout the period of TAB data recording.

j. Season 1, Season 2: Depending upon when the project HVAC is completed and ready for TAB, Season 1 is defined, thereby defining Season 2. Season 1 could be the season of maximum heating load, or the season of maximum cooling load.

k. Sound measurements terminology: Defined in AABC MN-1, NEBB MASV, or SMACNA 1858 (TABB).

l. TAB: Testing, adjusting, and balancing (of HVAC systems)

m. TAB'd: HVAC Testing/Adjusting/Balancing procedures performed

n. TAB Agency: TAB Firm

o. TAB team field leader: TAB team field leader

p. TAB team supervisor: TAB team engineer

q. TAB team technicians: TAB team assistants

r. TABB: Testing Adjusting and Balancing Bureau

1.2.1 Similar Terms

In some instances, terminology differs between the Contract and the TAB Standard primarily because the intent of this Section is to use the industry standards specified, along with additional requirements listed herein to produce optimal results.

The following table of similar terms is provided for clarification only. Contract requirements take precedent over the corresponding AABC, NEBB, or TABB requirements where differences exist.

SIMILAR TERMS			
Contract Term	AABC Term	NEBB Term	TABB Term
TAB Standard	National Standards for Testing and Balancing Heating, Ventilating, and Air Conditioning Systems	Procedural Standards for Testing, Adjusting and Balancing of Environmental Systems	International Standards for Environmental Systems Balance
TAB Specialist	TAB Engineer	TAB Supervisor	TAB Supervisor
Systems Readiness Check	Construction Phase Inspection	Field Readiness Check & Preliminary Field Procedures	Field Readiness Check & Prelim. Field Procedures

1.3 WORK DESCRIPTION

The work includes duct air leakage testing (DALT) and testing, adjusting, and balancing (TAB) of new heating, ventilating, and cooling (HVAC) air and water distribution systems including equipment and performance data, ducts, and piping which are located within, on, under, between, and adjacent to buildings, including records of existing conditions.

Perform TAB in accordance with the requirements of the TAB procedural standard recommended by the TAB trade association that approved the TAB Firm's qualifications. Comply with requirements of AABC MN-1, NEBB PROCEDURAL STANDARDS, or SMACNA 1780 (TABB) as supplemented and modified by this specification section. All recommendations and suggested practices contained in the TAB procedural standards are considered mandatory.

Conduct DALT and TAB of the indicated existing systems and equipment and submit the specified DALT and TAB reports for approval. Conduct DALT testing in compliance with the requirements specified in SMACNA 1972 CD, except as supplemented and modified by this section. Conduct DALT and TAB work in accordance with the requirements of this section.

1.3.1 Air Distribution Systems

Test, adjust, and balance systems (TAB) in compliance with this section. Obtain Contracting Officer's written approval before applying insulation to exterior of air distribution systems as specified under Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS.

1.3.2 Water Distribution Systems

TAB systems in compliance with this section. Obtain Contracting Officer's written approval before applying insulation to water distribution systems as specified under Section 23 07 00 THERMAL INSULATION FOR MECHANICAL

SYSTEMS. At Contractor's option and with Contracting Officer's written approval, the piping systems may be insulated before systems are TAB'd.

Terminate piping insulation immediately adjacent to each flow control valve, automatic control valve, or device. Seal the ends of pipe insulation and the space between ends of pipe insulation and piping, with waterproof vapor barrier coating.

After completion of work under this section, insulate the flow control valves and devices as specified under Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS.

1.3.3 TAB SCHEMATIC DRAWINGS

Show the following information on TAB Schematic Drawings:

1. A unique number or mark for each piece of equipment or terminal.

2. Air quantities at air terminals.

3. Air quantities and temperatures in air handling unit schedules.

4. Water quantities and temperatures in thermal energy transfer equipment schedules.

5. Water quantities and heads in pump schedules.

6. Water flow measurement fittings and balancing fittings.

7. Ductwork Construction and Leakage Testing Table that defines the DALT test requirements, including each applicable HVAC duct system ID or mark, duct pressure class, duct seal class, and duct leakage test pressure. This table is included in the file for Graphics for Unified Facilities Guide Specifications: http://www.wbdg.org/ffc/dod/unified-facilities-guide-specifications-ufgs/forms-gra

The Testing, Adjusting, and Balancing (TAB) Specialist must review the Contract Plans and Specifications and advise the Contracting Officer of any deficiencies that would prevent the effective and accurate TAB of the system, including records of existing conditions, and systems readiness check. The TAB Specialist must provide a Design Review Report individually listing each deficiency and the corresponding proposed corrective action necessary for proper system operation.

Submit three copies of the TAB Schematic Drawings and Report Forms to the Contracting Officer, no later than 21 days prior to the start of TAB field measurements.

1.4 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Records of Existing Conditions; G

TAB Firm; G

Designation of TAB Team Assistants; G

Designation of TAB Team Engineer; G or TAB Specialist; G

Designation of TAB Team Field Leader; G

SD-02 Shop Drawings

TAB Schematic Drawings and Report Forms; G

SD-03 Product Data

Equipment and Performance Data; G

TAB Related HVAC Submittals; G

A list of the TAB Related HVAC Submittals, no later than 7 days after the approval of the TAB team engineer and assistant.

TAB Procedures; G

Proposed procedures for TAB, submitted with the TAB Schematic Drawings and Report Forms.

Calibration; G

Systems Readiness Check; G

TAB Execution; G

TAB Verification; G

SD-06 Test Reports

Completed Pre-Final DALT Report; G

Certified Final DALT Report; G

TAB Design Review Report; G

TAB Report; G

SD-07 Certificates

Independent TAB Agency and Personnel Qualifications; G

DALT and TAB Submittal and Work Schedule; G

TAB Pre-Field Engineering Report; G

TAB Firm; G

Design Review Report; G

Pre-field DALT Preliminary Notification; G

Advanced Notice for TAB Field Work; G

Prerequisite HVAC Work Check Out List; G

1.5 QUALITY ASSURANCE

1.5.1 Independent TAB Agency and Personnel Qualifications

To secure approval for the proposed agency, submit information certifying that the TAB agency is a first tier subcontractor who is not affiliated with any other company participating in work on this contract, including design, furnishing equipment, or construction. Further, submit the following, for the agency, to Contracting Officer for approval:

a. Independent AABC or NEBB or TABB TAB agency:

TAB agency: AABC registration number and expiration date of current certification; or NEBB certification number and expiration date of current certification; or TABB certification number and expiration date of current certification.

TAB team supervisor: Name and copy of AABC or NEBB or TABB TAB supervisor certificate and expiration date of current certification.

TAB team field leader: Name and documented evidence that the team field leader has satisfactorily performed full-time supervision of TAB work in the field for not less than 3 years immediately preceding this contract's bid opening date.

TAB team field technicians: Names and documented evidence that each field technician has satisfactorily assisted a TAB team field leader in performance of TAB work in the field for not less than one year immediately preceding this contract's bid opening date.

Current certificates: Registrations and certifications are current, and valid for the duration of this contract. Renew Certifications which expire prior to completion of the TAB work, in a timely manner so that there is no lapse in registration or certification. TAB agency or TAB team personnel without a current registration or current certification are not to perform TAB work on this contract.

b. TAB Team Members: TAB team approved to accomplish work on this contract are full-time employees of the TAB agency. No other personnel is allowed to do TAB work on this contract.

c. Replacement of TAB team members: Replacement of members may occur if each new member complies with the applicable personnel qualifications and each is approved by the Contracting Officer.

1.5.2 TAB Standard

Perform TAB in accordance with the requirements of the standard under which the TAB Firm's qualifications are approved, i.e., AABC MN-1, NEBB PROCEDURAL STANDARDS, or SMACNA 1780 unless otherwise specified herein. All recommendations and suggested practices contained in the TAB Standard are considered mandatory. Use the provisions of the TAB Standard, including checklists, report forms, etc., as nearly as practical, to satisfy the Contract requirements. Use the TAB Standard for all aspects of TAB, including qualifications for the TAB Firm and Specialist and calibration of TAB instruments. Where the instrument manufacturer calibration recommendations are more stringent than those listed in the TAB Standard, adhere to the manufacturer's recommendations.

All quality assurance provisions of the TAB Standard such as performance guarantees are part of this contract. For systems or system components not covered in the TAB Standard, TAB procedures must be developed by the TAB Specialist. Where new procedures, requirements, etc., applicable to the Contract requirements have been published or adopted by the body responsible for the TAB Standard used (AABC, NEBB, or TABB), the requirements and recommendations contained in these procedures and requirements are considered mandatory, including the latest requirements of ASHRAE 62.1.

1.5.3 Qualifications

1.5.3.1 TAB Firm

The TAB Firm must be either a member of AABC or certified by the NEBB or the TABB and certified in all categories and functions where measurements or performance are specified on the plans and specifications.

Certification must be maintained for the entire duration of duties specified herein. If, for any reason, the firm loses subject certification during this period, the Contractor must immediately notify the Contracting Officer and submit another TAB Firm for approval. Any firm that has been the subject of disciplinary action by either the AABC, the NEBB, or the TABB within the five years preceding Contract Award is not be eligible to perform any duties related to the HVAC systems, including TAB. All work specified in this Section and in other related Sections to be performed by the TAB Firm will be considered invalid if the TAB Firm loses its certification prior to Contract completion and must be performed by an approved successor.

These TAB services are to assist the prime Contractor in performing the quality oversight for which it is responsible. The TAB Firm must be a prime subcontractor of the Contractor and be financially and corporately independent of the mechanical subcontractor, reporting directly to and paid by the Contractor.

1.5.3.2 TAB Specialist

The TAB Specialist must be either a member of AABC,an experienced technician of the Firm certified by the NEBB, or a Supervisor certified by the TABB. The certification must be maintained for the entire duration of duties specified herein. If, for any reason, the Specialist loses subject certification during this period, immediately notify the Contracting Officer and submit another TAB Specialist for approval. Any individual that has been the subject of disciplinary action by either the AABC, the NEBB, or the TABB within the five years preceding Contract Award is not eligible to perform any duties related to the HVAC systems, including TAB. All work specified in this Section and in other related Sections performed by the TAB Specialist will be considered invalid if the TAB Specialist loses its certification prior to Contract completion and must be performed by the approved successor.

1.5.3.3 TAB Specialist Responsibilities

TAB Specialist responsibilities include all TAB work specified herein and in related sections under his direct guidance. The TAB specialist is required to be onsite on a daily basis to direct TAB efforts. The TAB Specialist must participate in the commissioning process specified in Section 01 91 00.15 TOTAL BUILDING COMMISSIONING.

1.5.3.4 TAB Related HVAC Submittals

The TAB Specialist must prepare a list of the submittals from the Contract Submittal Register that relate to the successful accomplishment of all HVAC TAB. Accompany the submittals identified on this list with a letter of approval signed and dated by the TAB Specialist when submitted to the Government. Ensure that the location and details of ports, terminals, connections, etc., necessary to perform TAB are identified on the submittals.

1.5.4 Responsibilities

The Contractor is responsible for ensuring compliance with the requirements of this section. The following delineation of specific work responsibilities is specified to facilitate TAB execution of the various work efforts by personnel from separate organizations. This breakdown of specific duties is specified to facilitate adherence to the schedule listed in the paragraph TAB SUBMITTAL AND WORK SCHEDULE.

1.5.4.1 Contractor

a. TAB personnel: Ensure that the DALT work and the TAB work is accomplished by a group meeting the requirements specified in the paragraph TAB PERSONNEL QUALIFICATION REQUIREMENTS.

b. Pre-DALT/TAB meeting: Attend the meeting with the TAB Supervisor, and ensure that a representative is present for the sheetmetal contractor, mechanical contractor, electrical contractor, and automatic temperature controls contractor.

c. HVAC documentation: Furnish one complete set of the following HVAC-related documentation to the TAB agency:

    (1) Contract drawings and specifications

    (2) Approved submittal data for equipment

    (3) Construction work schedule

    (4) Up-to-date revisions and change orders for the previously listed items

d. Submittal and work schedules: Ensure that the schedule for submittals and work required by this section and specified in the paragraph TAB SUBMITTAL AND WORK SCHEDULE is met.

e. Coordination of supporting personnel:

    Provide the technical personnel, such as factory representatives or HVAC controls installer required by the TAB field team to support the DALT and the TAB field measurement work.

Provide equipment mechanics to operate HVAC equipment and ductwork mechanics to provide the field designated test ports to enable TAB field team to accomplish the DALT and the TAB field measurement work. Ensure these support personnel are present at the times required by the TAB team, and cause no delay in the DALT and the TAB field work.

Conversely, ensure that the HVAC controls installer has required support from the TAB team field leader to complete the controls check out.

f. Deficiencies: Ensure that the TAB Agency supervisor submits all Design/Construction deficiency notifications directly to the Contracting officer within 3 days after the deficiency is encountered. Further, ensure that all such notification submittals are complete with explanation, including documentation, detailing deficiencies.

g. Prerequisite HVAC work: Complete check out and debugging of HVAC equipment, ducts, and controls prior to the TAB engineer arriving at the project site to begin the TAB work. Debugging includes searching for and eliminating malfunctioning elements in the HVAC system installations, and verifying all adjustable devices are functioning as designed. Include as prerequisite work items, the deficiencies pointed out by the TAB team supervisor in the design review report.

h. Prior to the TAB field team's arrival, ensure completion of the applicable inspections and work items listed in the TAB team supervisor's pre-field engineering report. Do not allow the TAB team to commence TAB field work until all of the following are completed.

(1) HVAC system installations are fully complete.

(2) HVAC prerequisite checkout work lists specified in the paragraph PRE-FIELD TAB ENGINEERING REPORT are completed, submitted, and approved. Ensure that the TAB Agency gets a copy of the approved prerequisite HVAC work checklist.

(3) DALT field checks for all systems are completed.

(4) HVAC system filters are clean for both Season 1 and Season 2 TAB field work.

i. Advance notice: Furnish to the Contracting Officer with advance written notice for the commencement of the DALT field work and for the commencement of the TAB field work.

j. Insulation work: For required DALT work , ensure that insulation is not installed on ducts to be DALT'd until DALT work on the subject ducts is complete. Later, ensure that openings in duct and machinery insulation coverings for TAB test ports are marked, closed and sealed.

1.5.4.2 TAB Agency

Provide the services of a TAB team which complies with the requirements of the paragraph INDEPENDENT TAB AGENCY PERSONNEL QUALIFICATIONS. The work to be performed by the TAB agency is limited to testing, adjusting, and balancing of HVAC air and water systems to satisfy the requirements of this specification section.

1.5.4.3 TAB Team Supervisor

a. Overall management: Supervise and manage the overall TAB team work effort, including preliminary and technical DALT and TAB procedures and TAB team field work.

b. Pre-DALT/TAB meeting: Attend meeting with Contractor.

c. Design review report: Review project specifications and accompanying drawings to verify that the air systems and water systems are designed in such a way that the TAB engineer can accomplish the work in compliance with the requirements of this section. Verify the presence and location of permanently installed test ports and other devices needed, including gauge cocks, thermometer wells, flow control devices, circuit setters, balancing valves, and manual volume dampers.

d. Support required: Specify the technical support personnel required from the Contractor other than the TAB agency; such as factory representatives for temperature controls or for complex equipment. Inform the Contractor in writing of the support personnel needed and when they are needed. Furnish the notice as soon as the need is anticipated, either with the design review report, or the pre-field engineering report, the during the DALT or TAB field work.

e. Pre-field DALT preliminary notification: Monitor the completion of the duct installation of each system and provide the necessary written notification to the Contracting Officer.

f. Pre-field engineering report: Utilizing the following HVAC-related documentation; contract drawings and specifications, approved submittal data for equipment, up-to-date revisions and change orders; prepare this report.

g. Prerequisite HVAC work checklist: Ensure the Contractor gets a copy of this checklist at the same time as the pre-field engineering report is submitted.

h. Technical assistance for DALT work.

(1) Technical assistance: Provide immediate technical assistance to TAB field team.

(2) DALT field visit: Near the end of the DALT field work effort, visit the contract site to inspect the HVAC installation and the progress of the DALT field work. Conduct a site visit to the extent necessary to verify correct procedures are being implemented and to confirm the accuracy of the Pre-final DALT Report data which has been reported. Also, perform sufficient evaluation to allow the TAB supervisor to issue certification of the final report. Conduct the site visit full-time for a minimum of one 8 hour workday duration.

i. Final DALT report: Certify the DALT report. This certification includes the following work:

(1) Review: Review the Pre-final DALT report data. From these field reports, prepare the Certified Final DALT report.

(2) TAB Verification: Verify adherence, by the TAB field team, to the procedures specified in this section.

j. Technical Assistance for TAB Work: Provide immediate technical assistance to the TAB field team for the TAB work.

(1) TAB field visit: Near the end of the TAB field work effort, visit the contract site to inspect the HVAC installation and the progress of the TAB field work. Conduct site visit full-time for a minimum of one 8 hour workday duration. Review the TAB final report data and certify the TAB final report.

k. Certified TAB report: Certify the TAB report. This certification includes the following work:

(1) Review: Review the TAB field data report. From this field report, prepare the certified TAB report.

(2) Verification: Verify adherence, by the TAB field team, to the TAB plan prescribed by the pre-field engineering report and verify adherence to the procedures specified in this section.

l. Design/Construction deficiencies: Within 3 working days after the TAB Agency has encountered any design or construction deficiencies, the TAB Supervisor must submit written notification directly to the Contracting Officer, with a separate copy to the Contractor, of all such deficiencies. Provide in this submittal a complete explanation, including supporting documentation, detailing deficiencies. Where deficiencies are encountered that are believed to adversely impact successful completion of TAB, the TAB Agency must issue notice and request direction in the notification submittal.

m. TAB Field Check: The TAB team supervisor must attend and supervise TAB field check.

1.5.4.4 TAB Team Field Leader

a. Field manager: Manage, in the field, the accomplishment of the work specified in Part 3, EXECUTION.

b. Full time: Be present at the contract site when DALT field work or TAB field work is being performed by the TAB team; ensure day-to-day TAB team work accomplishments are in compliance with this section.

c. Prerequisite HVAC work: Do not bring the TAB team to the contract site until a copy of the prerequisite HVAC Checklist, with all work items certified by the Contractor to be working as designed, reaches the office of the TAB Agency.

1.5.5 Test Reports

1.5.5.1 Data from DALT Field Work

Report the data for the Pre-final DALT Report and Certified Final DALT Report in compliance the following requirements:

a. Report format: Submit report data on Air Duct Leakage Test Summary Report Forms as shown on Page 6-2 of SMACNA 1972 CD. In addition, submit in the report, a marked duct shop drawing which identifies each section of duct tested with assigned node numbers for each section. Include node numbers in the completed report forms to identify each duct section. The TAB supervisor must review and certify the report.

b. The TAB supervisor must include a copy of all calculations prepared in determining the duct surface area of each duct test section. In addition,provide the ductwork air leak testing (DALT) reports with a copy(s) of the calibration curve for each of the DALT test orifices used for testing.

c. Instruments: List the types of instruments actually used to measure the data. Include in the listing each instrument's unique identification number, calibration date, and calibration expiration date. Instruments must have been calibrated within one year of the date of use in the field. Instrument calibration must be traceable to the measuring standards of the National Institute of Standards and Technology.

d. Certification: Include the typed name of the TAB supervisor and the dated signature of the TAB supervisor.

1.5.5.2 Certified TAB Reports

Submit: TAB Report in the following manner:

a. Report format: Submit the completed pre-field data forms approved in the pre-field TAB Engineering Report completed by TAB field team, reviewed and certified by the TAB supervisor. Bind the report with a waterproof front and back cover. Include a table of contents identifying by page number the location of each report. Report forms and report data must be typewritten. Handwritten report forms or report data are not acceptable.

b. Temperatures: On each TAB report form reporting TAB work accomplished on HVAC thermal energy transfer equipment, include the indoor and outdoor dry bulb temperature range and indoor and outdoor wet bulb temperature range within which the TAB data was recorded.

c. System Diagrams: Provide updated diagrams with final installed locations of all terminals and devices, any numbering changes, and actual test locations. Use a key numbering system on the diagram which identifies each outlet contained in the outlet airflow report sheets.

d. Static Pressure Profiles: Report static pressure profiles for air duct systems. Report static pressure data for all supply, return, relief, exhaust and outside air ducts for the systems listed. Include the following in the static pressure report data, in addition to AABC/NEBB/TABB required data:

(1) Report supply fan, return fan, relief fan, and exhaust fan inlet and discharge static pressures.

(2) Report static pressure drop across chilled water coils, DX coils, electric resistance heating coils and heat reclaim devices installed in unit cabinetry or the system ductwork.

(3) Report static pressure drop across outside air, return air, and supply air automatic control dampers, both proportional and

two-position, installed in unit cabinetry.

e. Duct Traverses: Report duct traverses for main and branch main supply, return, exhaust, relief and outside air ducts. This includes all ducts, including those which lack 7 1/2 duct diameters upstream and 2 1/2 duct diameters downstream of straight duct unobstructed by duct fittings/offsets/elbows. The TAB Agency must evaluate and report findings on the duct traverses taken. Evaluate the suitability of the duct traverse measurement based on satisfying the qualifications for a pilot traverse plane as defined by AMCA 203, "Field Measurements", Section 8, paragraph 8.3, "Location of Traverse Plane."

f. Instruments: List the types of instruments actually used to measure the tab data. Include in the listing each instrument's unique identification number, calibration date, and calibration expiration date.

   Instrumentation, used for taking wet bulb temperature readings must provide accuracy of plus or minus 5 percent at the measured face velocities. Submit instrument manufacturer's literature to document instrument accuracy performance is in compliance with that specified.

g. Certification: Include the typed name of the TAB supervisor and the dated signature of the TAB supervisor.

h. Performance Curves: The TAB Supervisor must include, in the TAB Reports, factory pump curves and fan curves for pumps and fans TAB'd on the job.

i. Calibration Curves: The TAB Supervisor must include, in the TAB Reports, a factory calibration curve for installed flow control balancing valves, flow venturi's and flow orifices TAB'd on the job.

1.6 SEQUENCING AND SCHEDULING

1.6.1 DALT and TAB Submittal and Work Schedule

Submit this schedule,and TAB Schematic Drawings, adapted for this particular contract, to the Contracting Officer (CO) for review and approval. Include with the submittal the planned calendar dates for each submittal or work item. Resubmit an updated version for CO approval every 90 calendar days. Compliance with the following schedule is the Contractor's responsibility.

Qualify TAB Personnel: Within 45 calendar days after date of contract award, submit TAB agency and personnel qualifications.

Pre-DALT/TAB Meeting: Within 30 calendar days after the date of approval of the TAB agency and personnel, meet with the COTR.

Design Review Report: Within 60 calendar days after the date of the TAB agency personnel qualifications approval, submit design review report.

Pre-Field DALT Preliminary Notification: On completion of the duct installation for each system, notify the Contracting Officer in writing within 5 days after completion.

Ductwork Selected for DALT: Within 7 calendar days of Pre-Field DALT

Preliminary Notification, the COTR will select which of the project ductwork must be DALT'd.

DALT Field Work: Within 48 hours of COTR's selection, complete DALT field work on selected.

Submit Pre-final DALT Report: Within one working day after completion of DALT field work, submit Pre-final DALT Report. Separate Pre-final DALT reports may be submitted to allow phased testing from system to system.

DALT Work Field Check: Upon approval of the Pre-final DALT Report, schedule the COTR's DALT field check work with the Contracting Officer.

Submit Final DALT Report: Within 15 calendar days after completion of successful DALT Work Field Check, submit TAB report.

Pre-Field TAB Engineering Report: Within 15 calendar days after approval of the TAB agency Personnel Qualifications, submit the Pre-Field TAB Engineering Report.

Prerequisite HVAC Work Check Out List and Advanced Notice For TAB Field Work: At a minimum of 115 calendar days prior to CCD, submit prerequisite HVAC work check out list certified as complete, and submit advance notice of commencement of TAB field work.

TAB Field Work: At a minimum of 90 calendar days prior to CCD, accomplish TAB field work.

Submit TAB Report: Within 15 calendar days after completion of TAB field work, submit TAB report.

TAB Field Check: 30 calendar days after Season 1 TAB report is approved by the Contracting Officer, conduct field check.

Complete TAB Work: Prior to CCD, complete all TAB work.

TAB Field Work: At a minimum of 90 calendar days prior to CCD, accomplish TAB field work; submit TAB report; and conduct field check.

Complete TAB Work: Prior to CCD, complete all TAB work .

1.6.1.1 TAB Design Review Report

Submit typed report describing omissions and deficiencies in the HVAC system's design that would preclude the TAB team from accomplishing the duct leakage testing work and the TAB work requirements of this section. Provide a complete explanation including supporting documentation detailing the design deficiency. State that no deficiencies are evident if that is the case.

1.6.1.2 Pre-Field DALT Preliminary Notification

Notification: On completion of the installation of each duct system indicated to be DALT'd, notify the Contracting Officer in writing within 7 calendar days after completion.

1.6.1.3 TAB Pre-Field Engineering Report

Submit report containing the following information:

a. Step-by-step TAB procedure:

(1) Strategy: Describe the method of approach to the TAB field work from start to finish. Include in this description a complete methodology for accomplishing each seasonal TAB field work session.

(2) Air System Diagrams: Use the contract drawings and duct fabrication drawings if available to provide air system diagrams in the report showing the location of all terminal outlet supply, return, exhaust and transfer registers, grilles and diffusers. Use a key numbering system on the diagrams which identifies each outlet contained in the outlet airflow report sheets. Show intended locations of all traverses and static pressure readings.

(3) Procedural steps: Delineate fully the intended procedural steps to be taken by the TAB field team to accomplish the required TAB work of each air distribution system and each water distribution system. Include intended procedural steps for TAB work for subsystems and system components.

b. Pre-field data: Submit AABC or NEBB or SMACNA 1780 data report forms with the following pre-field information filled in:

(1) Design data obtained from system drawings, specifications, and approved submittals.

(2) Notations detailing additional data to be obtained from the contract site by the TAB field team.

(3) Designate the actual data to be measured in the TAB field work.

(4) Provide a list of the types of instruments, and the measuring range of each, which are anticipated to be used for measuring in the TAB field work. By means of a keying scheme, specify on each TAB data report form submitted, which instruments will be used for measuring each item of TAB data. If the selection of which instrument to use, is to be made in the field, specify from which instruments the choice will be made. Place the instrument key number in the blank space where the measured data would be entered.

c. Prerequisite HVAC work checkout list: Provide a list of inspections and work items which are to be completed by the Contractor. This list must be acted upon and completed by the Contractor and then submitted and approved by the Contracting Officer prior to the TAB team coming to the contract site.

At a minimum, a list of the applicable inspections and work items listed in the NEBB PROCEDURAL STANDARDS, Section III, "Preliminary TAB Procedures" under paragraphs titled, "Air Distribution System Inspection" and "Hydronic Distribution System Inspection" must be provided for each separate system to be TAB'd.

1.7 WARRANTY

Furnish workmanship and performance warranty for the DALT and TAB system work performed for a period not less than 1 years from the date of Government acceptance of the work; issued directly to the Government. Include provisions that if within the warranty period the system shows evidence of major performance deterioration, or is significantly out of tolerance, resulting from defective TAB or DALT workmanship, the corrective repair or replacement of the defective materials and correction of the defective workmanship is the responsibility of the TAB firm. Perform corrective action that becomes necessary because of defective materials and workmanship while system TAB and DALT is under warranty 7 days after notification, unless additional time is approved by the Contracting Officer. Failure to perform repairs within the specified period of time constitutes grounds for having the corrective action and repairs performed by others and the cost billed to the TAB firm. The Contractor must also provide a 1 year contractor installation warranty.

PART 2 PRODUCTS

Not Used

PART 3 EXECUTION

3.1 WORK DESCRIPTIONS OF PARTICIPANTS

Comply with requirements of this section.

3.2 PRE-DALT/TAB MEETING

Meet with the Contracting Officer's technical representative (COTR) to develop a mutual understanding relative to the details of the DALT work and TAB work requirements. Ensure that the TAB supervisor is present at this meeting. Requirements to be discussed include required submittals, work schedule, and field quality control.

3.3 DALT PROCEDURES

3.3.1 Instruments, Consumables and Personnel

Provide instruments, consumables and personnel required to accomplish the DALT field work. Follow the same basic procedure specified below for TAB Field Work, including maintenance and calibration of instruments, accuracy of measurements, preliminary procedures, field work, workmanship and treatment of deficiencies. Calibrate and maintain instruments in accordance with manufacturer's written procedures.

3.3.2 Advance Notice of Pre-Final DALT Field Work

On completion of the installation of each duct system indicated to be DALT'd, notify the Contracting Officer in writing prior to the COTR's duct selection field visit.

3.3.3 Ductwork To Be DALT'd

From each duct system indicated as subject to DALT, the COTR will randomly select sections of each completed duct system for testing by the Contractor's TAB Firm. The sections selected will not exceed 20 percent of the total measured linear footage of duct systems indicated as subject to DALT. Sections of duct systems subject to DALT will include 20 percent of main ducts, branch main ducts, branch ducts and plenums for supply, return, exhaust, and plenum ductwork.

It is acceptable for an entire duct system to be DALT'd instead of disassembling that system in order to DALT only the 20 percent portion specified above.

3.3.4 DALT Testing

Perform DALT on the HVAC duct sections of each system as selected by the COTR. Use the duct class, seal class, leakage class and the leak test pressure data indicated on the drawings, to comply with the procedures specified in SMACNA 1972 CD.

3.3.5 Completed Pre-Final DALT Report

After completion of the DALT work, prepare a Pre-final DALT Report using the reporting forms specified. TAB team to furnish data required by those data report forms. Prepare the report neatly and legibly; the Pre-final DALT report is the basis for the Final DALT Report. TAB supervisor must review and certify the Pre-final DALT Report and submit this report within one day of completion of DALT field work. Verbally notify the COTR that the field check of the Pre-final DALT Report data can commence.

3.3.6 Quality Assurance - COTR DALT Field Acceptance Testing

In the presence of the COTR and TAB team field leader, verify for accuracy Pre-final DALT Report data selected by the COTR. For each duct system, this acceptance testing shall be conducted on a maximum of 50 percent of the duct sections DALT'd.

Further, if any data on the Pre-final DALT report form for a given duct section is out-of-tolerance, then field acceptance testing shall be conducted on data for one additional duct section, preferably in the same duct system, in the presence of the COTR.

3.3.7 Additional COTR Field Acceptance Testing

If any of the duct sections checked for a given system are determined to have a leakage rate measured that exceeds the leakage rate allowed by SMACNA Leak Test Manual for an indicated duct construction class and sealant class, terminate data checking for that section. The associated Pre-final DALT Report data for the given duct system will be disapproved. Make the necessary corrections and prepare a revised Pre-final DALT Report. Reschedule a field check of the revised report data with the COTR.

3.3.8 Certified Final DALT Report

On successful completion of all field checks of the Pre-final DALT Report data for all systems, the TAB Supervisor is to assemble, review, certify and submit the Final DALT Report to the Contracting Officer for approval.

3.3.9 Prerequisite for TAB Field Work

Do not commence TAB field work prior to the completion and approval, for all systems, of the Final DALT Report.

3.4 TAB PROCEDURES

3.4.1 TAB Field Work

Test, adjust, and balance the HVAC systems until measured flow rates (air and water flow) are within plus or minus 5 percent of the design flow rates as specified or indicated on the contract documents.

That is, comply with the the requirements of AABC MN-1 or SMACNA 1780 (TABB) and SMACNA 1858 (TABB),except as supplemented and modified by this section.

Provide instruments and consumables required to accomplish the TAB work. Calibrate and maintain instruments in accordance with manufacturer's written procedures.

Test, adjust, and balance the HVAC systems until measured flow rates (air and water flow) are within plus or minus 5 percent of the design flow rates as specified or indicated on the contract documents. Conduct TAB work, including measurement accuracy, and sound measurement work in conformance with the AABC MN-1 and AABC MN-4, or NEBB TABES and NEBB MASV, or SMACNA 1780 (used by TABB) and SMACNA 1858 sound measurement procedures, except as supplemented and modified by this section.

3.4.2 Preliminary Procedures

Use the approved pre-field engineering report as instructions and procedures for accomplishing TAB field work. TAB engineer is to locate, in the field, test ports required for testing. It is the responsibility of the sheet metal contractor to provide and install test ports as required by the TAB engineer.

3.4.3 TAB Air Distribution Systems

3.4.3.1 Units With Coils

Report heating and cooling performance capacity tests for coils for the purpose of verifying that the coils meet the indicated design capacity. Submit the following data and calculations with the coil test reports:

a. For air handlers with capacities greater than 7.5 tons (90,000 Btu) cooling, such as factory manufactured units and central built-up units, conduct capacity tests in accordance with AABC MN-4, procedure 3.5, "Coil Capacity Testing."

   Do not determine entering and leaving wet and dry bulb temperatures by single point measurement, but by the average of multiple readings in compliance with paragraph 3.5-5, "Procedures", (in subparagraph d.) of AABC MN-4, Procedure 3.5, "Coil Capacity Testing."

   Submit part-load coil performance data from the coil manufacturer converting test conditions to design conditions; use the data for the purpose of verifying that the coils meet the indicated design capacity in compliance with AABC MN-4, Procedure 3.5, "Coil Capacity Testing," paragraph 3.5.7, "Actual Capacity Vs. Design Capacity" (in subparagraph c.).

b. For units with capacities of 7.5 tons (90,000 Btu) or less, such as fan coil units, duct mounted reheat coils associated with VAV terminal units, and unitary units, such as through-the-wall heat pumps:

Determine the apparent coil capacity by calculations using single point measurement of entering and leaving wet and dry bulb temperatures; submit the calculations with the coil reports.

3.4.3.2 Air Handling Units

Air handling unit systems including fans (air handling unit fans, exhaust fans and winter ventilation fans), coils, ducts, plenums, mixing boxes, terminal units, variable air volume boxes, and air distribution devices for supply air, return air, outside air, mixed air relief air, and makeup air.

3.4.3.3 Makeup Air Units

Makeup air unit systems including fans, coils, ducts, plenums, registers, diffusers, grilles, and louvers for supply air, return air, outside air, and mixed air.

3.4.3.4 Exhaust Fans

Exhaust fan systems including fans, ducts, plenums, grilles, and hoods for exhaust air.

3.4.4 TAB Water Distribution Systems

3.4.4.1 Chilled Water

Chilled water systems including chillers, pumps, coils, system balance valves and flow measuring devices.

For water chillers, report data as required by AABC, NEBB and TABB standard procedures, including refrigeration operational data.

3.4.5 TAB Work on Performance Tests Without Seasonal Limitations

3.4.5.1 Performance Tests

In addition to the TAB proportionate balancing work on the air distribution systems and the water distribution systems, accomplish TAB work on the HVAC systems which directly transfer thermal energy. TAB the operational performance of the heating systems and cooling systems.

3.4.5.2 Ambient Temperatures

On each tab report form used for recording data, record the outdoor and indoor ambient dry bulb temperature range and the outdoor and indoor ambient wet bulb temperature range within which the report form's data was recorded. Record these temperatures at beginning and at the end of data taking.

3.4.5.3 Water Chillers

For water chillers, report data as required by NEBB Form TAB 15-83, NEBB PROCEDURAL STANDARDS, including refrigeration operational data.

3.4.5.4 Coils

Report heating and cooling performance capacity tests for chilled water, DX for the purpose of verifying that the coils meet the indicated design capacity. Submit the following data and calculations with the coil test reports:

a. For Central station air handlers with capacities greater than 7.5 tons (90,000 Btu) cooling, such as factory manufactured units and central built-up units, conduct capacity tests in accordance with AABC MN-4, procedure 3.5, "Coil Capacity Testing".

   Entering and leaving wet and dry bulb temperatures are not determined by single point measurement, but the average of multiple readings in compliance with paragraph 3.5-5, "Procedures", (in subparagraph d.) of AABC MN-4, Procedure 3.5, "Coil Capacity Testing."

   Submit part-load coil performance data from the coil manufacturer converting test conditions to design conditions; use the data for the purpose of verifying that the coils meet the indicated design capacity in compliance with AABC MN-4, Procedure 3.5, "Coil Capacity Testing," paragraph 3.5.7, "Actual Capacity Vs. Design Capacity" (in subparagraph c.).

b. For units with capacities of 7.5 tons (90,000 Btu) or less, such as fan coil units, duct mounted reheat coils associated with VAV terminal units, and unitary units, such as through-the-wall heat pumps:

   Determine the apparent coil capacity by calculations using single point measurement of entering and leaving wet and dry bulb temperatures; submit the calculations with the coil reports.

3.4.6 Workmanship

Conduct TAB work on the HVAC systems until measured flow rates are within plus or minus 5 percent of the design flow rates as specified or indicated on the contract documents. This TAB work includes adjustment of balancing valves, balancing dampers, and sheaves. Further, this TAB work includes changing out fan sheaves and pump impellers if required to obtain air and water flow rates specified or indicated. If, with these adjustments and equipment changes, the specified or indicated design flow rates cannot be attained, contact the Contracting Officer for direction.

3.4.7 Deficiencies

Strive to meet the intent of this section to maximize the performance of the equipment as designed and installed. However, if deficiencies in equipment design or installation prevent TAB work from being accomplished within the range of design values specified in the paragraph WORKMANSHIP, provide written notice as soon as possible to the Contractor and the Contracting Officer describing the deficiency and recommended correction.

Responsibility for correction of installation deficiencies is the Contractor's. If a deficiency is in equipment design, call the TAB team supervisor for technical assistance. Responsibility for reporting design deficiencies to Contractor is the TAB team supervisor's.

3.4.8 TAB Reports

After completion of the TAB work, prepare a pre-final TAB report using the reporting forms approved in the pre-field engineering report. Data required by those approved data report forms is to be furnished by the TAB team. Except as approved otherwise in writing by the Contracting Officer, the TAB work and the TAB report is considered incomplete until the TAB work is accomplished to within the accuracy range specified in the paragraph WORKMANSHIP of this section.

Prepare the report neatly and legibly; the pre-final TAB report is the final TAB report minus the TAB supervisor's review and certification. Obtain, at the contract site, the TAB supervisor's review and certification of the TAB report.

Verbally notify the COTR that the field check of the TAB report data can commence; give this verbal notice 48 hours in advance of field check commencement. Do not schedule field check of the TAB report until the specified workmanship requirements have been met or written approval of the deviations from the requirements have been received from the Contracting Officer.

3.4.9 Quality Assurance - COTR TAB Field Acceptance Testing

3.4.9.1 TAB Field Acceptance Testing

During the field acceptance testing, verify, in the presence of the COTR, random selections of data (water, air quantities, air motion) recorded in the TAB Report. Points and areas for field acceptance testing are to be selected by the COTR. Measurement and test procedures are the same as approved for TAB work for the TAB Report.

Field acceptance testing includes verification of TAB Report data recorded for the following equipment groups:

Group 1: All chillers, return fans, computer room units, and air handling units (central stations).

Group 2: 25 percent of the VAV terminal boxes and associated diffusers and registers.

Group 3: 25 percent of the supply diffusers, registers, grilles associated with constant volume air handling units.

Group 4: 25 percent of the return grilles, return registers, exhaust grilles and exhaust registers.

Group 5: 25 percent of the supply fans, exhaust fans, and pumps.

Further, if any data on the TAB Report for Groups 2 through 5 is found not to fall within the range of plus 5 to minus 5 percent of the TAB Report data, additional group data verification is required in the presence of the COTR. Verify TAB Report data for one additional piece of equipment in that group. Continue this additional group data verification until out-of-tolerance data ceases to be found.

3.4.9.2 Additional COTR TAB Field Acceptance Testing

If any of the acceptance testing measurements for a given equipment group is found not to fall within the range of plus 5 to minus 5 percent of the TAB Report data, terminate data verification for all affected data for that group. The affected data for the given group will be disapproved. Make the necessary corrections and prepare a revised TAB Report. Reschedule acceptance testing of the revised report data with the COTR.

Further, if any data on the TAB Report for a given field acceptance test group is out-of-tolerance, then field test data for one additional field test group as specified herein. Continue this increase field test work until out-of-tolerance data ceases to to be found. This additional field testing is up and above the original 25 percent of the of reported data entries to be field tested.

If there are no more similar field test groups from which to choose, additional field testing from another, but different, type of field testing group must be tested.

3.4.9.3 Prerequisite for Approval

Compliance with the field acceptance testing requirements of this section is a prerequisite for the final Contracting Officer approval of the TAB Report submitted.

3.5 MARKING OF SETTINGS

Upon the final TAB work approval, permanently mark the settings of HVAC adjustment devices including valves, gauges, splitters, and dampers so that adjustment can be restored if disturbed at any time. Provide permanent markings clearly indicating the settings on the adjustment devices which result in the data reported on the submitted TAB report.

3.6 MARKING OF TEST PORTS

The TAB team is to permanently and legibly mark and identify the location points of the duct test ports. If the ducts have exterior insulation, make these markings on the exterior side of the duct insulation. Show the location of test ports on the as-built mechanical drawings with dimensions given where the test port is covered by exterior insulation.

-- End of Section --

SECTION 23 07 00

THERMAL INSULATION FOR MECHANICAL SYSTEMS
02/13, CHG 7: 05/20

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only. At the discretion of the Government, the manufacturer of any material supplied will be required to furnish test reports pertaining to any of the tests necessary to assure compliance with the standard or standards referenced in this specification.

AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS (ASHRAE)

ASHRAE 90.1 - IP	(2019; Errata 1 2019; Errata 2-5 2020; Addenda BY-CP 2020; Addenda AF-DB 2020; Addenda A-G 2020; Addenda F-Y 2021; Errata 6-8 2021; Interpretation 1-4 2020; Interpretation 5-8 2021 Addenda AS-AQ 2022) Energy Standard for Buildings Except Low-Rise Residential Buildings

ASTM INTERNATIONAL (ASTM)

ASTM A167	(2011) Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip
ASTM A240/A240M	(2020a) Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications
ASTM A580/A580M	(2018) Standard Specification for Stainless Steel Wire
ASTM B209	(2014) Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate
ASTM B209M	(2014) Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate (Metric)
ASTM C450	(2008) Standard Practice for Fabrication of Thermal Insulating Fitting Covers for NPS Piping, and Vessel Lagging
ASTM C533	(2017) Standard Specification for Calcium Silicate Block and Pipe Thermal Insulation
ASTM C534/C534M	(2020a) Standard Specification for Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular

	Form
ASTM C547	(2022) Standard Specification for Mineral Fiber Pipe Insulation
ASTM C552	(2022) Standard Specification for Cellular Glass Thermal Insulation
ASTM C585	(2010) Standard Practice for Inner and Outer Diameters of Thermal Insulation for Nominal Sizes of Pipe and Tubing
ASTM C591	(2021) Standard Specification for Unfaced Preformed Rigid Cellular Polyisocyanurate Thermal Insulation
ASTM C592	(2022a) Standard Specification for Mineral Fiber Blanket Insulation and Blanket-Type Pipe Insulation (Metal-Mesh Covered) (Industrial Type)
ASTM C612	(2014; R 2019) Standard Specification for Mineral Fiber Block and Board Thermal Insulation
ASTM C795	(2008; R 2018) Standard Specification for Thermal Insulation for Use in Contact with Austenitic Stainless Steel
ASTM C916	(2020) Standard Specification for Adhesives for Duct Thermal Insulation
ASTM C920	(2018) Standard Specification for Elastomeric Joint Sealants
ASTM C921	(2010; R 2015) Standard Practice for Determining the Properties of Jacketing Materials for Thermal Insulation
ASTM C1136	(2021) Standard Specification for Flexible, Low Permeance Vapor Retarders for Thermal Insulation
ASTM C1710	(2011) Standard Guide for Installation of Flexible Closed Cell Preformed Insulation in Tube and Sheet Form
ASTM D5590	(2000; R 2010; E 2012) Standard Test Method for Determining the Resistance of Paint Films and Related Coatings to Fungal Defacement by Accelerated Four-Week Agar Plate Assay
ASTM E84	(2020) Standard Test Method for Surface Burning Characteristics of Building Materials
ASTM E96/E96M	(2022a) Standard Test Methods for Gravimetric Determination of Water Vapor

	Transmission Rate of Materials
ASTM E2231	(2021) Standard Practice for Specimen Preparation and Mounting of Pipe and Duct Insulation Materials to Assess Surface Burning Characteristics

CALIFORNIA DEPARTMENT OF PUBLIC HEALTH (CDPH)

CDPH SECTION 01350	(2010; Version 1.1) Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources using Environmental Chambers

FM GLOBAL (FM)

FM APP GUIDE	(updated on-line) Approval Guide http://www.approvalguide.com/

GREEN SEAL (GS)

GS-36	(2013) Adhesives for Commercial Use

MANUFACTURERS STANDARDIZATION SOCIETY OF THE VALVE AND FITTINGS INDUSTRY (MSS)

MSS SP-58	(2018) Pipe Hangers and Supports - Materials, Design and Manufacture, Selection, Application, and Installation

MIDWEST INSULATION CONTRACTORS ASSOCIATION (MICA)

MICA Insulation Stds	(8th Ed) National Commercial & Industrial Insulation Standards

SCIENTIFIC CERTIFICATION SYSTEMS (SCS)

SCS	SCS Global Services (SCS) Indoor Advantage

SOUTH COAST AIR QUALITY MANAGEMENT DISTRICT (SCAQMD)

SCAQMD Rule 1168	(2017) Adhesive and Sealant Applications

U.S. DEPARTMENT OF DEFENSE (DOD)

MIL-A-3316	(1987; Rev C; Am 2 1990) Adhesives, Fire-Resistant, Thermal Insulation
MIL-A-24179	(1969; Rev A; Am 2 1980; Notice 1 1987; Notice 2 2020) Adhesive, Flexible Unicellular-Plastic Thermal Insulation

UNDERWRITERS LABORATORIES (UL)

UL 94	(2023; Reprint May 2023) UL Standard for Safety Tests for Flammability of Plastic Materials for Parts in Devices and Appliances

UL 723	(2020) UL Standard for Safety Test for Surface Burning Characteristics of Building Materials
UL 2818	(2022) GREENGUARD Certification Program For Chemical Emissions For Building Materials, Finishes And Furnishings

1.2 SYSTEM DESCRIPTION

1.2.1 General

Provide field-applied insulation and accessories on mechanical systems as specified herein; factory-applied insulation is specified under the piping, duct or equipment to be insulated. Provide insulation of chilled water systems outside of buildings as specified in this section.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" classification. Submittals not having a "G" classification are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

Submit the three SD types, SD-02 Shop Drawings, SD-03 Product Data, and SD-08 Manufacturer's Instructions at the same time for each system.

SD-02 Shop Drawings

- MICA Plates; G
- Pipe Insulation Systems and Associated Accessories
- Duct Insulation Systems and Associated Accessories
- Equipment Insulation Systems and Associated Accessories

SD-03 Product Data

- Pipe Insulation Systems; G
- Duct Insulation Systems; G
- Equipment Insulation Systems; G

SD-04 Samples

- Thermal Insulation; G
- Display Samples; G

SD-07 Certificates

- Indoor air quality for adhesives; S

SD-08 Manufacturer's Instructions

- Pipe Insulation Systems; G

Duct Insulation Systems; G

Equipment Insulation Systems; G

1.4 CERTIFICATIONS

1.4.1 Adhesives and Sealants

Provide products certified to meet indoor air quality requirements by UL 2818 (Greenguard) Gold, SCS Global Services Indoor Advantage Gold or provide certification or validation by other third-party programs that products meet the requirements of this Section. Provide current product certification documentation from certification body. When product does not have certification, provide validation that product meets the indoor air quality product requirements cited herein.

1.5 QUALITY ASSURANCE

1.5.1 Installer Qualification

Qualified installers will have successfully completed three or more similar type jobs within the last 5 years.

1.6 DELIVERY, STORAGE, AND HANDLING

Deliver materials in the manufacturer's unopened containers. Protect materials delivered and placed in storage from weather, humidity, dirt, dust and other contaminants. The Contracting Officer may reject insulation material and supplies that become dirty, dusty, wet, or contaminated by some other means. Attach manufacturer's stamp or label giving the name of the manufacturer and brand, and a description of the material, date codes, and approximate shelf life (if applicable) to packages or standard containers of insulation, jacket material, cements, adhesives, and coatings delivered for use, and samples required for approval. Insulation packages and containers must be asbestos free.

PART 2 PRODUCTS

2.1 STANDARD PRODUCTS

Provide materials which are the standard products of manufacturers regularly engaged in the manufacture of such products and that essentially duplicate items that have been in satisfactory use for at least 2 years prior to bid opening. Submit a complete list of materials, including manufacturer's descriptive technical literature, performance data, catalog cuts, and installation instructions. Include the product number, k-value, thickness and furnished accessories including adhesives, sealants and jackets for each mechanical system requiring insulation. The product data must be copyrighted, have an identifying or publication number, and have been published prior to the issuance date of this solicitation. Submit materials furnished under this section together in a booklet and in conjunction with the MICA plates booklet (SD-02). Annotate the product data to indicate which MICA plate is applicable.

2.1.1 Insulation System

Provide insulation systems in accordance with the approved MICA National Insulation Standards plates as supplemented by this specification. Provide field-applied insulation for heating, ventilating, and cooling

(HVAC) air distribution systems and piping systems that are located within, on, under, and adjacent to buildings; and for plumbing systems. Provide CFC and HCFC free insulation.

2.1.2 Surface Burning Characteristics

Unless otherwise specified, insulation must have a maximum flame spread index of 25 and a maximum smoke developed index of 50 when tested in accordance with ASTM E84. Determine flame spread, and smoke developed indexes, by ASTM E84 or UL 723. Test insulation in the same density and installed thickness as the material to be used in the actual construction. Prepare and mount test specimens according to ASTM E2231.

2.2 MATERIALS

Provide insulation that meets or exceed the requirements of ASHRAE 90.1 - IP. Ensure insulation exterior is cleanable, grease resistant, non-flaking and non-peeling. Provide compatible materials that do not contribute to corrosion, soften, or otherwise attack surfaces to which applied in either wet or dry state. Use materials on stainless steel surfaces meeting ASTM C795 requirements. Do not use calcium silicate on chilled or cold water systems. Use asbestos free materials. Provide product recognized under UL 94 (if containing plastic) and listed in FM APP GUIDE.

2.2.1 Adhesives

Provide non-aerosol adhesive products used on the interior of the building (defined as inside of the weatherproofing system) that meet either emissions requirements of CDPH SECTION 01350 (limit requirements for either office or classroom spaces regardless of space type) or VOC content requirements of SCAQMD Rule 1168 (HVAC duct sealants must meet limit requirements of "Other" category within SCAQMD Rule 1168 sealants table). Provide aerosol adhesives used on the interior of the building that meet either emissions requirements of CDPH SECTION 01350 (use the office or classroom requirements, regardless of space type) or VOC content requirements of GS-36. Provide certification or validation of indoor air quality for adhesives.

2.2.1.1 Acoustical Lining Insulation Adhesive

Provide a nonflammable, fire-resistant adhesive conforming to ASTM C916, Type I.

2.2.1.2 Lagging Adhesive

Lagging is the material used for thermal insulation, especially around a cylindrical object. This may include the insulation as well as the cloth/material covering the insulation. To resist mold/mildew, use lagging adhesive meeting ASTM D5590 with 0 growth rating. Provide nonflammable and fire-resistant lagging adhesives that have a maximum flame spread index of 25 and a maximum smoke developed index of 50 when tested in accordance with ASTM E84. Ensure adhesive is MIL-A-3316, Class 1, pigmented white and suitable for bonding fibrous glass cloth to faced and unfaced fibrous glass insulation board; for bonding cotton brattice cloth to faced and unfaced fibrous glass insulation board; for sealing edges of and bonding glass tape to joints of fibrous glass board; for bonding lagging cloth to thermal insulation; or Class 2 for attaching fibrous glass insulation to metal surfaces. Apply lagging adhesives in strict accordance with the manufacturer's recommendations for pipe and duct insulation.

2.2.1.3 Contact Adhesive

Adhesives may be any of, but not limited to, the neoprene based, rubber based, or elastomeric type that have a maximum flame spread index of 25 and a maximum smoke developed index of 50 when tested in accordance with ASTM E84. Ensure adhesive does not adversely affect, initially or in service, the insulation to which it is applied, nor cause any corrosive effect on metal to which it is applied. Ensure that any solvent dispersing medium or volatile component of the adhesive has no objectionable odor and does not contain any benzene or carbon tetrachloride. Ensure dried adhesive does not emit nauseous, irritating, or toxic volatile matters or aerosols when the adhesive is heated to any temperature up to 212 degrees F. The dried adhesive must be nonflammable and fire resistant. Flexible Elastomeric Adhesive: Comply with MIL-A-24179, Type II, Class I. Provide product listed in FM APP GUIDE.

2.2.2 Caulking

ASTM C920, Type S, Grade NS, Class 25, Use A.

2.2.3 Corner Angles

Nominal 0.016 inch aluminum 1 by 1 inch with factory applied kraft backing. Aluminum must be ASTM B209, Alloy 3003, 3105, or 5005.

2.2.4 Fittings

Fabricated Fittings are the prefabricated fittings for flexible elastomeric pipe insulation systems in accordance with ASTM C1710. Together with the flexible elastomeric tubes, they provide complete system integrity for retarding heat gain and controlling condensation drip from chilled-water and refrigeration systems. Flexible elastomeric, fabricated fittings provide thermal protection (0.25 k) and condensation resistance (0.05 Water Vapor Transmission factor). For satisfactory performance, use properly installed protective vapor retarder/barriers and vapor stops on high relative humidity and below ambient temperature applications to reduce movement of moisture through or around the insulation to the colder interior surface.

2.2.5 Finishing Cement

ASTM C450: Mineral fiber hydraulic-setting thermal insulating and finishing cement. All cements that may come in contact with Austenitic stainless steel must comply with ASTM C795.

2.2.6 Fibrous Glass Cloth and Glass Tape

Provide fibrous glass cloth, with 20X20 maximum mesh size, and glass tape with maximum flame spread index of 25 and a maximum smoke developed index of 50 when tested in accordance with ASTM E84. Provide tape consisting of 4 inch wide rolls. Provide Class 3 tape that is 4.5 ounces/square yard. Elastomeric Foam Tape: Black vapor-retarder foam tape with acrylic adhesive containing an anti-microbial additive.

2.2.7 Staples

Outward clinching type monel .

2.2.8 Jackets

2.2.8.1 Aluminum Jackets

Provide aluminum jackets consisting of corrugated, embossed or smooth sheet, 0.016 inch nominal thickness; ASTM B209, Temper H14, Temper H16, Alloy 3003, 5005, or 3105. Do not use corrugated aluminum jacket outdoors. Aluminum jacket securing bands must be Type 304 stainless steel, 0.015 inch thick, 1/2 inch wide for pipe under 12 inch diameter and 3/4 inch wide for pipe over 12 inch and larger diameter. Aluminum jacket circumferential seam bands must be 2 by 0.016 inch aluminum matching jacket material. Ensure bands for insulation below ground are 3/4 by 0.020 inch thick stainless steel, or fiberglass reinforced tape. The jacket may, at the option of the Contractor, be provided with a factory fabricated Pittsburgh or "Z" type longitudinal joint. When the "Z" joint is used, use bands at the circumferential joints that are designed by the manufacturer to seal the joints and hold the jacket in place.

2.2.8.2 Vapor Barrier/Vapor Retarder

Apply the following criteria to determine which system is required.

a. On ducts, equip piping and equipment operating below 85 degrees F or located outside with a vapor barrier.

2.2.9 Vapor Retarder Not Required

ASTM C921, Type II, Class D, minimum puncture resistance 50 Beach units on all surfaces except ductwork, where Type IV, maximum moisture vapor transmission 0.10, a minimum puncture resistance of 25 Beach units is acceptable. Provide jacket with a maximum flame spread index of 25 and a maximum smoke developed index of 50 when tested in accordance with ASTM E84.

2.2.10 Wire

Soft annealed ASTM A580/A580M Type 302, 304 or 316 stainless steel, 16 or 18 gauge.

2.2.11 Insulation Bands

Provide 1/2 inch wide; 26 gauge stainless steel insulation bands.

2.2.12 Sealants

Choose sealants from the butyl polymer type, the styrene-butadiene rubber type, or the butyl type of sealants. Provide sealants with a maximum permeance of 0.02 perms based on Procedure B for ASTM E96/E96M, and a maximum flame spread index of 25 and a maximum smoke developed index of 50 when tested in accordance with ASTM E84.

2.3 PIPE INSULATION SYSTEMS

Conform insulation materials to Table 1 and minimum insulation thickness as listed in Table 2 and meet or exceed the requirements of

ASHRAE 90.1 - IP. Limit pipe insulation materials to those listed herein and meeting the following requirements:

2.3.1 Aboveground Cold Pipeline (-30 to 60 deg. F)

Provide insulation for outdoor, indoor, exposed or concealed applications, as follows:

2.3.1.1 Flexible Elastomeric Cellular Insulation

Closed-cell, foam- or expanded-rubber materials containing anti-microbial additive, complying with ASTM C534/C534M, Grade 1, Type I or II. Type I, Grade 1 for tubular materials. Type II, Grade 1, for sheet materials. Ensure Type I and II have vapor retarder/vapor barrier skin on one or both sides of the insulation, and require an additional exterior vapor retarder covering for high relative humidity and below ambient temperature applications.

2.3.2 Aboveground Hot Pipeline (Above 60 deg. F)

Provide insulation for outdoor, indoor, exposed or concealed applications meeting the following requirements. Supply the insulation with manufacturer's recommended factory-applied jacket/vapor barrier.

2.3.2.1 Flexible Elastomeric Cellular Insulation

Closed-cell, foam- or expanded-rubber materials containing anti-microbial additive, complying with ASTM C534/C534M, Grade 1, Type I or II to 220 degrees F service. Type I for tubular materials. Type II for sheet materials.

2.3.2.2 Polyisocyanurate Insulation

ASTM C591, Type I. Supply the insulation with a factory applied vapor retarder/barrier that complies with Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS. The insulation and all covering must pass the flame spread index of 25 and the smoke developed index of 50 when tested in accordance with ASTM E84.

2.4 DUCT INSULATION SYSTEMS

2.4.1 Factory Applied Insulation

Provide factory-applied ASTM C534/C534M Grade 1, Type II, flexible elastomeric closed cell insulation according to manufacturer's recommendations for insulation with insulation manufacturer's standard reinforced fire-retardant vapor barrier.

2.4.1.1 Rigid Insulation

Calculate the minimum thickness in accordance with ASHRAE 90.1 - IP.

2.4.1.2 Blanket Insulation

Calculate minimum thickness in accordance with ASHRAE 90.1 - IP.

2.4.2 Duct Insulation Jackets

2.4.2.1 Metal Jackets

2.4.2.1.1 Aluminum Jackets

ASTM B209, Temper H14, minimum thickness of 27 gauge (0.016 inch), with factory-applied polyethylene and kraft paper moisture barrier on inside surface. Provide smooth surface jackets for jacket outside dimension 8 inches and larger. Provide corrugated surface jackets for jacket outside dimension 8 inches and larger. Provide stainless steel bands, minimum width of 1/2 inch.

2.5 EQUIPMENT INSULATION SYSTEMS

Insulate equipment and accessories as specified in Tables 5 and 6. In outside locations, provide insulation 1/2 inch thicker than specified. Increase the specified insulation thickness for equipment where necessary to equal the thickness of angles or other structural members to make a smooth, exterior surface. Submit a booklet containing manufacturer's published installation instructions for the insulation systems in coordination with the submitted MICA Insulation Stds plates booklet. Annotate their installation instructions to indicate which product data and which MICA plate are applicable. The instructions must be copyrighted, have an identifying or publication number, and have been published prior to the issuance date of this solicitation. A booklet is also required by paragraphs titled: Pipe Insulation Systems and Duct Insulation Systems.

PART 3 EXECUTION

3.1 APPLICATION - GENERAL

Apply insulation to unheated and uncooled piping and equipment. Do not compress flexible elastomeric cellular insulation at joists, studs, columns, ducts, and hangers. The insulation must not pull apart after a one hour period; replace any insulation found to pull apart after one hour.

3.1.1 Display Samples

Submit and display, after approval of materials, actual sections of installed systems, properly insulated in accordance with the specification requirements. Such actual sections must remain accessible to inspection throughout the job and will be reviewed from time to time for controlling the quality of the work throughout the construction site. Identify each material used by indicating on an attached sheet the specification requirement for the material and the material by each manufacturer intended to meet the requirement. The Contracting Officer will inspect display sample sections at the jobsite. Keep approved display sample sections on display at the jobsite during the construction period. Upon completion of construction, the display sample sections will be closed and sealed.

3.1.1.1 Pipe Insulation Display Sections

Include as a minimum an elbow or tee, a valve, dielectric waterways and flanges, a hanger with protection shield and insulation insert, or dowel as required, at support point, method of fastening and sealing insulation at longitudinal lap, circumferential lap, butt joints at fittings and on pipe runs, and terminating points for each type of pipe insulation used on the job, and for hot pipelines and cold pipelines, both interior and exterior, even when the same type of insulation is used for these services.

3.1.1.2 Duct Insulation Display Sections

Display sample sections for rigid and flexible duct insulation used on the job. Use a temporary covering to enclose and protect display sections for duct insulation exposed to weather

3.1.2 Installation

Except as otherwise specified, install material in accordance with the manufacturer's written instructions. Do not apply insulation materials until tests and heat tracing specified in other sections of this specification are completed. Remove material such as rust, scale, dirt and moisture from surfaces to receive insulation. Keep insulaton clean and dry. Do not remove insulation from its shipping containers until the day it is ready to use and return to like containers or equally protect from dirt and moisture at the end of each workday. Thoroughly clean insulation that becomes dirty prior to use. If insulation becomes wet or if cleaning does not restore the surfaces to like new condition, reject the insulation, and immediately remove from the jobsite. Stagger joints on multi layer insulation. Mix mineral fiber thermal insulating cement with demineralized water when used on stainless steel surfaces. Install insulation, jacketing and accessories in accordance with MICA Insulation Stds plates except where modified herein or on the drawings.

3.1.3 Firestopping

Where pipes and ducts pass through fire walls, fire partitions, above grade floors, and fire rated chase walls, seal the penetration with fire stopping materials as specified in Section 07 84 00 FIRESTOPPING.

3.1.4 Installation of Flexible Elastomeric Cellular Insulation

Install flexible elastomeric cellular insulation with seams and joints sealed with rubberized contact adhesive. Do not use flexible elastomeric cellular insulation on surfaces greater than 220 degrees F. Stagger seams when applying multiple layers of insulation. Protect insulation exposed to weather and not shown to have vapor barrier weatherproof jacketing with two coats of UV resistant finish or PVC or metal jacketing as recommended by the manufacturer after the adhesive is dry and cured.

3.1.4.1 Adhesive Application

Apply a brush coating of adhesive to both butt ends to be joined and to both slit surfaces to be sealed. Allow the adhesive to set until dry to touch but tacky under slight pressure before joining the surfaces. Ensure insulation seals at seams and joints are not capable of being pulled apart one hour after application. Replace insulation that can be pulled apart one hour after installation.

3.1.4.2 Adhesive Safety Precautions

Use natural cross-ventilation, local (mechanical) pickup, and/or general area (mechanical) ventilation to prevent an accumulation of solvent vapors, keeping in mind the ventilation pattern must remove any heavier-than-air solvent vapors from lower levels of the workspaces. Gloves and spectacle-type safety glasses are recommended in accordance with safe installation practices.

3.1.5 Welding

Welding is not permitted on piping, duct or equipment without written approval of the Contracting Officer. The capacitor discharge welding process may be used for securing metal fasteners to duct.

3.1.6 Pipes/Ducts/Equipment That Require Insulation

Insulation is required on all pipes, ducts, or equipment, except for omitted items as specified.

3.2 PIPE INSULATION SYSTEMS INSTALLATION

Install pipe insulation systems in accordance with the approved MICA Insulation Stds plates as supplemented by the manufacturer's published installation instructions.

3.2.1 Pipe Insulation

3.2.1.1 General

Install pipe insulation on aboveground hot and cold pipeline systems as specified below to form a continuous thermal retarder/barrier, including straight runs, fittings and appurtenances unless specified otherwise. Install full length units of insulation using a single cut piece to complete a run. Do not use cut pieces or scraps abutting each other. Omit pipe insulation on the following:

a. Pipe used solely for fire protection.

b. Chromium plated pipe to plumbing fixtures. However, for fixtures used by the physically handicapped, insulate the hot water supply and drain, including the trap, where exposed.

c. Sanitary drain lines.

d. Air chambers.

e. Adjacent insulation.

f. ASME stamps.

g. Access plates of fan housings.

h. Cleanouts or handholes.

3.2.1.2 Pipes Passing Through Walls, Roofs, and Floors

Provide continuous pipe insulation through the sleeve.

Provide an aluminum jacket or vapor barrier/weatherproofing self adhesive jacket (minimum 2 mils adhesive, 3 mils embossed) less than 0.0000 permeability, greater than 3 ply standard grade, silver, white, black and embossed with factory applied moisture retarder over the insulation wherever penetrations require sealing.

3.2.1.2.1 Penetrate Interior Walls

Provide aluminum jacket or vapor barrier/weatherproofing - self adhesive jacket (minimum 2 mils adhesive, 3 mils embossed) less than 0.0000 permeability, greater than 3 plies standard grade, silver, white, black and embossed which extends 2 inches beyond either side of the wall and secure on each end with a band.

3.2.1.2.2 Penetrating Floors

Extend the aluminum jacket from a point below the backup material to a point 10 inches above the floor with one band at the floor and one not more than 1 inch from the end of the aluminum jacket.

3.2.1.2.3 Penetrating Waterproofed Floors

Extend the aluminum jacket rom below the backup material to a point 2 inches above the flashing with a band 1 inch from the end of the aluminum jacket.

3.2.1.2.4 Penetrating Exterior Walls

Continue the aluminum jacket required for pipe exposed to weather through the sleeve to a point 2 inches beyond the interior surface of the wall.

3.2.1.2.5 Penetrating Roofs

Insulate pipe as required for interior service to a point flush with the top of the flashing and sealed with flashing sealant. Tightly butt the insulation for exterior application to the top of flashing and interior insulation. Extend the exterior aluminum jacket 2 inches down beyond the end of the insulation to form a counter flashing. Seal the flashing and counter flashing underneath with metal jacketing/flashing sealant.

3.2.1.3 Pipes Passing Through Hangers

Ensure insulation, whether hot or cold application, is continuous through hangers. Support all horizontal pipes 2 inches and smaller on hangers with the addition of a Type 40 protection shield to protect the insulation in accordance with MSS SP-58. Whenever insulation shows signs of being compressed, or when the insulation or jacket shows visible signs of distortion at or near the support shield, install insulation inserts as specified below for piping larger than 2 inches, or factory insulated hangers (designed with a load bearing core) can be used.

3.2.1.3.1 Horizontal Pipes Larger Than 2 Inches at 60 Degrees F and Above

Supported on hangers in accordance with MSS SP-58, and Section 22 00 00 PLUMBING, GENERAL PURPOSE.

3.2.1.3.2 Horizontal Pipes Larger Than 2 Inches and Below 60 Degrees F

Supported on hangers with the addition of a Type 40 protection shield in accordance with MSS SP-58. Install an insulation insert of cellular glass, prefabricated insulation pipe hangers, or perlite above 80 degrees F above each shield. Ensure insert covers no less than the bottom 180-degree arc of the pipe. Provide inserts that are the same thickness as the insulation, and extend 2 inches on each end beyond the protection shield. When insulation inserts are required in accordance with the above, and the insulation thickness is less than 1 inch, wooden or cork dowels or blocks may be installed between the pipe and the shield to prevent the weight of the pipe from crushing the insulation, as an option to installing insulation inserts. Ensure the insulation jacket is continuous over the wooden dowel, wooden block, or insulation insert.

3.2.1.3.3 Vertical Pipes

Supported with either Type 8 or Type 42 riser clamps with the addition of two Type 40 protection shields in accordance with MSS SP-58 covering the 360-degree arc of the insulation. Install an insulation insert of cellular glass or calcium silicate between each shield and the pipe. Ensure the insert covers the 360-degree arc of the pipe. Provide inserts that are the same thickness as the insulation, and extend 2 inches on each end beyond the protection shield. When insulation inserts are required in accordance with the above, and the insulation thickness is less than 1 inch, wooden or cork dowels or blocks may be installed between the pipe and the shield to prevent the hanger from crushing the insulation, as an option instead of installing insulation inserts. Ensure the insulation jacket is continuous over the wooden dowel, wooden block, or insulation insert. Support the vertical weight of the pipe with hangers located in a horizontal section of the pipe. When the pipe riser is longer than 30 feet, support the weight of the pipe additionally with hangers in the vertical run of the pipe that are directly clamped to the pipe, penetrating the pipe insulation. Use insulated hangers and seal the insulation jacket as indicated herein for anchors in a similar service.

3.2.1.3.4 Inserts

Covered with a jacket material of the same appearance and quality as the adjoining pipe insulation jacket, overlap the adjoining pipe jacket 1-1/2 inches, and seal as required for the pipe jacket. Use jacket material to cover inserts in flexible elastomeric cellular insulation conforming to ASTM C1136, Type 1, and is allowed to be of a different material than the adjoining insulation material.

3.2.1.4 Flexible Elastomeric Cellular Pipe Insulation

Use tubular form flexible elastomeric cellular pipe insulation for pipe sizes 6 inches and less. Grade 1, Do not stretch Type II sheet insulation used on pipes larger than 6 inches around the pipe. On pipes larger than 12 inches, adhere the insulation directly to the pipe on the lower 1/3 of the pipe. Stagger seams when applying multiple layers of insulation. Insulate sweat fittings with miter-cut pieces the same size as on adjacent piping. Insulate screwed fittings with sleeved fitting covers fabricated from miter-cut pieces and overlap and seal to the adjacent pipe insulation. Type II requires an additional exterior vapor retarder/barrier covering for high relative humidity and below ambient temperature applications.

3.2.1.5 Pipes in high abuse areas.

In high abuse areas such as janitor closets and traffic areas in equipment rooms, kitchens, and mechanical rooms, utilize aluminum or flexible laminate cladding (comprised of elastomeric, plastic or metal foil laminate) laminated self-adhesive (minimum 2 mils adhesive, 3 mils embossed) vapor barrier/weatherproofing jacket, - less than 0.0000 permeability; (greater than 3 ply, standard grade, silver, white, black and embossed) aluminum jackets. Protect pipe insulation to the 6 foot level.

3.2.1.6 Pipe Insulation Material and Thickness

Pipe insulation materials must be as listed in Table 1 and must meet or exceed the requirements ofASHRAE 90.1 - IP.

TABLE 1

Insulation Material for Piping

Service					
	Material	Specification	Type	Class	VR/VB Req'd
Chilled Water (Supply & Return, Dual Temperature Piping, 40 F nominal)					
	Flexible Elastomeric Cellular	ASTM C534/C534M	I		Yes
Condensate Drain Located Inside Building					
	Flexible Elastomeric Cellular	ASTM C534/C534M	I		No
Medium Temperature Hot Water, Steam and Condensate (251 to 350 Degrees F)					
	Flexible Elastomeric Cellular	ASTM C534/C534M	I	2	No
Note: VR/VB = Vapor Retarder/Vapor Barrier					

TABLE 2

Piping Insulation Thickness (inch)
Do not use integral wicking material in Chilled water applications exposed to outdoor ambient conditions in climatic zones 1 through 4.

Service						
	Material	Tube And Pipe Size (inch)				
		<1	1-<1.5	1.5-<4	4-<8	> or = >8
Chilled Water (40 Degrees F nominal)						
	Flexible Elastomeric Cellular	1	1	1	N/A	N/A
Chilled Water (Supply & Return, Dual Temperature Piping, 40 Degrees F nominal)						
	Flexible Elastomeric Cellular	1	1	1	N/A	N/A

TABLE 2						
Piping Insulation Thickness (inch) Do not use integral wicking material in Chilled water applications exposed to outdoor ambient conditions in climatic zones 1 through 4.						
Service						
	Material	Tube And Pipe Size (inch)				
		<1	1-<1.5	1.5-<4	4-<8	> or = >8
	Cellular Glass	1.5	1.5	1.5	1.5	1.5
	Flexible Elastomeric Cellular	1	1	1	N/A	N/A
	Mineral Fiber	1.5	3	3	4	4
		2.5*	*	3.5*		
	Calcium Silicate	2.5	3.5	4.5	4.5	5
	Perlite	2.5	3.5	4.5	4.5	5
	Flexible Elastomeric Cellular	1	1	1	N/A	N/A

3.2.2 Aboveground Cold Pipelines

Insulate the following cold pipelines for minus 30 to plus 60 degrees F in accordance with Table 2 except those piping listed in subparagraph Pipe Insulation in PART 3 as to be omitted. This includes but is not limited to the following:

a. Make-up water.

b. Refrigerant suction lines.

c. Chilled water.

d. Air conditioner condensate drains.

3.2.2.1 Insulation Material and Thickness

Determine insulation thickness for cold pipelines using Table 2.

3.2.2.2 Factory or Field applied Jacket

Cover insulation with a factory applied vapor retarder jacket/vapor barrier or field applied seal welded PVC jacket or greater than 3 ply laminated self-adhesive (minimum 2 mils adhesive, 3 mils embossed) vapor barrier/weatherproofing jacket - less than 0.0000 permeability, standard grade, sliver, white, black and embossed for use with Mineral Fiber, Cellular Glass, and Phenolic Foam Insulated Pipe. For insulation inside the building, to be protected with an aluminum jacket or greater than 3 ply vapor barrier/weatherproofing self-adhesive (minimum 2 mils adhesive, 3 mils embossed) product, less than 0.0000 permeability, standard grade, Embossed Silver, White & Black, install the insulation and vapor retarder jacket as specified herein. Install the aluminum jacket or greater than 3 ply vapor barrier/weatherproofing self-adhesive (minimum 2 mils adhesive, 3 mils embossed) product, less than 0.0000 permeability, standard grade, embossed silver, White & Black, as specified for piping exposed to weather, except sealing of the laps of the aluminum jacket is not required. In high abuse areas such as janitor closets and traffic areas in equipment rooms, kitchens, and mechanical rooms, provide aluminum jackets or greater than 3 ply vapor barrier/weatherproofing self-adhesive (minimum 2 mils adhesive, 3 mils embossed) product, less than 0.0000 permeability, standard grade, embossed silver, white & black, for pipe insulation to the 6 ft level.

3.2.2.3 Installing Insulation for Straight Runs Hot and Cold Pipe

Apply insulation to the pipe with tight butt joints. Seal all butted joints and ends with joint sealant and seal with a vapor retarder coating, greater than 3 ply laminate jacket - less than 0.0000 perm adhesive tape or PVDC adhesive tape.

3.2.2.3.1 Longitudinal Laps of the Jacket Material

Overlap not less than 1-1/2 inches. Provide butt strips 3 inches wide for circumferential joints.

3.2.2.3.2 Laps and Butt Strips

Secure with adhesive and staple on 4 inch centers if not factory self-sealing. If staples are used, seal in accordance with paragraph STAPLES below. Note that staples are not required with cellular glass systems.

3.2.2.3.3 Factory Self-Sealing Lap Systems

May be used when the ambient temperature is between 40 and 120 degrees F during installation. Install the lap system in accordance with manufacturer's recommendations. Use a stapler only if specifically recommended by the manufacturer. Where gaps occur, replace the section or repair the gap by applying adhesive under the lap and then stapling.

3.2.2.3.4 Staples

Coat all staples, including those used to repair factory self-seal lap systems, with a vapor retarder coating or PVDC adhesive tape or greater than 3 ply laminate jacket - 0.0000 perm adhesive tape. Coat all seams, except those on factory self-seal systems, with vapor retarder coating or PVDC adhesive tape or greater than 3 ply laminate jacket - less than 0.0000 perm adhesive tape.

3.2.2.3.5 Breaks and Punctures in the Jacket Material

Patch by wrapping a strip of jacket material around the pipe and secure it with adhesive, staple, and coat with vapor retarder coating or PVDC adhesive tape or greater than 3 ply laminate jacket - less than 0.0000 perm adhesive tape. Extend the patch not less than 1-1/2 inches past the break.

3.2.2.3.6 Penetrations Such as Thermometers

Fill the voids in the insulation and seal with vapor retarder coating or PVDC adhesive tape or greater than 3 ply laminate jacket - less than 0.0000 perm adhesive tape.

3.2.2.3.7 Flexible Elastomeric Cellular Pipe Insulation

Install by slitting the tubular sections and applying them onto the piping or tubing. Alternately, whenever possible slide un-slit sections over the open ends of piping or tubing. Secure all seams and butt joints and seal with adhesive. When using self seal products, secure only the butt joints with adhesive. Push insulation on the pipe, never pulled. Stretching of insulation may result in open seams and joints. Clean cut all edges. Rough or jagged edges of the insulation are not be permitted. Use proper tools such as sharp knives. Do not stretch Grade 1, Type II sheet insulation around the pipe when used on pipe larger than 6 inches. On pipes larger than 12 inches, adhere sheet insulation directly to the pipe on the lower 1/3 of the pipe.

3.2.2.4 Insulation for Fittings and Accessories

a. Butt pipe insulation tightly to the insulation of the fittings and accessories. Seal the butted joints and ends with joint sealant and seal with a vapor retarder coating or PVDC adhesive tape or greater than 3 ply laminate jacket - less than 0.0000 perm adhesive tape.

b. Place precut or preformed insulation around all fittings and accessories and conform to MICA plates except as modified herein: 5 for anchors; 10, 11, and 13 for fittings; 14 for valves; and 17 for flanges and unions. Insulation must be the same insulation as the pipe insulation, including same density, thickness, and thermal conductivity. Where precut/preformed is unavailable, rigid preformed pipe insulation sections may be segmented into the shape required. Use insulation of the same thickness and conductivity as the adjoining pipe insulation. If nesting size insulation is used, overlap the insulation 2 inches or one pipe diameter. Elbows insulated using segments must conform to MICA Tables 12.20 "Mitered Insulation Elbow'. Submit a booklet containing completed MICA Insulation Stds plates detailing each insulating system for each pipe, duct, or equipment insulating system, after approval of materials and prior to applying insulation.

   (1) Ensure MICA plates detail the materials to be installed and the specific insulation application. Submit all MICA plates required showing the entire insulating system, including plates required to show insulation penetrations, vessel bottom and top heads, legs, and skirt insulation as applicable. Present all variations of insulation systems including locations, materials, vaporproofing, jackets and insulation accessories.

   (2) If the Contractor elects to submit detailed drawings instead of edited MICA Plates, ensure the detail drawings are technically equivalent to the edited MICA Plate submittal.

c. Upon completion of insulation installation on flanges, unions, valves, anchors, fittings and accessories, terminations, seams, joints and insulation not protected by factory vapor retarder jackets or PVC fitting covers must be protected with PVDC or greater than 3 ply laminate jacket - less than 0.0000 perm adhesive tape or two coats of vapor retarder coating with a minimum total thickness of 1/16 inch, applied with glass tape embedded between coats. Overlap tap seams 1 inch. Extend the coating out onto the adjoining pipe insulation 2 inches. Protect fabricated insulation with a factory vapor retarder jacket with either greater than 3 ply laminate jacket - less than 0.0000 perm adhesive tape, standard grade, silver, white, black and embossed or PVDC adhesive tape or two coats of vapor retarder coating with a minimum thickness of 1/16 inch and with a 2 inch wide glass tape embedded between coats. Where fitting insulation butts to pipe insulation, seal the joints with a vapor retarder coating and a 4 inch wide ASJ tape which matches the jacket of the pipe insulation.

d. Insulate anchors attached directly to the pipe for a sufficient distance to prevent condensation but no less than 6 inches from the insulation surface.

e. Mark insulation to show the location of unions, strainers, and check valves.

3.2.2.5 Optional PVC Fitting Covers

At the option of the Contractor, premolded, one or two piece PVC fitting covers may be used in lieu of the vapor retarder and embedded glass tape. Use factory precut or premolded insulation segments under the fitting covers for elbows. Use insulation segmentswhich are the same insulation as the pipe insulation including same density, thickness, and thermal conductivity. Secure the covers by PVC vapor retarder tape, adhesive, seal welding or with tacks made for securing PVC covers. Seal seams in the cover, and tacks and laps to adjoining pipe insulation jacket, with vapor retarder tape to ensure that the assembly has a continuous vapor seal.

3.2.3 Aboveground Hot Pipelines

3.2.3.1 General Requirements

Insulate all hot pipe lines above 60 degrees F, except those piping listed in subparagraph Pipe Insulation in PART 3 as to be omitted, in accordance with Table 2. This includes but is not limited to the following:

a. Domestic hot water supply & re-circulating system.

b. Steam.

c. Condensate & compressed air discharge.

d. Hot water heating.

e. Heated oil.

f. Water defrost lines in refrigerated rooms.

Cover insulation, in accordance with manufacturer's recommendations, with a factory applied Type I jacket or field applied aluminum where required or seal welded PVC.

3.2.3.2 Insulation for Fittings and Accessories

Butt pipe insulation tightly to the insulation of the fittings and accessories. Seal butted joints and ends with joint sealant. Mark insulation to show the location of unions, strainers, check valves and other components that would otherwise be hidden from view by the insulation.

3.2.3.2.1 Precut or Preformed

Place precut or preformed insulation around all fittings and accessories. Use the same insulation as the pipe insulation, including same density, thickness, and thermal conductivity.

3.2.3.2.2 Rigid Preformed

Where precut/preformed is unavailable, rigid preformed pipe insulation sections may be segmented into the shape required. Use insulation that is the same thickness and conductivity as the adjoining pipe insulation. If nesting size insulation is used, do not overlap insulation 2 inches or one pipe diameter. Elbows insulated using segments must conform to MICA Tables 12.20 "Mitered Insulation Elbow".

3.2.4 Piping Exposed to Weather

Insulate and jacket piping exposed to weather as specified for the applicable service inside the building. After this procedure, apply a laminated self-adhesive (minimum 2 mils adhesive, 3 mils embossed) vapor barrier/weatherproofing jacket - less than 0.0000 permeability (greater than 3 ply, standard grade, silver, white, black and embossed aluminum jacket, stainless steel or PVC jacket.

PVC jacketing requires no factory-applied jacket beneath it, however apply an all service jacket if factory applied jacketing is not furnished. Treat flexible elastomeric cellular insulation exposed to weather in accordance with paragraph INSTALLATION OF FLEXIBLE ELASTOMERIC CELLULAR INSULATION in PART 3.

3.2.4.1 Aluminum Jacket

The jacket for hot piping may be factory applied. Overlap the jacket no less than 2 inches at longitudinal and circumferential joints and secure with bands at no more than 12 inch centers. Overlap longitudinal joints down to shed water and locate at 4 or 8 o'clock positions. Seal joints on piping 60 degrees F and below with metal jacketing/flashing sealant while overlapping to prevent moisture penetration. Where jacketing on piping 60 degrees F and below abuts an un-insulated surface, caulk joints to prevent moisture penetration. Seal joints on piping above 60 degrees F with a moisture retarder.

3.2.4.2 Insulation for Fittings

Insulate and finish flanges, unions, valves, fittings, and accessories as specified for the applicable service. Apply two coats of breather emulsion type weatherproof mastic (impermeable to water, permeable to air) recommended by the insulation manufacturer with glass tape embedded between coats. Overlap tap no less than 1 inch and the adjoining aluminum jacket no less than 2 inches. Factory preformed aluminum jackets may be used in lieu of the above. Provide molded PVC fitting covers when PVC jackets are used for straight runs of pipe. Provide PVC fitting covers that have adhesive welded joints and are weatherproof laminated self-adhesive (minimum 2 mils adhesive, 3 mils embossed) vapor barrier/weatherproofing jacket - less than 0.0000 permeability, (greater than 3 ply, standard grade, silver, white, black and embossed, and UV resistant.

3.2.4.3 PVC Jacket

Provide ultraviolet resistant PVC jacket that is adhesive welded weather tight with manufacturer's recommended adhesive. Include provision for thermal expansion.

3.2.4.4 Stainless Steel Jackets

ASTM A167 or ASTM A240/A240M; Type 304, minimum thickness of 33 gauge (0.010 inch), smooth surface with factory-applied polyethylene and kraft paper moisture barrier on inside surface. Provide stainless steel bands, minimum width of 1/2 inch.

3.2.5 Below Ground Pipe Insulation

Insulate below ground pipes in accordance with Table 2, except as precluded in subparagraph Pipe Insulation in PART 3. This includes, but is not limited to the following:

a. Heated oil.

b. Domestic hot water.

c. Heating hot water.

d. Dual temperature water.

e. Steam.

f. Condensate.

3.2.5.1 Type of Insulation

Insulate below ground pipe with Cellular Glass insulation, in accordance with manufacturer's instructions for application with thickness as determined from Table 2 (whichever is the most restrictive).

3.2.5.2 Installation of Below ground Pipe Insulation

a. Coat bore surfaces of the insulation with a thin coat of gypsum cement of a type recommended by the insulation manufacturer. Ensure coating thickness is sufficient to fill surface cells of insulation. Do not use mastic type materials for this coating. Note that unless this is for a cyclic application (i.e., one that fluctuates between high and low temperature on a daily process basis) there is no need to bore coat the material.

b. Use stainless steel bands, 3/4 inch wide by 0.020 inch thick to secure insulation in place. Apply a minimum of two bands per section of insulation. As an alternate, fiberglass reinforced tape may be used to secure insulation on piping up to 12 inches in diameter. Apply a minimum of two bands per section of insulation.

c. Terminate insulation at anchor blocks but continue through sleeves and manholes.

d. At point of entry to buildings, terminate underground insulation 2 inches inside the wall or floor, butt tightly against the aboveground insulation and seal the butt joint with high temperature silicone sealant and cover with fibrous glass tape.

e. Make provision for expansion and contraction of the insulation system in accordance with the insulation manufacturer's recommendations.

f. Insulate flanges, couplings, valves, and fittings with factory pre-molded, prefabricated, or field-fabricated sections of insulation of the same material and thickness as the adjoining pipe insulation. Secure insulation sections as recommended by the manufacturer.

g. Finish insulation, including fittings, with three coats of asphaltic mastic, with 6 by 5.5 mesh synthetic reinforcing fabric embedded between coats. Overlap fabric a minimum of 2 inches at joints. Ensure total film thickness is a minimum of 3/16 inch. As an alternate, apply a prefabricated bituminous laminated jacket, reinforced with internal reinforcement mesh, to the insulation. Use jacketing material and application procedures that match manufacturer's written instructions. Vapor barrier - less than 0.0000 permeability self adhesive (minimum 2 mils adhesive, 3 mils embossed) jacket greater than 3 ply, standard grade, silver, white, black and embossed or greater than 8 ply (minimum 2.9 mils adhesive), heavy duty, white or natural). Use application procedures that match the manufacturer's written instructions.

h. At termination points, other than building entrances, use mastic and cloth or tape to cover the ends of insulation and extend 2 inches along the bare pipe.

3.3 DUCT INSULATION SYSTEMS INSTALLATION

Install duct insulation systems in accordance with the approved MICA Insulation Stds plates as supplemented by the manufacturer's published installation instructions. Duct insulation minimum thickness and insulation level must be as listed in Table 3 and must meet or exceed the requirements ofASHRAE 90.1 - IP.

Except for oven hood exhaust duct insulation, install corner angles on external corners of insulation on ductwork in exposed finished spaces before covering with jacket. Air conditioned spaces are defined as those spaces directly supplied with cooled conditioned air (or provided with a cooling device such as a fan-coil unit) and heated conditioned air (or provided with a heating device such as a unit heater, radiator or convector).

3.3.1 Duct Insulation Minimum Thickness

Duct insulation minimum thickness in accordance with Table 4.

Table 4 - Minimum Duct Insulation (inches)	
Cold Air Ducts	2.0
Relief Ducts	1.5
Fresh Air Intake Ducts	1.5

3.3.2 Insulation and Vapor Retarder/Vapor Barrier for Cold Air Duct

Provide insulation and vapor retarder/vapor barrier for the following cold air ducts and associated equipment.

a. Supply ducts.

b. Return air ducts.

c. Relief ducts.

d. Flexible run-outs (field-insulated).

e. Plenums.

f. Duct-mounted coil casings.

g. Coil headers and return bends.

h. Coil casings.

i. Fresh air intake ducts.

j. Filter boxes.

k. Mixing boxes (field-insulated).

l. Supply fans (field-insulated).

m. Site-erected air conditioner casings.

n. Ducts exposed to weather.

o. Combustion air intake ducts.

Use insulation for rectangular ducts that is flexible type where concealed, minimum density 3/4 pcf, and rigid type where exposed, minimum density 3 pcf. Provide insulation for both concealed or exposed round/oval ducts that is flexible type, minimum density 3/4 pcf or a semi rigid board, minimum density 3 pcf, formed or fabricated to a tight fit, edges beveled and joints tightly butted and staggered. Provide insulation for all exposed ducts with either a white, paint-able, factory-applied Type I jacket or a field applied vapor retarder/vapor barrier jacket coating finish as specified. Ensure the total field applied dry film thickness is approximately 1/16 inch. Provide insulation on all concealed duct with a factory-applied Type I or II vapor retarder/vapor barrier jacket. Continue duct insulation through sleeves and prepare openings except firewall penetrations. Duct insulation terminating at fire dampers, must be continuous over the damper collar and retaining angle of fire dampers, which are exposed to unconditioned air and which may be prone to condensate formation. Provide duct insulation and vapor retarder/vapor barrier to cover the collar, neck, and un-insulated surfaces of diffusers, registers and grills. Apply vapor retarder/vapor barrier materials to form a complete unbroken vapor seal over the insulation. Seal sheet metal duct in accordance with Section 23 30 00 HVAC AIR DISTRIBUTION.

3.3.2.1 Installation on Concealed Duct

a. For rectangular, oval or round ducts, attach flexible insulation by applying adhesive around the entire perimeter of the duct in 6 inch wide strips on 12 inch centers.

b. For rectangular and oval ducts, 24 inches and larger, additionally secure insulation to bottom of ducts using mechanical fasteners. Space fasteners on 16 inch centers and no more than 16 inches from duct corners.

c. For rectangular, oval and round ducts, provide mechanical fasteners on sides of duct risers for all duct sizes. Space fasteners on 16 inch centers and no more than 16 inches from duct corners.

d. Impale insulation on the mechanical fasteners (self stick pins) where used and press thoroughly into the adhesive. Take care to ensure vapor retarder/vapor barrier jacket joints overlap 2 inches. Do not compress insulation to a thickness less than that specified. Carry insulation over standing seams and trapeze-type duct hangers.

e. Where mechanical fasteners are used, install self-locking washers and trim and bend the pin over.

f. Secure jacket overlaps with staples and tape as necessary to ensure a secure seal. Coat staples, tape and seams with a brush coat of vapor retarder coating or PVDC adhesive tape or greater than 3 ply laminate (minimum 2 mils adhesive, 3 mils embossed) - less than 0.0000 perm adhesive tape.

g. Cover breaks in the jacket material with patches of the same material as the vapor retarder jacket. Do not extend patches less than 2 inches beyond the break or penetration in all directions and secure with tape and staples. Seal staples and tape joints with a brush coat of vapor retarder coating or PVDC adhesive tape or greater than 3 ply laminate (minimum 2 mils adhesive, 3 mils embossed) - less than 0.0000 perm adhesive tape.

h. At jacket penetrations such as hangers, thermometers, and damper operating rods, fill voids in the insulation and seal the penetration with a brush coat of vapor retarder coating or PVDC adhesive tape greater than 3 ply laminate (minimum 2 mils adhesive, 3 mils embossed) - less than 0.0000 perm adhesive tape.

i. Seal insulation terminations and pin punctures and flash with a reinforced vapor retarder coating finish or tape with a brush coat of vapor retarder coating.. Ensure the coating overlaps the adjoining insulation and un-insulated surface 2 inches. Extend pin puncture coatings 2 inches from the puncture in all directions.

j. Where insulation standoff brackets occur, extend insulation under the bracket and terminate the jacket at the bracket.

3.3.2.2 Installation on Exposed Duct Work

a. For rectangular ducts, secure rigid insulation to the duct by mechanical fasteners on all four sides of the duct, space no more than 12 inches apart and no more than 3 inches from the edges of the insulation joints. Provide a minimum of two rows of fasteners for each side of duct 12 inches and larger. Provide one row for each side of duct less than 12 inches. Provide mechanical fasteners that are corrosion resistant as G60 coated galvanized steel, and indefinitely sustain a 50 lb tensile dead load test perpendicular to the duct wall.

b. Form duct insulation with minimum jacket seams. Fasten each piece of rigid insulation to the duct using mechanical fasteners. When the height of projections is less than the insulation thickness, bring insulation up to standing seams, reinforcing, and other vertical projections and do not carry over. Continue vapor retarder/barrier jacket across seams, reinforcing, and projections. When height of projections is greater than the insulation thickness, carry over insulation and jacket . Apply insulation with joints tightly butted. Neatly bevel insulation around name plates and access plates and doors.

c. Impale insulation on the fasteners; install self-locking washers and trim and bend the pin over.

d. Seal joints in the insulation jacket with a 4 inch wide strip of tape. Seal taped seams with a brush coat of vapor retarder coating.

e. Cover breaks and ribs or standing seam penetrations in the jacket material with a patch of the same material as the jacket. Do not extend patches less than 2 inches beyond the break or penetration and secure with tape and staple. Seal staples and joints with a brush coat of vapor retarder coating.

f. At jacket penetrations such as hangers, thermometers, and damper operating rods, fill the voids in the insulation and seal the penetrations with a flashing sealant.

g. Seal and flash insulation terminations and pin punctures with a reinforced vapor retarder coating finish. Ensure coating overlaps the adjoining insulation and un-insulated surface 2 inches. Extend pin puncture coatings 2 inches from the puncture in all directions.

h. Insulate oval and round ducts, flexible type, with factory Type I jacket insulation with minimum density of 3/4 pcf, attach in accordance with MICA standards.

3.3.3 Insulation for Warm Air Duct

Provide insulation and vapor barrier for the following warm air ducts and associated equipment:.

a. Supply ducts.

b. Return air ducts.

c. Relief air ducts

d. Flexible run-outs (field insulated).

e. Plenums.

f. Duct-mounted coil casings.

g. Coil-headers and return bends.

h. Coil casings.

i. Fresh air intake ducts.

j. Filter boxes.

k. Mixing boxes.

l. Supply fans.

m. Site-erected air conditioner casings.

n. Ducts exposed to weather.

o. Exhaust ducts passing through concealed spaces exhausting conditioned air.

Provide insulation for rectangular ducts that is flexible type where concealed, and rigid type where exposed. Provide insulation on exposed ducts with a white, paint-able, factory-applied Type II jacket, or finish with adhesive finish. Use flexible type insulation for round ducts, with a factory-applied Type II jacket. Provide insulation on concealed duct with a factory-applied Type II jacket. Accomplish adhesive finish where indicated to be used by applying two coats of adhesive with a layer of glass cloth embedded between the coats. Ensure total dry film thickness is approximately 1/16 inch. Continue duct insulation through sleeves and prepare openings. Terminate duct insulation at fire dampers and flexible connections.

3.3.3.1 Installation on Concealed Duct

a. For rectangular, oval and round ducts, attach insulation by applying adhesive around the entire perimeter of the duct in 6 inch wide strips on 12 inch centers.

b. For rectangular and oval ducts 24 inches and larger, secure insulation to the bottom of ducts using mechanical fasteners. Space fasteners on 18 inch centers and no more than 18 inches from duct corner.

c. For rectangular, oval and round ducts, provide mechanical fasteners on sides of duct risers for all duct sizes. Space fasteners on 18 inch centers and no more than 18 inches from duct corners.

d. Impale insulation on the mechanical fasteners where used. Do not compress insulation to a thickness less than that specified. Carry insulation over standing seams and trapeze-type hangers.

e. Install self-locking washers where mechanical fasteners are used and trim and bend the pin over.

f. Do not overlap insulatio jacket less than 2 inches at joints and secure the lap and staple on 4 inch centers.

3.3.3.2 Installation on Exposed Duct

a. For rectangular ducts, secure the rigid insulation to the duct using mechanical fasteners on all four sides of the duct, space no more than 16 inches apart and no more than 6 inches from the edges of the insulation joints. Provide a minimum of two rows of fasteners for each side of duct 12 inches and larger and a minimum of one row for each side of duct less than 12 inches.

b. Form duct insulation with factory-applied jacket with minimum jacket seams, and fasten each piece of rigid insulation to the duct using mechanical fasteners. When the height of projection is less than the insulation thickness, bring insulation up to standing seams, reinforcing, and other vertical projections and do not carry over the projection. Continue jacket across seams, reinforcing, and projections. Where the height of projections is greater than the insulation thickness, carry insulation and jacket over the projection.

c. Impale insulation on the fasteners; install self-locking washers and trim and bend the pin over.

d. Seal joints on jacketed insulation with a 4 inch wide strip of tape and brush with vapor retarder coating.

e. Cover breaks and penetrations in the jacket material with a patch of the same material as the jacket. Extend patches no less than 2 inches beyond the break or penetration and secure with adhesive and staple.

f. Seal insulation terminations and pin punctures with tape and brush with vapor retarder coating.

g. Insulate oval and round ducts, flexible type, with factory Type I jacket insulation, minimum density of 3/4 pcf attach by staples spaced no more than 16 inches and no more than 6 inches from the degrees of joints. Seal joints in accordance with item "d." above.

3.3.4 Ducts Handling Air for Dual Purpose

For air handling ducts for dual purpose below and above 60 degrees F, insulate ducts as specified for cold air duct.

3.3.5 Insulation for Evaporative Cooling Duct

Insulate evaporative cooling supply duct located in spaces not evaporatively cooled. Use material and installation requirements as specified for duct insulation for warm air duct.

3.3.6 Duct Test Holes

After duct systems have been tested, adjusted, and balanced, repair breaks in the insulation and jacket in accordance with the applicable section of this specification for the type of duct insulation to be repaired.

3.3.7 Duct Exposed to Weather

3.3.7.1 Installation

Insulate and finish ducts exposed to weather as specified for the applicable service for exposed duct inside the building. After the above is accomplished, further finish the insulation as detailed in the following subparagraphs.

3.3.7.2 Round Duct

Laminated self-adhesive (minimum 2 mils adhesive, 3 mils embossed) vapor barrier/weatherproofing jacket - Less than 0.0000 permeability, (greater than 3 ply, standard grade, silver, white, black and embossed or greater than 8 ply, heavy duty, white and natural) membrane must be applied overlapping material by 3 inches no bands or caulking needed - see manufacturer's recommended installation instructions. Aluminum jacket with factory applied moisture retarder must be applied with the joints lapped no less than 3 inches and secured with bands located at circumferential laps and at no more than 12 inch intervals throughout. Lap horizontal joints down to shed water and located at 4 or 8 o'clock position. Seal joints with metal jacketing sealant to prevent moisture penetration. Where jacketing abuts an un-insulated surface, seal joints with metal jacketing sealant.

3.3.7.3 Fittings

Finish fittings and other irregular shapes as specified for rectangular ducts.

3.3.7.4 Rectangular Ducts

Apply two coats of weather barrier mastic reinforced with fabric or mesh for outdoor application to the entire surface. Ensure each coat of weatherproof mastic has a minimum thickness of 1/16 inch. Ensure exterior is a metal jacketing applied for mechanical abuse and weather protection, and secure with screws or vapor barrier/weatherproofing jacket less than 0.0000 permeability greater than 3 ply, standard grade, silver, white, black, and embossed or greater than 8 ply, heavy duty white and natural. Apply membrane overlapping material by 3 inches. No bands or caulking needed-see manufacturing recommend installation instructions.

3.4 EQUIPMENT INSULATION SYSTEMS INSTALLATION

Install equipment insulation systems in accordance with the approved MICA Insulation Stds plates as supplemented by the manufacturer's published installation instructions.

3.4.1 General

Provide removable insulation sections to cover parts of equipment that must be opened periodically for maintenance including vessel covers, fasteners, flanges and accessories. Omit equipment insulation on the following:

a. Hand-holes.

b. Boiler manholes.

c. Cleanouts.

d. ASME stamps.

e. Manufacturer's nameplates.

f. Duct Test/Balance Test Holes.

3.4.2 Insulation for Cold Equipment

Cold equipment below 60 degrees F: Furnish insulation on equipment handling media below 60 degrees F including the following:

a. Pumps.

b. Refrigeration equipment parts that are not factory insulated.

c. Drip pans under chilled equipment.

d. Cold water storage tanks.

e. Water softeners.

f. Duct mounted coils.

g. Cold and chilled water pumps.

h. Pneumatic water tanks.

i. Roof drain bodies.

j. Air handling equipment parts that are not factory insulated.

k. Expansion and air separation tanks.

3.4.2.1 Insulation Type

Provide insulation suitable for the temperature encountered. Provide material and thicknesses as shown in Table 5:

TABLE 5

Insulation Thickness for Cold Equipment (inches)

Equipment handling media at indicated temperature		
	Material	Thickness (inches)
35 to 60 degrees F		
	Cellular Glass	1.5
	Flexible Elastomeric Cellular	1
1 to 34 degrees F		
	Cellular Glass	3
	Flexible Elastomeric Cellular	1.5

TABLE 5		
Insulation Thickness for Cold Equipment (inches)		
Equipment handling media at indicated temperature		
	Material	Thickness (inches)
Minus 30 to 0 degrees F		
	Cellular Glass	3.5
	Flexible Elastomeric Cellular	1.75

3.4.2.2 Pump Insulation

a. Insulate pumps by forming a box around the pump housing. Construct the box by forming the bottom and sides using joints that do not leave raw ends of insulation exposed. Join joints between sides and between sides and bottom by adhesive with lap strips for rigid mineral fiber and contact adhesive for flexible elastomeric cellular insulation. Ensure box conforms to the requirements of MICA Insulation Stds plate No. 49 when using flexible elastomeric cellular insulation. Ensure joints between top cover and sides fit tightly forming a female shiplap joint on the side pieces and a male joint on the top cover, thus making the top cover removable.

b. Protect exposed insulation corners with corner angles.

c. Upon completion of installation of the insulation, including removable sections, apply two coats of vapor retarder coating with a layer of glass cloth embedded between the coats. The total dry thickness of the finish must be 1/16 inch. Provide a parting line between the box and the removable sections allowing the removable sections to be removed without disturbing the insulation coating. Apply flashing sealant to parting line, between equipment and removable section insulation, and at all penetrations.

3.4.2.3 Other Equipment

a. Form or fabricate insulation to fit the equipment. To ensure a tight fit on round equipment, bevel edges and tightly butt and stagger joints.

b. Secure insulation in place with bands or wires at intervals as recommended by the manufacturer but no more than 12 inch centers except adhere flexible elastomeric cellular with contact adhesive. Protect insulation corners under wires and bands with suitable corner angles.

c. Install cellular glass in accordance with manufacturer's instructions. Seal joints and ends with joint sealant, and seal with a vapor retarder coating.

d. Use removable insulation on heads of heat exchangers. Fabricate removable section joints using a male-female shiplap type joint. Finish the entire surface of the removable section by applying two coats of vapor retarder coating with a layer of glass cloth embedded between the coats. The total dry thickness of the finish must be 1/16 inch.

e. Protect exposed insulation corners with corner angles.

f. Apply insulation on equipment with ribs over 6 by 6 inches by 12 gauge welded wire fabric which has been cinched in place, or if approved by the Contracting Officer, spot weld to the equipment over the ribs. Secure insulation to the fabric with J-hooks and 2 by 2 inches washers or securely band or wire in place on 12 inch centers.

3.4.2.4 Vapor Retarder/Vapor Barrier

Upon completion of installation of insulation, caulk penetrations. Apply two coats of vapor retarder coating or vapor barrier jacket over insulation, including removable sections, with a layer of open mesh synthetic fabric embedded between the coats. Ensure the total dry thickness of the finish is 1/16 inch. Apply flasing sealant or vapor barrier tape to parting line between equipment and removable section insulation.

3.4.3 Insulation for Hot Equipment

Furnish insulation on equipment handling media above 60 degrees F including the following:

a. Converters.

b. Heat exchangers.

c. Hot water generators.

d. Water heaters.

e. Pumps handling media above 130 degrees F.

f. Fuel oil heaters.

g. Hot water storage tanks.

h. Air separation tanks.

i. Surge tanks.

j. Flash tanks.

k. Feed-water heaters.

l. Unjacketed boilers or parts of boilers.

m. Boiler flue gas connection from boiler to stack (if inside).

n. Induced draft fans.

o. Fly ash and soot collectors.

p. Condensate receivers.

3.4.3.1 Insulation

Provide insulation suitable for the temperature encountered. Insulate shell and tube-type heat exchangers for the temperature of the shell medium.

Determine insulation thickness for hot equipment using Table 6:

TABLE 6

Insulation Thickness for Hot Equipment (inches)

Equipment handling steam or media at indicated pressure or temperature limit		
	Material	Thickness (inches)
15 psig or 250 degrees F		
	Rigid Mineral Fiber	2
	Flexible Mineral Fiber	2
	Flexible Elastomeric Cellular (<200 F)	1

3.4.3.2 Insulation of Boiler Stack and Diesel Engine Exhaust Pipe

Inside mechanical Room, bevel insulation neatly around openings and provide sheet metal insulation stop strips around such openings. Apply a skim coat of hydraulic setting cement directly to insulation. Apply a flooding coat of adhesive over hydraulic setting cement, and while still wet, press a layer of glass cloth or tape into adhesive and seal laps and edges with adhesive. Coat glass cloth with adhesive. When dry, apply a finish coat of adhesive at can-consistency so that when dry no glass weave is observed. Provide metal jackets for stacks that are located above finished floor and spaces outside mechanical room. Apply metal jackets directly over insulation and secure with 3/4 inch wide metal bands spaced on 18 inch centers. Do not insulate name plates. Provide insulation type and thickness in accordance with the following Table 7.

TABLE 7

Insulation and Thickness for
Boiler Stack and Diesel Engine Exhaust Pipe

Service & Surface Temperature Range (Degrees F)						
	Material	Outside Diameter (Inches)				
		0.25 - 1.25	1 - 1.67	3.5-5	6 - 10	> or = 11 - 36
Boiler Stack (Up to 400 degrees F)						

TABLE 7						
Insulation and Thickness for Boiler Stack and Diesel Engine Exhaust Pipe						
Service & Surface Temperature Range (Degrees F)						
	Material	Outside Diameter (Inches)				
		0.25 - 1.25	1 - 1.67	3.5-5	6 - 10	> or = 11 - 36
	Mineral Fiber ASTM C585 Class B-3, ASTM C547 Class 1, or ASTM C612 Class 1	N/A	N/A	3	3.5	4
	Calcium Silicate ASTM C533, Type 1	N/A	N/A	3	3.5	4
	Cellular Glass ASTM C552, Type II	1.5	1.5	1.5	2	2.5
Boiler Stack (401 to 600 degrees F)						
	Mineral Fiber ASTM C547 Class 2, ASTM C592 Class 1, or ASTM C612 Class 3	N/A	N/A	4	4	5
	Calcium Silicate ASTM C533, Type I or II	N/A	N/A	4	4	4
	Mineral Fiber/Cellular Glass Composite:					
	Mineral Fiber ASTM C547 Class 2, ASTM C592 Class 1, or ASTM C612 Class 3	1	1	1	1	2

3.4.3.3 Insulation of Pumps

Insulate pumps by forming a box around the pump housing. Construct the box by forming the bottom and sides using joints that do not leave raw ends of insulation exposed. Band bottom and sides to form a rigid housing that does not rest on the pump. Ensure joints between top cover and sides fit tightly. The top cover must have a joint forming a female shiplap joint on the side pieces and a male joint on the top cover, making the top cover removable. Apply two coats of Class I adhesive over insulation, including removable sections, with a layer of glass cloth embedded between the coats. Provide a parting line between the box and the removable sections allowing the removable sections to be removed without disturbing the insulation coating. The total dry thickness of the finish must be 1/16 inch. Apply caulking to parting line of the removable sections and penetrations.

3.4.3.4 Other Equipment

a. Form or fabricate insulation to fit the equipment. To ensure a tight fit on round equipment, bevel edges and tightly butt and stagger joints.

b. Secure insulation in place with bands or wires at intervals as recommended by the manufacturer but no greater than 12 inch centers except adhere flexible elastomeric cellular. Protect insulation corners under wires and bands with suitable corner angles.

c. On high vibration equipment, set cellular glass insulation in a coating of bedding compound as recommended by the manufacturer, and seal joints with bedding compound. Fill mineral fiber joints with finishing cement.

d. Provide removable insulation on heads of heat exchangers. Fabricate the removable section joint using a male-female shiplap type joint. Finish the entire surface of the removable section as specified.

e. Protect exposed insulation corners with corner angles.

f. On equipment with ribs, such as boiler flue gas connection, draft fans, and fly ash or soot collectors, apply insulation over 6 by 6 inch by 12 gauge welded wire fabric which has been cinched in place, or if approved by the Contracting Officer, spot weld to the equipment over the ribs. Secure insulation to the fabric with J-hooks and 2 by 2 inch washers or securely band or wire in place on 12 inch (maximum) centers.

g. On equipment handling media above 600 degrees F, apply insulation in two or more layers with staggered joints.

h. Upon completion of installation of insulation, caulk penetrations. Apply two coats of adhesive over insulation, including removable sections, with a layer of glass cloth embedded between the coats. The total dry thickness of the finish must be 1/16 inch. Apply caulking to parting line between equipment and removable section insulation.

3.4.4 Equipment Handling Dual Temperature Media

Below and above 60 degrees F: insulate equipment handling dual temperature media as specified for cold equipment.

3.4.5 Equipment Exposed to Weather

3.4.5.1 Installation

Insulate equipment exposed to weather and finish in accordance with the requirements for ducts exposed to weather in paragraph DUCT INSULATION INSTALLATION.

3.4.5.2 Optional Panels

At the option of the Contractor, prefabricated metal insulation panels may be used in lieu of the insulation and finish previously specified. Thermal performance must be equal to or better than that specified for field applied insulation. Provide panels that are the standard catalog product of a manufacturer of metal insulation panels. Provide fastenings, flashing, and support system conforming to published recommendations of the manufacturer for weatherproof installation and that prevent moisture from entering the insulation. Design panels to accommodate thermal expansion and to support a 250 pound walking load without permanent deformation or permanent damage to the insulation. Exterior metal cover sheet must be aluminum and exposed fastenings must be stainless steel or aluminum.

-- End of Section --

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SECTION 23 09 00

INSTRUMENTATION AND CONTROL FOR HVAC
02/19, CHG 3: 05/21

PART 1 GENERAL

1.1 SUMMARY

Provide a complete Direct Digital Control (DDC) system suitable for the control of the heating, ventilating and air conditioning (HVAC) and other building-level systems as indicated and shown and in accordance with Section 23 09 13 INSTRUMENTATION AND CONTROL DEVICES FOR HVAC, Section 23 09 23.02 BACNET DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS for BACnet or Niagara BACnet systems, and other referenced Sections.

1.1.1 Proprietary Systems

1.1.1.1 Proprietary Systems Exempted From Open Protocol Requirements

The following systems are specifically exempted from the open protocol requirements of Section 23 09 23.02 BACNET DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS:

a. A simple split (DX) system consisting of a single indoor unit and a single outdoor unit from the same manufacturer.

b. Systems in Table I (previously approved by the designer in accordance with UFC 3-410-02).

TABLE I: Systems Approved to Use Proprietary Communications		
System	Type (Multi-Split/VRF or Chiller/Boiler Plant)	Proprietary Multi-Split Engineering Tool Software Required (for Multi-Split/VRF only)

c. A system (not already shown Table I) of multiple boilers or multiple chillers communicating with a proprietary network for which an approved request has been obtained and for which: all units are from the same manufacturer, they are all co-located in the same room, the network connecting them is fully contained in that room, and the units are operating using a common "plant" sequence of operation which stages the units in a manner that requires operational parameters be shared between them and which cannot be accomplished with a single lead-lag command from a third-party controller.

1.1.1.2 Implementation of Proprietary Systems

For proprietary systems exempted from open protocol requirements, a proprietary network and DDC hardware communicating via proprietary protocol are permitted. For these systems a building control network meeting the requirements of Section 23 09 23.02 BACNET DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS must also be provided, along with a gateway or interface to connect the proprietary system to the open building control network.

The proprietary system gateway or interface must provide the required functionaliality as shown on the points schedule. Scheduling, alarming, trending, overrides, network inputs, network outputs and other protocol related requirements must be met on the open protocol control system as specified in Section 23 09 23.02 BACNET DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS.

1.1.1.3 Proprietary Multi-Split Engineering Tool Software

For each permitted proprietary systems in Table 1 shown as requiring Proprietary Multi-Split Engineering Tool Software, provide the software needed to replace a unit and configure the replacement. Submit hard copies of the software user manuals with the software submittal.

Submit Proprietary Multi-Split Engineering Tool Software on CD-ROM as a Technical Data Package. Submit three hard copies of the software user manual for each piece of software.

1.1.2 System Requirements

Provide systems meeting the requirements this Section and other Sections referenced by this Section, and which have the following characteristics:

a. The system implements the control sequences of operation shown in the Contract Drawings using DDC hardware to control mechanical and electrical equipment

b. The system meet the requirements of this specification as a stand-alone system and does not require connection to any other system.

c. Control sequences reside in DDC hardware in the building. The building control network is not dependent upon connection to a Utility Monitoring and Control System (UMCS) Front End or to any other system for performance of control sequences. To the greatest extent practical, the hardware performs control sequences without reliance on the building network, unless otherwise pre-approved by the Contracting Officer.

d. The hardware is installed such that individual control equipment can be replaced by similar control equipment from other equipment manufacturers with no loss of system functionality.

e. All necessary documentation, configuration information, programming tools, programs, drivers, and other software are licensed to and otherwise remain with the Government such that the Government or their agents are able to perform repair, replacement, upgrades, and expansions of the system without subsequent or future dependence on the Contractor, Vendor or Manufacturer.

f. Sufficient documentation and data, including rights to documentation and data, are provided such that the Government or their agents can execute work to perform repair, replacement, upgrades, and expansions of the system without subsequent or future dependence on the

Contractor, Vendor or Manufacturer.

g. Hardware is installed and configured such that the Government or their agents are able to perform repair, replacement, and upgrades of individual hardware without further interaction with the Contractor, Vendor or Manufacturer.

h. All Niagara Framework components have an unrestricted interoperability license with a Niagara Compatibility Statement (NiCS) following the Tridium Open NiCS Specification and have a value of "ALL" for "Station Compatibility In", "Station Compatibility Out", "Tool Compatibility In" and "Tool Compatibility Out". Note that this will result in the following entries in the license file:

```
accept.station.in="*"
accept.station.out="*"
accept.wb.in="*"
accept.wb.out="*"
```

1.1.3 End to End Accuracy

Select products, install and configure the system such that the maximum error of a measured value as read from the DDC Hardware over the network is less than the maximum allowable error specified for the sensor or instrumentation.

1.1.4 Verification of Dimensions

After becoming familiar with all details of the work, verify all dimensions in the field, and advise the Contracting Officer of any discrepancy before performing any work.

1.1.5 Drawings

The Government will not indicate all offsets, fittings, and accessories that may be required on the drawings. Carefully investigate the mechanical, electrical, and finish conditions that could affect the work to be performed, arrange such work accordingly, and provide all work necessary to meet such conditions.

1.2 RELATED SECTIONS

Related work specified elsewhere:

a. Section 23 09 23.02 BACNET DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS for BACnet systems with or without Niagara Framework.

b. Section 23 09 13 INSTRUMENTATION AND CONTROL DEVICES FOR HVAC

c. Section 01 91 00.15 10 TOTAL BUILDING COMMISSIONING

1.3 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS (ASHRAE)

ASHRAE 135	(2020; Interpretation 1-8 2021; Errata 1-2 2021; Addenda CD 2021; Addenda BY-CE 2022; Interpretation 9-10 2022) BACnet—A Data Communication Protocol for Building Automation and Control Networks
ASHRAE FUN IP	(2021) Fundamentals Handbook, I-P Edition
ASHRAE FUN SI	(2021) Fundamentals Handbook, SI Edition

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE C62.41	(1991; R 1995) Recommended Practice on Surge Voltages in Low-Voltage AC Power Circuits

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA 250	(2020) Enclosures for Electrical Equipment (1000 Volts Maximum)

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2020; TIA 22-1; ERTA 1 2022) National Electrical Code
NFPA 90A	(2021) Standard for the Installation of Air Conditioning and Ventilating Systems

TRIDIUM, INC (TRIDIUM)

Niagara Framework	(2012) NiagaraAX User's Guide
Tridium Open NiCS	(2005) Understanding the NiagaraAX Compatibility Statement (NiCS)

U.S. DEPARTMENT OF DEFENSE (DOD)

UFC 3-410-02	(2018; with Change 2, 2021) Direct Digital Control for HVAC and Other Building Control Systems

UNDERWRITERS LABORATORIES (UL)

UL 5085-3	(2006; Reprint Jan 2022) UL Standard for Safety Low Voltage Transformers - Part 3: Class 2 and Class 3 Transformers

1.4 DEFINITIONS

The following list of definitions includes terms used in Sections referenced by this Section and are included here for completeness.The definitions contained in this Section may disagree with how terms are defined or used in other documents, including documents referenced by this Section. The definitions included here are the authoritative definitions for this Section and all Sections referenced by this Section.

After each term the protocol related to that term is included in parenthesis.

1.4.1 Alarm Generation (All protocols)

Alarm Generation is the monitoring of a value, comparison of the value to alarm conditions and the creation of an alarm when the conditions set for the alarm are met. Note that this does NOT include delivery of the alarm to the final destination (such as a user interface).

1.4.2 Building Automation and Control Network (BACnet) (BACnet)

The term BACnet is used in two ways. First meaning the BACnet Protocol Standard - the communication requirements as defined by ASHRAE 135 including all annexes and addenda. The second to refer to the overall technology related to the ASHRAE 135 protocol.

1.4.3 BACnet Advanced Application Controller (B-AAC) (BACnet)

A hardware device BTL Listed as a B-AAC, which is required to support BACnet Interoperability Building Blocks (BIBBs) for scheduling and alarming, but is not required to support as many BIBBs as a B-BC.

1.4.4 BACnet Application Specific Controller (B-ASC) (BACnet)

A hardware device BTL Listed as a B-ASC, with fewer BIBB requirements than a B-AAC. It is intended for use in a specific application.

1.4.5 BACnet Building Controller (B-BC) (BACnet)

A hardware device BTL Listed as a B-BC. A general-purpose, field-programmable device capable of carrying out a variety of building automation and control tasks including control and monitoring via direct digital control (DDC) of specific systems and data storage for trend information, time schedules, and alarm data. Like the other BTL Listed controller types (B-AAC, B-ASC etc.) a B-BC device is required to support the server ("B") side of the ReadProperty and WriteProperty services, but unlike the other controller types it is also required to support the client ("A") side of these services. Communication between controllers requires that one of them support the client side and the other support the server side, so a B-BC is often used when communication between controllers is needed.

1.4.6 BACnet Broadcast Management Device (BBMD) (BACnet)

A communications device, typically combined with a BACnet router. A BBMD forwards BACnet broadcast messages to BACnet/IP devices and other BBMDs connected to the same BACnet/IP network. Each IP subnet that is part of a BACnet/IP network must have at least one BBMD. Note there are additional restrictions when multiple BBMDs share an IP subnet.

1.4.7 BACnet/IP (BACnet)

An extension of BACnet, Annex J, defines the use of a reserved UDP socket to transmit BACnet messages over IP networks. A BACnet/IP network is a collection of one or more IP subnets that share the same BACnet network number. See also paragraph BACNET BROADCAST MANAGEMENT DEVICE.

1.4.8 BACnet Internetwork (BACnet)

Two or more BACnet networks, connected with BACnet routers. In a BACnet Internetwork, there exists only one message path between devices.

1.4.9 BACnet Interoperability Building Blocks (BIBBs) (BACnet)

A BIBB is a collection of one or more ASHRAE 135 Services intended to define a higher level of interoperability. BIBBs are combined to build the BACnet functional requirements for a device in a specification. Some BIBBs define additional requirements (beyond requiring support for specific services) in order to achieve a level of interoperability. For example, the BIBB DS-V-A (Data Sharing-View-A), which would typically be used by a front-end, not only requires the client to support the ReadProperty Service, but also provides a list of data types (Object / Properties) which the client must be able to interpret and display for the user.

In the BIBB shorthand notation, -A is the client side and -B is the server side.

The following is a list of some BIBBs used by this or referenced Sections:	
DS-COV-A	Data Sharing-Change of Value (A side)
DS-COV-B	Data Sharing-Change of Value (B side)
NM-RC-B	Network Management-Router Configuration (B side)
DS-RP-A	Data Sharing-Read Property (A side)
DS-RP-B	Data Sharing-Read Property (B side)
DS-RPM-A	Data Sharing-Read Property Multiple (A Side)
DS-RPM-B	Data Sharing-Read Property Multiple (B Side)
DS-WP-A	Data Sharing-Write Property (A Side)
DM-TS-B	Device Management-Time Synchronization (B Side)
DM-UTC-B	Device Management-UTC Time Synchronization (B Side)
DS-WP-B	Data Sharing-Write Property (B side)
SCHED-E-B	Scheduling-External (B side)
DM-OCD-B	Device Management-Object Creation and Deletion (B side)
AE-N-I-B	Alarm and Event-Notification Internal (B Side)
AE-N-E-B	Alarm and Event-Notification External (B Side)
T-VMT-I-B	Trending-Viewing and Modifying Trends Internal (B Side)

The following is a list of some BIBBs used by this or referenced Sections:	
T-VMT-E-B	Trending-Viewing and Modifying Trends External (B Side)

1.4.10 BACnet Network (BACnet)

In BACnet, a portion of the control Internetwork consisting of one or more segments connected by repeaters. Networks are separated by routers.

1.4.11 BACnet Operator Display (B-OD) (BACnet)

A basic operator interface with limited capabilities relative to a B-OWS. It is not intended to perform direct digital control. A B-OD profile could be used for LCD devices, displays affixed to BACnet devices, handheld terminals or other very simple user interfaces.

1.4.12 BACnet Segment (BACnet)

One or more physical segments interconnected by repeaters (ASHRAE 135).

1.4.13 BACnet Smart Actuator (B-SA) (BACnet)

A simple actuator device with limited resources intended for specific applications.

1.4.14 BACnet Smart Sensor (B-SS) (BACnet)

A simple sensing device with limited resources.

1.4.15 BACnet Testing Laboratories (BTL) (BACnet)

Established by BACnet International to support compliance testing and interoperability testing activities and consists of BTL Manager and the BTL Working Group (BTL-WG). BTL also publishes Implementation Guidelines.

1.4.16 BACnet Testing Laboratories (BTL) Listed (BACnet)

A device that has been listed by BACnet Testing Laboratory. Devices may be certified to a specific device profile, in which case the listing indicates that the device supports the required capabilities for that profile, or may be listed as "other".

1.4.17 Binary (All protocols)

A two-state system where an "ON" condition is represented by a high signal level and an "OFF" condition is represented by a low signal level. 'Digital' is sometimes used interchangeably with 'binary'.

1.4.18 Broadcast (BACnet)

Unlike most messages, which are intended for a specific recipient device, a broadcast message is intended for all devices on the network.

1.4.19 Building Control Network (BCN) (All protocols)

The network connecting all DDC Hardware within a building (or specific group of buildings).

1.4.20 Building Point of Connection (BPOC) (All protocols)

A FPOC for a Building Control System. (This term is being phased out of use in preference for FPOC but is still used in some specifications and criteria. When it was used, it typically referred to a piece of control hardware. The current FPOC definition typically refers instead to IT hardware.)

1.4.21 Commandable (All protocols)

See Overridable.

1.4.22 Commandable Objects (BACnet)

Commandable Objects have a Commandable Property, Priority_Array, and Relinquish_Default Property as defined in ASHRAE 135, Clause 19.2, Command Prioritization.

1.4.23 Configurable (All protocols)

A property, setting, or value is configurable if it can be changed via hardware settings on the device, via the use of engineering software or over the control network from the front end, and is retained through (after) loss of power.

In a Niagara Framework BACnet system, a property, setting, or value is configurable if it can be changed via one or more of:

1) via BACnet services (including proprietary BACnet services)
2) via hardware settings on the device
3) via the Niagara Framework

Note this is more stringent than the ASHRAE 135 definition.

1.4.24 Control Logic Diagram (All protocols)

A graphical representation of control logic for multiple processes that make up a system.

1.4.25 Device (BACnet)

A Digital Controller that contains a BACnet Device Object and uses BACnet to communicate with other devices.

1.4.26 Device Object (BACnet)

Every BACnet device requires one Device Object, whose properties represent the network visible properties of that device. Every Device Object requires a unique Object Identifier number on the BACnet Internetwork. This number is often referred to as the device instance or device ID.

1.4.27 Device Profile (BACnet)

A collection of BIBBs determining minimum BACnet capabilities of a device, defined in ASHRAE 135. Standard device profiles include BACnet Advanced Workstations (B-AWS), BACnet Building Controllers (B-BC), BACnet Advanced Application Controllers (B-AAC), BACnet Application Specific Controllers (B-ASC), BACnet Smart Actuator (B-SA), and BACnet Smart Sensor (B-SS).

1.4.28 Digital Controller (All protocols)

An electronic controller, usually with internal programming logic and digital and analog input/output capability, which performs control functions.

1.4.29 Direct Digital Control (DDC) (All protocols)

Digital controllers performing control logic. Usually the controller directly senses physical values, makes control decisions with internal programs, and outputs control signals to directly operate switches, valves, dampers, and motor controllers.

1.4.30 Field Point of Connection (FPOC) (All protocols)

The FPOC is the point of connection between the UMCS IP Network and the field control network (either an IP network, a non-IP network, or a combination of both). The hardware at this location which provides the connection is generally an IT device such as a switch, IP router, or firewall.

In general, the term "FPOC Location" means the place where this connection occurs, and "FPOC Hardware" means the device that provides the connection. Sometimes the term "FPOC" is used to mean either and its actual meaning (i.e. location or hardware) is determined by the context in which it is used.

1.4.31 Fox Protocol (Niagara Framework)

The protocol used for communication between components in the Niagara Framework. By default, Fox uses TCP port 1911.

1.4.32 Gateway (All protocols)

A device that translates from one protocol application data format to another. Devices that change only the transport mechanism of the protocol - "translating" from TP/FT-10 to Ethernet/IP or from BACnet MS/TP to BACnet over IP for example - are not gateways as the underlying data format does not change. Gateways are also called Communications Bridges or Protocol Translators.

A Niagara Framework Supervisory Gateway is one type of Gateway.

1.4.33 IEEE 802.3 Ethernet (All protocols)

A family of local-area-network technologies providing high-speed networking features over various media, typically Cat 5, 5e or Cat 6 twisted pair copper or fiber optic cable.

1.4.34 Internet Protocol (IP, TCP/IP, UDP/IP) (All protocols)

A communication method, the most common use is the World Wide Web. At the lowest level, it is based on Internet Protocol (IP), a method for conveying and routing packets of information over various LAN media. Two common protocols using IP are User Datagram Protocol (UDP) and Transmission Control Protocol (TCP). UDP conveys information to well-known "sockets" without confirmation of receipt. TCP establishes connections, also known as "sessions", which have end-to-end confirmation and guaranteed sequence of delivery.

1.4.35 Input/Output (I/O) (All protocols)

Physical inputs and outputs to and from a device, although the term sometimes describes network or "virtual" inputs or outputs. See also "Points".

1.4.36 I/O Expansion Unit (All protocols)

An I/O expansion unit provides additional point capacity to a digital controller

1.4.37 IP subnet (All protocols)

A group of devices which share a defined range IP addresses. Devices on a common IP subnet can share data (including broadcasts) directly without the need for the traffic to traverse an IP router.

1.4.38 JACE (Niagara Framework)

Java Application Control Engine. See paragraph NIAGARA FRAMEWORK SUPERVISORY GATEWAY

1.4.39 Local-Area Network (LAN) (All protocols)

A communication network that spans a limited geographic area and uses the same basic communication technology throughout.

1.4.40 Local Display Panels (LDPs) (All protocols)

A DDC Hardware with a display and navigation buttons, and must provide display and adjustment of points as shown on the Points Schedule and as indicated.

1.4.41 MAC Address (All protocols)

Media Access Control address. The physical device address that identifies a device on a Local Area Network.

1.4.42 Master-Slave/Token-Passing (MS/TP) (BACnet)

Data link protocol as defined by the BACnet standard. Multiple speeds (data rates) are permitted by the BACnet MS/TP standard.

1.4.43 Monitoring and Control (M&C) Software (All protocols)

The UMCS 'front end' software which performs supervisory functions such as alarm handling, scheduling and data logging and provides a user interface for monitoring the system and configuring these functions.

1.4.44 Network Number (BACnet)

A site-specific number assigned to each network. This network number must be unique throughout the BACnet Internetwork.

1.4.45 Niagara Framework (Niagara Framework)

A set of hardware and software specifications for building and utility control owned by Tridium Inc. and licensed to multiple vendors. The

Framework consists of front end (M&C) software, web based clients, field level control hardware, and engineering tools. While the Niagara Framework is not adopted by a recognized standards body and does not use an open licensing model, it is sufficiently well-supported by multiple HVAC vendors to be considered a de-facto Open Standard.

1.4.46 Niagara Framework Supervisory Gateway (Niagara Framework)

DDC Hardware component of the Niagara Framework. A typical Niagara architecture has Niagara specific supervisory gateways at the IP level and other (non-Niagara specific) controllers on field networks (TP/FT-10, MS/TP, etc.) beneath the Niagara supervisory gateways. The Niagara specific controllers function as a gateway between the Niagara framework protocol (Fox) and the field network beneath. These supervisory gateways may also be used as general purpose controllers and also have the capability to provide a web-based user interface.

Note that different vendors refer to this component by different names. The most common name is "JACE"; other names include (but are not limited to)"EC-BOS", "FX-40", "TMN", "SLX" and "UNC".

1.4.47 Object (BACnet)

An ASHRAE 135 Object. The concept of organizing BACnet information into standard components with various associated Properties. Examples include Analog Input objects and Binary Output objects.

1.4.48 Object Identifier (BACnet)

A grouping of two Object properties: Object Type (e.g. Analog Value, Schedule, etc.) and Object Instance (in this case, a number). Object Identifiers must be unique within a device.

1.4.49 Object Instance (BACnet)

See paragraph OBJECT IDENTIFIER

1.4.50 Object Properties (BACnet)

Attributes of an object. Examples include present value and high limit properties of an analog input object. Properties are defined in ASHRAE 135; some are optional and some are required. Objects are controlled by reading from and writing to object properties.

1.4.51 Operator Configurable (All protocols)

Operator configurable values are values that can be changed from a single common front end user interface across multiple vendor systems.

For Niagara Framework Systems, a property, setting, or value is Operator Configurable when it is configurable from a Niagara Framework Front End.

1.4.52 Override (All protocols)

Changing the value of a point outside of the normal sequence of operation where the change has priority over the sequence and where there is a mechanism for releasing the change such that the point returns to the normal value. Overrides persist until released or overridden at the same or higher priority but are not required to persist through a loss of power. Overrides are often used by operators to change values, and generally originate at a user interface (workstation or local display panel).

1.4.53 Packaged Equipment (All protocols)

Packaged equipment is a single piece of equipment provided by a manufacturer in a substantially complete and operable condition, where the controls (DDC Hardware) are factory installed, and the equipment is sold and shipped from the manufacturer as a single entity. Disassembly and reassembly of a large piece of equipment for shipping does not prevent it from being packaged equipment. Package units may require field installation of remote sensors. Packaged equipment is also called a "packaged unit".

Note industry may use the term "Packaged System" to mean a collection of equipment that is designed to work together where each piece of equipment is packaged equipment and there is a network that connects the equipment together. A "packaged system" of this type is NOT packaged equipment; it is a collection of packaged equipment, and each piece of equipment must individually meet specification requirements.

1.4.54 Packaged Unit (All protocols)

See packaged equipment.

1.4.55 Performance Verification Test (PVT) (All protocols)

The procedure for determining if the installed BAS meets design criteria prior to final acceptance. The PVT is performed after installation, testing, and balancing of mechanical systems. Typically the PVT is performed by the Contractor in the presence of the Government.

1.4.56 Physical Segment (BACnet)

A single contiguous medium to which BACnet devices are attached (ASHRAE 135).

1.4.57 Polling (All protocols)

A device periodically requesting data from another device.

1.4.58 Points (All protocols)

Physical and virtual inputs and outputs. See also paragraph INPUT/OUTPUT (I/O).

1.4.59 Proportional, Integral, and Derivative (PID) Control Loop (All protocols)

Three parameters used to control modulating equipment to maintain a setpoint. Derivative control is often not required for HVAC systems (leaving "PI" control).

1.4.60 Proprietary (BACnet)

Within the context of BACnet, any extension of or addition to object types, properties, PrivateTransfer services, or enumerations specified in ASHRAE 135. Objects with Object_Type values of 128 and above are

Proprietary Objects. Properties with Property_Identifier of 512 and above are proprietary Properties.

1.4.61 Protocol Implementation Conformance Statement (PICS) (BACnet)

A document, created by the manufacturer of a device, which describes which portions of the BACnet standard may be implemented by a given device. ASHRAE 135 requires that all ASHRAE 135 devices have a PICS, and also defines a minimum set of information that must be in it. A device as installed for a specific project may not implement everything in its PICS.

1.4.62 Repeater (All protocols)

A device that connects two control network segments and retransmits all information received on one side onto the other.

1.4.63 Router (All protocols)

A device that connects two ASHRAE 135 networks and controls traffic between the two by retransmitting signals received from one side onto the other based on the signal destination. Routers are used to subdivide a BACnet internetwork and to limit network traffic.

1.4.64 Segment (All protocols)

A 'single' section of a control network that contains no repeaters or routers. There is generally a limit on the number of devices on a segment, and this limit is dependent on the topology/media and device type.

1.4.65 Standard BACnet Objects (BACnet)

Objects with Object_Type values below 128 and specifically enumerated in Clause 21 of ASHRAE 135. Objects which are not proprietary. See paragraph PROPRIETARY.

1.4.66 Standard BACnet Properties (BACnet)

Properties with Property_Identifier values below 512 and specifically enumerated in Clause 21 of ASHRAE 135. Properties which are not proprietary. See Proprietary.

1.4.67 Standard BACnet Services (BACnet)

ASHRAE 135 services other than ConfirmedPrivateTransfer or UnconfirmedPrivateTransfer. See paragraph PROPRIETARY.

1.4.68 UMCS (All protocols)

UMCS stands for Utility Monitoring and Control System. The term refers to all components by which a project site monitors, manages, and controls real-time operation of HVAC and other building systems. These components include the UMCS "front-end" and all field building control systems connected to the front-end. The front-end consists of Monitoring and Control Software (user interface software), browser-based user interfaces and network infrastructure.

The network infrastructure (the "UMCS Network"), is an IP network connecting multiple building or facility control networks to the

Monitoring and Control Software.

1.4.69 UMCS Network (All protocols)

The UMCS Network connects multiple building or facility control networks to the Monitoring and Control Software.

1.4.70 Writable Property (BACnet)

A Property is Writable when it can be changed through the use of one or more of the WriteProperty services defined in ASHRAE 135, Clause 15 regardless of the value of any other Property. Note that in the ASHRAE 135 standard, some Properties may be writable when the Out of Service Property is TRUE; for purposes of this Section, Properties that are only writable when the Out of Service Property is TRUE are not considered to be Writable.

1.5 PROJECT SEQUENCING

TABLE II: PROJECT SEQUENCING lists the sequencing of submittals as specified in paragraph SUBMITTALS (denoted by an 'S' in the 'TYPE' column) and activities as specified in PART 3 EXECUTION (denoted by an 'E' in the 'TYPE' column). TABLE II does not specify overall project milestone and completion dates.

a. Sequencing for Submittals: The sequencing specified for submittals is the deadline by which the submittal must be initially submitted to the Government. Following submission there will be a Government review period as specified in Section 01 33 00 SUBMITTAL PROCEDURES. If the submittal is not accepted by the Government, revise the submittal and resubmit it to the Government within 14 days of notification that the submittal has been rejected. Upon resubmittal there will be an additional Government review period. If the submittal is not accepted the process repeats until the submittal is accepted by the Government.

b. Sequencing for Activities: The sequencing specified for activities indicates the earliest the activity may begin.

c. Abbreviations: In TABLE II the abbreviation AAO is used for 'after approval of' and 'ACO' is used for 'after completion of'.

TABLE II. PROJECT SEQUENCING

ITEM #	TYPE	DESCRIPTION	SEQUENCING (START OF ACTIVITY OR DEADLINE FOR SUBMITTAL)
1	S	Existing Conditions Report	
2	S	DDC Contractor Design Drawings	
3	S	Manufacturer's Product Data	
4	S	Pre-construction QC Checklist	
5	E	Install Building Control System	AAO #1 thru #4

TABLE II. PROJECT SEQUENCING

ITEM #	TYPE	DESCRIPTION	SEQUENCING (START OF ACTIVITY OR DEADLINE FOR SUBMITTAL)
6	E	Start-Up and Start-Up Testing	ACO #5
7	S	Post-Construction QC Checklist	ACO #6
8	S	Programming Software Configuration Software Niagara Framework Engineering Tool Niagara Framework Wizards	ACO #6
9	S	Draft As-Built Drawings	ACO #6
10	S	Start-Up Testing Report	ACO #6
11	S	PVT Procedures	before schedule start of #12 and AAO #10
12	E	Execute PVT	AAO #9 and #11
13	S	PVT Report	ACO #12
14	S	Controller Application Programs Controller Configuration Settings Niagara Framework Supervisory Gateway Backups	AAO #13
15	S	Final As-Built Drawings	AAO #13
16	S	O&M Instructions	AAO #15

TABLE II. PROJECT SEQUENCING

ITEM #	TYPE	DESCRIPTION	SEQUENCING (START OF ACTIVITY OR DEADLINE FOR SUBMITTAL)
17	S	Training Documentation	AAO #10 and before scheduled start of #18
18	E	Training	AAO #16 and #17
19	S	Closeout QC Checklist	ACO #18

1.6 SUBMITTALS

Government approval is required for submittals with a "G" classification. Submittals not having a "G" classification are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

DDC Contractor Design Drawings; G

Draft As-Built Drawings; G

Final As-Built Drawings; G

SD-03 Product Data

Programming Software; G

Controller Application Programs; G

Configuration Software; G

Controller Configuration Settings; G

Proprietary Multi-Split Engineering Tool Software; G

Manufacturer's Product Data; G

Niagara Framework Supervisory Gateway Backups; G

Niagara Framework Engineering Tool; G

SD-05 Design Data

Boiler Or Chiller Plant Gateway Request

SD-06 Test Reports

Pre-Construction Quality Control (QC) Checklist; G

Post-Construction Quality Control (QC) Checklist; G

Start-Up Testing Report; G

PVT Procedures; G

PVT Report; G

SD-10 Operation and Maintenance Data

Operation and Maintenance (O&M) Instructions; G

Training Documentation; G

SD-11 Closeout Submittals

Enclosure Keys; G

Password Summary Report; G

Closeout Quality Control (QC) Checklist; G

1.7 DATA PACKAGE AND SUBMITTAL REQUIREMENTS

Technical data packages consisting of technical data and computer software (meaning technical data which relates to computer software) which are specifically identified in this project and which may be defined/required in other specifications must be delivered strictly in accordance with the CONTRACT CLAUSES and in accordance with the Contract Data Requirements List, DD Form 1423. Data delivered must be identified by reference to the particular specification paragraph against which it is furnished. All submittals not specified as technical data packages are considered 'shop drawings' under the Federal Acquisition Regulation Supplement (FARS) and must contain no proprietary information and be delivered with unrestricted rights.

1.8 SOFTWARE FOR DDC HARDWARE AND GATEWAYS

Provide all software related to the programming and configuration of DDC Hardware and Gateways as indicated. License all Software to the project site. The term "controller" as used in these requirements means both DDC Hardware and Gateways.

1.8.1 Configuration Software

For each type of controller, provide the configuration tool software in accordance with Section 23 09 23.02 BACNET DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS. Submit hard copies of the software user manuals for each software with the software submittal.

Submit Configuration Software on CD-ROM as a Technical Data Package. Submit three hard copies of the software user manual for each piece of software.

1.8.2 Controller Configuration Settings

For each controller, provide copies of the installed configuration settings as source code compatible with the configuration tool software for that controller in accordance with Section 23 09 23.02 BACNET DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS.

Submit Controller Configuration Settings on CD-ROM as a Technical Data Package. Include on the CD-ROM a list or table of contents clearly indicating which files are associated with each device. Submit 2 copies of the Controller Configuration Settings CD-ROM.

1.8.3 Programming Software

For each type of programmable controller, provide the programming software in accordance with Section 23 09 23.02 BACNET DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS. Submit hard copies of software user manuals for each software with the software submittal.

Submit Programming Software on CD-ROM as a Technical Data Package. Submit three hard copies of the software user manual for each piece of software.

1.8.4 Controller Application Programs

For each programmable controller, provide copies of the application program as source code compatible with the programming software for that controller in accordance with Section 23 09 23.02 BACNET DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS.

Submit Controller Application Programs on CD-ROM as a Technical Data Package. Include on the CD-ROM a list or table of contents clearly indicating which application program is associated with each device. Submit 2 copies of the Controller Application Programs CD-ROM.

1.8.5 Niagara Framework Supervisory Gateway Backups

For each Niagara Framework Supervisory Gateway, provide a backup of all software within the Niagara Framework Supervisory Gateway, including configuration settings. This backup must be sufficient to allow the restoration of the Niagara Framework Supervisory Gateway or the replacement of the Niagara Framework Supervisory Gateway.

Submit backups for each Niagara Framework Supervisory Gateway on CD-ROM as a Technical Data Package. Mark each backup indicating clearly the source Niagara Framework Supervisory Gateway.

1.8.6 Niagara Framework Engineering Tool(for all Niagara Framework system)

Provide a Niagara Framework Engineering Tool in accordance with Section 23 09 23.02 BACNET DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS. Submit software user manuals with the Niagara Framework Engineering Tool submittal.

Submit the Niagara Framework Engineering Tool on CD-ROM as a Technical Data Package. Submit three hard copies of the software user manual for the Niagara Framework Engineering Tool.

1.9 BOILER OR CHILLER PLANT GATEWAY REQUEST

If requesting the use of a gateway to a boiler or chiller plant as indicated in paragraph Proprietary Systems Exempted From Open Protocol Requirements, submit a Boiler or Chiller Plant Gateway Request describing the configuration of the boilers or chillers including model numbers for equipment and controllers, the sequence of operation for the units, and a justification for the need to operate the units on a shared non-BACnet network.

1.10 QUALITY CONTROL CHECKLISTS

The QC Checklist for Niagara Framework Based BACnet Systems in APPENDIX A of this Section must be completed by the Contractor's Chief Quality Control (QC) Representative and submitted as indicated.

The QC Representative must verify each item indicated and initial in the space provided to indicate that the requirement has been met. The QC Representative must sign and date the Checklist prior to submission to the Government.

1.10.1 Pre-Construction Quality Control (QC) Checklist

Complete items indicated as Pre-Construction QC Checklist items in the QC Checklist. Submit four copies of the Pre-Construction QC Checklist.

1.10.2 Post-Construction Quality Control (QC) Checklist

Complete items indicated as Post-Construction QC Checklist items in the QC Checklist. Submit four copies of the Post-Construction QC Checklist.

1.10.3 Closeout Quality Control (QC) Checklist

Complete items indicated as Closeout QC Checklist items in the QC Checklist. Submit four copies of the Closeout QC Checklist.

PART 2 PRODUCTS

Provide products meeting the requirements of Section 23 09 13 INSTRUMENTATION AND CONTROL DEVICES FOR HVAC, Section 23 09 23.02 BACNET DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS for BACnet or Niagara BACnet systems, other referenced Sections, and this Section.

2.1 GENERAL PRODUCT REQUIREMENTS

Units of the same type of equipment must be products of a single manufacturer. Each major component of equipment must have the manufacturer's name and address, and the model and serial number in a conspicuous place. Materials and equipment must be standard products of a manufacturer regularly engaged in the manufacturing of these and similar products. The standard products must have been in a satisfactory commercial or industrial use for two years prior to use on this project. The two year use must include applications of equipment and materials under similar circumstances and of similar size. DDC Hardware not meeting the two-year field service requirement is acceptable provided it has been successfully used by the Contractor in a minimum of two previous projects. The equipment items must be supported by a service organization. Items of the same type and purpose must be identical, including equipment, assemblies, parts and components.

2.2 PRODUCT DATA

Provide manufacturer's product data sheets documenting compliance with product specifications for each product provided under Section 23 09 13 INSTRUMENTATION AND CONTROL DEVICES FOR HVAC, Section 23 09 23.02 BACNET DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS, or this Section. Provide product data for all products in a single indexed compendium, organized by product type.

For all BACnet hardware: for each manufacturer, model and version (revision) of DDC Hardware provide the Protocol Implementation Conformance Statement (PICS) in accordance with Section 23 09 23.02 BACNET DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS.

Submit Manufacturer's Product Data on CD-ROM.

2.3 OPERATION ENVIRONMENT

Unless otherwise specified, provide products rated for continuous operation under the following conditions:

a. Pressure: Pressure conditions normally encountered in the installed location.

b. Vibration: Vibration conditions normally encountered in the installed location.

c. Temperature:

   (1) Products installed indoors: Ambient temperatures in the range of 32 to 112 degrees F and temperature conditions outside this range normally encountered at the installed location.

   (2) Products installed outdoors or in unconditioned indoor spaces: Ambient temperatures in the range of 0 to 120 degrees F and temperature conditions outside this range normally encountered at the installed location.

d. Humidity: 10 to 95 percent relative humidity, noncondensing and humidity conditions outside this range normally encountered at the installed location.

2.4 WIRELESS CAPABILITY

For products incorporating any wireless capability (including but not limited to radio frequency (RF), infrared and optical), provide products for which wireless capability can be permanently disabled at the device. Optical and infrared capabilities may be disabled via a permanently affixed opaque cover plate.

2.5 ENCLOSURES

Enclosures supplied as an integral (pre-packaged) part of another product are acceptable. Provide two Enclosure Keys for each lockable enclosure on a single ring per enclosure with a tag identifying the enclosure the keys operate. Provide enclosures meeting the following minimum requirements:

2.5.1 Outdoors

For enclosures located outdoors, provide enclosures meeting NEMA 250 Type 4 requirements.

2.5.2 Mechanical and Electrical Rooms

For enclosures located in mechanical or electrical rooms, provide enclosures meeting NEMA 250 Type 2 requirements.

2.5.3 Other Locations

For enclosures in other locations including but not limited to occupied spaces, above ceilings, and in plenum returns, provide enclosures meeting NEMA 250 Type 1 requirements.

2.6 WIRE AND CABLE

Provide wire and cable meeting the requirements of NFPA 70 and NFPA 90A in addition to the requirements of this specification and referenced specifications.

2.6.1 Terminal Blocks

For terminal blocks which are not integral to other equipment, provide terminal blocks which are insulated, modular, feed-through, clamp style with recessed captive screw-type clamping mechanism, suitable for DIN rail mounting, and which have enclosed sides or end plates and partition plates for separation.

2.6.2 Control Wiring for Binary Signals

For Control Wiring for Binary Signals, provide 18 AWG copper or thicker wire rated for 300-volt service.

2.6.3 Control Wiring for Analog Signals

For Control Wiring for Analog Signals, provide 18 AWG or thicker, copper, single- or multiple-twisted wire meeting the following requirements:

a. minimum 2 inch lay of twist

b. 100 percent shielded pairs

c. at least 300-volt insulation

d. each pair has a 20 AWG tinned-copper drain wire and individual overall pair insulation

e. cables have an overall aluminum-polyester or tinned-copper cable-shield tape, overall 20 AWG tinned-copper cable drain wire, and overall cable insulation.

2.6.4 Power Wiring for Control Devices

For 24-volt circuits, provide insulated copper 18 AWG or thicker wire rated for 300 VAC service. For 120-volt circuits, provide 14 AWG or thicker stranded copper wire rated for 600-volt service.

2.6.5 Transformers

Provide UL 5085-3 approved transformers. Select transformers sized so that the connected load is no greater than 80 percent of the transformer rated capacity.

PART 3 EXECUTION

3.1 INSTALLATION

Fully install and test the control system in accordance Section 23 09 13 INSTRUMENTATION AND CONTROL DEVICES FOR HVAC, Section 23 09 23.02 BACNET DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS for BACnet or Niagara BACnet systems, and this Section.

3.1.1 Dielectric Isolation

Provide dielectric isolation where dissimilar metals are used for connection and support. Install control system in a matter that provides clearance for control system maintenance by maintaining access space required to calibrate, remove, repair, or replace control system devices. Install control system such that it does not interfere with the clearance requirements for mechanical and electrical system maintenance.

3.1.2 Penetrations in Building Exterior

Make all penetrations through and mounting holes in the building exterior watertight.

3.1.3 Device Mounting Criteria

Install devices in accordance with the manufacturer's recommendations and as indicated and shown. Provide a weathershield for all devices installed outdoors. Provide clearance for control system maintenance by maintaining access space required to calibrate, remove, repair, or replace control system devices. Provide clearance for mechanical and electrical system maintenance; do not not interfere with the clearance requirements for mechanical and electrical system maintenance.

3.1.4 Labels and Tags

Key all labels and tags to the unique identifiers shown on the As-Built drawings. For labels exterior to protective enclosures provide engraved plastic labels mechanically attached to the enclosure or DDC Hardware. Labels inside protective enclosures may be attached using adhesive, but must not be hand written. For tags, provide plastic or metal tags mechanically attached directly to each device or attached by a metal chain or wire.

a. Label all Enclosures and DDC Hardware.

b. Tag Airflow measurement arrays (AFMA) with flow rate range for signal output range, duct size, and pitot tube AFMA flow coefficient.

c. Tag duct static pressure taps at the location of the pressure tap

3.1.5 Surge Protection

3.1.5.1 Power-Line Surge Protection

Protect equipment connected to AC circuits to withstand power-line surges in accordance with IEEE C62.41. Do not use fuses for surge protection.

3.1.5.2 Surge Protection for Transmitter and Control Wiring

Protect DDC hardware against or provided DDC hardware capable of withstanding surges induced on control and transmitter wiring installed outdoors and as shown. Protect equipment against the following two waveforms:

a. A waveform with a 10-microsecond rise time, a 1000-microsecond decay time and a peak current of 60 amps.

b. A waveform with an 8-microsecond rise time, a 20-microsecond decay time and a peak current of 500 amperes.

3.1.6 Basic Cybersecurity Requirements

3.1.6.1 Passwords

For all devices with a password, change the password from the default password. Do not use the same password for more than one device. Coordinate selection of passwords with Base Controls Shop. Provide a Password Summary Report documenting the password for each device and describing the procedure to change the password for each device.

Provide two hardcopies of the Password Summary Report, each copy in its own sealed envelope.

3.1.6.2 Wireless Capability

Unless otherwise indicated, disable wireless capability (including but not limited to radio frequency (RF), infrared and optical) for all devices with wireless capability. Optical and infrared capabilities may be disabled via a permanently affixed opaque cover plate. Password protecting a wireless connections does not meet this requirement; the wireless capability must be disabled.

3.1.6.3 IP Network Physical Security

Install all IP Network media in conduit. Install all IP devices including but not limited to IP-enabled DDC hardware and IP Network Hardware in lockable enclosures.

3.2 DRAWINGS AND CALCULATIONS

Provide drawings in the form and arrangement indicated and shown. Use the same abbreviations, symbols, nomenclature and identifiers shown. Assign a unique identifier as shown to each control system element on a drawing. When packaging drawings, group schedules by system. When space allows, it is permissible to include multiple schedules for the same system on a single sheet. Except for drawings covering all systems, do not put information for different systems on the same sheet.

Submit hardcopy drawings on 36 by 24 inches and 18 by 12 inches sheets, and electronic drawings in PDF and in AutoCAD format. In addition, submit electronic drawings in editable Excel format for all drawings that are tabular, including but not limited to the Point Schedule and Equipment Schedule.

a. Submit DDC Contractor Design Drawings consisting of each drawing indicated with pre-construction information depicting the intended control system design and plans. Submit DDC Contractor Design Drawings as a single complete package: three hard copies and three copies on CD-ROM.

b. Submit Draft As-Built Drawings consisting of each drawing indicated updated with as-built data for the system prior to PVT. Submit Draft As-Built Drawings as a single complete package: three hard copies and three copies on CD-ROM.

c. Submit Final As-Built Drawings consisting of each drawing indicated updated with all final as-built data. Final As-Built Drawings as a single complete package: three hard copies and three copies on CD-ROM.

3.2.1 Sample Drawings

Sample drawings in electronic format are available at the Whole Building Design Guide page for this section:
http://www.wbdg.org/ffc/dod/unified-facilities-guide-specifications-ufgs/ufgs-23-09-00
These drawings may prove useful in demonstrating expected drawing formatting and example content and are provided for illustrative purposes only. Note that these drawings do not meet the content requirements of this Section and must be completed to meet project requirements.

3.2.2 Drawing Index and Legend

Provide an HVAC Control System Drawing Index showing the name and number of the building, military site, State or other similar designation, and Country. In the Drawing Index, list all Contractor Design Drawings, including the drawing number, sheet number, drawing title, and computer filename when used. In the Design Drawing Legend, show and describe all symbols, abbreviations and acronyms used on the Design Drawings. Provide a single Index and Legend for the entire drawing package.

3.2.3 Thermostat and Occupancy Sensor Schedule

Provide a thermostat and occupancy sensor schedule containing each thermostat's unique identifier, room identifier and control features and functions as shown. Provide a single thermostat and occupancy sensor schedule for the entire project.

3.2.4 Valve Schedule

Provide a valve schedule containing each valve's unique identifier, size, flow coefficient Kv (Cv), pressure drop at specified flow rate, spring range, positive positioner range, actuator size, close-off pressure to torque data, dimensions, and access and clearance requirements data. In the valve schedule include actuator selection data supported by calculations of the force required to move and seal the valve, access and clearance requirements. Provide a single valve schedule for the entire project.

3.2.5 Damper Schedule

Provide a damper schedule containing each damper's unique identifier, type (opposed or parallel blade), nominal and actual sizes, orientation of axis and frame, direction of blade rotation, actuator size and spring ranges, operation rate, positive positioner range, location of actuators and damper end switches, arrangement of sections in multi-section dampers, and methods of connecting dampers, actuators, and linkages. Include the AMCA

511 maximum leakage rate at the operating static-pressure differential for each damper in the Damper Schedule. Provide a single damper schedule for the entire project.

3.2.6 Project Summary Equipment Schedule

Provide a project summary equipment schedule containing the manufacturer, model number, part number and descriptive name for each control device, hardware and component provided under this specification. Provide a single project equipment schedule for the entire project.

3.2.7 Equipment Schedule

Provide system equipment schedules containing the unique identifier, manufacturer, model number, part number and descriptive name for each control device, hardware and component provided under this specification. Provide a separate equipment schedule for each HVAC system.

3.2.8 Occupancy Schedule

Provide an occupancy schedule drawing containing the same fields as the occupancy schedule Contract Drawing with Contractor updated information. Provide a single occupancy schedule for the entire project.

3.2.9 DDC Hardware Schedule

Provide a single DDC Hardware Schedule for the entire project and including following information for each device.

3.2.9.1 DDC Hardware Identifier

The Unique DDC Hardware Identifier for the device.

3.2.9.2 HVAC System

The system "name" used to identify a specific system (the name used on the system schematic drawing for that system).

3.2.9.3 BACnet Device Information

3.2.9.3.1 Device Object Identifier

The Device Object Identifier: The Object_Identifier of the Device Object

3.2.9.3.2 Network Number

The Network Number for the device.

3.2.9.3.3 MAC Address

The MAC Address for the device

3.2.9.3.4 BTL Listing

The BTL Listing of the device. If the device is listed under multiple BTL Profiles, indicate the profile that matches the use and configuration of the device as installed.

3.2.9.3.5 Proprietary Services Information

If the device uses non-standard ASHRAE 135 services as defined and permitted in Section 23 09 23.02 BACNET DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS, indicate that the device uses non-standard services and include a description of all non-standard services used. Describe usage and content such that a device from another vendor can interoperate with the device using the non-standard service. Provide descriptions with sufficient detail to allow a device from a different manufacturer to be programmed to both read and write the non-standard service request:

a. read: interpret the data contained in the non-standard service and;

b. write: given similar data, generate the appropriate non-standard service request.

3.2.9.3.6 Alarming Information

Indicate whether the device is used for alarm generation, and which types of alarm generation the device implements: intrinsic, local algorithmic, remote algorithmic.

3.2.9.3.7 Scheduling Information

Indicate whether the device is used for scheduling.

3.2.9.3.8 Trending Information

Indicate whether the device is used for trending, and indicate if the device is used to trend local values, remote values, or both.

3.2.9.4 Niagara Station ID

The Niagara Station ID for each Niagara Framework Supervisory Gateway

3.2.10 Points Schedule

Provide a Points Schedule in tabular form for each HVAC system, with the indicated columns and with each row representing a hardware point, network point or configuration point in the system.

a. When a Points Schedule was included in the Contract Drawing package, use the same fields as the Contract Drawing with updated information in addition to the indicated fields.

b. When Point Schedules are included in the contract package, items requiring contractor verification or input have been shown in angle brackets ("<" and ">"), such as <___> for a required entry or <value> for a value requiring confirmation. Complete all items in brackets as well as any blank cells. Do not modify values which are not in brackets without approval.

Points Schedule Columns must include:

3.2.10.1 Point Name

The abbreviated name for the point using the indicated naming convention.

3.2.10.2 Description

A brief functional description of the point such as "Supply Air Temperature".

3.2.10.3 DDC Hardware Identifier

The Unique DDC Hardware Identifier shown on the DDC Hardware Schedule and used across all drawings for the DDC Hardware containing the point.

3.2.10.4 Settings

The value and units of any setpoints, configured setpoints, configuration parameters, and settings related to each point.

3.2.10.5 Range

The range of values, including units, associated with the point, including but not limited to a zone temperature setpoint adjustment range, a sensor measurement range, occupancy values for an occupancy input, or the status of a safety.

3.2.10.6 Input or Output (I/O) Type

The type of input or output signal associated with the point. Use the following abbreviations for entries in this column:

a. AI: The value comes from a hardware (physical) Analog Input

b. AO: The value is output as a hardware (physical) Analog Output

c. BI: The value comes from a hardware (physical) Binary Input

d. BO: The value is output as a hardware (physical) Binary Output

e. PULSE: The value comes from a hardware (physical) Pulse Accumulator Input

f. NET-IN: The value is provided from the network (generally from another device). Use this entry only when the value is received from another device as part of scheduling or as part of a sequence of operation, not when the value is received on the network for supervisory functions such as trending, alarming, override or display at a user interface.

g. NET-OUT: The value is provided to another controller over the network. Use this entry only when the value is transmitted to another device as part of scheduling or as part of a sequence of operation, not when the value is transmitted on the network for supervisory functions such as trending, alarming, override or display at a user interface.

3.2.10.7 Object and Property Information

The Object Type and Instance Number for the Object associated with the point. If the value of the point is not in the Present_Value Property, then also provide the Property ID for the Property containing the value of the point. Any point that is displayed at the front end or on an LDP, is trended, is used by another device on the network, or has an alarm condition must be documented here.

3.2.10.8 Niagara Station ID

The Niagara Station ID of the Niagara Framework Supervisory Gateway the point is mapped into.

3.2.10.9 Network Data Exchange Information (Gets Data From, Sends Data To)

Provide the DDC Hardware Identifier of other DDC Hardware the point is shared with.

3.2.10.10 Override Information (Object Type and Instance Number)

For each point requiring an Override and not residing in a Niagara Framework Supervisory Gateway, indicate if the Object for the point is Commandable or, if the use of a separate Object was specifically approved by the Contracting Officer, provide the Object Type and Instance Number of the Object to be used in overriding the point.

3.2.10.11 Alarm Information

For Niagara BACnet systems: Indicate the Alarm Generation Type and Notification Class Object Instance Number for each point requiring an alarm. (Note that not all alarms will have a Notification Class Object.)

3.2.10.12 Configuration Information

Indicate the means of configuration associated with each point. For points in a Niagara Framework Supervisory Gateway, indicate the point within the Niagara Framework Supervisory Gateway used to configure the value. For other points:

a. For Operator Configurable Points indicate BACnet Object and Property information (Name, Type, Identifiers) containing the configurable value. Indicate whether the property is writable always, or only when Out_Of_Service is TRUE.

b. For Configurable Points indicate the BACnet Object and Property information as for Operator Configurable points, or identification of the configurable settings from within the engineering software for the device or identification of the hardware settings on the device.

3.2.11 Riser Diagram

The Riser Diagram of the Building Control Network may be in tabular form, and must show all DDC Hardware and all Network Hardware, including network terminators. For each item, provide the unique identifier, common descriptive name, physical sequential order (previous and next device on the network), room identifier and location within room. A single riser diagram must be submitted for the entire system.

3.2.12 Control System Schematics

Provide control system schematics in the same form as the control system schematic Contract Drawing with Contractor updated information. Provide a control system schematic for each HVAC system.

3.2.13 Sequences of Operation

Provide HVAC control system sequence of operation and in the same format as the Contract Drawings. Within these drawings, refer to devices by their unique identifiers. Submit sequences of operation for each HVAC system

3.2.14 Controller, Motor Starter and Relay Wiring Diagram

Provide controller wiring diagrams as functional wiring diagrams which show the interconnection of conductors and cables to each controller and to the identified terminals of input and output devices, starters and package equipment. Show necessary jumpers and ground connections and the labels of all conductors. Identify sources of power required for control systems and for packaged equipment control systems back to the panel board circuit breaker number, controller enclosures, magnetic starter, or packaged equipment control circuit. Show each power supply and transformer not integral to a controller, starter, or packaged equipment. Show the connected volt-ampere load and the power supply volt-ampere rating. Provide wiring diagrams for each HVAC system.

3.3 CONTROLLER TUNING

Tune each controller in a manner consistent with that described in the ASHRAE FUN IP and in the manufacturer's instruction manual. Tuning must consist of adjustment of the proportional, integral, and where applicable, the derivative (PID) settings to provide stable closed-loop control. Each loop must be tuned while the system or plant is operating at a high gain (worst case) condition, where high gain can generally be defined as a low-flow or low-load condition. Upon final adjustment of the PID settings, in response to a change in controller setpoint, the controlled variable must settle out at the new setpoint with no more than two (2) oscillations above and below setpoint. Upon settling out at the new setpoint the controller output must be steady. With the exception of naturally slow processes such as zone temperature control, the controller must settle out at the new setpoint within five (5) minutes. Set the controller to its correct setpoint and record and submit the final PID configuration settings with the O&M Instructions and on the associated Points Schedule.

3.4 START-UP

3.4.1 Start-Up Test

Perform the following startup tests for each control system to ensure that the described control system components are installed and functioning per this specification.

Adjust, calibrate, measure, program, configure, set the time schedules, and otherwise perform all necessary actions to ensure that the systems function as indicated and shown in the sequence of operation and other contract documents.

3.4.1.1 Systems Check

An item-by-item check must be performed for each HVAC system

3.4.1.1.1 Step 1 - System Inspection

With the system in unoccupied mode and with fan hand-off-auto switches in the OFF position, verify that power and main air are available where required and that all output devices are in their failsafe and normal positions. Inspect each local display panel and each M&C Client to verify that all displays indicate shutdown conditions.

3.4.1.1.2 Step 2 - Calibration Accuracy Check

Perform a two-point accuracy check of the calibration of each HVAC control system sensing element and transmitter by comparing the value from the test instrument to the network value provided by the DDC Hardware. Use digital indicating test instruments, such as digital thermometers, motor-driven psychrometers, and tachometers. Use test instruments with accuracy at least twice as accurate as the specified sensor accuracy and with calibration traceable to National Institute of Standards and Technology standards. Check one the first check point in the bottom one-third of the sensor range, and the second in the top one-third of the sensor range. Verify that the sensing element-to-DDC readout accuracies at two points are within the specified product accuracy tolerances, and if not recalibrate or replace the device and repeat the calibration check.

3.4.1.1.3 Step 3 - Actuator Range Check

With the system running, apply a signal to each actuator through the DDC Hardware controller. Verify proper operation of the actuators and positioners for all actuated devices and record the signal levels for the extreme positions of each device. Vary the signal over its full range, and verify that the actuators travel from zero stroke to full stroke within the signal range. Where applicable, verify that all sequenced actuators move from zero stroke to full stroke in the proper direction, and move the connected device in the proper direction from one extreme position to the other. For valve actuators and damper actuators, perform the actuator range check under normal system pressures.

3.4.1.2 Weather Dependent Test

Perform weather dependent test procedures in the appropriate climatic season.

3.4.2 Start-Up Testing Report

Submit 4 copies of the Start-Up Testing Report. The report may be submitted as a Technical Data Package documenting the results of the tests performed and certifying that the system is installed and functioning per this specification, and is ready for the Performance Verification Test (PVT).

3.5 PERFORMANCE VERIFICATION TEST (PVT)

3.5.1 PVT Procedures

Prepare PVT Procedures explaining step-by-step, the actions and expected results that will demonstrate that the control system performs in accordance with the sequences of operation, and other contract documents. Submit 4 copies of the PVT Procedures. The PVT Procedures may be submitted as a Technical Data Package.

3.5.1.1 Sensor Accuracy Checks

Include a one-point accuracy check of each sensor in the PVT procedures.

3.5.1.2 Endurance Test

Include a one-week endurance test as part of the PVT during which the system is operated continuously.

Use the building control system Niagara Trend Log Objects to trend all points shown as requiring a trend on the Point Schedule for the entire endurance test. If insufficient buffer capacity exists to trend the entire endurance test, upload trend logs during the course of the endurance test to ensure that no trend data is lost.

3.5.1.3 PVT Equipment List

Include in the PVT procedures a control system performance verification test equipment list that lists the equipment to be used during performance verification testing. For each piece of equipment, include manufacturer name, model number, equipment function, the date of the latest calibration, and the results of the latest calibration

3.5.2 PVT Execution

Demonstrate compliance of the control system with the contract documents. Using test plans and procedures approved by the Government, software capable of reading and writing COV Notification Subscriptions, Notification Class Recipient List Properties, event enrollments, demonstrate all physical and functional requirements of the project. Show, step-by-step, the actions and results demonstrating that the control systems perform in accordance with the sequences of operation. Do not start the performance verification test until after receipt of written permission by the Government, based on Government approval of the PVT Plan and Draft As-Builts and completion of balancing. UNLESS GOVERNMENT WITNESSING OF A TEST IS SPECIFICALLY WAIVED BY THE GOVERNMENT, PERFORM ALL TESTS WITH A GOVERNMENT WITNESS. Do not conduct tests during scheduled seasonal off periods of base heating and cooling systems. If the system experiences any failures during the endurance test portion of the PVT, repair the system repeat the endurance test portion of the PVT until the system operates continuously and without failure for the specified endurance test period.

3.5.3 PVT Report

Prepare and submit a PVT report documenting all tests performed during the PVT and their results. Include all tests in the PVT procedures and any additional tests performed during PVT. Document test failures and repairs conducted with the test results.

Submit four copies of the PVT Report. The PVT Report may be submitted as a Technical Data Package.

3.6 OPERATION AND MAINTENANCE (O&M) INSTRUCTIONS

Provide HVAC control System Operation and Maintenance Instructions which include:

a. "Data Package 3" as indicated in Section 01 78 23 OPERATION AND

MAINTENANCE DATA for each piece of control equipment.

b. HVAC control system sequences of operation formatted as indicated.

c. Procedures for the HVAC system start-up, operation and shut-down including the manufacturer's supplied procedures for each piece of equipment, and procedures for the overall HVAC system.

d. As-built HVAC control system detail drawings formatted as indicated.

e. Routine maintenance checklist. Provide the routine maintenance checklist arranged in a columnar format, where the first column lists all installed devices, the second column states the maintenance activity or that no maintenance required, the third column states the frequency of the maintenance activity, and the fourth column is used for additional comments or reference.

f. Qualified service organization list, including at a minimum company name, contact name and phone number.

g. Start-Up Testing Report.

h. Performance Verification Test (PVT) Procedures and Report.

Submit 2 copies of the Operation and Maintenance Instructions, indexed and in booklet form. The Operation and Maintenance Instructions may be submitted as a Technical Data Package.

3.7 TRAINING

Conduct a training course for two operating staff members designated by the Government in the maintenance and operation of the system, including specified hardware and software. Conduct 16 hours of training at the project site within 30 days after successful completion of the performance verification test. The Government reserves the right to make audio and visual recordings (using Government supplied equipment)of the training sessions for later use. Provide audiovisual equipment and other training materials and supplies required to conduct training. A training day is defined as 8 hours of classroom instruction, including two 15 minute breaks and excluding lunchtime, Monday through Friday, during the daytime shift in effect at the training facility.

3.7.1 Training Documentation

Prepare training documentation consisting of:

a. Course Attendee List: Develop the list of course attendees in coordination with and signed by the Controls shop supervisor.

b. Training Manuals: Provide training manuals which include an agenda, defined objectives for each lesson, and a detailed description of the subject matter for each lesson. When presenting portions of the course material by audiovisuals, deliver copies of those audiovisuals as a part of the printed training manuals.

3.7.2 Training Course Content

For guidance in planning the required instruction, assume that attendees will have a high school education, and are familiar with HVAC systems.

During the training course, cover all of the material contained in the Operating and Maintenance Instructions, the layout and location of each controller enclosure, the layout of one of each type of equipment and the locations of each, the location of each control device external to the panels, the location of the compressed air station, preventive maintenance, troubleshooting, diagnostics, calibration, adjustment, commissioning, tuning, and repair procedures. Typical systems and similar systems may be treated as a group, with instruction on the physical layout of one such system. Present the results of the performance verification test and the Start-Up Testing Report as benchmarks of HVAC control system performance by which to measure operation and maintenance effectiveness.

3.7.3 Training Documentation Submittal Requirements

Submit hardcopy training manuals and all training materials on CD-ROM. Provide one hardcopy manual for each trainee on the Course Attendee List and 2 additional copies for archive at the project site. Provide 2 copies of the Course Attendee List with the archival copies. Training Documentation may be submitted as a Technical Data Package.

APPENDIX A

QC CHECKLIST FOR NIAGARA FRAMEWORK BASED BACNET SYSTEMS

This checklist is not all-inclusive of the requirements of this specification and should not be interpreted as such.

Instructions: Initial each item in the space provided (|____|) verifying that the requirement has been met.

This checklist is for (circle one:)

Pre-Construction QC Checklist Submittal

Post-Construction QC Checklist Submittal

Close-out QC Checklist Submittal

Items verified for Pre-Construction, Post-Construction and Closeout QC Checklist Submittals:

1	All DDC Hardware is numbered on Control System Schematic Drawings.	|____|
2	Signal lines on Control System Schematic are labeled with the signal type.	|____|
3	Local Display Panel (LDP) Locations are shown on Control System Schematic drawings.	|____|

Items verified for Post-Construction and Closeout QC Checklist Submittals:

4	All sequences are performed as specified using DDC Hardware.	|____|
5	Training schedule and course attendee list has been developed and coordinated with shops and submitted.	|____|

Items verified for Closeout QC Checklist Submittal:

6	Final As-built Drawings, including all Points Schedule drawings, accurately represent the final installed system.	|____|
7	Programming software has been submitted for all programmable controllers.	|____|
8	All software has been licensed to the Government.	
9	O&M Instructions have been completed and submitted.	|____|
10	Training course has been completed.	|____|

QC CHECKLIST FOR NIAGARA FRAMEWORK BASED BACNET SYSTEMS			
11	All DDC Hardware is installed on a BACnet ASHRAE 135 network using either MS/TP in accordance with Clause 9 or IP in accordance with Annex J.		|____|
12	All DDC Hardware is BTL listed.		|____|
13	Communication between DDC Hardware is only via BACnet using standard services, except as specifically permitted by the specification. Non-standard services have been fully documented in the DDC Hardware Schedule.		|____|
14	Scheduling, Alarming, and Trending have been implemented using Niagara Framework objects and services, and BACnet Instrinsic Alarming as indicated.		|____|
15	All Properties indicated as required to be Writable are Writable and Overrides have been provided as indicated		|____|
____ ___________________			
	(QC Representative Signature) (Date)		

-- End of Section --

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SECTION 23 09 13

INSTRUMENTATION AND CONTROL DEVICES FOR HVAC
11/15, CHG 2: 05/21

PART 1 GENERAL

1.1 SUMMARY

This section provides for the instrumentation control system components excluding direct digital controllers, network controllers, gateways etc. that are necessary for a completely functional automatic control system. When combined with a Direct Digital Control (DDC) system, the Instrumentation and Control Devices covered under this section must be a complete system suitable for the control of the heating, ventilating and air conditioning (HVAC) and other building-level systems as specified and indicated.

a. Install hardware to perform the control sequences as specified and indicated and to provide control of the equipment as specified and indicated.

b. Install hardware such that individual control equipment can be replaced by similar control equipment from other equipment manufacturers with no loss of system functionality.

c. Install and configure hardware such that the Government or their agents are able to perform repair, replacement, and upgrades of individual hardware without further interaction with the installing Contractor.

1.1.1 Verification of Dimensions

After becoming familiar with all details of the work, verify all dimensions in the field, and advise the Contracting Officer of any discrepancy before performing any work.

1.1.2 Drawings

The Government will not indicate all offsets, fittings, and accessories that may be required on the drawings. Carefully investigate the mechanical, electrical, and finish conditions that could affect the work to be performed, arrange such work accordingly, and provide all work necessary to meet such conditions.

1.2 RELATED SECTIONS

Related work specified elsewhere.

Section 23 30 00 HVAC AIR DISTRIBUTION

Section 23 09 00 INSTRUMENTATION AND CONTROL FOR HVAC

Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM

1.3 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AIR MOVEMENT AND CONTROL ASSOCIATION INTERNATIONAL, INC. (AMCA)

AMCA 500-D	(2018) Laboratory Methods of Testing Dampers for Rating
AMCA 511	(2010; R 2016) Certified Ratings Program for Air Control Devices

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME B16.15	(2018) Cast Copper Alloy Threaded Fittings Classes 125 and 250
ASME B16.18	(2021) Cast Copper Alloy Solder Joint Pressure Fittings
ASME B16.22	(2021) Wrought Copper and Copper Alloy Solder Joint Pressure Fittings
ASME B16.26	(2018) Standard for Cast Copper Alloy Fittings for Flared Copper Tubes
ASME B16.34	(2021) Valves - Flanged, Threaded and Welding End
ASME B40.100	(2022) Pressure Gauges and Gauge Attachments

ASTM INTERNATIONAL (ASTM)

ASTM A536	(1984; R 2019; E 2019) Standard Specification for Ductile Iron Castings
ASTM B32	(2020) Standard Specification for Solder Metal
ASTM B75/B75M	(2020) Standard Specification for Seamless Copper Tube
ASTM B88	(2022) Standard Specification for Seamless Copper Water Tube

FLUID CONTROLS INSTITUTE (FCI)

FCI 70-2	(2021) Control Valve Seat Leakage

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 142	(2007; Errata 2014) Recommended Practice for Grounding of Industrial and Commercial Power Systems - IEEE Green Book

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA 250	(2020) Enclosures for Electrical Equipment (1000 Volts Maximum)

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2020; TIA 22-1; ERTA 1 2022) National Electrical Code
NFPA 90A	(2021) Standard for the Installation of Air Conditioning and Ventilating Systems

UNDERWRITERS LABORATORIES (UL)

UL 555	(2006; Reprint Aug 2016) UL Standard for Safety Fire Dampers
UL 555S	(2014; Reprint Oct 2020) UL Standard for Safety Smoke Dampers
UL 5085-3	(2006; Reprint Jan 2022) UL Standard for Safety Low Voltage Transformers - Part 3: Class 2 and Class 3 Transformers

1.4 SUBMITTALS

Submittal requirements are specified in Section 23 09 00 INSTRUMENTATION AND CONTROL FOR HVAC.

1.5 DELIVERY AND STORAGE

Store and protect products from the weather, humidity, and temperature variations, dirt and dust, and other contaminants, within the storage condition limits published by the equipment manufacturer.

1.6 INPUT MEASUREMENT ACCURACY

Select, install and configure sensors, transmitters and DDC Hardware such that the maximum error of the measured value at the input of the DDC hardware is less than the maximum allowable error specified for the sensor or instrumentation.

PART 2 PRODUCTS

2.1 EQUIPMENT

2.1.1 General Requirements

All products used to meet this specification must meet the indicated requirements, but not all products specified here will be required by every project. All products must meet the requirements both Section 23 09 00 INSTRUMENTATION AND CONTROL FOR HVAC and this Section.

2.1.2 Operation Environment Requirements

Unless otherwise specified, provide products rated for continuous operation under the following conditions:

2.1.2.1 Pressure

Pressure conditions normally encountered in the installed location.

2.1.2.2 Vibration

Vibration conditions normally encountered in the installed location.

2.1.2.3 Temperature

a. Products installed indoors: Ambient temperatures in the range of 32 to 112 degrees F and temperature conditions outside this range normally encountered at the installed location.

b. Products installed outdoors or in unconditioned indoor spaces: Ambient temperatures in the range of 0 to 120 degrees F and temperature conditions outside this range normally encountered at the installed location.

2.1.2.4 Humidity

10 to 95 percent relative humidity, non-condensing and also humidity conditions outside this range normally encountered at the installed location.

2.2 WEATHERSHIELDS

Provide weathershields constructed of galvanized steel painted white, unpainted aluminum, aluminum painted white, or white PVC.

2.3 TUBING

2.3.1 Copper

Provide ASTM B75/B75M or ASTM B88 rated tubing meeting the following requirements:

a. For tubing 0.375 inch outside diameter and larger provide tubing with minimum wall thickness equal to ASTM B88, Type M

b. For tubing less than 0.375 inch outside diameter provide tubing with minimum wall thickness of 0.025 inch

c. For exposed tubing and tubing for working pressures greater than 30 psig provide hard copper tubing.

d. Provide fittings which are ASME B16.18 or ASME B16.22 solder type using ASTM B32 95-5 tin-antimony solder, or which are ASME B16.26 compression type.

2.4 WIRE AND CABLE

Provide wire and cable meeting the requirements of NFPA 70 and NFPA 90A in addition to the requirements of this specification and referenced specifications.

2.4.1 Terminal Blocks

For terminal blocks which are not integral to other equipment, provide terminal blocks which are insulated, modular, feed-through, clamp style with recessed captive screw-type clamping mechanism, suitable for DIN rail mounting, and which have enclosed sides or end plates and partition plates for separation.

2.4.2 Control Wiring for Binary Signals

For Control Wiring for Binary Signals, provide 18 AWG copper or thicker wire rated for 300-volt service.

2.4.3 Control Wiring for Analog Signals

For Control Wiring for Analog Signals, provide 18 AWG or thicker, copper, single- or multiple-twisted wire meeting the following requirements:

a. minimum 2 inch lay of twist

b. 100 percent shielded pairs

c. at least 300-volt insulation

d. each pair has a 20 AWG tinned-copper drain wire and individual overall pair insulation

e. cables have an overall aluminum-polyester or tinned-copper cable-shield tape, overall 20 AWG tinned-copper cable drain wire, and overall cable insulation.

2.4.4 Power Wiring for Control Devices

For 24-volt circuits, provide insulated copper 18 AWG or thicker wire rated for 300 VAC service. For 120-volt circuits, provide 14 AWG or thicker stranded copper wire rated for 600-volt service.

2.4.5 Transformers

Provide UL 5085-3 approved transformers. Select transformers sized so that the connected load is no greater than 80 percent of the transformer rated capacity.

2.5 AUTOMATIC CONTROL VALVES

Provide valves with stainless-steel stems and stuffing boxes with extended necks to clear the piping insulation. Provide valves with bodies meeting ASME B16.34 or ASME B16.15 pressure and temperature class ratings based on the design operating temperature and 150 percent of the system design operating pressure. Unless otherwise specified or indicated, provide valves meeting FCI 70-2 Class III leakage rating. Provide valves rated for modulating or two-position service as indicated, which close against a differential pressure indicated as the Close-Off pressure and which are Normally-Open, Normally-Closed, or Fail-In-Last-Position as indicated.

2.5.1 Valve Type

2.5.1.1 Liquid Service 150 Degrees F or Less

Use either globe valves or ball valves except that butterfly valves may be used for sizes 4 inch and larger.

2.5.2 Valve Flow Coefficient and Flow Characteristic

2.5.2.1 Two-Way Modulating Valves

Provide the valve coefficient (Cv) indicated. Provide equal-percentage flow characteristic for liquid service except for butterfly valves. Provide linear flow characteristic for steam service except for butterfly valves.

2.5.2.2 Three-Way Modulating Valves

Provide the valve coefficient (Cv) indicated. Provide linear flow characteristic with constant total flow throughout full plug travel.

2.5.3 Two-Position Valves

Use full line size full port valves with maximum available (Cv).

2.5.4 Globe Valves

2.5.4.1 Liquid Service Not Exceeding 150 Degrees F

a. Valve body and body connections:

   (1) valves 1-1/2 inches and smaller: brass or bronze body, with threaded or union ends

   (2) valves from 2 inches to 3 inches inclusive: brass, bronze, or iron bodies. 2 inch valves with threaded connections; 2-1/2 to 3 inches valves with flanged connections

b. Internal valve trim: Brass or bronze.

c. Stems: Stainless steel.

d. Provide valves compatible with a solution of 50 percent ethylene or propylene glycol.

2.5.5 Ball Valves

2.5.5.1 Liquid Service Not Exceeding 150 Degrees F

a. Valve body and connections:

   (1) valves 1-1/2 inches and smaller: bodies of brass or bronze, with threaded or union ends

   (2) valves from 2 inches to 3 inches inclusive: bodies of brass, bronze, or iron. 2 inch valves with threaded connections; valves from 2-1/2 to 3 inches with flanged connections.

b. Ball: Stainless steel or nickel-plated brass or chrome-plated brass.

c. Seals: Reinforced Teflon seals and EPDM O-rings.

d. Stem: Stainless steel, blow-out proof.

e. Provide valves compatible with a solution of 50 percent ethylene or propylene glycol.

2.5.6 Butterfly Valves

Provide butterfly valves which are threaded lug type suitable for dead-end service and modulation to the fully-closed position, with carbon-steel bodies or with ductile iron bodies in accordance with ASTM A536. Provide butterfly valves with non-corrosive discs, stainless steel shafts supported by bearings, and EPDM seats suitable for temperatures from -20 to +250 degrees F. Provide valves with rated Cv of the Cv at 70 percent (60 degrees) open position. Provide valves meeting FCI 70-2 Class VI leakage rating.

2.5.7 Pressure Independent Control Valves (PICV)

Provide pressure independent control valves which include a regulator valve which maintains the differential pressure across a flow control valve. Pressure independent control valves must accurately control the flow from 0-100 percent full rated flow regardless of changes in the piping pressure and not vary the flow more than plus or minus 5 percent at any given flow control valve position when the PICV differential pressure lies between the manufacturer's stated minimum and maximum. The rated minimum differential pressure for steady flow must not exceed 5 psid across the PICV. Provide either globe or ball type valves meeting the indicated requirements for globe and ball valves. Provide valves with a flow tag listing full rated flow and minimum required pressure drop. Provide valves with factory installed Pressure/Temperature ports ("Pete's Plugs") to measure the pressure drop to determine the valve flow rate.

2.6 DAMPERS

2.6.1 Damper Assembly

Provide single damper sections with blades no longer than 48 inches and which are no higher than 72 inches and damper blade width of 8 inches or less. When larger sizes are required, combine damper sections. Provide dampers made of steel, or other materials where indicated and with assembly frames constructed of 0.07 inch minimum thickness galvanized steel channels with mitered and welded corners. Steel channel frames constructed of 0.06 inch minimum thickness are acceptable provided the corners are reinforced.

a. Flat blades must be made rigid by folding the edges. Blade-operating linkages must be within the frame so that blade-connecting devices within the same damper section must not be located directly in the air stream.

b. Damper axles must be 1/2 inch minimum, plated steel rods supported in the damper frame by stainless steel or bronze bearings. Blades mounted vertically must be supported by thrust bearings.

c. Provide dampers which do not exceed a pressure drop through the damper of 0.04 inches water gauge at 1000 ft/min in the wide-open position. Provide dampers with frames not less than 2 inch in width. Provide dampers which have been tested in accordance with AMCA 500-D.

2.6.2 Operating Linkages

For operating links external to dampers, such as crank arms, connecting rods, and line shafting for transmitting motion from damper actuators to dampers, provide links able to withstand a load equal to at least 300 percent of the maximum required damper-operating force without deforming. Rod lengths must be adjustable. Links must be brass, bronze, zinc-coated steel, or stainless steel. Working parts of joints and clevises must be brass, bronze, or stainless steel. Adjustments of crank arms must control the open and closed positions of dampers.

2.6.3 Damper Types

2.6.3.1 Flow Control Dampers

Provide parallel-blade or opposed blade type dampers for outside air, return air, relief air, exhaust, face and bypass dampers as indicated on the Damper Schedule. Blades must have interlocking edges. The channel frames of the dampers must be provided with jamb seals to minimize air leakage. Unless otherwise indicated, dampers must meet AMCA 511 Class 1A requirements. Outside air damper seals must be suitable for an operating temperature range of -40 to +167 degrees F. Dampers must be rated at not less than 2000 ft/min air velocity.

2.6.3.2 Mechanical Rooms and Other Utility Space Ventilation Dampers

Provide utility space ventilation dampers as indicated. Unless otherwise indicated provide AMCA 511 class 3 dampers. Provide dampers rated at not less than 1500 ft/min air velocity.

2.6.3.3 Smoke Dampers

Provide smoke-damper and actuator assemblies which meet the current requirements of NFPA 90A, UL 555, and UL 555S. For combination fire and smoke dampers provide dampers rated for 250 degrees F Class II leakage per UL 555S.

2.7 SENSORS AND INSTRUMENTATION

Unless otherwise specified, provide sensors and instrumentation which incorporate an integral transmitter. Sensors and instrumentation, including their transmitters, must meet the specified accuracy and drift requirements at the input of the connected DDC Hardware's analog-to-digital conversion.

2.7.1 Analog and Binary Transmitters

Provide transmitters which match the characteristics of the sensor. Transmitters providing analog values must produce a linear 4-20 mAdc, 0-10 Vdc signal corresponding to the required operating range and must have zero and span adjustment. Transmitters providing binary values must have dry contacts rated at 1A at 24 Volts AC.

2.7.2 Network Transmitters

Sensors and Instrumentation incorporating an integral network connection are considered DDC Hardware and must meet the DDC Hardware requirements of 23 09 23.02 BACNET DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS when used in a BACnet network.

2.7.3 Temperature Sensors

Provide the same sensor type throughout the project. Temperature sensors may be provided without transmitters. Where transmitters are used, the range must be the smallest available from the manufacturer and suitable for the application such that the range encompasses the expected range of temperatures to be measured. The end to end accuracy includes the combined effect of sensitivity, hysteresis, linearity and repeatability between the measured variable and the end user interface (graphic presentation) including transmitters if used.

2.7.3.1 Sensor Accuracy and Stability of Control

2.7.3.1.1 Conditioned Space Temperature

Plus or minus 0.5 degree F over the operating range.

2.7.3.1.2 Unconditioned Space Temperature

a. Plus or minus 1 degree F over the range of 30 to 131 degrees F AND

b. Plus or minus 4 degrees F over the rest of the operating range.

2.7.3.1.3 Duct Temperature

Plus or minus 0.5 degree F

2.7.3.1.4 Outside Air Temperature

a. Plus or minus 2 degrees F over the range of -30 to +130 degrees F AND

b. Plus or minus 1 degree F over the range of 30 to 130 degrees F.

2.7.3.1.5 High Temperature Hot Water

Plus or minus 3.6 degrees F.

2.7.3.1.6 Chilled Water

Plus or minus 0.8 degrees F over the range of 35 to 65 degrees F.

2.7.3.2 Transmitter Drift

The maximum allowable transmitter drift: 0.25 degrees F per year.

2.7.3.3 Point Temperature Sensors

Point Sensors must be encapsulated in epoxy, series 300 stainless steel, anodized aluminum, or copper.

2.7.3.4 Temperature Sensor Details

2.7.3.4.1 Room Type

Provide the sensing element components within a decorative protective cover suitable for surrounding decor.

2.7.3.4.2 Duct Probe Type

Ensure the probe is long enough to properly sense the air stream temperature.

2.7.3.4.3 Duct Averaging Type

Continuous averaging sensors must be one foot in length for each 1 square foot of duct cross-sectional area, and a minimum length of 5 feet.

2.7.3.4.4 Pipe Immersion Type

For pipes with larger than 3 inch diameter, provide minimum 3 inch immersion. For pipes with less than 3 inch diameter, provide immersion at least half the diameter of the pipe. Provide each sensor with a corresponding pipe-mounted sensor well, unless indicated otherwise. Sensor wells must be stainless steel when used in steel piping, and brass when used in copper piping.

2.7.3.4.5 Outside Air Type

Provide the sensing element rated for outdoor use

2.7.4 Relative Humidity Sensor

Relative humidity sensors must use bulk polymer resistive or thin film capacitive type non-saturating sensing elements capable of withstanding a saturated condition without permanently affecting calibration or sustaining damage. The sensors must include removable protective membrane filters. Where required for exterior installation, sensors must be capable of surviving below freezing temperatures and direct contact with moisture without affecting sensor calibration. When used indoors, the sensor must be capable of being exposed to a condensing air stream (100 percent relative humidity) with no adverse effect to the sensor's calibration or other harm to the instrument. The sensor must be of the wall-mounted or duct-mounted type, as required by the application, and must be provided with any required accessories. Sensors used in duct high-limit applications must have a bulk polymer resistive sensing element. Duct-mounted sensors must be provided with a duct probe designed to protect the sensing element from dust accumulation and mechanical damage. Relative humidity (RH) sensors must measure relative humidity over a range of 0 percent to 100 percent with an accuracy of plus or minus 2 percent. RH sensors must function over a temperature range of 40 to 135 degrees F and must not drift more than 1 percent per year.

2.7.5 Carbon Dioxide (CO2) Sensors

Provide photometric type CO2 sensors with integral transducers and linear output. Carbon dioxide (CO2) sensors must measure CO2 concentrations between 0 to 2000 parts per million (ppm) using non-dispersible infrared (NDIR) technology with an accuracy of plus or minus 50 ppm and a maximum response time of 1 minute. The sensor must be rated for operation at ambient air temperatures within the range of 32 to 122 degrees F and relative humidity within the range of 20 to 95 percent (non-condensing). The sensor must have a maximum drift of 2 percent per year. The sensor chamber must be manufactured with a non-corrosive material that does not affect carbon dioxide sample concentration. Duct mounted sensors must be provided with a duct probe designed to protect the sensing element from dust accumulation and mechanical damage. The sensor must have a calibration interval no less than 5 years.

2.7.6 Differential Pressure Instrumentation

2.7.6.1 Differential Pressure Sensors

Provide Differential Pressure Sensors with ranges as indicated or as required for the application. Pressure sensor ranges must not exceed the high end range indicated on the Points Schedule by more than 50 percent. The over pressure rating must be a minimum of 150 percent of the highest design pressure of either input to the sensor. The accuracy must be plus or minus 1 percent of full scale. The sensor must have a maximum drift of 2 percent per year

2.7.6.2 Differential Pressure Switch

Provide differential pressure switches with a user-adjustable setpoint which are sized for the application such that the setpoint is between 25 percent and 75 percent of the full range. The over pressure rating must be a minimum of 150 percent of the highest design pressure of either input to the sensor. The switch must have two sets of contacts and each contact must have a rating greater than it's connected load. Contacts must open or close upon rise of pressure above the setpoint or drop of pressure below the setpoint as indicated.

2.7.7 Flow Sensors

2.7.7.1 Airflow Measurement Array (AFMA)

2.7.7.1.1 Airflow Straightener

Provide AFMAs which contain an airflow straightener if required by the AFMA manufacturer's published installation instructions. The straightener must be contained inside a flanged sheet metal casing, with the AFMA located as specified according to the published recommendation of the AFMA manufacturer. In the absence of published documentation, provide airflow straighteners if there is any duct obstruction within 5 duct diameters upstream of the AFMA. Air-flow straighteners, where required, must be constructed of 0.125 inch aluminum honeycomb and the depth of the straightener must not be less than 1.5 inches.

2.7.7.1.2 Resistance to Airflow

The resistance to air flow through the AFMA, including the airflow straightener must not exceed 0.085 inch water gauge at an airflow of 2,000 fpm. AFMA construction must be suitable for operation at airflows of up to 5000 fpm over a temperature range of 40 to 120 degrees F.

2.7.7.1.3 Outside Air Temperature

In outside air measurement or in low-temperature air delivery applications, provide an AFMA certified by the manufacturer to be accurate as specified over a temperature range of -20 to +120 degrees F .

2.7.7.1.4 Pitot Tube AFMA

Each Pitot Tube AFMA must contain an array of velocity sensing elements. The velocity sensing elements must be of the multiple pitot tube type with averaging manifolds. The sensing elements must be distributed across the duct cross section in the quantity and pattern specified or recommended by the published installation instructions of the AFMA manufacturer.

a. Pitot Tube AFMAs for use in airflows over 600 fpm must have an accuracy of plus or minus 5 percent over a range of 500 to 2500 fpm.

b. Pitot Tube AFMAs for use in airflows under 600 fpm must have an accuracy of plus or minus 5 percent over a range of 125 to 2500 fpm.

2.7.7.1.5 Electronic AFMA

Each electronic AFMA must consist of an array of velocity sensing elements of the resistance temperature detector (RTD) or thermistor type. The sensing elements must be distributed across the duct cross section in the quantity and pattern specified or recommended by the published application data of the AFMA manufacturer. Electronic AFMAs must have an accuracy of plus or minus 5 percent over a range of 125 to 5,000 fpm and the output must be temperature compensated over a range of 32 to 212 degrees F.

2.7.7.1.6 Fan Inlet Measurement Devices

Fan inlet measurement devices cannot be used unless indicated on the drawings or schedules.

2.7.7.2 Orifice Plate

Orifice plate must be made of an austenitic stainless steel sheet of 0.125 inch nominal thickness with an accuracy of plus or minus 1 percent of full flow. The orifice plate must be flat within 0.002 inches. The orifice surface roughness must not exceed 20 micro-inches. The thickness of the cylindrical face of the orifice must not exceed 2 percent of the pipe inside diameter or 12.5 percent of the orifice diameter, whichever is smaller. The upstream edge of the orifice must be square and sharp. Where orifice plates are used, concentric orifice plates must be used in all applications except steam flow measurement in horizontal pipelines.

2.7.7.3 Flow Nozzle

Flow nozzle must be made of austenitic stainless steel with an accuracy of plus or minus 1 percent of full flow. The inlet nozzle form must be elliptical and the nozzle throat must be the quadrant of an ellipse. The thickness of the nozzle wall and flange must be such that distortion of the nozzle throat from strains caused by the pipeline temperature and pressure, flange bolting, or other methods of installing the nozzle in the pipeline must not cause the accuracy to degrade beyond the specified limit. The outside diameter of the nozzle flange or the design of the flange facing must be such that the nozzle throat must be centered accurately in the pipe.

2.7.7.4 Venturi Tube

Venturi tube must be made of cast iron or cast steel and must have an accuracy of plus or minus 1 percent of full flow. The throat section must be lined with austenitic stainless steel. Thermal expansion characteristics of the lining must be the same as that of the throat casting material. The surface of the throat lining must be machined to a plus or minus 50 micro inch finish, including the short curvature leading from the converging entrance section into the throat.

2.7.7.5 Annular Pitot Tube

Annular pitot tube must be made of austenitic stainless steel with an accuracy of plus or minus 2 percent of full flow and a repeatability of plus or minus 0.5 percent of measured value. The unit must have at least one static port and no less than four total head pressure ports with an averaging manifold.

2.7.7.6 Insertion Turbine Flowmeter

Provide dual axial turbine flowmeter with all installation hardware necessary to enable insertion and removal of the meter without system shutdown. All parts must meet or exceed the pressure classification of the pipe system it is installed in. Insertion Turbine Flowmeter accuracy must be plus or minus 0.5 percent of rate at calibrated velocity., within plus or minus of rate over a 10:1 turndown and within plus or minus 2 percent of rate over a 50:1 turndown. Repeatability must be plus or minus 0.25 percent of reading. The meter flow sensing element must operate over a range suitable for the installed location with a pressure loss limited to 1 percent of operating pressure at maximum flow rate. The flowmeter ,must include either dry contact pulse outputs, 4-20mA, 0-10Vdc or 0-5Vdc outputs. The turbine rotor assembly must be constructed of Series 300 stainless steel and use Teflon seals.

2.7.7.7 Vortex Shedding Flowmeter

Vortex Shedding Flowmeter accuracy must be within plus or minus 0.8 percent of the actual reading over the range of the meter. Steam meters must contain density compensation by direct measurement of temperature. Mass flow inferred from specified steam pressure are not acceptable. The flow meter body must be made of austenitic stainless steel and include a weather tight NEMA 4X electronics enclosure. The vortex shedding flowmeter body must not require removal from the piping in order to replace the shedding sensor.

2.7.7.8 Ultrasonic Flow Meter

Provide Ultrasonic Flow Meters complete with matched transducers, self aligning installation hardware and transducer cables. Ultrasonic transducers must be optimized for the specific pipe and process conditions for the application. The flow meter accuracy must plus or minus 1 percent of rate from 0 to 40 ft/sec. The flowmeter must include either dry contact pulse outputs, 4-20mA, 0-10Vdc or 0-5Vdc output.

2.7.7.9 Insertion Magnetic Flow Meter

Provide insertion type magnetic flowmeters with all installation hardware necessary to enable insertion and removal of the meter without system shutdown. All parts must meet or exceed the pressure classification of the pipe system it is installed in. Flowmeter accuracy must be no greater than plus or minus 1 percent of rate from 2 to 20 feet/sec. Wetted material parts must be 300 series stainless steel. The flowmeter must include either dry contact pulse outputs, 4-20mA, 0-10Vdc or 0-5Vdc outputs.

2.7.7.10 Positive Displacement Flow Meter

The flow meter must be a direct reading, gerotor, nutating disc or vane type displacement device rated for liquid service as indicated. A counter must be mounted on top of the meter, and must consist of a non-resettable mechanical totalizer for local reading, and a pulse transmitter for remote reading. The totalizer must have a six digit register to indicate the volume passed through the meter in gallons, and a sweep-hand dial to indicate down to 0.25 gallons. The pulse transmitter must have a hermetically sealed reed switch which is activated by magnets fixed on gears of the counter. The meter must have a bronze body with threaded or flanged connections as required for the application. Output accuracy must be plus or minus 2 percent of the flow range. The maximum pressure drop at full flow must be 5 psig.

2.7.7.11 Flow Meters, Paddle Type

Sensor must be non-magnetic, with forward curved impeller blades designed for water containing debris. Sensor accuracy must be plus or minus 1 percent of rate of flow, minimum operating flow velocity must be 1 foot per second. Sensor repeatability and linearity must be plus or minus 1 percent. Materials which will be wetted must be made from non-corrosive materials and must not contaminate water. The sensor must be rated for installation in pipes of 3 to 40 inch diameters. The transmitter housing must be a NEMA 250 Type 4 enclosure.

2.7.7.12 Flow Switch

Flow switch must have a repetitive accuracy of plus or minus 10 percent of actual flow setting. Switch actuation must be adjustable over the operating flow range, and must be sized for the application such that the setpoint is between 25 percent and 75 percent of the full range.. The switch must have Form C snap-action contacts, rated for the application. The flow switch must have non flexible paddle with magnetically actuated contacts and be rated for service at a pressure greater than the installed conditions. Flow switch for use in sewage system must be rated for use in corrosive environments encountered.

2.7.7.13 Gas Flow Meter

Gas flow meter must be diaphragm or bellows type (gas positive displacement meters) for flows up to 2500 SCFH and axial flow turbine type for flows above 2500 SCFH, designed specifically for natural gas supply metering, and rated for the pressure, temperature, and flow rates of the installation. Meter must have a minimum turndown ratio of 10 to 1 with an accuracy of plus or minus 1 percent of actual flow rate. The meter index must include a direct reading mechanical totalizing register and electrical impulse dry contact output for remote monitoring. The electrical impulse dry contact output must not require field adjustment or calibration. The electrical impulse dry contact output must have a minimum resolution of 100 cubic feet of gas per pulse and must not exceed 15 pulses per second at the design flow.

2.7.8 Electrical Instruments

Provide Electrical Instruments with an input range as indicated or sized for the application. Unless otherwise specified, AC instrumentation must be suitable for 60 Hz operation.

2.7.8.1 Current Transducers

Current transducers must accept an AC current input and must have an accuracy of plus or minus 2 percent of full scale. The device must have a means for calibration. Current transducers for variable frequency applications must be rated for variable frequency operation.

2.7.8.2 Current Sensing Relays (CSRs)

Current sensing relays (CSRs) must provide a normally-open contact with a voltage and amperage rating greater than its connected load. Current sensing relays must be of split-core design. The CSR must be rated for operation at 200 percent of the connected load. Voltage isolation must be a minimum of 600 volts. The CSR must auto-calibrate to the connected load or be adjustable and field calibrated. Current sensors for variable frequency applications must be rated for variable frequency operation.

2.7.8.3 Voltage Transducers

Voltage transducers must accept an AC voltage input and have an accuracy of plus or minus 0.25 percent of full scale. The device must have a means for calibration. Line side fuses for transducer protection must be provided.

2.7.9 Carbon Monoxide Analyzer

Carbon monoxide analyzer must consist of an infrared light source in a weather proof steel enclosure for duct or stack mounting. An optical detector/analyzer in a similar enclosure, suitable for duct or stack mounting must be provided. Both assemblies must include internal blower systems to keep optical windows free of dust and ash at all times. The third component of the analyzer must be the electronics cabinet. Automatic flue gas temperature compensation and manual/automatic zeroing devices must be provided. Unit must read parts per million (ppm) of carbon monoxide in the range of 100 to 10,000 ppm and the response time must be less than 3 seconds to 90 percent value. Unit measurement range must not exceed specified range by more that 50 percent. Repeatability must be plus or minus 1 percent of full scale with an accuracy of plus or minus 1 percent of full scale.

2.7.10 Vibration Switch

Vibration switch must be solid state, enclosed in a NEMA 250 Type 4 or Type 4X housing with sealed wire entry. Unit must have two independent sets of Form C switch contacts with one set to shutdown equipment upon excessive vibration and a second set for monitoring alarm level vibration. The vibration sensing range must be a true rms reading, suitable for the application. The unit must include either displacement response for low speed or velocity response for high speed application. The frequency range must be at least 3 Hz to 500 Hz. Contact time delay must be 3 seconds. The unit must have independent start-up and running delay on each switch contact. Alarm limits must be adjustable and setpoint accuracy must be plus or minus 10 percent of setting with repeatability of plus or minus 2 percent.

2.7.11 Conductivity Sensor

Sensor must include local indicating meter and must be suitable for measurement of conductivity of water in boilers, chilled water systems, condenser water systems, distillation systems, or potable water systems as indicated. Sensor must sense from 0 to 10 microSeimens per centimeter (μS/cm) for distillation systems, 0 to 100 μS/cm for boiler, chilled water, and potable water systems and 0 to 1000 μS/cm for condenser water systems. Contractor must field verify the ranges for particular applications and adjust the range as required. The output must be temperature compensated over a range of 32 to 212 degrees F. The accuracy must be plus or minus 2 percent of the full scale reading. Sensor must have automatic zeroing and must require no periodic maintenance or recalibration.

2.7.12 Turbidity Sensor

Sensor must include a local indicating meter and must be suitable for measurement of turbidity of water. Sensor must sense from 0 to 1000 Nephelometric Turbidity Units (NTU). Range must be field-verified for the particular application and adjusted as required. The output must be temperature compensated over a range of 32 to 212 degrees F. The accuracy must be plus or minus 5 percent of full scale reading. Sensor must have automatic zeroing and must not require periodic maintenance or recalibration.

2.7.13 Chlorine Detector

The detector must measure concentrations of chlorine in water in the range 0 to 20 ppm with a repeatability of plus or minus 1 percent of full scale and an accuracy of plus or minus 2 percent of full scale. The Chlorine Detector transmitter must be housed in a non-corrosive NEMA 250 Type 4X enclosure. Detector must include a local panel with adjustable alarm trip level, local audio and visual alarm with silence function.

2.7.14 Floor Mounted Leak Detector

Leak detectors must use electrodes mounted at slab level with a minimum built-in-vertical adjustment of 0.125 inches. Detector must have a binary output. The indicator must be manual reset type.

2.7.15 Temperature Switch

2.7.15.1 Duct Mount Temperature Low Limit Safety Switch (Freezestat)

Duct mount temperature low limit switches (Freezestats) must be manual reset, low temperature safety switches at least 1 foot long per square foot of coverage which must respond to the coldest 18 inch segment with an accuracy of plus or minus 3.6 degrees F. The switch must have a field-adjustable setpoint with a range of at least 30 to 50 degrees F. The switch must have two sets of contacts, and each contact must have a rating greater than its connected load. Contacts must open or close upon drop of temperature below setpoint as indicated and must remain in this state until reset.

2.7.15.2 Pipe Mount Temperature Limit Switch (Aquastat)

Pipe mount temperature limit switches (aquastats) must have a field adjustable setpoint between 60 and 90 degrees F, an accuracy of plus or minus 3.6 degrees F and a 10 degrees F fixed deadband. The switch must have two sets of contacts, and each contact must have a rating greater than its connected load. Contacts must open or close upon change of temperature above or below setpoint as indicated.

2.7.16 Damper End Switches

Each end switch must be a hermetically sealed switch with a trip lever and over-travel mechanism. The switch enclosure must be suitable for mounting on the duct exterior and must permit setting the position of the trip lever that actuates the switch. The trip lever must be aligned with the damper blade.

End switches integral to an electric damper actuator are allowed as long as at least one is adjustable over the travel of the actuator.

2.7.17 Air Quality Sensors

Provide full spectrum air quality sensors using a hot wire element based on the Taguchi principle. The sensor must monitor a wide range of gaseous volatile organic components common in indoor air contaminants like paint fumes, solvents, cigarette smoke, and vehicle exhaust. The sensor must automatically compensate for temperature and humidity, have span and calibration potentiometers, operate on 24 VDC power with output of 0-10 VDC, and have a service rating of 32 to 140 degrees F and 5 to 95 percent relative humidity.

2.8 INDICATING DEVICES

All indicating devices must display readings in English (inch-pound) units.

2.8.1 Thermometers

Provide bi-metal type thermometers at locations indicated. Thermometers must have either 9 inch long scales or 3.5 inch diameter dials, with insertion, immersion, or averaging elements. Provide matching thermowells for pipe-mounted installations. Select scale ranges suitable for the intended service, with the normal operating temperature near the scale's midpoint. The thermometer's accuracy must be plus or minus 2 percent of the scale range.

2.8.1.1 Piping System Thermometers

Piping system thermometers must have brass, malleable iron or aluminum alloy case and frame, clear protective face, permanently stabilized glass tube with indicating-fluid column, white face, black numbers, and a 9 inch scale. Piping system thermometers must have an accuracy of plus or minus 1 percent of scale range. Thermometers for piping systems must have rigid stems with straight, angular, or inclined pattern. Thermometer stems must have expansion heads as required to prevent breakage at extreme temperatures. On rigid-stem thermometers, the space between bulb and stem must be filled with a heat-transfer medium.

2.8.1.2 Air-Duct Thermometers

Air-duct thermometers must have perforated stem guards and 45-degree adjustable duct flanges with locking mechanism.

2.8.2 Pressure Gauges

Provide pipe-mounted pressure gauges at the locations indicated. Gauges must conform to ASME B40.100 and have a 4 inch diameter dial and shutoff cock. Select scale ranges suitable for the intended service, with the normal operating pressure near the scale's midpoint. The gauge's accuracy must be plus or minus 2 percent of the scale range.

Gauges must be suitable for field or panel mounting as required, must have black legend on white background, and must have a pointer traveling through a 270-degree arc. Gauge range must be suitable for the application with an upper end of the range not to exceed 150 percent of the design upper limit. Accuracy must be plus or minus 3 percent of scale range. Gauges must meet requirements of ASME B40.100.

2.8.3 Low Differential Pressure Gauges

Gauges for low differential pressure measurements must be a minimum of 3.5 inch (nominal) size with two sets of pressure taps, and must have a diaphragm-actuated pointer, white dial with black figures, and pointer zero adjustment. Gauge range must be suitable for the application with an upper end of the range not to exceed 150 percent of the design upper limit. Accuracy must be plus or minus two percent of scale range.

2.9 OUTPUT DEVICES

2.9.1 Actuators

Actuators must be electric (electronic) . All actuators must be normally open (NO), normally closed (NC) or fail-in-last-position (FILP) as indicated. Normally open and normally closed actuators must be of mechanical spring return type. Electric actuators must have an electronic cut off or other means to provide burnout protection if stalled. Actuators must have a visible position indicator. Electric actuators must provide position feedback to the controller as indicated. Actuators must smoothly and fully open or close the devices to which they are applied. Electric actuators must have a full stroke response time in both directions of 90 seconds or less at rated load. Electric actuators must be of the foot-mounted type with an oil-immersed gear train or the direct-coupled type. Where multiple electric actuators operate from a common signal, the actuators must provide an output signal identical to its input signal to the additional devices. All actuators must be rated for their operating environment. Actuators used outdoors must be designed and rated for outdoor use. Actuators under continuous exposure to water, such as those used in sumps, must be submersible.

Actuators incorporating an integral network connection are considered DDC Hardware and must meet the DDC Hardware requirements of Section 23 09 23.02 BACNET DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS.

2.9.1.1 Valve Actuators

Valve actuators must provide shutoff pressures and torques as indicated on the Valve Schedule.

2.9.1.2 Damper Actuators

Damper actuators must provide the torque necessary per damper manufacturer's instructions to modulate the dampers smoothly over its full range of operation and torque must be at least 6 inch-pounds/1 square foot of damper area for opposed blade dampers and 9 inch-pounds/1 square foot of damper area for parallel blade dampers.

2.9.1.3 Electric Actuators

Each actuator must have distinct markings indicating the full-open and full-closed position Each actuator must deliver the torque required for continuous uniform motion and must have internal end switches to limit the travel, or be capable of withstanding continuous stalling without damage. Actuators must function properly within 85 to 110 percent of rated line voltage. Provide actuators with hardened steel running shafts and gears of steel or copper alloy. Fiber or reinforced nylon gears may be used for torques less than 16 inch-pounds..

a. Two-position actuators must be single direction, spring return, or reversing type. Two position actuator signals may either be the control power voltage or line voltage as needed for torque or appropriate interlock circuits.

b. Modulating actuators must be capable of stopping at any point in the cycle, and starting in either direction from any point. Actuators must be equipped with a switch for reversing direction, and a button to disengage the clutch to allow manual adjustments. Provide the actuator with a hand crank for manual adjustments, as applicable. Modulating actuator input signals can either be a 4 to 20 mAdc or a 0-10 VDC signal.

c. Floating or pulse width modulation actuators are acceptable for non-fail safe applications unless indicated otherwise provided that the floating point control (timed actuation) must have a scheduled re-calibration of span and position no more than once a day and no less than once a week. The schedule for the re-calibration should not affect occupied conditions and be staggered between equipment to prevent falsely loading or unloading central plant equipment.

2.9.2 Solenoid-Operated Electric to Pneumatic Switch (EPS)

Solenoid-Operated Electric to Pneumatic Switches (EPS) must accept a voltage input to actuate its air valve. Each valve must have three-port operation: common, normally open, and normally closed. Each valve must have an outer cast aluminum body and internal parts of brass, bronze, or stainless steel. The air connection must be a 0.38 inch NPT threaded connection. Valves must be rated for 50 psig.

2.9.3 Electric to Pneumatic Transducers (EP)

Electric to Pneumatic Transducers (EPs) must convert either a 4-20 mAdc input signal, a 0-10 Vdc input signal to a proportional 0 to 20 psig pneumatic output. The EP must withstand pressures at least 150 percent of the system supply air pressure (main air). EPs must include independent offset and span adjustment. Steady state air consumption must not be greater than 0.05 scfm. EPs must have a manual adjustable override for the EP pneumatic output. EPs must have sufficient output capacity to provide full range stroke of the actuated device in both directions within 90 seconds.

2.9.4 Relays

Relays must have contacts rated for the intended application, indicator light, and dust proof enclosure. The indicator light must be lit when the coil is energized and off when coil is not energized.

Control relay contacts must have utilization category and ratings selected for the application. Each set of contacts must incorporate a normally open (NO), normally closed (NC) and common contact. Relays must be rated for a minimum life of one million operations.

2.10 USER INPUT DEVICES

User Input Devices, including potentiometers, switches and momentary contact push-buttons. Potentiometers must be of the thumb wheel or sliding bar type. Momentary Contact Push-Buttons may include an adjustable timer for their output. User input devices must be labeled for their function.

2.11 MULTIFUNCTION DEVICES

Multifunction devices are products which combine the functions of multiple sensor, user input or output devices into a single product. Unless otherwise specified, the multifunction device must meet all requirements of each component device. Where the requirements for the component devices conflict, the multifunction device must meet the most stringent of the requirements.

2.11.1 Current Sensing Relay Command Switch

The Current Sensing Relay portion must meet all requirements of the Current Sensing Relay input device. The Command Switch portion must meet all requirements of the Relay output device except that it must have at least one normally-open (NO) contact.

Current Sensing Relays used for Variable Frequency Drives must be rated for Variable Frequency applications unless installed on the source side of the drive. If used in this situation, the threshold for showing status must be set to allow for the VFD's control power when the drive is not enabled and provide indication of operation when the drive is enabled at minimum speed.

2.11.2 Space Sensor Module

Space Sensor Modules must be multifunction devices incorporating a temperature sensor and one or more of the following as specified and indicated on the Space Sensor Module Schedule:

a. A temperature indicating device.

b. A User Input Device which must adjust a temperature setpoint output.

c. A User Input Momentary Contact Button and an output to the control system indicating zone occupancy.

d. A three position User Input Switch labeled to indicate heating, cooling and off positions ('HEAT-COOL-OFF' switch) and providing corresponding outputs to the control system.

e. A two position User Input Switch labeled with 'AUTO' and 'ON' positions and providing corresponding output to the control system..

f. A multi-position User Input Switch with 'OFF' and at least two fan speed positions and providing corresponding outputs to the control system.

Space Sensor Modules cannot contain mercury (Hg).

PART 3 EXECUTION

3.1 INSTALLATION

3.1.1 General Installation Requirements

Perform the installation under the supervision of competent technicians regularly employed in the installation of DDC systems.

3.1.1.1 Device Mounting Criteria

All devices must be installed in accordance with manufacturer's recommendations and as specified and indicated. Control devices to be installed in piping and ductwork must be provided with required gaskets, flanges, thermal compounds, insulation, piping, fittings, and manual valves for shutoff, equalization, purging, and calibration. Strap-on temperature sensing elements must not be used except as specified. Spare thermowells must be installed adjacent to each thermowell containing a sensor and as indicated. Devices located outdoors must have a weathershield.

3.1.1.2 Labels and Tags

Match labels and tags to the unique identifiers indicated on the As-Built drawings. Label all enclosures and instrumentation. Tag all sensors and actuators in mechanical rooms. Tag airflow measurement arrays to show flow rate range for signal output range, duct size, and pitot tube AFMA flow coefficient. Tag duct static pressure taps at the location of the pressure tap. Provide plastic or metal tags, mechanically attached directly to each device or attached by a metal chain or wire. Labels exterior to protective enclosures must be engraved plastic and mechanically attached to the enclosure or instrumentation. Labels inside protective enclosures may attached using adhesive, but must not be hand written.

3.1.2 Weathershield

Provide weathershields for sensors located outdoors. Install weathershields such that they prevent the sun from directly striking the sensor and prevent rain from directly striking or dripping onto the sensor. Install weather shields with adequate ventilation so that the sensing element responds to the ambient conditions of the surroundings. When installing weathershields near outside air intake ducts, install them such that normal outside air flow does not cause rainwater to strike the sensor.

3.1.3 Room Instrument Mounting

Mount room instruments, including but not limited to wall mounted non-adjustable space sensor modules and sensors located in occupied spaces, 48 inches above the floor unless otherwise indicated. Install adjustable devices to be ADA compliant unless otherwise indicated on the Room Sensor Schedule:

a. Space Sensor Modules for Fan Coil Units may be either unit or wall mounted but not mounted on an exterior wall.

b. Wall mount all other Space Sensor Modules.

3.1.4 Indication Devices Installed in Piping and Liquid Systems

Provide snubbers for gauges in piping systems subject to pulsation. For gauges for steam service use pigtail fittings with cock. Install thermometers and temperature sensing elements in liquid systems in thermowells. Provide spare Pressure/Temperature Ports (Pete's Plug) for all temperature and pressure sensing elements installed in liquid systems for calibration/testing.

3.1.5 Occupancy Sensors

Provide a sufficient quantity of occupancy sensors to provide complete coverage of the area (room or space). Occupancy sensors are to be ceiling mounted. Install occupancy sensors in accordance with NFPA 70 requirements and the manufacturer's instructions. Do not locate occupancy sensors within 6 feet of HVAC outlets or heating ducts, or where they can "see" beyond any doorway. Installation above doorway(s) is preferred. Do not use ultrasonic sensors in spaces containing ceiling fans. Install sensors to detect motion to within 2 feet of all room entrances and to not trigger due to motion outside the room. Set the off-delay timer to 15 minutes unless otherwise indicated. Adjust sensors prior to beneficial occupancy, but after installation of furniture systems, shelving, partitions, etc. For each controlled area, provide one hundred percent coverage capable of detecting small hand-motion movements, accommodating all occupancy habits of single or multiple occupants at any location within the controlled room.

3.1.6 Switches

3.1.6.1 Temperature Limit Switch

Provide a temperature limit switch (freezestat) to sense the temperature at the location indicated. Provide a sufficient number of temperature limit switches (freezestats) to provide complete coverage of the duct section but no less than 1 foot in length per square foot of cross sectional area. Install manual reset limit switches in approved, accessible locations where they can be reset easily. Install temperature limit switch (freezestat) sensing elements in a side-to-side (not top-to-bottom) serpentine pattern with the relay section at the highest point and in accordance with the manufacturer's installation instructions.

3.1.6.2 Hand-Off Auto Switches

Wire safety controls such as smoke detectors and freeze protection thermostats to protect the equipment during both hand and auto operation.

3.1.7 Temperature Sensors

Install temperature sensors in locations that are accessible and provide a good representation of sensed media. Installations in dead spaces are not acceptable. Calibrate and install sensors according to manufacturer’s instructions. Select sensors only for intended application as designated or recommended by manufacturer.

3.1.7.1 Room Temperature Sensors

Mount the sensors on interior walls to sense the average room temperature at the locations indicated. Avoid locations near heat sources such as copy machines or locations by supply air outlet drafts. Mount the center of all user-adjustable sensors at the heights indicated. Non user-adjustable sensors can be mounted as indicated in paragraph ROOM INSTRUMENT MOUNTING.

3.1.7.2 Duct Temperature Sensors

3.1.7.2.1 Probe Type

Place tip of the sensor in the middle of the airstream or in accordance with manufacturer's recommendations or instructions.Provide a gasket between the sensor housing and the duct wall. Seal the duct penetration air tight. When installed in insulated duct, provide enclosure or stand off fitting to accommodate the thickness of duct insulation to allow for maintenance or replacement of the sensor and wiring terminations. Seal the duct insulation penetration vapor tight.

3.1.7.2.2 Averaging Type

Weave the sensing element in a serpentine fashion from side to side perpendicular to the flow, across the duct or air handler cross-section, using durable non-metal supports in accordance with manufacturer's installation instructions. Avoid tight radius bends or kinking of the sensing element. Prevent contact between the sensing element and the duct or air handler internals. Provide a duct access door at the sensor location. The access door must be hinged on the side, factory insulated, have cam type locks, and be as large as the duct will permit, maximum 18 by 18 inches. For sensors inside air handlers, the sensors must be fully accessible through the air handler's access doors without removing any of the air handler's internals.

3.1.7.3 Immersion Temperature Sensors

Provide thermowells for sensors measuring piping, tank, or pressure vessel temperatures. Locate wells to sense continuous flow conditions. Do not install wells using extension couplings. When installed on insulated piping, provide stand enclosure or stand off fitting to accommodate the thickness of the pipe insulation and allow for maintenance or replacement of the sensor or wiring terminations. Where piping diameters are smaller than the length of the wells, provide wells in piping at elbows to sense flow across entire area of well. Wells must not restrict flow area to less than 70 percent of pipe area. Increase piping size as required to avoid restriction. Provide the sensor well with a heat-sensitive transfer agent between the sensor and the well interior ensuring contact between the sensor and the well.

3.1.7.4 Outside Air Temperature Sensors

Provide outside air temperature sensors on the building's north side with a protective weather shade that does not inhibit free air flow across the sensing element, and protects the sensor from snow, ice, and rain. Location must not be near exhaust hoods and other areas such that it is not influenced by radiation or convection sources which may affect the reading. Provide a shield to shade the sensor from direct sunlight.

3.1.8 Air Flow Measurement Arrays (AFMA)

Locate Outside Air AFMAs downstream from the Outside Air filters.

Install AFMAs with the manufacturer's recommended minimum distances between upstream and downstream disturbances. Airflow straighteners may be used to reduce minimum distances as recommended by the AFMA manufacturer.

3.1.9 Duct Static Pressure Sensors

Locate the duct static pressure sensing tap at 75 percent of the distance between the first and last air terminal units. If the transmitter output is a 0-10Vdc signal, locate the transmitter in the same enclosure as the air handling unit (AHU) controller for the AHU serving the terminal units. If a remote duct static pressure sensor is to be used, run the signal wire back to the controller for the air handling unit.

3.1.10 Relative Humidity Sensors

Install relative humidity sensors in supply air ducts at least 10 feet downstream of humidity injection elements.

3.1.11 Meters

3.1.11.1 Flowmeters

Install flowmeters to ensure minimum straight unobstructed piping for at least 10 pipe diameters upstream and at least 5 pipe diameters downstream of the flowmeter, and in accordance with the manufacturer's installation instructions.

3.1.11.2 Energy Meters

Locate energy meters as indicated. Connect each meter output to the DDC system, to measure both instantaneous demand/energy and other variables as indicated.

3.1.12 Dampers

3.1.12.1 Damper Actuators

Provide spring return actuators which fail to a position that protects the served equipment and space on all control dampers related to freeze protection or force protection. For all outside, makeup and relief dampers provide dampers which fail closed. Terminal fan coil units, terminal VAV units, convectors, and unit heaters nay be non-spring return unless indicated otherwise. Do not mount actuators in the air stream. Do not connect multiple actuators to a common drive shaft. Install actuators so that their action seal the damper to the extent required to maintain leakage at or below the specified rate and so that they move the blades smoothly throughout the full range of motion.

3.1.12.2 Damper Installation

Install dampers straight and true, level in all planes, and square in all dimensions. Dampers must move freely without undue stress due to twisting, racking (parallelogramming), bowing, or other installation error. External linkages must operate smoothly over the entire range of motion, without deformation or slipping of any connecting rods, joints or brackets that will prevent a return to it's normal position. Blades must close completely and leakage must not exceed that specified at the rated static pressure. Provide structural support for multi-section dampers. Acceptable methods of structural support include but are not limited to

U-channel, angle iron, corner angles and bolts, bent galvanized steel stiffeners, sleeve attachments, braces, and building structure. Where multi-section dampers are installed in ducts or sleeves, they must not sag due to lack of support. Do not use jackshafts to link more than three damper sections. Do not use blade to blade linkages. Install outside and return air dampers such that their blades direct their respective air streams towards each other to provide for maximum mixing of air streams.

3.1.13 Valves

Install the valves in accordance with the manufacturer's instructions.

3.1.13.1 Valve Actuators

Provide spring return actuators on all control valves where freeze protection is required. Spring return actuators for terminal fan coil units, terminal VAV units, convectors, and unit heaters are not required unless indicated otherwise.

3.1.14 Thermometers and Gauges

3.1.14.1 Thermometers

Mount devices to allow reading while standing on the floor or ground, as applicable.

3.1.15 Wire and Cable

Provide complete electrical wiring for the Control System, including wiring to transformer primaries. Wire and Cable must be installed without splices between control devices and in accordance with NFPA 70 and NFPA 90A. Instrumentation grounding must be installed per the device manufacturer's instructions and as necessary to prevent ground loops, noise, and surges from adversely affecting operation of the system. Test installed ground rods as specified in IEEE 142. Cables and conductor wires must be tagged at both ends, with the identifier indicated on the shop drawings. Electrical work must be as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM and as indicated. Wiring external to enclosures must be run in raceways

Install control circuit wiring not in raceways in a neat and safe manner. Wiring must not use the suspended ceiling system (including tiles, frames or hangers) for support. Where conduit or raceways are required, control circuit wiring must not run in the same conduit/raceway as power wiring over 50 volts. Run all circuits over 50 volts in conduit, metallic tubing, covered metal raceways, or armored cable.

3.1.16 Copper Tubing

Provide hard-drawn copper tubing in exposed areas and either hard-drawn or annealed copper tubing in concealed areas. Use only tool-made bends. Use only brass or copper solder joint type fittings, except for connections to apparatus. For connections to apparatus use brass compression type fittings.

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SECTION 23 09 23.02

BACNET DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS
02/19, CHG 1: 02/20

PART 1 GENERAL

1.1 SUMMARY

Provide a complete Direct Digital Control (DDC) system suitable for the control of the heating, ventilating and air conditioning (HVAC) and other building-level systems as specified and shown and in accordance with Section 23 09 00 INSTRUMENTATION AND CONTROL FOR HVAC.

1.1.1 System Requirements

Provide a system meeting the requirements of both Section 23 09 00 INSTRUMENTATION AND CONTROL FOR HVAC and this Section and with the following characteristics:

a. Except for Gateways, the control system must be an open implementation of BACnet technology using ASHRAE 135 and Fox as the communications protocols. The system must use standard ASHRAE 135 Objects and Properties and the Niagara Framework. The system must use standard ASHRAE 135 Services and the Niagara Framework exclusively for communication over the network. Gateways to packaged units must communicate with other DDC hardware using ASHRAE 135 or the Fox protocol exclusively and may communicate with packaged equipment using other protocols. The control system must be installed such that any two ASHRAE 135 devices on the Internetwork can communicate using standard ASHRAE 135 Services.

b. Install and configure control hardware to provide ASHRAE 135 Objects and Properties or Niagara Framework Objectsas indicated and as needed to meet the requirements of this specification.

c. Use Niagara Framework hardware and software exclusively for scheduling, trending, and communication with a front end (UMCS). Use Niagara Framework or standard BACnet Objects and services for alarming. Use the Fox protocol for all communication between Niagara Framework Supervisory Gateways; use the ASHRAE 135 protocol for all other building communication.

d. Use Niagara Framework Version 4.0 or later.

1.1.2 Verification of Specification Requirements

Review all specifications related to the control system installation and advise the Contracting Officer of any discrepancies before performing any work. If Section 23 09 00 INSTRUMENTATION AND CONTROL FOR HVAC or any other Section referenced in this specification is not included in the project specifications advise the Contracting Officer and either obtain the missing Section or obtain Contracting Officer approval before performing any work.

1.2 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS (ASHRAE)

ASHRAE 135 (2020; Interpretation 1-8 2021; Errata 1-2 2021; Addenda CD 2021; Addenda BY-CE 2022; Interpretation 9-10 2022) BACnet—A Data Communication Protocol for Building Automation and Control Networks

BACNET INTERNATIONAL (BTL)

BTL Guide (v.49; 2017) BACnet Testing Laboratory Implementation Guidelines

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 802.3 (2022) Ethernet

TELECOMMUNICATIONS INDUSTRY ASSOCIATION (TIA)

TIA-485 (1998a; R 2012) Electrical Characteristics of Generators and Receivers for Use in Balanced Digital Multipoint Systems

TRIDIUM, INC (TRIDIUM)

Niagara Framework (2012) NiagaraAX User's Guide

Tridium Open NiCS (2005) Understanding the NiagaraAX Compatibility Statement (NiCS)

U.S. FEDERAL COMMUNICATIONS COMMISSION (FCC)

FCC Part 15 Radio Frequency Devices (47 CFR 15)

UNDERWRITERS LABORATORIES (UL)

UL 916 (2015; Reprint Oct 2021) UL Standard for Safety Energy Management Equipment

1.3 DEFINITIONS

For definitions related to this section, see Section 23 09 00 INSTRUMENTATION AND CONTROL FOR HVAC.

1.4 SUBMITTALS

Submittal requirements related to this Section are specified in Section 23 09 00 INSTRUMENTATION AND CONTROL FOR HVAC.

PART 2 PRODUCTS

All products used to meet this specification must meet the indicated requirements, but not all products specified here will be required by every project. All products must meet the requirements both Section 23 09 00 INSTRUMENTATION AND CONTROL FOR HVAC and this Section.

2.1 NETWORK HARDWARE

2.1.1 BACnet Router

All BACnet Routers must be BACnet/IP Routers and must perform layer 3 routing of ASHRAE 135 packets over an IP network in accordance with ASHRAE 135 Annex J and Clause 6. The router must provide the appropriate connection to the IP network and connections to one or more ASHRAE 135 MS/TP networks. Devices used as BACnet Routers must meet the requirements for DDC Hardware, and except for Niagara Framework Supervisory Gateways, devices used as BACnet routers must support the NM-RC-B BIBB.

2.1.2 BACnet Gateways

In addition to the requirements for DDC Hardware, the BACnet Gateway must be a Niagara Framework Supervisory Gateway or must meet the following requirements:

a. It must perform bi-directional protocol translation from one non-ASHRAE 135 protocol to ASHRAE 135. BACnet Gateways must incorporate a network connection to an ASHRAE 135 network (either BACnet over IP in accordance with Annex J or MS/TP) and a separate connection appropriate for the non-ASHRAE 135 protocol and media.

b. It must retain its configuration after a power loss of an indefinite time, and must automatically return to their pre-power loss state once power is restored.

c. It must allow bi-directional mapping of data between the non-ASHRAE 135 protocol and Standard Objects as defined in ASHRAE 135. It must support the DS-RP-B BIBB for Objects requiring read access and the DS-WP-B BIBB for Objects requiring write access.

d. It must support the DS-COV-B BIBB.

Although Gateways must meet DDC Hardware requirements , except for Niagara Framework Supervisory Gateways, they are not DDC Hardware and must not be used when DDC Hardware is required. (Niagara Framework Supervisory Gateways are both Gateways and DDC Hardware.)

2.1.3 Ethernet Switch

Ethernet Switches must be managed switches and must autoconfigure between 10,100 and 1000 megabits per second (MBPS).

2.2 CONTROL NETWORK WIRING

a. BACnet MS/TP communications wiring must be in accordance with ASHRAE 135. The wiring must use shielded, three wire (twisted-pair with reference) cable with characteristic impedance between 100 and 120 ohms. Distributed capacitance between conductors must be less than 30 pF per foot.

b. Building Control Network Backbone IP Network must use Ethernet media.

Ethernet cables must be CAT-5e at a minimum and meet all requirements of IEEE 802.3.

2.3 DIRECT DIGITAL CONTROL (DDC) HARDWARE

2.3.1 General Requirements

All DDC Hardware must meet the following requirements:

a. It must be locally powered and must incorporate a light to indicate the device is receiving power.

b. It must conform to the BTL Guide

c. It must be BACnet Testing Laboratory (BTL) Listed.

d. The Manufacturer's Product Data submittal for each piece of DDC Hardware must include the Protocol Implementation Conformance Statement (PICS) for that hardware as specified in Section 23 09 00 INSTRUMENTATION AND CONTROL FOR HVAC.

e. It must communicate and be interoperable in accordance with ASHRAE 135 and have connections for BACnet IP or MS/TP control network wiring.

f. Other than devices controlling terminal units or functioning solely as a BACnet Router, it must support DS-COV-B, DS-RPM-A and DS-RPM-B BIBBs.

g. Devices supporting the DS-RP-A BIBB must also support the DS-COV-A BIBB.

h. Application programs, configuration settings and communication information must be stored in a manner such that they persist through loss of power:

   (1) Application programs must persist regardless of the length of time power is lost.

   (2) Configured settings must persist for any loss of power less than 2,500 hours.

   (3) Communication information, including but not limited to COV subscriptions, event reporting destinations, Notification Class Object settings, and internal communication settings, must persist for any loss of power less than 2,500 hours.

i. Internal Clocks:

   (1) Clocks in DDC Hardware incorporating a Clock must continue to function for 120 hours upon loss of power to the DDC Hardware.

   (2) DDC Hardware incorporating a Clock must support the DM-TS-B or DM-UTC-B BIBB.

j. It must have all functionality indicated and required to support the application (Sequence of Operation or portion thereof) in which it is used, including but not limited to providing Objects or Niagara Framework Points as specified and as indicated on the Points Schedule.

k. In addition to these general requirements and the DDC Hardware

Input-Output (I/O) Function requirements, all DDC Hardware must also meet any additional requirements for the application in which it is used (e.g. scheduling, alarming, trending, etc.).

l. It must meet FCC Part 15 requirements and have UL 916 or equivalent safety listing.

m. Except for Niagara Framework Supervisory Gateways, Device must support Commandable Objects to support Override requirements as detailed in PART 3 EXECUTION

n. User interfaces which allow for modification of Properties or settings must be password-protected.

o. Devices communicating BACnet MS/TP must meet the following requirements:

(1) Must have a configurable Max_Master Property.

(2) DDC Hardware other than hardware controlling a single terminal unit must have a configurable Max_Info_Frames Property.

(3) Must respond to any valid request within 50 msec with either the appropriate response or with a response of "Reply Postponed".

(4) Must use twisted pair with reference and shield (3-wire media) wiring, or twisted pair with shield (2-wire media) wiring and use half-wave rectification.

p. Devices communicating BACnet/IP must use UDP Port 0xBAC0. Devices with configurable UDP Ports must default to 0xBAC0.

q. All Device IDs, Network Numbers, and BACnet MAC addresses of devices must be fully configurable without limitation, except MS/TP MAC addresses may be limited by ASHRAE 135 requirements.

r. Except for Niagara Framework Supervisory Gateways, DDC Hardware controlling a single terminal unit must have:

(1) Objects (including the Device Object) with an Object Name Property of at least 8 characters in length.

(2) A configurable Device Object Name.

(3) A configurable Device Object Description Property at least 16 characters in length.

s. Except for Objects in either Niagara Framework Supervisory Gateways or DDC Hardware controlling a single terminal unit, all Objects (including Device Objects) must:

(1) Have a configurable Object Name Property of at least 12 characters in length.

(2) Have a configurable Object Description Property of at least 24 characters in length.

t. For programmable DDC Hardware, provide and license to the project site all programming software required to program the Hardware in accordance with Section 23 09 00 INSTRUMENTATION AND CONTROL FOR HVAC.

u. For programmable DDC Hardware, provide copies of the installed application programs (all software that is not common to every controller of the same manufacturer and model) as source code compatible with the supplied programming software in accordance with Section 23 09 00 INSTRUMENTATION AND CONTROL FOR HVAC. The submitted application program must be the complete application necessary for controller to function as installed and be sufficient to allow replacement of the installed controller with another controller of the same type.

2.3.2 Hardware Input-Output (I/O) Functions

DDC Hardware incorporating hardware input-output (I/O) functions must meet the following requirements:

2.3.2.1 Analog Inputs

DC Hardware analog inputs (AIs) must be implemented using ASHRAE 135 Analog Input Objects and perform analog to digital (A-to-D) conversion with a minimum resolution of 8 bits plus sign or better as needed to meet the accuracy requirements specified in Section 23 09 00. Signal conditioning including transient rejection must be provided for each analog input. Analog inputs must be capable of being individually calibrated for zero and span. Calibration via software scaling performed as part of point configuration is acceptable. The AI must incorporate common mode noise rejection of at least 50 dB from 0 to 100 Hz for differential inputs, and normal mode noise rejection of at least 20 dB at 60 Hz from a source impedance of 10,000 ohms.

2.3.2.2 Analog Outputs

DDC Hardware analog outputs (AOs) must be implemented using ASHRAE 135 Analog Output Objects and perform digital to analog (D-to-A) conversion with a minimum resolution of 8 bits plus sign, and output a signal with a range of 4-20 mAdc or 0-10 Vdc. Analog outputs must be capable of being individually calibrated for zero and span. Calibration via software scaling performed as part of point configuration is acceptable. DDC Hardware with Hand-Off-Auto (H-O-A) switches for analog outputs must provide for overriding the output through the range of 0 percent to 100 percent

2.3.2.3 Binary Inputs

DDC Hardware binary inputs (BIs) must be implemented using ASHRAE 135 Binary Input Objects and accept contact closures and must ignore transients of less than 5 milli-second duration. Protection against a transient 50VAC must be provided.

2.3.2.4 Binary Outputs

DDC Hardware binary outputs (BOs) must be implemented using ASHRAE 135 Binary Output Objects and provide relay contact closures or triac outputs for momentary and maintained operation of output devices. DDC Hardware with H-O-A switches for binary outputs must provide for overriding the output open or closed.

2.3.2.4.1 Relay Contact Closures

Closures must have a minimum duration of 0.1 second. Relays must provide at least 180V of isolation. Electromagnetic interference suppression must be provided on all output lines to limit transients to 50 Vac. Minimum contact rating must be 0.5 amperes at 24 Vac.

2.3.2.4.2 Triac Outputs

Triac outputs must provide at least 180 V of isolation. Minimum contact rating must be 0.5 amperes at 24 Vac.

2.3.2.5 Pulse Accumulator

DDC Hardware pulse accumulators must be implemented using either an ASHRAE 135 Accumulator Object or an ASHRAE 135 Analog Value Object where the Present_Value is the totalized pulse count. Pulse accumulators must accept contact closures, ignore transients less than 5 msec duration, protect against
transients of 50 VAC, and accept rates of at least 20 pulses per second.

2.3.2.6 ASHRAE 135 Objects for Hardware Inputs and Outputs

The requirements for use of ASHRAE 135 objects for hardware input and outputs includes devices where the hardware sensor or actuator is integral to the controller (e.g. a VAV box with integral damper actuator, a smart sensor, a VFD, etc.)

2.3.2.7 Integrated H-O-A Switches

Where integrated H-O-A switches are provided on hardware outputs, controller must provide means of monitoring position or status of H-O-A switch. This feedback may be provided via the Niagara Framework or via any valid BACnet method, including the use of proprietary Objects, Properties, or Services.

2.3.3 Local Display Panel (LDP)

The Local Display Panels (LDPs) must be DDC Hardware with a display and navigation buttons or a touch screen display, and must provide display and adjustment of Niagara Framework points or ASHRAE 135 Properties as indicated on the Points Schedule and as specified. LDPs must be either BTL Listed as a B-OD, B-OWS, B-AWS, or be an integral part of another piece of DDC Hardware listed as a B-BC. For LDPs listed as B-OWS or B-AWS, the hardware must be BTL listed and the product must come factory installed with all applications necessary for the device to function as an LDP.

The adjustment of values using display and navigation buttons must be password protected.

2.3.4 Expansion Modules and Tethered Hardware

A single piece of DDC Hardware may consist of a base unit and also:

a. An unlimited number of hardware expansion modules, where the individual hardware expansion modules are designed to directly connect, both mechanically and electrically, to the base unit hardware. The expansion modules must be commercially available as an optional add-on to the base unit.

b. A single piece of hardware connected (tethered) to a base unit by a single cable where the cable carries a proprietary protocol between the base unit and tethered hardware. The tethered hardware must not contain control logic and be commercially available as an optional add-on to the base unit as a single package.

Note that this restriction on tethered hardware does not apply to sensors or actuators using standard binary or analog signals (not a communications protocol); sensors or actuators using standard binary or analog signals are not considered part of the DDC Hardware.

Hardware capable of being installed stand-alone, or without a separate base unit, is DDC Hardware and must not be used as expansion modules or tethered hardware.

2.3.5 Supervisory Control Requirements

2.3.5.1 Alarm Generation Hardware

Non-Niagara Framework DDC Hardware used for alarm generation must meet the following requirements:

a. Device must support the AE-N-I-B BIBB

b. The Recipient_List Property must be Writable for all Notification Class Objects used for alarm generation.

c. For all Objects implementing Intrinsic Alarming, the following Properties must be Writable:

(1) Time_Delay
(2) High_Limit
(3) Low_Limit
(4) Deadband
(5) Event_Enable
(6) If the issue date of this project specification is after 1 January 2016, Time_Delay_Normal must be writable.

d. It is preferred, but not required, that devices support the DM-OCD-B BIBB on all Notification Class Objects. It is also preferred, but not required that devices supporting the DM-OCD-B BIBB accept any valid value as an initial value for properties of Notification Class Objects.

2.3.6 Niagara Framework Supervisory Gateway

Any device implementing the Niagara Framework is a Niagara Framework Supervisory Gateway and must meet these requirements. In addition to the general requirements for all DDC Hardware, Niagara Framework Supervisory Gateway Hardware must:

a. Be direct digital control hardware.

b. Have an unrestricted interoperability license and its Niagara Compatibility Statement (NiCS) must follow the Tridium Open NiCS

Specification.

c. Manage communications between a field control network and the Niagara Framework Monitoring and Control Software, and between itself and other Niagara Framework Supervisory Gateways. Niagara Framework Supervisory Gateway Hardware must use Fox protocol for communication with other Niagara Framework Components, regardless of the manufacturer of the other components.

d. Be fully programmable using the Niagara Framework Engineering Tool and must support the following:

   (1) Time synchronization, Calendar, and Scheduling using Niagara Scheduling Objects

   (2) Alarm generation and routing using the Niagara Alarm Service

   (3) Trending using the Niagara History Service and Niagara Trend Log Objects

   (4) Integration of field control networks using the Niagara Framework Engineering Tool

   (5) Configuration of integrated field control system using the Niagara Framework Engineering Tool when supported by the field control system

e. Meet the following minimum hardware requirements:

   (1) One 10/100 Mbps Ethernet Port

   (2) One or more MS/TP ports.

f. Provide access to field control network data and supervisory functions via web interface and support a minimum of 16 simultaneous users. Note: implementation of this capability may not be required on all projects.

g. Submit a backup of each Niagara Framework Supervisory Gateway as specified in Section 23 09 00 INSTRUMENTATION AND CONTROL FOR HVAC. The backup must be sufficient to restore a Niagara Framework Supervisory Gateway to the final as-built condition such that a new Niagara Framework Supervisory Gateway loaded with the backup is indistinguishable in functionality from the original.

2.4 NIAGARA FRAMEWORK ENGINEERING TOOL

The Niagara Framework Engineering Tool must be Niagara Workbench or an equivalent Niagara Framework engineering tool software must:

a. Have an unrestricted interoperability license and its Niagara Compatibility Statement (NiCS) must follow the Tridium Open NiCS Specification.

b. Be capable of performing network configuration for Niagara Framework Supervisory Gateways and Niagara Framework Monitoring and Control Software.

c. Be capable of programming and configuring of Niagara Framework

Supervisory Gateways and Niagara Framework Monitoring and Control Software.

d. Be capable of discovery of Niagara Framework Supervisory Gateways and all points mapped into each Niagara Framework Supervisory Gateway and making these points accessible to Niagara Framework Monitoring and Control Software.

PART 3 EXECUTION

3.1 CONTROL SYSTEM INSTALLATION3.1.1 Niagara Framework Engineering Tool

Provide a Niagara Framework Engineering Tool.

3.1.2 Building Control Network (BCN)

Install the Building Control Network (BCN) as a single BACnet Internetwork consisting of a single IP network as the BCN Backbone and zero or more BACnet MS/TP networks. Note that in some cases there may only be a single device on the BCN Backbone.

Except for the IP Network and as permitted for the non-BACnet side of Gateways, use exclusively ASHRAE 135 networks.

3.1.2.1 Building Control Network IP Backbone

Install IP Network Cabling in conduit. Install Ethernet Switches in lockable enclosures. Install the Building Control Network (BCN) IP Backbone such that it is available at the Facility Point of Connection (FPOC) location. When the FPOC location is a room number, provide sufficient additional media to ensure that the Building Control Network (BCN) IP Backbone can be extended to any location in the room.

Use UDP port 0xBAC0 for all BACnet traffic on the IP network. (Note that in a Niagara Framework system there may not be BACnet traffic on the IP Network)

3.1.2.2 BACnet MS/TP Networks

When using MS/TP, provide MS/TP networks in accordance with ASHRAE 135 and in accordance with the ASHRAE 135 figure "Mixed Devices on 3-Conductor Cable with Shield" (Figure 9-1.4 in the 2012 version of ASHRAE 135). Ground the shield at the BACnet Router and at no other point. Ground the reference wire at the BACnet Router through a 100 ohm resistor and do not ground it at any other point. In addition:

a. Provide each segment in a doubly terminated bus topology in accordance with TIA-485.

b. Provide each segment with 2 sets of network bias resistors in accordance with ASHRAE 135, with one set of resistors at each end of the MS/TP network.

c. Use 3 wire (twisted pair and reference) with shield media for all MS/TP media installed inside. Use fiber optic isolation in accordance with ASHRAE 135 for all MS/TP media installed outside buildings, or between multiple buildings.

d. For 18 AWG cable, use segments with a maximum length of 4000 ft. When using greater distances or different wire gauges comply with the electrical specifications of TIA-485.

e. For each controller that does not use the reference wire provide transient suppression at the network connection of the controller if the controller itself does not incorporate transient suppression.

f. Install no more than 32 devices on each MS/TP segment. Do not use MS/TP to MS/TP routers.

g. Connect each MS/TP network to the BCN backbone via a Niagara Framework Supervisory Gateway configured as a BACnet Router.

h. For BACnet Routers, configure the MS/TP MAC address to 0. Assign MAC Addresses to other devices consecutively beginning at 1, with no gaps.

i. Configure the Max_Master Property of all devices to be 31.

3.1.2.3 Building Control Network (BCN) Installation

Provide a building control network meeting the following requirements:

a. Install all DDC Hardware connected to the Building Control Network.

b. Where multiple pieces of DDC Hardware are used to execute one sequence, install all DDC Hardware executing that sequence on a single MS/TP network dedicated to that sequence.

c. Traffic between BACnet networks must be exclusively via BACnet routers.

d. Use the Fox protocol for all traffic both originating and terminating at Niagara Framework components. Use the Fox protocol for all traffic originating or terminating at a Niagara Framework UMCS (including traffic to or from a future UMCS). All other traffic, including traffic between ASHRAE 135 devices and traffic between Niagara Framework Supervisory Gateways and ASHRAE 135 devices must be in accordance with ASHRAE 135.

3.1.3 DDC Hardware

Install all DDC Hardware that connects to an IP network in lockable enclosure. Install other DDC Hardware that is not in suspended ceilings in lockable enclosures. For all DDC hardware with a user interface, coordinate with site to determine proper passwords and configure passwords into device.

a. Except for zone sensors (thermostats), install all Tethered Hardware within 6 feet of its base unit.

b. Install and configure all BTL-Listed devices in a manner consistent with their BTL Listing such that the device as provided still meets all requirements necessary for its BTL Listing.

c. Install and configure all BTL-Listed devices in a manner consistent with the BTL Device Implementation Guidelines such that the device as provided meets all those Guidelines.

3.1.3.1 Device Identifiers, Network Addresses, and IP addresses

a. Do not use any Device Identifier or Network Number already used by another BACnet system at the project site..

3.1.3.2 ASHRAE 135 Object Name Property and Object Description Property

Configure the Object_Names and Object_Descriptions properties of all ASHRAE 135 Objects (including Device Objects) as indicated on the Points Schedule (Point Name and Point Description) and as specified. At a minimum:

a. Except for DDC Hardware controlling a single terminal unit, configure the Object_Name and Object_Description properties of all Objects (including Device Objects) as indicated on the Points Schedule and as specified.

b. In DDC Hardware controlling a single terminal unit, configure the Device Object_Name and Device Object_Description as indicated on the Points Schedule and as specified.

When Points Schedule entries exceed the length limitations in the device, notify Eglin DDC Shop and provide recommended alternatives for approval.

3.1.3.3 Niagara Framework Point Names and Descriptions

Configure the names and descriptions of all Points in Niagara Framework Supervisory Gateways as indicated on the Points Schedule and as specified.

3.1.3.4 Niagara Station IDs

Ensure that Niagara Station IDs of new Niagara Framework Supervisory Gateways are maintained as unique within UMCS front-end, including ensuring they do not conflict with any existing Niagara Station ID.

3.1.3.5 Hand-Off-Auto (H-O-A) Switches

Provide Hand-Off-Auto (H-O-A) switches as specified and as indicated on the Points Schedule. Provide H-O-A switches that are integral to the controller hardware, an external device co-located with (in the same enclosure as) the controller, integral to the controlled equipment, or an external device co-located with (in the same enclosure as) the controlled equipment.

a. For H-O-A switches integral to DDC Hardware, meet the requirements specified in paragraph DIRECT DIGITAL CONTROL (DDC) HARDWARE.

b. For external H-O-A switches used for binary outputs, provide for overriding the output open or closed.

c. For eternal H-O-A switches used for analog outputs, provide for overriding through the range of 0 percent to 100 percent.

3.1.3.6 Local Display Panels

Provide LDPs to display and override values of points in a Niagara Framework Supervisory Gateway or ASHRAE 135 Object Properties as indicated on the Points Schedule. Install LDPs displaying points for anything other than a terminal unit in the same room as the equipment. Install LDPs displaying points for only terminal units in a mechanical room central to the group of terminal units it serves. For LDPs using WriteProperty to commandable objects to implement an override, write values with priority 9.

3.1.3.7 MS/TP Slave Devices

Configure all MS/TP devices as Master devices. Do not configure any devices to act as slave devices.

3.1.3.8 Change of Value (COV) and Read Property

a. To the greatest extent possible, configure all devices to support the SubscribeCOV service (the DS-COV-B BIBB). At a minimum, all devices supporting the DS-RP-B BIBB, other than devices controlling only a single terminal unit, must be configured to support the DS-COV-B BIBB.

b. Whenever supported by the server side, configure client devices to use the DS-COV-A BIBB.

3.1.3.9 Engineering Units

Configure devices to use English (Inch-Pound) engineering units as follows:

a. Temperature in degrees F

b. Air or natural gas flows in cubic feet per minute (CFM)

c. Water in gallons per minute (GPM)

d. Steam flow in pounds per hour (pph)

e. Differential Air pressures in inches of water column (IWC)

f. Water, steam, and natural gas pressures in PSI

g. Enthalpy in BTU/lb

h. Heating and cooling energy in MBTU (1MBTU = 1,000,000 BTU))

i. Cooling load in tons (1 ton = 12,000 BTU/hour)

j. Heating load in MBTU/hour (1MBTU = 1,000,000 BTU)

k. Electrical Power: kilowatts (kW)

l. Electrical Energy: kilowatt-hours (kWh)

3.1.3.10 Occupancy Modes

Use the following correspondence between value and occupancy mode whenever an occupancy state or value is required:

a. OCCUPIED mode: a value of one
b. UNOCCUPIED mode: a value of two
c. WARM-UP/COOL-DOWN (PRE-OCCUPANCY) mode: a value of three

Note that elsewhere in this Section the Schedule Object is required to also support a value of four, which is reserved for future use. Also note that the behavior of a system in each of these occupancy modes is indicated in the sequence of operation for the system.

3.1.3.11 Use of BACnet Objects

Except as specifically indicated for Niagara Framework Objects, Use only standard non-proprietary ASHRAE 135 Objects and services to accomplish the project scope of work as follows:

a. Use Analog Input or Analog Output Objects for all analog hardware I/O. Do not use Analog Value Object for analog hardware I/O) .

b. Use Binary Input or Binary Output Objects for all binary hardware I/O. Do not use Binary Value Objects for binary hardware I/O.

c. Use Analog Value Objects for analog setpoints.

d. Use Accumulator Objects or Analog Value Objects for pulse inputs.

e. For occupancy modes, use Multistate Value Objects and the correspondence between value and occupancy mode specified in paragraph OCCUPANCY MODES.

f. Use a combination of Niagara Framework Alarm Extensions and Alarm Services, Intrinsic Alarming, and Notification Class Objects for alarm generation.

g. For all other points shown on the Points Schedule as requiring an ASHRAE 135 Object, use the Object type shown on the Points Schedule or, if no Object Type is shown, use a standard Object appropriate to the point.

3.1.3.11.1 Niagara Framework Objects

Points in the Niagara Framework Supervisory Gateway, even if used in a sequence or are shown on the Points Schedule, are not required to be exposed as BACnet Objects unless they are required to be available on the network by another device or sequence of operation (i.e. there is some other reason they are needed).

Use a Niagara Framework Supervisory Gateway as specified for all scheduling and trending. Use a Niagara Framework Supervisory Gateway as specified for all alarming except for intrinsic alarming.

3.1.3.12 Use of Standard BACnet Services

Except as noted in this paragraph, for all DDC Hardware (including Niagara Frameworks Supervisory Gateways when communicating with non-Niagara Framework DDC Hardware) use Standard BACnet Services as defined in this specification (which excludes some ASHRAE 135 services) exclusively for application control functionality and communication.

DDC Hardware that cannot meet this requirement may use non-standard services provided they can provide identical functionality using Standard BACnet Services when communicating with BACnet devices from a different vendor. When implementing non-standard services, document all non-standard services in the DDC Hardware Schedule as specified and as specified in Section 23 09 00 INSTRUMENTATION AND CONTROL FOR HVAC.

3.1.3.13 Device Application Configuration

a. For every property, setting or value shown on the Points Schedule or otherwise indicated as Configurable, provide a value that is retained through loss of power and can be changed via one or more of:

   (1) BACnet services (including proprietary services)

   (2) Hardware settings on the device

   (3) The Niagara Framework

b. For every property, setting or value in non-Niagara Framework Hardware shown on the Points Schedule or otherwise indicated as Operator Configurable, provide a value that is retained through loss of power and can be changed via one or more of:

   (1) A Writable Property of a standard BACnet Object

   (2) A Property of a standard BACnet Object that is Writable when Out_Of_Service is TRUE and Out_Of_Service is Writable.
   (3) Using some other method supported by a Niagara Framework Supervisory Gateway

c. Configure Niagara Framework Supervisory Gateways such that the property, setting or value is configurable from a Niagara Framework Front End.

d. For every property, setting or value in a Niagara Framework Supervisory Gateway which is shown on the Points Schedule or otherwise indicated as Operator Configurable, configure the value to be configurable from within the Niagara Framework such that it can be configured from a system graphic page at a Niagara Framework Front End.

3.1.3.14 Niagara Framework Engineering Tool

Use the Niagara Framework Engineering Tool to fully discover the field control system and make all field control system information available to the Niagara Framework Supervisory Gateway. Ensure that all points on the points schedule are available to the front end via the Fox protocol.

3.1.3.15 Graphics and Web Pages

Configure Niagara Framework Supervisory Gateways to use web pages to provide a graphical user interface including System Displays, including overrides, as indicated on the Points Schedule and as specified. Label all points on displays with full English language descriptions, the point name as indicated on the Points Schedule, andthe point description as indicated on the Points Schedule. Configure user permissions for access to and executions of action using graphic pages. Coordinate user permissions with the Controls shop supervisor. Configure the web server to use HTTPS based on the Transport Layer Security (TLS) protocol in accordance with RFC 5246 using a Government furnished certificate.

3.1.4 Scheduling, Alarming, Trending, and Overrides

3.1.4.1 Scheduling
Configure schedules in Niagara Framework Supervisory Gateway using Niagara Schedule Objects as indicated on the Points Schedule and as specified.

When the schedule is controlling occupancy modes in DDC Hardware other than a Niagara Framework Supervisory Gateway use the indicated correspondence between value and occupancy mode.

Provide a separate schedule for each AHU including it's associated Terminal Units and for each stand-alone Terminal Unit (those not dependent upon AHU service).

3.1.4.2 Alarm Configuration

Configure alarm generation and management as indicated on the Points Schedule and as specified. Configure alarm generation in Niagara Framework Supervisory Gateways using Niagara Framework Alarm Extensions and Alarm Services or in other DDC Hardware (not Niagara Framework Supervisory Gateways) using ASHRAE 135 Intrinsic Alarming. Configure alarm management and routing for all alarms, including those generated via intrinsic alarming in other devices, in the Niagara Framework Supervisory Gateway such that the alarms are able to be accessed from the Niagara Framework Front End.

Where Intrinsic Alarming is used, configure intrinsic alarming as specified in paragraph "Configuration of ASHRAE 135 Intrinsic Alarm Generation". Configure a Niagara Framework Supervisory Gateway to provide a means to configure the intrinsic alarm parameters such that the Intrinsic Alarm is configurable from the front end via the Niagara Framework.

3.1.4.3 Configuration of ASHRAE 135 Intrinsic Alarm Generation

Intrinsic alarm generation must meet the following requirements:

Configure alarm generation as indicated on the Points Schedule and as specified using Intrinsic Alarming in accordance with ASHRAE 135 or Algorithmic Alarming in accordance with ASHRAE 135. Alarm generation must meet the following requirements:

a. Send alarm events as Alarms (not Events).

b. Use the ConfirmedNotification Service for alarm events.

c. For alarm generation, support two priority levels for alarms: critical and non-critical. Configure the Priority of Notification Class Objects to use Priority 112 for critical and 224 for non-critical alarms.

d. Number of Notification Class Objects for Alarm Generation:

    (1) If the device implements non-critical alarms, or if any Object in the device supports Intrinsic Alarms, then provide a single Notification Class Object specifically for (shared by) all non-critical alarms.

    (2) If the device implements critical alarms, provide a single Notification Class Object specifically for (shared by) all critical alarms.

    (3) If the device implements both critical and non-critical alarms, provide both Notification Class Objects (one for critical, one for

non-critical).

(4) If the device controls equipment other than a single terminal unit, provide both Notification Class Objects (one for critical, one for non-critical) even if no alarm generation is required at time of installation.

e. For all intrinsic alarms configure the Limit_Enable Property to set both HighLimitEnable and LowLimitEnable to TRUE. If the specified alarm conditions are for a single-sided alarm (only High_Limit used or only Low_Limit used) assign a value to the unused limit such that the unused alarm condition will not occur.

f. For all objects supporting intrinsic alarming, even if no alarm generation is required during installation, configure the following Properties as follows:

(1) Notification_Class to point to the non-Critical Notification Class Object in that device.

(2) Limit_Enable to enable both the HighLimitEnable and LowLimitEnable

(3) Notify_Type to Alarm

g. Configure the Recipient_List Property of the Notification Class Object to point to the Niagara Framework Supervisory Gateway managing the alarm.

3.1.4.4 Trending

Perform all trending using a Niagara Framework Supervisory Gateway using Niagara Framework History Extensions and Niagara Framework History Service exclusively.

3.1.4.5 Overrides

Provide an override for each point shown on the Points Schedule as requiring an override. Use the Niagara Framework for all overrides to points in Niagara Framework Supervisory Gateways. For overrides to other points, provide an override to a point in a Niagara Framework Supervisory Gateway via the Niagara Framework where the Niagara Framework Supervisory Gateway overrides the other point as specified.

Unless otherwise approved, provide Commandable Objects to support all Overrides in non-Niagara Framework Supervisory Gateway DDC Hardware. With specific approval from the Contracting Officer, Overrides for points which are not hardware outputs and which are in DDC hardware controlling a single terminal unit may support overrides via an additional Object provided for the override. No other means of implementing Overrides may be used.

a. Where Commandable Objects are used, ensure that WriteProperty service requests with a Priority of 10 or less take precedence over the SEQUENCE VALUE and that WriteProperty service request with a priority of 11 or more have a lower precedence than the SEQUENCE VALUE.

b. For devices implementing overrides via additional Objects, provide

Objects which are NOT Written to as part of the normal Sequence of Operations and are Writable when Out_Of_Service is TRUE and Out_Of_Service is Writable. Use this point as an Override of the normal value when Out_Of_Service is TRUE and the normal value otherwise. Note these Objects may be modified as part of the sequence via local processes, but must not be modified by local processes when Out_Of_Service is TRUE.

3.1.5 BACnet Gateways

The requirements in this paragraph do not themselves permit the installation of hardware not meeting the other requirements of this section. Except for proprietary systems specifically indicated in Section 23 09 00, all control hardware installed under this project must meet the requirements of this specification, including the control hardware providing the network interface for a package unit or split system specified under another section. Only use gateways to connect to pre-existing control devices, and to proprietary systems specifically permitted by Section 23 09 00.

3.1.5.1 General Gateway Requirements

Provide BACnet Gateways to connect non-BACnet control hardware in accordance with the following:

a. Configure gateways to map writable data points in the controlled equipment to Writable Properties of Standard Objects, or to Niagara Framework points, as indicated in the Points Schedule and as specified.

b. Configure gateway to map readable data points in the controlled equipment to Readable Properties of Standard Objects, or to Niagara Framework points, as indicated in the Points Schedule and as specified.

c. Configure gateway to support the DS-COV-B BIBB for all points mapped to BACnet Objects.

d. Do not use non-BACnet control hardware for controlling built-up units or any other equipment that was not furnished with factory-installed controls. (Note: A Niagara Framework Supervisory Gateway is BACnet control hardware.)

e. Do not use non-BACnet control hardware for system scheduling functions.

f. Each gateway must communicate with and perform protocol translation for non-BACnet control hardware controlling one and only one package unit or a single non-BACnet system specifically permitted by Section 23 09 00.

g. Connect one network port on the gateway to the Building Control Backbone IP Network or to a BACnet MS/TP network and the other port to the single piece of controlled equipment or the non-BACnet system specifically permitted by Section 23 09 00..

h. For gateways to existing package units or simple split systems, non-BACnet network wiring connecting the gateway to the package unit must not exceed 10 feet in length and must connect to exactly two devices: the controlled equipment (packaged unit) or split system interface and the gateway.

SECTION 23 21 23

HYDRONIC PUMPS
08/17

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME B1.1	(2003; R 2018) Unified Inch Screw Threads (UN and UNR Thread Form)

ASTM INTERNATIONAL (ASTM)

ASTM A123/A123M	(2017) Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
ASTM A307	(2021) Standard Specification for Carbon Steel Bolts, Studs, and Threaded Rod 60 000 PSI Tensile Strength

HYDRAULIC INSTITUTE (HI)

HI 1.1-1.2	(2014) Rotodynamic (Centrifugal) Pump for Nomenclature and Definitions
HI 9.6.4	(2009) Rotodynamic Pumps for Vibration Analysis and Allowable Values
HI ANSI/HI 2.1-2.2	(2014) Rotodynamic Vertical Pumps of Radial, Mixed, and Axial Flow Types for Nomenclature and Definitions
HI ANSI/HI 9.6.3	(2017) Rotodynamic Pumps - Guideline for Operating Regions - B120
HI ANSI/HI 14.6	(2011) Rotodynamic Pumps for Hydraulic Performance Acceptance Tests - A136

INTERNATIONAL CODE COUNCIL (ICC)

ICC IgCC	(2021) International Green Construction Code

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA MG 1	(2021) Motors and Generators
NEMA Z535.4	(2011; R 2017) Product Safety Signs and Labels

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2020; TIA 22-1; ERTA 1 2022) National Electrical Code

SOCIETY FOR PROTECTIVE COATINGS (SSPC)

SSPC Paint 21	(1982; E 2004) White or Colored Silicone Alkyd Paint (Type I, High Gloss and Type II, Medium Gloss)
SSPC Paint 25	(1997; E 2004) Zinc Oxide, Alkyd, Linseed Oil Primer for Use Over Hand Cleaned Steel, Type I and Type II

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

29 CFR 1910.219	Mechanical Power Transmission Apparatus

UNDERWRITERS LABORATORIES (UL)

UL 778	(2016; Reprint Jun 2021) UL Standard for Safety Motor-Operated Water Pumps

1.2 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

System Coordination; G

SD-03 Product Data

Instructions; G

Equipment Data; G

Training Period; G

SD-06 Test Reports

Field Quality Control

SD-07 Certificates

Manufacturer's Representative

SD-10 Operation and Maintenance Data

Operation and Maintenance Manuals; G

Training; G

1.3 QUALITY ASSURANCE

1.3.1 Manufacturer Services

Provide the services of a manufacturer's representative experienced in the installation, adjustment, and operation of the equipment specified. The representative must supervise the installation, adjustment, testing of the equipment, and conduct training.

Submit the names and qualifications of the manufacturer's representative and training engineers and written certification from the manufacturer that the representative and trainers are technically qualified.

1.3.2 Standard Products

Provide material and equipment which are the standard products of a manufacturer regularly engaged in the manufacture of such products and that essentially duplicate equipment that has been in satisfactory HVAC operation at least 2 years prior to issuance of this solicitation. Support equipment with a service organization that is reasonably convenient to the jobsite. Pumps and motors of the same types must each be the product of one manufacturer.

1.3.3 Conformance with Agency Requirements

Where materials or equipment are specified to be an approved type, attach the seal or label of approval from a nationally recognized testing agency, adequately equipped and competent to perform such services. A written certificate from the testing agency must accompany the materials or equipment and be submitted stating that the items have been tested and that they conform to the applicable requirements of the specifications and to the standards listed herein. The certificate must indicate the methods of testing used by the testing agency. In lieu of a certificate from a testing agency, published catalog specification data, accompanied by the manufacturer's certified statement to the effect that the items are in accordance with the applicable requirements of the specifications and the referenced standards, will be considered and may be acceptable as evidence that the items conform with agency requirements.

1.4 DELIVERY, STORAGE, AND HANDLING

Protect equipment, delivered and designated for storage, from the weather, humidity and temperature variations, dirt and dust, or other contaminants.

PART 2 PRODUCTS

2.1 SYSTEM DESCRIPTION

Hydronic pumps used for heating and air conditioning applications are defined by the type of impeller, number of impellers, type of casing, method of connection to the driver, and mounting position. Provide centrifugal water pumps of the types indicated and specified. Use an electric motor driving unit for each pump as indicated and specified.

2.1.1 Selection Criteria

Select pumps at a point within the maximum efficiency for a given impeller casing combination. Deviations within 3 percent of maximum efficiency are permissible, provided the lesser efficiency is not less than the scheduled efficiency in the construction design documents. Pumps having impeller diameters larger or smaller than manufacturer's published maximum and minimum impeller diameters for a given impeller casing combination will be rejected. Pump performance data, as shown in performance curves, must be based on factory tests using precision instrumentation and exacting procedures as detailed in HI ANSI/HI 14.6.

2.1.2 System Coordination

Submit drawings containing complete wiring and piping schematic diagrams and any other details required to demonstrate that the system has been coordinated and will properly function as a unit. Show the proposed layout and anchorage of equipment and appurtenances, and equipment relationship to other parts of the work including clearances for maintenance and operation. Provide a complete listing of equipment, materials and miscellaneous components including mechanical seals, bearings, and couplings.

2.1.3 Safety Requirements

Fully enclose or guard couplings, projecting set-screws, keys, and other rotating parts, that pose an entangling hazards..

2.2 MATERIALS AND EQUIPMENT

2.2.1 Nameplates

Securely affix a standard nameplate to pumps and motors in a conspicuous place showing the manufacturer's name, address, type or style, model, serial number, and catalog number. In addition, for each pump show the capacity in gpm at rated speed in rpm and total head in feet of water. For each electric motor show at least the minimum information required by NEMA MG 1. Show such other information as the manufacturer may consider necessary to complete identification on the nameplate. Pumps must be listed and labeled by UL, and comply with UL 778 for pumps not using universal motors rated more than 250 volts such as circulating pumps.

2.2.2 Framed Instructions

Submit proposed diagrams, instructions, and other sheets, prior to posting. Post approved wiring and control diagrams showing the complete layout of the entire system, including equipment, piping valves, and control sequence, framed under glass or in approved laminated plastic, where directed. Provide condensed operating instructions explaining preventive maintenance procedures, methods of checking the system for normal safe operation, and procedures for safely starting and stopping the system, framed as specified above for the wiring and control diagrams, and posted beside the diagrams. Post the framed instructions before acceptance testing of the systems.

2.2.3 Pump Characteristic

Construct hydronic water pumps in accordance with HI 1.1-1.2 and HI ANSI/HI 2.1-2.2.

Operate pumps at optimum efficiencies to produce the most economical pumping system under the conditions encountered and size to make optimum match with the system head curve as shown. Pumps must furnish not less than 150 percent of rated capacity at a total discharge head of not less than 65 percent of total rated head. Operate pumps at specified system fluid temperatures without vapor binding and cavitation. Operate pumps to HI ANSI/HI 9.6.3 standard for Preferred Operationg Region (POR).

2.2.4 Pump Drivers

Provide electric motors as indicated for each pump and in compliance with Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM .

2.2.5 Equipment Data

Submit manufacturer's descriptive data and technical literature, performance charts and curves for all impeller sizes for a given casing, catalog cuts, and installation instructions. Provide spare parts data for each different item of material and equipment specified, after approval of the detail drawings and not later than three (3) months prior to the date of beneficial occupancy. Include a complete list of parts and supplies, with current unit prices and local source of supply with contact information.

Submit catalog information, certified pumps curves, rated capacities, final impeller dimensions, and accessories provided for the product indicated. Indicate operating point of each pump on curves. Furnish pump curves for each pump and combination of pumps designed to operate in parallel. The pump curve must show as a minimum; bhp, flow, total dynamic head, efficiency, NPSH, impeller diameter and system curve (individually and in combination for each pump operating in a parallel application). Select pumps operating in parallel operation to cross the system curve when operating individually.

2.3 HYDRONIC PUMPS

Provide centrifugal, single-stage type, or multi-stage type, designed for HVAC service in the following configurations:

Configuration	Pump No.
Small In-Line	CHWP-1/CHWP-2

2.3.1 Small In-Line

Provide pumps with capacities as indicated,suitable for 225 degrees F operation at 175 psig working pressure. The pump must be single stage, in-line design, in cast iron bronze fitted construction. The pump internals must be capable of being serviced without disturbing piping connections.

2.3.1.1 Pump Shaft

The pump must have a solid steel shaft with a coupler between the pump and motor shafts. For non-stainless steel shafts, employ a non-ferrous shaft sleeve to completely cover the wetted area under the seal.

2.3.1.2 Bearing

The bearing assembly must house maintenance-free permanently lubricated bearings.

2.3.1.3 Seal Assembly

Equip the pump with an internal self-flushing mechanical seal assembly. Seal assembly must have Buna bellows and seat gasket, stainless steel spring, and be of a carbon ceramic design with the carbon face rotating against a stationary ceramic face.

2.3.1.4 Impeller

Provide impeller of cast bronze or brass material. Impeller must be hydraulically and dynamically balanced to HI 9.6.4 balance grade G6.3, keyed to the shaft and secured by a locking capscrew or nut.

2.3.1.5 Volute

Pump volute must be of cast iron. The connection style on cast iron pumps must be flanged.

2.3.1.6 Motor Mount

To ensure alignment, mount the motor to the bearing assembly via a bolted motor bracket assembly. Use a replaceable resilient rubber motor mount to assist in aligning the motor shaft with the pump shaft.

2.3.1.7 Motors

NEMA MG 1; premium efficiency; non-overloading at any point on the pump curve; maintenance free with permanently lubricated bearings; and resilient mounted for smaller sizes, rigid mounted otherwise.

2.4 ELECTRICAL WORK

Provide electrical motor driven equipment specified herein complete with motors, motor starters, and controls. Provide electric equipment and wiring in accordance with Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Electrical characteristics must be as indicated. Provide motor starters complete with properly sized thermal overload protection in each phase and other appurtenances necessary for the motor control specified. Each motor must be of sufficient capacity to drive the equipment at the specified capacity without exceeding the nameplate rating of the motor when operating at proper electrical system voltage and frequency. Manual or automatic control and protective or signal devices required for the operation herein specified and any control wiring required for controls and devices but not indicated must be provided under this section of the specifications.

2.5 ELECTRICAL EQUIPMENT

Provide electrical equipment in conformance with Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Provide electrical motor driven equipment herein specified complete with motors, motor starters, and controls. Motor controls, equipment, and wiring must be in accordance with NFPA 70.

2.5.1 Electric Motors

Drive each electric motor-driven pump by a continuous-duty electric motor with enclosure type for specific service as defined in paragraph HYDRONIC PUMPS. Motor must have a 1.5 service factor. Provide synchronous motors having normal-starting-torque and low-starting-current characteristics, and of sufficient size so that the nameplate horsepower rating will not be exceeded throughout the entire published pump characteristic curve. Integral size motors must be the premium efficiency type in accordance with NEMA MG 1. Pump electric motor efficiencies must meet or exceed the requirements of the ICC IgCC standard. Motor bearings must provide smooth operations under the conditions encountered for the life of the motor. Provide adequate thrust bearing in the motor to carry the weight of all rotating parts plus the hydraulic thrust and be capable of withstanding upthrust imposed during pump starting. Motors must be rated 460 volts, 3 phase, 60 Hz and such rating must be stamped on the nameplate. Provide motors in conformance with NEMA MG 1.

2.5.2 Control Equipment

Automatically controlled pumps must have three-position "MANUAL-OFF-AUTOMATIC" selector switch in cover. Provide additional controls or protective devices as indicated.

2.5.3 Variable Speed Control

The variable speed motor controllers must meet the requirements of UFGS 26 29 23 ADJUSTABLE SPEED DRIVE SYSTEMS UNDER 600 VOLTS.

2.6 EQUIPMENT APPURTENANCES

2.6.1 Attachments

Furnish all necessary bolts, nuts, washers, bolt sleeves, and other types of attachments with the equipment for the installation of the equipment. Bolts conform to the requirements of ASTM A307 and hexagonal nuts of the same quality as the bolts used. Threads must be clean-cut and conform to ASME B1.1. Bolts, nuts, and washers specified to be galvanized or not otherwise indicated or specified, must be zinc coated after being threaded, by the hot-dip process conforming to ASTM A123/A123M as appropriate. Bolts, nuts, and washers specified or indicated to be stainless steel must be Type 316.

2.6.2 Equipment Guards

Provide equipment driven by open shafts, belts, chains, or gears with all-metal guards enclosing the drive mechanism. Secure guards in position with steel braces or straps that permit easy removal for servicing the equipment. Coupler guards must comply with current national safety standards including 29 CFR 1910.219 and NEMA Z535.4. Provide guards with gaps no greater than 0.250 inches, safety orange in color, and have an NEMA Z535.4 compliant warning label.

2.6.3 Tools

Furnish a complete set of all special tools which may be necessary for the adjustment, operation, maintenance, and disassembly of all equipment. Special tools are considered to be those tools which because of their limited use are not normally available, but which are necessary for the particular equipment. Special tools must be high-grade, smooth, forged, alloy, tool steel. Furnish one pressure grease gun for each type of grease required. Deliver all tools at the same time as the equipment to which they pertain. Properly store and safeguard such tools until completion of the work, at which time deliver them to the Contracting Officer.

2.7 FINISHES

All motors, pump casings, and similar parts of equipment must be thoroughly cleaned, primed, and given two finish coats of paint at the factory in accordance with the recommendations of the manufacturer. Give ferrous surfaces not to be painted a shop coat of grease or other suitable rust-resistant coating.

PART 3 EXECUTION

3.1 EXAMINATION

After becoming familiar with all details of the work, verify all dimensions in the field and advise the Contracting Officer of any discrepancy before performing the work.

3.2 INSTALLATION

Install each pump and motor in accordance with the written instructions of the manufacturer. Provide access space around the device for servicing no less than the minimum recommended by the manufacturer.

3.3 FIELD QUALITY CONTROL

After installation of the pumping units and appurtenances, including coupling guard, is complete, carry out operating tests to assure that the pumping installation operates properly. Give each pumping unit a running field test in the presence of the Contracting Officer for a minimum of 2 hours. Operate each pumping unit at its rated capacity or such other point on its head-capacity curve selected by the Contracting Officer. Provide an accurate and acceptable method of measuring the discharge flow. Tests must assure that the units and appurtenances have been installed correctly, that there is no objectionable heating, vibration, or noise from any parts, and that all manual and automatic controls function properly. If any deficiencies are revealed during any tests, correct such deficiencies and reconduct the tests.

Submit test reports in booklet form showing all field tests performed to adjust each component and all field tests performed to prove compliance with the specified performance criteria, upon completion and testing of the installed system. Each test report must indicate the final position of controls.

3.4 FIELD PAINTING

Do not paint stainless steel, galvanized steel, and nonferrous surfaces.

3.4.1 Touch-up painting

Factory painted items requiring touching up in the field must be thoroughly cleaned of all foreign material, and primed and topcoated with the manufacturer's standard factory finish.

3.4.2 Exposed Ferrous Surfaces

Paint exposed ferrous surfaces with two coats of enamel paint conforming to SSPC Paint 21. Solvent clean factory primed surfaces before painting. Surfaces that have not been factory primed must be prepared and primed with one coat of SSPC Paint 25 or in accordance with the enamel paint manufacturer's recommendations.

3.5 CLOSEOUT ACTIVITIES

3.5.1 Operation and Maintenance Manuals

Submit one complete set at the time the tests procedure is submitted; remaining sets before the contract is completed. Permanently bind each in a hard cover. Inscribe the following identification on the covers: the words "OPERATING AND MAINTENANCE INSTRUCTIONS," name and location of the building, name of the Contractor, and contract number. Place flysheets before instructions covering each subject. Use 8-1/2 by 11 inches paper for instruction sheets, with large sheets of drawings folded in.

Include, but do not limit to, the following in the Instructions:

a. System layout showing piping, valves, and controls.

b. Approved wiring and control diagrams including variable frequency drives.

c. A control sequence describing startup, operation, and shutdown.

d. Operating and maintenance instructions for each piece of equipment, including task list for routine maintenance, routine inspections, intermediate inspections, and annual inspections; lubrication instructions; and troubleshooting guide.

e. Manufacturer's bulletins, cuts, and descriptive data; and parts list and recommended spare parts.

3.5.2 Training

Upon completion of the work, and at a time designated by the Contracting Officer, provide the services of one or more competent engineers for a training period of not less than 8 hours to instruct a representative of the Government in the contents of the operation and maintenance manuals for the equipment furnished under these specifications. These field instructions must cover all the items contained in the bound instructions. Submit the training course curriculum and training instructions 14 days prior to the start of training.

-- End of Section --

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SECTION 23 30 00

HVAC AIR DISTRIBUTION
05/20, CHG 1: 02/22

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AIR MOVEMENT AND CONTROL ASSOCIATION INTERNATIONAL, INC. (AMCA)

AMCA 201	(2002; R 2011) Fans and Systems
AMCA 210	(2016) Laboratory Methods of Testing Fans for Aerodynamic Performance Rating
AMCA 300	(2014) Reverberant Room Method for Sound Testing of Fans
AMCA 301	(2014) Methods for Calculating Fan Sound Ratings from Laboratory Test Data
AMCA 500-D	(2018) Laboratory Methods of Testing Dampers for Rating

AIR-CONDITIONING, HEATING AND REFRIGERATION INSTITUTE (AHRI)

AHRI 410	(2001; Addendum 1 2002; Addendum 2 2005; Addendum 3 2011) Forced-Circulation Air-Cooling and Air-Heating Coils
AHRI 430	(2009) Central-Station Air-Handling Units
AHRI 880 I-P	(2011) Performance Rating of Air Terminals
AHRI 885	(2008; Addendum 2011) Procedure for Estimating Occupied Space Sound Levels in the Application of Air Terminals and Air Outlets
AHRI Guideline D	(1996) Application and Installation of Central Station Air-Handling Units

AMERICAN BEARING MANUFACTURERS ASSOCIATION (ABMA)

ABMA 9	(2015) Load Ratings and Fatigue Life for Ball Bearings
ABMA 11	(2014) Load Ratings and Fatigue Life for Roller Bearings

AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS (ASHRAE)

ASHRAE 52.2	(2012) Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size
ASHRAE 62.1	(2022) Ventilation for Acceptable Indoor Air Quality
ASHRAE 70	(2006; R 2021) Method of Testing the Performance of Air Outlets and Inlets
ASHRAE 90.1 - IP	(2019; Errata 1 2019; Errata 2-5 2020; Addenda BY-CP 2020; Addenda AF-DB 2020; Addenda A-G 2020; Addenda F-Y 2021; Errata 6-8 2021; Interpretation 1-4 2020; Interpretation 5-8 2021 Addenda AS-AQ 2022) Energy Standard for Buildings Except Low-Rise Residential Buildings
ASHRAE 90.1 - SI	(2019; Errata 1-4 2020; Addenda BY-CP 2020; Addenda AF-DB 2020; Addenda A-G 2020; Addenda F-Y 2021; Errata 5-7 2021; Interpretation 1-4 2020; Interpretation 5-8 2021; Addenda AU-CM 2022) Energy Standard for Buildings Except Low-Rise Residential Buildings

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME A13.1	(2020) Scheme for the Identification of Piping Systems

ASTM INTERNATIONAL (ASTM)

ASTM A53/A53M	(2022) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM A123/A123M	(2017) Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
ASTM A167	(2011) Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip
ASTM A924/A924M	(2022) Standard Specification for General Requirements for Steel Sheet, Metallic-Coated by the Hot-Dip Process
ASTM B117	(2019) Standard Practice for Operating Salt Spray (Fog) Apparatus
ASTM B766	(1986; R 2015) Standard Specification for

	Electrodeposited Coatings of Cadmium
ASTM C553	(2013; R 2019) Standard Specification for Mineral Fiber Blanket Thermal Insulation for Commercial and Industrial Applications
ASTM C1071	(2019) Standard Specification for Fibrous Glass Duct Lining Insulation (Thermal and Sound Absorbing Material)
ASTM D520	(2000; R 2011) Zinc Dust Pigment
ASTM D1654	(2008; R 2016; E 2017) Standard Test Method for Evaluation of Painted or Coated Specimens Subjected to Corrosive Environments
ASTM D3359	(2017) Standard Test Methods for Rating Adhesion by Tape Test
ASTM E2016	(2022) Standard Specification for Industrial Woven Wire Cloth

CALIFORNIA DEPARTMENT OF PUBLIC HEALTH (CDPH)

CDPH SECTION 01350	(2010; Version 1.1) Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources using Environmental Chambers

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA MG 1	(2021) Motors and Generators
NEMA MG 10	(2017) Energy Management Guide for Selection and Use of Fixed Frequency Medium AC Squirrel-Cage Polyphase Induction Motors
NEMA MG 11	(1977; R 2012) Energy Management Guide for Selection and Use of Single Phase Motors

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 90A	(2021) Standard for the Installation of Air Conditioning and Ventilating Systems
NFPA 701	(2023; ERTA 1 2023) Standard Methods of Fire Tests for Flame Propagation of Textiles and Films

SHEET METAL AND AIR CONDITIONING CONTRACTORS' NATIONAL ASSOCIATION (SMACNA)

SMACNA 1403	(2008) Accepted Industry Practice for Industrial Duct Construction, 2nd Edition
SMACNA 1966	(2020) HVAC Duct Construction Standards Metal and Flexible, 4th Edition

SOUTH COAST AIR QUALITY MANAGEMENT DISTRICT (SCAQMD)

SCAQMD Rule 1168	(2017) Adhesive and Sealant Applications

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

40 CFR 82	Protection of Stratospheric Ozone

UNDERWRITERS LABORATORIES (UL)

UL 6	(2022) UL Standard for Safety Electrical Rigid Metal Conduit-Steel
UL 181	(2013; Reprint Dec 2021) UL Standard for Safety Factory-Made Air Ducts and Air Connectors
UL 586	(2009; Reprint Dec 2017) UL Standard for Safety High-Efficiency Particulate, Air Filter Units
UL 705	(2017; Reprint Aug 2022) UL Standard for Safety Power Ventilators
UL 900	(2015; Reprint Aug 2022) UL Standard for SafetyStandard for Air Filter Units
UL 1995	(2015; Reprint Aug 2022) UL Standard for Safety Heating and Cooling Equipment
UL Bld Mat Dir	(updated continuously online) Building Materials Directory
UL Electrical Construction	(2012) Electrical Construction Equipment Directory

1.2 SYSTEM DESCRIPTION

Furnish ductwork, piping offsets, fittings, and accessories as required to provide a complete installation. Coordinate the work of the different trades to avoid interference between piping, equipment, structural, and electrical work. Provide complete, in place, all necessary offsets in piping and ductwork, and all fittings, and other components, required to install the work as indicated and specified.

1.2.1 Mechanical Equipment Identification

The number of charts and diagrams must be equal to or greater than the number of mechanical equipment rooms. Where more than one chart or diagram per space is required, mount these in edge pivoted, swinging leaf, extruded aluminum frame holders which open to 170 degrees.

1.2.1.1 Charts

Provide chart listing of equipment by designation numbers and capacities such as flow rates, pressure and temperature differences, heating and cooling capacities, horsepower, pipe sizes, and voltage and current characteristics.

1.2.2 Service Labeling

Label equipment, including fans, air handlers, terminal units, etc. with labels made of self-sticking, plastic film designed for permanent installation. Provide labels in accordance with the typical examples below:

SERVICE	LABEL AND TAG DESIGNATION
Air handling unit Number	AHU - _____
Control and instrument air	CONTROL AND INSTR.
Exhaust Fan Number	EF - _____
VAV Box Number	VAV - _____

Identify similar services with different temperatures or pressures. Where pressures could exceed 125 pounds per square inch, gage, include the maximum system pressure in the label. Label and arrow piping in accordance with the following:

a. Each point of entry and exit of pipe passing through walls.

b. Each change in direction, i.e., elbows, tees.

c. In congested or hidden areas and at all access panels at each point required to clarify service or indicated hazard.

d. In long straight runs, locate labels at distances within eyesight of each other not to exceed 75 feet. All labels must be visible and legible from the primary service and operating area.

For Bare or Insulated Pipes	
for Outside Diameters of	Lettering
1/2 thru 1-3/8 inch	1/2 inch
1-1/2 thru 2-3/8 inch	3/4 inch
2-1/2 inch and larger	1-1/4 inch

1.2.3 Color Coding

Color coding of all piping systems must be in accordance with ASME A13.1 .

1.3 SUBMITTALS

Government approval is required for submittals with a "G" classification. Submittals not having a "G" classification are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Detail Drawings; G

SD-03 Product Data

Metallic Flexible Duct

Insulated Nonmetallic Flexible Duct Runouts

Duct Connectors

Duct Access Doors; G

Manual Balancing Dampers; G

Diffusers

Registers and Grilles

Louvers

In-Line Centrifugal Fans

Axial Flow Fans

Air Handling Units; G

Variable Volume, Single Duct Terminal Units; G,

Indoor Air Quality for Duct Sealants

SD-06 Test Reports

Performance Tests; G

SD-07 Certificates

Ozone Depleting Substances Technician Certification

SD-08 Manufacturer's Instructions

Manufacturer's Installation Instructions

Operation and Maintenance Training

SD-10 Operation and Maintenance Data

Operation and Maintenance Manuals; G

Manual Balancing Dampers; G

In-Line Centrifugal Fans; G

Axial Flow Fans; G

Air Handling Units; G

Variable Volume, Single Duct Terminal Units; G

SD-11 Closeout Submittals

Indoor Air Quality During Construction

1.4 QUALITY ASSURANCE

Except as otherwise specified, approval of materials and equipment is based on manufacturer's published data.

a. Where materials and equipment are specified to conform to the standards of the Underwriters Laboratories, the label of or listing with reexamination in UL Bld Mat Dir, and UL 6 is acceptable as sufficient evidence that the items conform to Underwriters Laboratories requirements. In lieu of such label or listing, submit a written certificate from any nationally recognized testing agency, adequately equipped and competent to perform such services, stating that the items have been tested and that the units conform to the specified requirements. Outline methods of testing used by the specified agencies.

b. Where materials or equipment are specified to be constructed or tested, or both, in accordance with the standards of the ASTM International (ASTM), the ASME International (ASME), or other standards, a manufacturer's certificate of compliance of each item is acceptable as proof of compliance.

c. Conformance to such agency requirements does not relieve the item from compliance with other requirements of these specifications.

d. Where products are specified to meet or exceed the specified energy efficiency requirement of FEMP-designated or ENERGY STAR covered product categories, equipment selected must have as a minimum the efficiency rating identified under "Energy-Efficient Products" at http://femp.energy.gov/procurement.

1.4.1 Prevention of Corrosion

Protect metallic materials against corrosion. Provide rust-inhibiting treatment and standard finish for the equipment enclosures. Do not use aluminum in contact with earth, and where connected to dissimilar metal. Protect aluminum by approved fittings, barrier material, or treatment. Provide hot-dip galvanized ferrous parts such as anchors, bolts, braces, boxes, bodies, clamps, fittings, guards, nuts, pins, rods, shims, thimbles, washers, and miscellaneous parts not of corrosion-resistant steel or nonferrous materials in accordance with ASTM A123/A123M for exterior locations and cadmium-plated in conformance with ASTM B766 for interior locations.

1.4.2 Asbestos Prohibition

Do not use asbestos and asbestos-containing products.

1.4.3 Ozone Depleting Substances Technician Certification

All technicians working on equipment that contain ozone depleting refrigerants must be certified as a Section 608 Technician to meet requirements in 40 CFR 82, Subpart F. Provide copies of technician certifications to the Contracting Officer at least 14 calendar days prior to work on any equipment containing these refrigerants.

1.4.4 Detail Drawings

Submit detail drawings showing equipment layout, including assembly and installation details and electrical connection diagrams; ductwork layout showing the location of all supports and hangers, typical hanger details, gauge reinforcement, reinforcement spacing rigidity classification, and static pressure and seal classifications. Include any information required to demonstrate that the system has been coordinated and functions properly as a unit on the drawings and show equipment relationship to other parts of the work, including clearances required for operation and maintenance. Submit drawings showing bolt-setting information, and foundation bolts prior to concrete foundation construction for all equipment indicated or required to have concrete foundations. Submit function designation of the equipment and any other requirements specified throughout this Section with the shop drawings.

1.4.5 Test Procedures

Conduct performance tests as required in Section 23 05 93 Testing, Adjusting and Balancing for HVAC and Section 23 09 00 Instrumentation and Control for HVAC.

1.5 DELIVERY, STORAGE, AND HANDLING

Protect stored equipment at the jobsite from the weather, humidity and temperature variations, dirt and dust, or other contaminants. Additionally, cap or plug all pipes until installed.

PART 2 PRODUCTS

2.1 STANDARD PRODUCTS

Provide components and equipment that are "standard products" of a manufacturer regularly engaged in the manufacturing of products that are of a similar material, design and workmanship. "Standard products" is defined as being in satisfactory commercial or industrial use for 2 years before bid opening, including applications of components and equipment under similar circumstances and of similar size, satisfactorily completed by a product that is sold on the commercial market through advertisements, manufacturers' catalogs, or brochures. Products having less than a 2-year field service record are acceptable if a certified record of satisfactory field operation, for not less than 6000 hours exclusive of the manufacturer's factory tests, can be shown. Provide equipment items that are supported by a service organization. In product categories covered by ENERGY STAR or the Federal Energy Management Program, provide equipment that is listed on the ENERGY STAR Qualified Products List or that meets or exceeds the FEMP-designated Efficiency Requirements.

2.2 IDENTIFICATION PLATES

In addition to standard manufacturer's identification plates, provide engraved laminated phenolic identification plates for each piece of mechanical equipment. Identification plates are to designate the function of the equipment. Submit designation with the shop drawings. Provide identification plates that are layers, black-white-black, engraved to show white letters on black background. Letters must be upper case. Identification plates that are 1-1/2-inches high and smaller must be

1/16-inch thick, with engraved lettering 1/8-inch high; identification plates larger than 1-1/2-inches high must be 1/8-inch thick, with engraved lettering of suitable height. Identification plates 1-1/2-inches high and larger must have beveled edges. Install identification plates using a compatible adhesive.

2.3 EQUIPMENT GUARDS AND ACCESS

Fully enclose or guard belts, pulleys, chains, gears, couplings, projecting setscrews, keys, and other rotating parts exposed to personnel contact according to OSHA requirements. Properly guard or cover with insulation of a type specified, high temperature equipment and piping exposed to contact by personnel or where it creates a potential fire hazard.

2.4 ELECTRICAL WORK

a. Provide motors, controllers, integral disconnects, contactors, and controls with their respective pieces of equipment, except controllers indicated as part of motor control centers. Provide electrical equipment, including motors and wiring, as specified in Section 26 20 00INTERIOR DISTRIBUTION SYSTEM. Provide manual or automatic control and protective or signal devices required for the operation specified and control wiring required for controls and devices specified, but not shown. For packaged equipment, include manufacturer provided controllers with the required monitors and timed restart.

b. For single-phase motors, provide high-efficiency type, fractional-horsepower alternating-current motors, including motors that are part of a system, in accordance with NEMA MG 11. Provide premium efficiency type integral size motors in accordance with NEMA MG 1.

c. For polyphase motors, provide squirrel-cage medium induction motors, including motors that are part of a system , and that meet the efficiency ratings for premium efficiency motors in accordance with NEMA MG 1. Select premium efficiency polyphase motors in accordance with NEMA MG 10.

d. Provide motors in accordance with NEMA MG 1 and of sufficient size to drive the load at the specified capacity without exceeding the nameplate rating of the motor. Provide motors rated for continuous duty with the enclosure specified. Provide motor duty that allows for maximum frequency start-stop operation and minimum encountered interval between start and stop. Provide motor torque capable of accelerating the connected load within 20 seconds with 80 percent of the rated voltage maintained at motor terminals during one starting period. Provide motor starters complete with thermal overload protection and other necessary appurtenances. Fit motor bearings with grease supply fittings and grease relief to outside of the enclosure.

e. Where two-speed or variable-speed motors are indicated, solid-state variable-speed controllers are allowed to accomplish the same function. Use solid-state variable-speed controllers for motors rated 10 hp or less and adjustable frequency drives for larger motors. Provide variable frequency drives for motors as specified in Section 26 29 23 ADJUSTABLE SPEED DRIVE SYSTEMS UNDER 600 VOLTS.

2.5 ANCHOR BOLTS

Provide anchor bolts for equipment placed on concrete equipment pads or on concrete slabs. Bolts to be of the size and number recommended by the equipment manufacturer and located by means of suitable templates. Installation of anchor bolts must not degrade the surrounding concrete.

2.6 INDOOR AIR QUALITY

Provide equipment and components that comply with the requirements of ASHRAE 62.1 unless more stringent requirements are specified herein.

2.7 DUCT SYSTEMS

2.7.1 Metal Ductwork

Provide metal ductwork construction, including all fittings and components, that complies with SMACNA 1966, as supplemented and modified by this specification.

a. Provide radius type elbows with a centerline radius of 1.5 times the width or diameter of the duct where space permits. Otherwise, elbows having a minimum radius equal to the width or diameter of the duct or square elbows with factory fabricated turning vanes are allowed.

b. Provide ductwork that meets the requirements of Seal Class A. Provide ductwork in VAV systems upstream of the VAV boxes that meets the requirements of Seal Class A.

c. Provide sealants that conform to fire hazard classification specified in Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS and are suitable for the range of air distribution and ambient temperatures to which it is exposed. Do not use pressure sensitive tape as a sealant. Provide duct sealant products that meet either emissions requirements of CDPH SECTION 01350 (limit requirements for either office or classroom spaces regardless of space type) or VOC content requirements of SCAQMD Rule 1168 (HVAC duct sealants are classified as "Other" within the SCAQMD Rule 1168 sealants table). Provide validation of indoor air quality for duct sealants.

d. Make spiral lock seam duct, and flat oval with duct sealant and lock with not less than 3 equally spaced drive screws or other approved methods indicated in SMACNA 1966. Apply the sealant to the exposed male part of the fitting collar so that the sealer is on the inside of the joint and fully protected by the metal of the duct fitting. Apply one brush coat of the sealant over the outside of the joint to at least 2 inch band width covering all screw heads and joint gap. Dents in the male portion of the slip fitting collar are not acceptable.

e. Fabricate outdoor air intake ducts and plenums with watertight soldered or brazed joints and seams.

2.7.1.1 Metallic Flexible Duct

a. Provide duct that conforms to UL 181 and NFPA 90A with factory-applied insulation, vapor barrier, and end connections. Provide duct assembly that does not exceed 25 for flame spread and 50 for smoke developed. Provide ducts designed for working pressures of 2 inches water gauge positive and 1.5 inches water gauge negative. Provide flexible round duct length that does not exceed 5 feet. Secure connections by applying adhesive for 2 inches over rigid duct, apply flexible duct 2 inches over rigid duct, apply metal clamp, and provide minimum of three No. 8 sheet metal screws through clamp and rigid duct.

b. Inner duct core: Provide interlocking spiral or helically corrugated flexible core constructed of zinc-coated steel, aluminum, or stainless steel; or constructed of inner liner of continuous galvanized spring steel wire helix fused to continuous, fire-retardant, flexible vapor barrier film, inner duct core.

c. Insulation: Provide inner duct core that is insulated with mineral fiber blanket type flexible insulation, minimum of 1 inch thick. Provide insulation covered on exterior with manufacturer's standard fire retardant vapor barrier jacket for flexible round duct.

2.7.1.2 Insulated Nonmetallic Flexible Duct Runouts

Use flexible duct runouts only where indicated. Runout length is indicated on the drawings, and is not to exceed 5 feet. Provide runouts that are preinsulated, factory fabricated, and that comply with NFPA 90A and UL 181. Provide either field or factory applied vapor barrier. Provide not less than 20 ounce glass fabric duct connectors coated on both sides with neoprene. Where coil induction or high velocity units are supplied with vertical air inlets, use a streamlined, vaned and mitered elbow transition piece for connection to the flexible duct or hose. Provide a die-stamped elbow and not a flexible connector as the last elbow to these units other than the vertical air inlet type. Insulated flexible connectors are allowed as runouts. Provide insulated material and vapor barrier that conform to the requirements of Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS. Do not expose the insulation material surface to the air stream.

2.7.1.3 General Service Duct Connectors

Provide a flexible duct connector approximately 6 inches in width where sheet metal connections are made to fans or where ducts of dissimilar metals are connected. For round/oval ducts, secure the flexible material by stainless steel or zinc-coated, iron clinch-type draw bands. For rectangular ducts, install the flexible material locked to metal collars using normal duct construction methods. Provide a composite connector system that complies with NFPA 701 and is classified as "flame-retardent fabrics" in UL Bld Mat Dir.

2.7.2 Duct Access Doors

Provide hinged access doors conforming to SMACNA 1966 in ductwork and plenums where indicated and at all air flow measuring primaries, automatic dampers, fire dampers, coils, thermostats, and other apparatus requiring service and inspection in the duct system. Provide access doors upstream and downstream of air flow measuring primaries and heating and cooling coils. Provide doors that are a minimum 15 by 18 inches, unless otherwise shown. Where duct size does not accommodate this size door, make the doors as large as practicable. Equip doors 24 by 24 inches or larger with fasteners operable from inside and outside the duct. Use insulated type doors in insulated ducts.

2.7.3 Manual Balancing Dampers

Furnish manual balancing dampers with accessible operating mechanisms. Use chromium plated operators (with all exposed edges rounded) in finished portions of the building. Provide manual volume control dampers that are operated by locking-type quadrant operators. Install dampers that are 2 gauges heavier than the duct in which installed. Unless otherwise indicated, provide opposed blade type multileaf dampers with maximum blade width of 12 inches. Provide access doors or panels for all concealed damper operators and locking setscrews. Provide stand-off mounting brackets, bases, or adapters not less than the thickness of the insulation when the locking-type quadrant operators for dampers are installed on ducts to be thermally insulated, to provide clearance between the duct surface and the operator. Provide stand-off mounting items that are integral with the operator or standard accessory of the damper manufacturer.

2.7.4 Air Supply And Exhaust Air Dampers

Provide outdoor air supply and exhaust air dampers that have a maximum leakage rate when tested in accordance with AMCA 500-D as required by ASHRAE 90.1 - IP, including maximum Damper Leakage for:

a. Climate Zones 1,2,6,7,8 the maximum damper leakage at 1.0 inch w.g. for motorized dampers is 4 cfm per square foot of damper area and non-motorized dampers are not allowed.

b. All other Climate Zones the maximum damper leakage at 1.0 inch w.g. is 10 cfm per square foot and for non-motorized dampers is 20 cfm per square foot of damper area.

Dampers smaller than 24 inches in either direction may have leakage of 40 cfm per square foot.

2.7.5 Air Deflectors (Volume Extractors) and Branch Connections

Provide fixed air deflectors (volume extractors), also called turning vanes, in 90 degree elbows.

2.7.6 Plenums and Casings for Field-Fabricated Units

2.7.6.1 Plenum and Casings

Fabricate and erect plenums and casings as shown in SMACNA 1966, as applicable. Construct system casing of not less than 16 gauge galvanized sheet steel. Furnish cooling coil drain pans with 1 inch threaded outlet to collect condensation from the cooling coils. Fabricate drain pans from not lighter than 16 gauge steel, galvanized after fabrication or of 18 gauge corrosion-resisting sheet steel conforming to ASTM A167, Type 304, welded and stiffened. Thermally insulate drain pans exposed to the atmosphere to prevent condensation. Coat insulation with a flame resistant waterproofing material. Provide separate drain pans for each vertical coil section, and a separate drain line for each pan. Size pans to ensure capture of entrained moisture on the downstream-air side of the coil. Seal openings in the casing, such as for piping connections, to prevent air leakage. Size the water seal for the drain to maintain a pressure of at least 2 inch water gauge greater than the maximum negative pressure in the coil space.

2.7.6.2 Casing

Terminate casings at the curb line and bolt each to the curb using galvanized angle, as indicated in SMACNA 1966.

2.7.6.3 Access Doors

Provide access doors in each section of the casing. Weld doorframes in place, gasket each door with neoprene, hinge with minimum of two brass hinges, and fasten with a minimum of two brass tension fasteners operable from inside and outside of the casing. Where possible, make doors 36 by 18 inches and locate them 18 inches above the floor. Where the space available does not accommodate doors of this size, use doors as large as the space accommodates. Swing doors so that fan suction or pressure holds doors in closed position, airtight. Provide a push-button station, located inside the casing, to stop the supply.

2.7.6.4 Factory-Fabricated Insulated Sheet Metal Panels

Factory-fabricated components are allowed for field-assembled units, provided all requirements specified for field-fabricated plenums and casings are met. Provide panels of modular design, pretested for structural strength, thermal control, condensation control, and acoustical control. Seal and insulate panel joints. Provide and gasket access doors to prevent air leakage. Provide panel construction that is not less than 20 gauge galvanized sheet steel, assembled with fasteners treated against corrosion. Provide standard length panels that deflect not more than 1/2 inch under operation. Construct details, including joint sealing, not specifically covered, as indicated in SMACNA 1966. Construct the plenums and casings to withstand the specified internal pressure of the air systems.

2.7.6.5 Duct Liner

Unless otherwise specified, duct liner is not permitted.

2.7.7 Diffusers, Registers, and Grilles

Provide factory-fabricated units of aluminum that distribute the specified quantity of air evenly over space intended without causing noticeable drafts, air movement faster than 50 fpm in occupied zone, or dead spots anywhere in the conditioned area. Provide outlets for diffusion, spread, throw, and noise level as required for specified performance. Certify performance according to ASHRAE 70. Provide sound rated and certified inlets and outlets according to ASHRAE 70. Provide sound power level as indicated. Provide diffusers and registers with volume damper with accessible operator, unless otherwise indicated; or if standard with the manufacturer, an automatically controlled device is acceptable. Provide opposed blade type volume dampers for all diffusers and registers, except linear slot diffusers. Provide linear slot diffusers with round or elliptical balancing dampers. Where the inlet and outlet openings are located less than 7 feet above the floor, protect them by a grille or screen according to NFPA 90A.

2.7.7.1 Diffusers

Provide diffuser types indicated. Furnish ceiling mounted units with anti-smudge devices, unless the diffuser unit minimizes ceiling smudging through design features. Provide diffusers with air deflectors of the type indicated. Provide air handling troffers or combination light and ceiling diffusers conforming to the requirements of UL Electrical Construction for the interchangeable use as cooled or heated air supply diffusers or return air units. Install ceiling mounted units with rims tight against ceiling. Provide sponge rubber gaskets between ceiling and surface mounted diffusers for air leakage control. Provide suitable trim for flush mounted diffusers. For connecting the duct to diffuser, provide duct collar that is airtight and does not interfere with volume controller. Provide return or exhaust units that are similar to supply diffusers.

2.7.7.2 Registers and Grilles

Provide return and exhaust registers that are fixed horizontal or vertical louver type similar in appearance to the supply register face. Furnish registers with sponge-rubber gasket between flanges and wall or ceiling. Provide grilles as specified for registers, without volume control damper.

2.7.8 Louvers

Provide louvers for installation in exterior walls that are associated with the air supply and distribution system as specified in Section 08 91 00 METAL WALL LOUVERS.

2.7.9 Bird Screens and Frames

Provide bird screens that conform to ASTM E2016, No. 2 mesh, aluminum or stainless steel. Provide "medium-light" rated aluminum screens. Provide "light" rated stainless steel screens. Provide removable type frames fabricated from either stainless steel or extruded aluminum.

2.8 AIR SYSTEMS EQUIPMENT

2.8.1 Fans

Test and rate fans according to AMCA 210. Calculate system effect on air moving devices in accordance with AMCA 201 where installed ductwork differs from that indicated on drawings. Install air moving devices to minimize fan system effect. Where system effect is unavoidable, determine the most effective way to accommodate the inefficiencies caused by system effect on the installed air moving device. The sound power level of the fans must not exceed 85 dBA when tested according to AMCA 300 and rated in accordance with AMCA 301. Provide all fans with an AMCA seal. Connect fans to the motors either directly or indirectly with V-belt drive. Use V-belt drives designed for not less than 120 percent of the connected driving capacity. Provide variable pitch motor sheaves for 15 hp and below, and fixed pitch as defined by AHRI Guideline D (A fixed-pitch sheave is provided on both the fan shaft and the motor shaft. This is a non-adjustable speed drive.). Select variable pitch sheaves to drive the fan at a speed which can produce the specified capacity when set at the approximate midpoint of the sheave adjustment. When fixed pitch sheaves are furnished, provide a replaceable sheave when needed to achieve system air balance. Provide motors for V-belt drives with adjustable rails or bases. Provide removable metal guards for all exposed V-belt drives, and provide speed-test openings at the center of all rotating shafts. Provide fans with personnel screens or guards on both suction and supply ends, except that the screens need not be provided, unless otherwise indicated, where ducts are connected to the fan. Provide fan and motor assemblies with vibration-isolation supports or mountings as indicated. Use vibration-isolation units that are standard products with published loading ratings. Select each fan to produce the capacity required at the fan static pressure indicated. Provide sound power level as indicated. Obtain the sound power level values according to AMCA 300. Provide standard AMCA arrangement, rotation, and discharge as indicated. Provide power ventilators that conform to UL 705 and have a UL label.

2.8.1.1 In-Line Centrifugal Fans

Provide in-line fans with centrifugal backward inclined blades, stationary discharge conversion vanes, internal and external belt guards, and adjustable motor mounts. Mount fans in a welded tubular casing. Provide a fan that axially flows the air in and out. Streamline inlets with conversion vanes to eliminate turbulence and provide smooth discharge air flow. Enclose and isolate fan bearings and drive shafts from the air stream. Provide precision, self aligning ball or roller type fan bearings that are sealed against dust and dirt and are permanently lubricated. Provide L50 rated bearing life at not less than 200,000 hours as defined by ABMA 9 and ABMA 11. Provide motors with totally enclosed enclosure. Provide magnetic motor starters across-the-line with general-purpose enclosures.

2.8.1.2 Axial Flow Fans

Provide axial flow fans complete with drive components and belt guard, with steel housing, cast fan wheel, cast or welded steel diffusers, fan shaft, bearings, and mounting frame as a factory-assembled unit. Provide fan wheels that are dynamically balanced and keyed to the fan shaft, with radially projecting blades of airfoil cross-section. Enclose and isolate fan bearings and drive shafts from the air stream. Permanently lubricate fan bearings or provide them with accessible grease fittings. Provide precision self-aligning ball or roller type fan bearings that are sealed against dust and dirt. Provide fan bearings that have a L50 rated bearing life at not less than 200,000 hours of operation as defined by ABMA 9 and ABMA 11. Provide fan inlets with an aerodynamically shaped bell and an inlet cone. Install diffuser or straightening vanes at the fan discharge to minimize turbulence and provide smooth discharge air flow. Furnish fan unit with inlet screen, and automatic operation adjustable inlet vanes. Unless otherwise indicated, provide motors that do not exceed 1800 rpm and have totally enclosed enclosure.

2.8.2 Coils

Provide fin-and-tube type coils constructed of seamless copper tubes and aluminum or copper fins mechanically bonded or soldered to the tubes. Provide casing and tube support sheets that are not lighter than 16 gauge galvanized steel, formed to provide structural strength. When required, provide multiple tube supports to prevent tube sag. Mount coils for counterflow service. Rate and certify coils to meet the requirements of AHRI 410. Except for hot water coils, provide factory applied phenolic, vinyl or epoxy/electrodeposition coating.

2.8.2.1 Water Coils

Install water coils with a pitch of not less than 1/8 inch/foot of the tube length toward the drain end. Use headers constructed of cast iron, welded steel or copper. Furnish each coil with a plugged vent and drain connection extending through the unit casing. Provide removable water coils with drain pans. Pressure test coils in accordance with UL 1995.

2.8.3 Air Filters

List air filters according to requirements of UL 900, except list high efficiency particulate air filters of 99.97 percent efficiency by the DOP Test method under the Label Service to meet the requirements of UL 586.

2.8.3.1 Extended Surface Pleated Panel Filters

Provide 2 inch depth, sectional, disposable type filters of the size indicated with a MERV of 8 when tested according to ASHRAE 52.2. Provide initial resistance at 500 fpm that does not exceed 0.36 inches water gauge. Provide UL Class 2 filters, and nonwoven cotton and synthetic fiber mat media. Attach a wire support grid bonded to the media to a moisture resistant fiberboard frame. Bond all four edges of the filter media to the inside of the frame to prevent air bypass and increase rigidity.

2.8.3.2 Holding Frames

Fabricate frames from not lighter than 16 gauge sheet steel with rust-inhibitor coating. Equip each holding frame with suitable filter holding devices. Provide gasketed holding frame seats. Make all joints airtight.

2.8.3.3 Filter Gauges

Provide dial type filter gauges, diaphragm actuated draft for all filter stations, including those filters which are furnished as integral parts of factory fabricated air handling units. Provide gauges that are at least 3-7/8 inches in diameter, with white dials with black figures, and graduations with a minimum range of 1 inch of water beyond the specified final resistance for the filter bank on which each gauge is applied. Provide each gauge with a screw operated zero adjustment and two static pressure tips with integral compression fittings, two molded plastic vent valves, two 5 foot minimum lengths of 1/4 inch diameter aluminum tubing, and all hardware and accessories for gauge mounting.

2.9 AIR HANDLING UNITS

2.9.1 Field-Fabricated Air Handling Units

Provide built-up units as specified in paragraph DUCT SYSTEMS. Provide fans, coils spray-coil dehumidifiers, and air filters as specified in paragraph AIR SYSTEMS EQUIPMENT for types indicated.

2.9.2 Factory-Fabricated Air Handling Units

Provide single-zone draw-through type units as indicated. Units must include fans, coils, airtight insulated casing, prefilters, adjustable V-belt drives, belt guards for externally mounted motors, access sections where indicated, combination sectional filter-mixing box, vibration-isolators, and appurtenances required for specified operation. Provide vibration isolators as indicated. Physical dimensions of each air handling unit must be suitable to fit space allotted to the unit with the capacity indicated. Provide air handling unit that is rated in accordance with AHRI 430 and AHRI certified for cooling.

2.9.2.1 Casings

Provide the following:

a. Casing sections 2 inch double wall type, constructed of a minimum 18 gauge galvanized steel, or 18 gauge corrosion-resisting sheet steel conforming to ASTM A167, Type 304.Inner casing of double-wall units that are a minimum 20 gauge solid galvanized steel or corrosion-resisting sheet steel conforming to ASTM A167, Type 304. Design and construct casing with an integral insulated structural galvanized steel frame such that exterior panels are non-load bearing.

b. Individually removable exterior panels with standard tools. Removal must not affect the structural integrity of the unit. Furnish casings with access sections, according to paragraph AIR HANDLING UNITS, inspection doors, and access doors, all capable of opening a minimum of 90 degrees, as indicated.

c. Insulated, fully gasketed, double-wall type inspection and access doors, of a minimum 18 gauge outer and 20 gauge inner panels made of either galvanized steel or corrosion-resisting sheet steel conforming to ASTM A167, Type 304. Provide rigid doors with heavy duty hinges and latches. Inspection doors must be a minimum 12 inches wide by 12 inches high. Access doors must be a minimum 24 inches wide, the full height of the unit casing or a minimum of 6 foot, whichever is less.

d. Double-wall insulated type drain pan (thickness equal to exterior casing) constructed of 16 gauge corrosion resisting sheet steel conforming to ASTM A167, Type 304, conforming to ASHRAE 62.1. Construct drain pans water tight, treated to prevent corrosion, and designed for positive condensate drainage. When 2 or more cooling coils are used, with one stacked above the other, condensate from the upper coils must not flow across the face of lower coils. Provide intermediate drain pans or condensate collection channels and downspouts, as required to carry condensate to the unit drain pan out of the air stream and without moisture carryover. Construct drain pan to allow for easy visual inspection, including underneath the coil without removal of the coil and to allow complete and easy physical cleaning of the pan underneath the coil without removal of the coil. Provide coils that are individually removable from the casing.

e. Casing insulation that conforms to NFPA 90A. Insulate single-wall casing sections handling conditioned air with not less than 1 inch thick, 1-1/2 pound density coated fibrous glass material having a thermal conductivity not greater than 0.23 Btu/hr-sf-F. Insulate double-wall casing sections handling conditioned air with not less than 2 inches of the same insulation specified for single-wall casings. Foil-faced insulation is not an acceptable substitute for use with double wall casing. Seal double wall insulation completely by inner and outer panels.

f. Factory applied fibrous glass insulation that conforms to ASTM C1071, except that the minimum thickness and density requirements do not apply, and that meets the requirements of NFPA 90A. Make air handling unit casing insulation uniform over the entire casing. Foil-faced insulation is not an acceptable substitute for use on double-wall access doors and inspections doors and casing sections.

g. Duct liner material, coating, and adhesive that conforms to fire-hazard requirements specified in Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS. Protect exposed insulation edges and joints where insulation panels are butted with a metal nosing strip or coat to meet erosion resistance requirements of ASTM C1071.

h. A latched and hinged inspection door, in the fan and coil sections. Plus additional inspection doors, access doors and access sections where indicated.

2.9.2.2 Heating and Cooling Coils

Provide coils as specified in paragraph AIR SYSTEMS EQUIPMENT.

2.9.2.3 Air Filters

Provide air filters as specified in paragraph AIR SYSTEMS EQUIPMENT for types and thickness indicated.

2.9.2.4 Fans

Provide the following:

a. Fans that are double-inlet, centrifugal type with each fan in a separate scroll. Dynamically balance fans and shafts prior to installation into air handling unit, then after it has been installed in the air handling unit, statically and dynamically balance the entire fan assembly. Mount fans on steel shafts, accurately ground and finished.

b. Fan bearings that are sealed against dust and dirt and are precision self-aligning ball or roller type, with L50 rated bearing life at not less than 200,000 hours as defined by ABMA 9 and ABMA 11. Provide bearings that are permanently lubricated or lubricated type with lubrication fittings readily accessible at the drive side of the unit. Support bearings by structural shapes, or die formed sheet structural members, or support plates securely attached to the unit casing. Do not fasten bearings directly to the unit sheet metal casing. Furnish fans and scrolls with coating indicated.

2.9.2.5 Access Sections and Filter/Mixing Boxes

Provide access sections where indicated and furnish with access doors as shown. Construct access sections and filter/mixing boxes in a manner identical to the remainder of the unit casing and equip with access doors. Design mixing boxes to minimize air stratification and to promote thorough mixing of the air streams.

2.10 TERMINAL UNITS

2.10.1 Variable Air Volume (VAV) Terminal Units

a. Provide VAV terminal units that are the type, size, and capacity shown, mounted in the ceiling or wall cavity, plus units that are suitable for single duct system applications. Provide actuators and controls as specified in paragraph SUPPLEMENTAL COMPONENTS/SERVICES, subparagraph CONTROLS. For each VAV terminal unit, provide a temperature sensor in the unit discharge ductwork.

b. Provide unit enclosures that are constructed of galvanized steel not lighter than 22 gauge or aluminum sheet not lighter than 18 gauge. Provide single or multiple discharge outlets as required. Units with flow limiters are not acceptable. Provide unit air volume that is factory preset and readily field adjustable without special tools.

c. Attach a flow chart to each unit. Base acoustic performance of the terminal units upon units tested according to AHRI 880 I-P with the calculations prepared in accordance with AHRI 885. Provide sound power level as indicated. Show discharge sound power for minimum and 1-1/2 inches water gauge inlet static pressure. Provide acoustical lining according to NFPA 90A.

2.10.1.1 Variable Volume, Single Duct Terminal Units

Provide variable volume, single duct, terminal units with a calibrated air volume sensing device, air valve or damper, actuator, and accessory relays. Provide units that control air volume to within plus or minus 5 percent of each air set point volume as determined by the thermostat with variations in inlet pressures from 3/4 to 6 inch water gauge. Provide units with an internal resistance not exceeding 0.4 inch water gauge at maximum flow range. Provide external differential pressure taps separate from the control pressure taps for air flow measurement with a 0 to 1 inch water gauge range.

2.11 FACTORY PAINTING

Factory paint new equipment, which are not of galvanized construction. Paint with a corrosion resisting paint finish according to ASTM A123/A123M or ASTM A924/A924M. Clean, phosphatize and coat internal and external ferrous metal surfaces with a paint finish which has been tested according to ASTM B117, ASTM D1654, and ASTM D3359. Submit evidence of satisfactory paint performance for a minimum of 125 hours for units to be installed indoors and 500 hours for units to be installed outdoors. Provide rating of failure at the scribe mark that is not less than 6, average creepage not greater than 1/8 inch. Provide rating of the inscribed area that is not less than 10, no failure. On units constructed of galvanized steel that have been welded, provide a final shop docket of zinc-rich protective paint on exterior surfaces of welds or welds that have burned through from the interior according to ASTM D520 Type I.

Field paint factory painting that has been damaged prior to acceptance by the Contracting Officer in compliance with the requirements of paragraph FIELD PAINTING OF MECHANICAL EQUIPMENT.

2.12 SUPPLEMENTAL COMPONENTS/SERVICES

2.12.1 Condensate Drain Lines

Provide and install condensate drainage for each item of equipment that generates condensate in accordance with Section 23 64 26 CHILLED, CHILLED-HOT, AND CONDENSER WATER PIPING SYSTEMS except as modified herein.

2.12.2 Backflow Preventers

The requirements for backflow preventers are specified in Section 22 00 00 PLUMBING, GENERAL PURPOSE.

2.12.3 Controls

The requirements for controls are specified in Section 23 05 93 TESTING, ADJUSTING, AND BALANCING OF HVAC SYSTEMS and Section 23 09 00 INSTRUMENTATION AND CONTROL FOR HVAC.

PART 3 EXECUTION

3.1 EXAMINATION

After becoming familiar with all details of the work, verify all dimensions in the field, and advise the Contracting Officer of any discrepancy before performing the work.

3.2 INSTALLATION

a. Install materials and equipment in accordance with the requirements of the contract drawings and approved manufacturer's installation instructions. Accomplish installation by workers skilled in this type of work. Perform installation so that there is no degradation of the designed fire ratings of walls, partitions, ceilings, and floors.

b. No installation is permitted to block or otherwise impede access to any existing machine or system. Install all hinged doors to swing open a minimum of 120 degrees. Provide an area in front of all access doors that clears a minimum of the manufacturer's required maintenance access. feet. In front of all access doors to electrical circuits, clear the area the minimum distance to energized circuits as specified in OSHA Standards, part 1910.333 (Electrical-Safety Related work practices)and an additional 3 feet.

c. Except as otherwise indicated, install emergency switches and alarms in conspicuous locations. Mount all indicators, to include gauges, meters, and alarms in order to be easily visible by people in the area.

3.2.1 Condensate Drain Lines

Provide water seals in the condensate drain from all units. Provide a depth of each seal of 2 inches plus the number of inches, measured in water gauge, of the total static pressure rating of the unit to which the drain is connected. Provide water seals that are constructed of 2 tees and an appropriate U-bend with the open end of each tee plugged. Provide pipe cap or plug cleanouts where indicated. Connect drains indicated to connect to the sanitary waste system using an indirect waste fitting. Insulate air conditioner drain lines as specified in Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS.

3.2.2 Equipment and Installation

Provide frames and supports for tanks, compressors, pumps, valves, air handling units, fans, coils, dampers, and other similar items requiring supports. Floor mount or ceiling hang air handling units as indicated. Anchor and fasten as detailed. Set floor-mounted equipment on not less than 6 inch concrete pads or curbs doweled in place unless otherwise indicated. Make concrete foundations heavy enough to minimize the intensity of the vibrations transmitted to the piping, duct work and the surrounding structure, as recommended in writing by the equipment manufacturer. In lieu of a concrete pad foundation, build a concrete pedestal block with isolators placed between the pedestal block and the floor. Make the concrete foundation or concrete pedestal block a mass not less than three times the weight of the components to be supported. Provide the lines connected to the pump mounted on pedestal blocks with flexible connectors. Submit foundation drawings as specified in paragraph DETAIL DRAWINGS.

3.2.3 Access Panels

Install access panels for concealed valves, vents, controls, dampers, and items requiring inspection or maintenance of sufficient size, and locate them so that the concealed items are easily serviced and maintained or completely removed and replaced.

3.2.4 Flexible Duct

Install pre-insulated flexible duct in accordance with the latest printed instructions of the manufacturer to ensure a vapor tight joint. Provide hangers, when required to suspend the duct, of the type recommended by the duct manufacturer and set at the intervals recommended.

3.2.5 Metal Ductwork

Install according to SMACNA 1966 unless otherwise indicated. Install duct supports for sheet metal ductwork according to SMACNA 1966, unless otherwise specified. Do not use friction beam clamps indicated in SMACNA 1966. Anchor risers on high velocity ducts in the center of the vertical run to allow ends of riser to move due to thermal expansion. Erect supports on the risers that allow free vertical movement of the duct. Attach supports only to structural framing members and concrete slabs. Do not anchor supports to metal decking unless a means is provided and approved for preventing the anchor from puncturing the metal decking. Where supports are required between structural framing members, provide suitable intermediate metal framing. Where C-clamps are used, provide retainer clips.

3.2.6 FRP Ductwork

Provide fibrous glass reinforced plastic ducting and related structures that conform to SMACNA 1403. Provide flanged joints where indicated. Crevice-free butt lay-up joints are acceptable where flanged joints are not indicated. When ambient temperatures are lower than 50 degrees F, heat cure joints by exothermic reaction heat packs.

3.2.7 Insulation

Provide thickness and application of insulation materials for ductwork, piping, and equipment according to Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS. Externally insulate outdoor air intake ducts and plenums.

3.2.8 Duct Test Holes

Provide holes with closures or threaded holes with plugs in ducts and plenums as indicated or where necessary for the use of pitot tube in balancing the air system. Plug insulated duct at the duct surface, patched over with insulation and then marked to indicate location of test hole if needed for future use.

3.2.9 Power Transmission Components Adjustment

Test V-belts and sheaves for proper alignment and tension prior to operation and after 72 hours of operation at final speed. Uniformly load belts on drive side to prevent bouncing. Make alignment of direct driven couplings to within 50 percent of manufacturer's maximum allowable range of misalignment.

3.3 EQUIPMENT PADS

Provide equipment pads to the dimensions shown or, if not shown, to conform to the shape of each piece of equipment served with a minimum 3-inch margin around the equipment and supports. Allow equipment bases and foundations, when constructed of concrete or grout, to cure a minimum of 14 calendar days before being loaded.

3.4 CUTTING AND PATCHING

Install work in such a manner and at such time that a minimum of cutting and patching of the building structure is required. Make holes in exposed locations, in or through existing floors, by drilling and smooth by sanding. Use of a jackhammer is permitted only where specifically approved. Make holes through masonry walls to accommodate sleeves with an iron pipe masonry core saw.

3.5 CLEANING

Thoroughly clean surfaces of piping and equipment that have become covered with dirt, plaster, or other material during handling and construction before such surfaces are prepared for final finish painting or are enclosed within the building structure. Before final acceptance, clean mechanical equipment, including piping, ducting, and fixtures, and free from dirt, grease, and finger marks. When the work area is in an occupied space such as office, protect all furniture and equipment from dirt and debris. Incorporate housekeeping for field construction work which leaves all furniture and equipment in the affected area free of construction generated dust and debris; and, all floor surfaces vacuum-swept clean.

3.6 PENETRATIONS

Provide sleeves and prepared openings for duct mains, branches, and other penetrating items, and install during the construction of the surface to be penetrated. Cut sleeves flush with each surface. Place sleeves for round duct 15 inches and smaller. Build framed, prepared openings for round duct larger than 15 inches and square, rectangular or oval ducts. Sleeves and framed openings are also required where grilles, registers, and diffusers are installed at the openings. Provide one inch clearance between penetrating and penetrated surfaces except at grilles, registers, and diffusers. Pack spaces between sleeve or opening and duct or duct insulation with mineral fiber conforming with ASTM C553, Type 1, Class B-2.

3.6.1 Sleeves

Fabricate sleeves, except as otherwise specified or indicated, from 20 gauge thick mill galvanized sheet metal. Where sleeves are installed in bearing walls or partitions, provide black steel pipe conforming with ASTM A53/A53M, Schedule 20.

3.6.2 Framed Prepared Openings

Fabricate framed prepared openings from 20 gauge galvanized steel, unless otherwise indicated.

3.6.3 Insulation

Provide duct insulation in accordance with Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS continuous through sleeves and prepared openings.

3.6.4 Firestopping

Where ducts pass through fire-rated walls, fire partitions, and fire rated chase walls, seal the penetration with fire stopping materials as specified in Section 07 84 00 FIRESTOPPING.

3.7 FIELD PAINTING OF MECHANICAL EQUIPMENT

Clean, pretreat, prime and paint metal surfaces; except aluminum surfaces need not be painted. Apply coatings to clean dry surfaces. Clean the surfaces to remove dust, dirt, rust, oil and grease by wire brushing and solvent degreasing prior to application of paint, except clean to bare metal on metal surfaces subject to temperatures in excess of 120 degrees F. Where more than one coat of paint is specified, apply the second coat after the preceding coat is thoroughly dry. Lightly sand damaged painting and retouch before applying the succeeding coat. Provide aluminum or light gray finish coat.

3.7.1 Temperatures less than 120 degrees F

Immediately after cleaning, apply one coat of pretreatment primer applied to a minimum dry film thickness of 0.3 mil, one coat of primer applied to a minimum dry film thickness of one mil; and two coats of enamel applied to a minimum dry film thickness of one mil per coat to metal surfaces subject to temperatures less than 120 degrees F.

3.8 IDENTIFICATION SYSTEMS

Provide identification tags made of brass, engraved laminated plastic, or engraved anodized aluminum, indicating service and item number on all valves and dampers. Provide tags that are 1-3/8 inch minimum diameter with stamped or engraved markings. Make indentations black for reading clarity. Attach tags to valves with No. 12 AWG 0.0808-inch diameter corrosion-resistant steel wire, copper wire, chrome-plated beaded chain or plastic straps designed for that purpose.

3.9 DUCTWORK LEAK TEST

The requirements for ductwork leak tests are specified in Section 23 05 93 TESTING, ADJUSTING AND BALANCING FOR HVAC.

3.10 TESTING, ADJUSTING, AND BALANCING

The requirements for testing, adjusting, and balancing are specified in Section 23 05 93 TESTING, ADJUSTING AND BALANCING FOR HVAC. Begin testing, adjusting, and balancing only when the air supply and distribution, including controls, has been completed, with the exception of performance tests.

3.11 PERFORMANCE TESTS

Conduct performance tests as required in Section 23 05 93 Testing, Adjusting and Balancing for HVAC and Section 23 09 00 Instrumentation and Control for HVAC.

3.12 CLEANING AND ADJUSTING

Provide a temporary bypass for water coils to prevent flushing water from passing through coils. Thoroughly clean ducts, plenums, and casing of debris and blow free of small particles of rubbish and dust and then vacuum clean before installing outlet faces. Wipe equipment clean, with no traces of oil, dust, dirt, or paint spots. Provide temporary filters prior to startup of all fans that are operated during construction, and provide new filters after all construction dirt has been removed from the building, and the ducts, plenums, casings, and other items specified have been vacuum cleaned. Perform and document that proper "Indoor Air Quality During Construction" procedures have been followed; provide documentation showing that after construction ends, and prior to occupancy, new filters were provided and installed. Maintain system in this clean condition until final acceptance. Properly lubricate bearings with oil or grease as recommended by the manufacturer. Tighten belts to proper tension. Adjust control valves and other miscellaneous equipment requiring adjustment to setting indicated or directed. Adjust fans to the speed indicated by the manufacturer to meet specified conditions. Maintain all equipment installed under the contract until close out documentation is received, the project is completed and the building has been documented as beneficially occupied.

3.13 OPERATION AND MAINTENANCE

3.13.1 Operation and Maintenance Manuals

Submit six manuals at least 2 weeks prior to field training. Submit data complying with the requirements specified in Section 01 78 23 OPERATION AND MAINTENANCE DATA. Submit Data Package 3 for the items/units listed under SD-10 Operation and Maintenance Data

3.13.2 Operation And Maintenance Training

Conduct a training course for the members of the operating staff as designated by the Contracting Officer. Make the training period consist of a total of 8 hours of normal working time and start it after all work specified herein is functionally completed and the Performance Tests have been approved. Conduct field instruction that covers all of the items contained in the Operation and Maintenance Manuals as well as demonstrations of routine maintenance operations. Submit the proposed On-site Training schedule concurrently with the Operation and Maintenance Manuals and at least 14 days prior to conducting the training course.

-- End of Section --

SECTION 23 64 10

WATER CHILLERS, VAPOR COMPRESSION TYPE
11/16, CHG 2: 08/18

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AIR-CONDITIONING, HEATING AND REFRIGERATION INSTITUTE (AHRI)

AHRI 550/590 I-P	(2020) Performance Rating Of Water-Chilling and Heat Pump Water-Heating Packages Using the Vapor Compression Cycle

AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS (ASHRAE)

ANSI/ASHRAE 15 & 34	(2013) ANSI/ASHRAE Standard 15-Safety Standard for Refrigeration Systems and ANSI/ASHRAE Standard 34-Designation and Safety Classification of Refrigerants

AMERICAN WELDING SOCIETY (AWS)

AWS Z49.1	(2021) Safety in Welding and Cutting and Allied Processes

ASTM INTERNATIONAL (ASTM)

ASTM B117	(2019) Standard Practice for Operating Salt Spray (Fog) Apparatus
ASTM D520	(2000; R 2011) Zinc Dust Pigment
ASTM E84	(2020) Standard Test Method for Surface Burning Characteristics of Building Materials

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA MG 1	(2021) Motors and Generators
NEMA MG 11	(1977; R 2012) Energy Management Guide for Selection and Use of Single Phase Motors

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

40 CFR 82	Protection of Stratospheric Ozone

1.2 SUBMITTALS

Government approval is required for submittals with a "G" classification. Submittals not having a "G" classification are for Contractor Quality

Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Water Chiller; G

Posted Instructions

Verification of Dimensions

Factory Tests

System Performance Tests

Demonstrations

Refrigerant

SD-06 Test Reports

Factory Tests

System Performance Tests

SD-07 Certificates

Ozone Depleting Substances Technician Certification

SD-08 Manufacturer's Instructions

Water Chiller - Installation Instructions; G

SD-10 Operation and Maintenance Data

Operation and Maintenance Manuals; G

SD-11 Closeout Submittals

Indoor Air Quality During Construction

1.3 CERTIFICATIONS

1.3.1 Ozone Depleting Substances Technician Certification

All technicians working on equipment that contain ozone depleting refrigerants must be certified as a Section 608 Technician to meet requirements in 40 CFR 82, Subpart F. Provide copies of technician certifications to the Contracting Officer at least 14 calendar days prior to work on any equipment containing these refrigerants.

1.4 SAFETY REQUIREMENTS

Exposed moving parts, parts that produce high operating temperature, parts which may be electrically energized, and parts that may be a hazard to operating personnel must be insulated, fully enclosed, guarded, or fitted with other types of safety devices. Safety devices must be installed so that proper operation of equipment is not impaired. Welding and cutting safety requirements must be in accordance with AWS Z49.1.

1.5 DELIVERY, STORAGE, AND HANDLING

Stored items must be protected from the weather, humidity and temperature variations, dirt and dust, or other contaminants. Proper protection and care of all material both before and during installation will be the Contractor's responsibility. Any materials found to be damaged must be replaced at the Contractor's expense. During installation, piping and similar openings must be capped to keep out dirt and other foreign matter.

1.6 PROJECT REQUIREMENTS

1.6.1 Verification of Dimensions

The Contractor must become familiar with all details of the work, verify all dimensions in the field, and advise the Contracting Officer of any discrepancy before performing any work.

PART 2 PRODUCTS

2.1 STANDARD COMMERCIAL PRODUCTS

Materials and equipment will be standard Commercial cataloged products of a manufacturer regularly engaged in the manufacturing of such products, which are of a similar material, design and workmanship. These products must have a two year record of satisfactory field service prior to bid opening. The two year record of service must include applications of equipment and materials under similar circumstances and of similar size. Products having less than a two year record of satisfactory field service will be acceptable if a certified record of satisfactory field service for not less than 6000 hours can be shown. The 6000 hour service record must not include any manufacturer's prototype or factory testing. Satisfactory field service must have been completed by a product that has been, and presently is being sold or offered for sale on the commercial market through the following copyrighted means: advertisements, manufacturer's catalogs, or brochures.

2.2 MANUFACTURER'S STANDARD NAMEPLATES

Major equipment including chillers, compressors, compressor drivers, condensers, water coolers, receivers, refrigerant leak detectors, heat exchanges, fans, and motors must have the manufacturer's name, address, type or style, model or serial number, and catalog number on a plate secured to the item of equipment. Plates must be durable and legible throughout equipment life. Plates must be fixed in prominent locations with nonferrous screws or bolts.

2.3 ELECTRICAL WORK

a. Provide motors, controllers, integral disconnects, contactors, and controls with their respective pieces of equipment, except controllers indicated as part of motor control centers. Provide electrical equipment, including motors and wiring, as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Manual or automatic control and protective or signal devices required for the operation specified and control wiring required for controls and devices specified, but not shown, must be provided. For packaged equipment, the manufacturer must provide controllers including the required monitors and timed restart.

b. For single-phase motors, provide high-efficiency type, fractional-horsepower alternating-current motors, including motors that are part of a system, in accordance with NEMA MG 11.

c. For polyphase motors, provide squirrel-cage medium induction motors, including motors that are part of a system, and that meet the efficiency ratings for premium efficiency motors in accordance with NEMA MG 1.

d. Provide motors in accordance with NEMA MG 1 and of sufficient size to drive the load at the specified capacity without exceeding the nameplate rating of the motor. Motors must be rated for continuous duty with the enclosure specified. Motor duty requirements must allow for maximum frequency start-stop operation and minimum encountered interval between start and stop. Motor torque must be capable of accelerating the connected load within 20 seconds with 80 percent of the rated voltage maintained at motor terminals during one starting period. Provide motor starters complete with thermal overload protection and other necessary appurtenances. Motor enclosure type may be either TEAO or TEFC.

e. Where two-speed motors are indicated, variable-speed controllers may be provided to accomplish the same function. Provide variable frequency drives for motors as specified in Section 26 29 23 ADJUSTABLE SPEED DRIVE (ASD) SYSTEMS UNDER 600 VOLTS.

f. Provide inverter duty premium efficiency motors for use with variable frequency drives.

2.4 SELF-CONTAINED WATER CHILLERS, VAPOR COMPRESSION TYPE

Unless necessary for delivery purposes, units must be assembled, leak-tested, charged (refrigerant and oil), and adjusted at the factory. In lieu of delivery constraints, a chiller may be assembled, leak-tested, charged (refrigerant and oil), and adjusted at the job site by a factory representative. Unit components delivered separately must be sealed and charged with a nitrogen holding charge. Parts weighing 50 pounds or more which must be removed for inspection, cleaning, or repair, such as motors, gear boxes, cylinder heads, casing tops, condenser, and cooler heads, must have lifting eyes or lugs. Chiller must be provided with a single point wiring connection for incoming power supply. Chiller's condenser and water cooler must be provided with standard water boxes with flanged connections.

2.4.1 Scroll, Reciprocating, or Rotary Screw Type

Chiller must be certified for performance per AHRI 550/590 I-P. If specified performance is outside of the Application Rating Conditions of AHRI 550/590 I-P, Table 2 then the chiller's performance must be rated in accordance with AHRI 550/590 I-P. Chiller must conform to ANSI/ASHRAE 15 & 34. As a minimum, chiller must include the following components as defined in paragraph CHILLER COMPONENTS.

a. Refrigerant and oil

b. Structural base

c. Chiller refrigerant circuit

d. Controls package

e. Scroll, reciprocating, or rotary screw compressor

f. Compressor driver, electric motor

g. Compressor driver connection

h. Water cooler (evaporator)

i. Air-cooled condenser coil

2.5 CHILLER COMPONENTS

2.5.1 Refrigerant and Oil

Refrigerants must be one of the fluorocarbon gases. Refrigerants must have number designations and safety classifications in accordance with ANSI/ASHRAE 15 & 34. CFC-based refrigerants are prohibited. Refrigerants must have an Ozone Depletion Potential (ODP) no greater than 0.0, with the exception of R-123. Provide SDS sheets for all refrigerants.

2.5.2 Structural Base

Chiller and individual chiller components must be provided with a factory-mounted structural steel base (welded or bolted) or support legs. Chiller and individual chiller components must be isolated from the building structure by means of vibration isolators with published load ratings. Vibration isolators must have isolation characteristics as recommended by the manufacturer for the unit supplied and the service intended.

2.5.3 Chiller Refrigerant Circuit

Chiller refrigerant circuit must be completely piped and factory leak tested in accordance with ANSI/ASHRAE 15 & 34. Circuit must include as a minimum a combination filter and drier, combination sight glass and moisture indicator, an electronic or thermostatic expansion valve with external equalizer or float valve, charging ports, compressor service valves for field-serviceable compressors, and superheat adjustment.

2.5.4 Controls Package

Provide chillers with a complete factory-mounted, microprocessor based operating and safety control system. Controls package must contain as a minimum a digital display, an on-auto-off switch, motor starters, disconnect switches, power wiring, and control wiring. Controls package must provide operating controls, monitoring capabilities, programmable setpoints, safety controls, and BAS interfaces as defined below.

2.5.4.1 Operating Controls

Chiller must be provided with the following adjustable operating controls as a minimum.

a. Leaving chilled water temperature control

b. Adjustable timer or automated controls to prevent a compressor from short cycling

c. Automatic lead/lag controls (adjustable) for multi-compressor units

d. Load limiting

e. System capacity control to adjust the unit capacity in accordance with the system load and the programmable setpoints. Controls must automatically re-cycle the chiller on power interruption.

f. Startup and head pressure controls to allow system operation at all ambient temperatures down to 0 degrees F.

2.5.4.2 Monitoring Capabilities

During normal operations, the control system must be capable of monitoring and displaying the following operating parameters. Access and operation of display must not require opening or removing any panels or doors.

a. Entering and leaving chilled water temperatures

c. Self diagnostic

d. Operation status

e. Operating hours

f. Number of starts

g. Compressor status (on or off)

h. Compressor load (percent)

i. Refrigerant discharge and suction pressures

j. Magnetic bearing levitation status (if applicable)

k. Magnetic bearing temperatures (if applicable)

l. Oil pressure

2.5.4.3 Configurable Setpoints

The control system must be capable of being configured directly at the unit's interface panel. No parameters may be capable of being changed without first entering a security access code. The programmable setpoints must include the following as a minimum:

a. Leaving Chilled Water Temperature

a. Time Clock/Calendar Date

2.5.4.4 Safety Controls with Manual Reset

Chiller must be provided with the following safety controls which automatically shutdown the chiller and which require manual reset.

a. Low chilled water temperature protection

b. High condenser refrigerant discharge pressure protection

c. Low evaporator pressure protection

d. Chilled water flow detection

e. High motor winding temperature protection

f. Low oil flow protection if applicable

g. Magnetic bearing controller (MBC), Internal fault (if applicable)

h. MBC, High bearing temperature (if applicable)

i. MBC, Communication fault (if applicable)

j. MBC, Power supply fault (if applicable)

2.5.4.5 Safety Controls with Automatic Reset

Chiller must be provided with the following safety controls which automatically shutdown the chiller and which provide automatic reset.

a. Over/under voltage protection

b. Chilled water flow interlock

c. MBC, Vibration (if applicable)

d. MBC, No levitation (if applicable)

2.5.4.6 Remote Alarm

During the initiation of a safety shutdown, a chiller's control system must be capable of activating a remote alarm bell. In coordination with the chiller, the Contractor must provide an alarm circuit (including transformer if applicable) and a minimum 4 inch diameter alarm bell. Alarm circuit must activate bell in the event of machine shutdown due to the chiller's monitoring of safety controls. The alarm bell must not sound for a chiller that uses low-pressure cutout as an operating control.

2.5.4.7 Utility Monitoring and Control System Interface

Provide a Utility Monitoring and Control System (UMCS) interface meeting the requirements of Section 23 09 00 INSTRUMENTATION AND CONTROL FOR HVAC and the requirements of Section 23 09 23.02 BACNET DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS. The interface must provide all system operating conditions, capacity controls, and safety shutdown conditions as network points. In addition, the following points must be overridable via the network interface:

a. Unit Start/Stop

b. Leaving Chilled Water Temperature Setpoint

2.5.5 Compressor(s)

2.5.5.1 Scroll Compressor(s)

Compressors must be of the hermetically sealed design. Compressors must be mounted on vibration isolators to minimize vibration and noise. Rotating parts must be statically and dynamically balanced at the factory to minimize vibration. Lubrication system must be centrifugal pump type equipped with a means for determining oil level and an oil charging valve. Crankcase oil heater must be provided.

2.5.6 Compressor Driver, Electric Motor

Components such as motors, starters, and wiring must be in accordance with paragraph ELECTRICAL WORK. Motor starter must be unit mounted as indicated with starter type, wiring, and accessories coordinated with the chiller manufacturer.

2.5.7 Water Cooler (Evaporator)

Cooler must be of the shell-and-coil or shell-and-tube type design. Cooler shell must be constructed of seamless or welded steel. Coil bundles must be totally removable and arranged to drain completely. Tubes must be seamless copper, plain, integrally finned with smooth bore or integrally finned with enhanced bore. Each tube must be individually replaceable. Tubes must be installed into carbon mild steel tube sheets by rolling. Tube baffles must be properly spaced to provide adequate tube support and cross flow. Performance must be based on a water velocity not less than 3 fps nor more than 12 fps and a fouling factor per AHRI 550/590 I-P.

Brazed plate heat exchanger must be constructed of 304 or 316 stainless steel, designed to a refrigerant-side working pressure of 430 psig and a waterside working pressure of 150 psig. Evaporator must be factory tested at 1.1 times maximum allowable refrigerant side working pressure and 1.5 times maximum allowable water side working pressure. Provide cooler with factory-installed flow switches. All water connections must use either flanged or grooved-pipe connections. Factory insulate all cold surfaces.

2.5.8 Air-Cooled Condenser Coil

The condenser coil must be of the microchannel heat exchanger technology (MCHX) type consisting of a series of flat tubes containing a series of multiple, parallel flow microchannels layered between the refrigerant manifolds in a two-pass arrangement. Provide coils constructed of aluminum alloys for fins, tubes, and manifolds. Coil must be factory leak and pressure tested after assembly in accordance with ANSI/ASHRAE 15 & 34.

Coil must be entirely coated in accordance with the requirements of paragraph COIL CORROSION PROTECTION.

2.6 FABRICATION

2.6.1 Factory Coating

Unless otherwise specified, equipment and component items, when fabricated from ferrous metal, must be factory finished with the manufacturer's standard finish, except that items located outside of buildings must have weather resistant finishes that will withstand 500 hours exposure to the salt spray test specified in ASTM B117 using a 5 percent sodium chloride solution. Immediately after completion of the test, the specimen must show no signs of blistering, wrinkling, cracking, or loss of adhesion and no sign of rust creepage beyond 1/8 inch on either side of the scratch mark. Cut edges of galvanized surfaces where hot-dip galvanized sheet steel is used must be coated with a zinc-rich coating conforming to ASTM D520, Type I.

2.6.2 Factory Applied Insulation

Chiller must be provided with factory installed insulation on surfaces subject to sweating including the water cooler, suction line piping, economizer, and cooling lines. Insulation on heads of coolers may be field applied, however it must be installed to provide easy removal and replacement of heads without damage to the insulation. Where motors are the gas-cooled type, factory installed insulation must be provided on the cold-gas inlet connection to the motor per manufacturer's standard practice. Factory insulated items installed outdoors are not required to be fire-rated. As a minimum, factory insulated items installed indoors must have a flame spread index no higher than 75 and a smoke developed index no higher than 150. Factory insulated items (no jacket) installed indoors and which are located in air plenums, in ceiling spaces, and in attic spaces must have a flame spread index no higher than 25 and a smoke developed index no higher than 50. Flame spread and smoke developed indexes must be determined by ASTM E84. Insulation must be tested in the same density and installed thickness as the material to be used in the actual construction. Material supplied by a manufacturer with a jacket must be tested as a composite material. Jackets, facings, and adhesives must have a flame spread index no higher than 25 and a smoke developed index no higher than 50 when tested in accordance with ASTM E84.

2.6.3 Coil Corrosion Protection

Provide coil with a uniformly applied epoxy electrodeposition type coating to all coil surface areas without material bridging between fins. Submit product data on the type coating selected, the coating thickness, the application process used, the estimated heat transfer loss of the coil, and verification of conformance with the salt spray test requirement. Coating must be applied at either the coil or coating manufacturer's factory. Coating process must ensure complete coil encapsulation. Coating must be capable of withstanding a minimum 3,000 hours exposure to the salt spray test specified in ASTM B117 using a 5 percent sodium chloride solution.

2.7 FACTORY TESTS

2.7.1 Chiller Performance Test

The Contractor and proposed chiller manufacturer shall be responsible for performing the chiller factory test to validate the specified full load capacity, full load EER, in accordance with AHRI 550/590 I-P except as indicated. The Contractor and chiller manufacturer must provide to the Government a certified chiller factory test report in accordance with AHRI 550/590 I-P to confirm that the chiller performs as specified. Tests must be conducted in an AHRI certified test facility in conformance with AHRI 550/590 I-P procedures and tolerances, except as indicated. At a minimum, chiller capacity must be validated to meet the scheduled requirements indicated on the drawings. Tolerance or deviation must be in strict accordance with AHRI 550/590 I-P. Stable operation at minimum load of 10 percent of total capacity must be demonstrated during the factory test.

2.7.1.1 Temperature Adjustments

Temperature adjustments must adhere to AHRI 550/590 I-P to adjust from the design fouling factor to the clean tube condition. Test temperature adjustments must be verified prior to testing by the manufacturer. There must be no exceptions to conducting the test with clean tubes with the temperature adjustments per AHRI 550/590 I-P. The manufacturer must clean the tubes prior to testing to obtain a test fouling factor of 0.0000.

2.7.1.2 Test Instrumentation

The factory test instrumentation must be per AHRI 550/590 I-P and the calibration must be traceable to the National Institute of Standards and Technology.

2.7.1.3 Equipment Adjustments

If the equipment fails to perform within allowable tolerances, the manufacturer must be allowed to make necessary revisions to his equipment and retest as required. The manufacturer shall assume all expenses incurred by the Government to witness the retest.

PART 3 EXECUTION

3.1 INSTALLATION

Installation of water chiller systems including materials, installation, workmanship, fabrication, assembly, erection, examination, inspection, and testing must be in accordance with the manufacturer's written installation instructions, including the following:

(1) Water chiller - installation instructions

3.1.1 Installation Instructions

Provide manufacturer's standard catalog data, at least 5 weeks prior to the purchase or installation of a particular component, highlighted to show features such as materials, dimensions, options, performance and efficiency. Data must include manufacturer's recommended installation instructions and procedures. Data must be adequate to demonstrate compliance with contract requirements.

3.1.2 Vibration Isolation

If vibration isolation is specified for a unit, vibration isolator literature must be included containing catalog cuts and certification that the isolation characteristics of the isolators provided meet the manufacturer's recommendations.

3.1.3 Posted Instructions

Provide posted instructions, including equipment layout, wiring and control diagrams, piping, valves and control sequences, and typed condensed operation instructions. The condensed operation instructions must include preventative maintenance procedures, methods of checking the system for normal and safe operation, and procedures for safely starting and stopping the system. The posted instructions must be framed under glass or laminated plastic and be posted where indicated by the Contracting Officer.

3.1.4 Verification of Dimensions

Provide a letter including the date the site was visited, conformation of existing conditions, and any discrepancies found.

3.1.5 System Performance Test Schedules

Provide a schedule, at least 2 weeks prior to the start of related testing, for the system performance tests. The schedules must identify the proposed date, time, and location for each test.

3.1.6 Certificates

Where the system, components, or equipment are specified to comply with requirements of AGA, NFPA, ARI, ASHRAE, ASME, or UL, proof of such compliance must be provided. The label or listing of the specified agency must be acceptable evidence. In lieu of the label or listing, a written certificate from an approved, nationally recognized testing organization equipped to perform such services, stating that the items have been tested and conform to the requirements and testing methods of the specified agency may be submitted. When performance requirements of this project's drawings and specifications vary from standard ARI rating conditions, computer printouts, catalog, or other application data certified by ARI or a nationally recognized laboratory as described above must be included. If ARI does not have a current certification program that encompasses such application data, the manufacturer may self certify that his application data complies with project performance requirements in accordance with the specified test standards.

3.1.7 Operation and Maintenance Manuals

Provide Six complete copies of an operation manual in bound 8 1/2 by 11 inch booklets listing step-by-step procedures required for system startup, operation, abnormal shutdown, emergency shutdown, and normal shutdown at least 4 weeks prior to the first training course. The booklets must include the manufacturer's name, model number, and parts list. The manuals must include the manufacturer's name, model number, service manual, and a brief description of all equipment and their basic operating features. Six complete copies of maintenance manual in bound 8 1/2 by 11 inch booklets listing routine maintenance procedures, possible breakdowns and repairs, and a trouble shooting guide. The manuals must include piping and equipment layouts and simplified wiring and control diagrams of the system as installed.

3.1.8 Field Applied Insulation

Field installed insulation must be as specified in Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS, except as defined differently herein.

3.2 FACTORY TEST SCHEDULING AND REPORTS

Provide schedules which identify the date, time, and location for each test. Schedules must be submitted for the Chiller Performance Tests.

Six copies of the certified test report must be forwarded to the Government for approval prior to project acceptance. Calibration curves and information sheets for all instrumentation must be included. Provide copies in bound 8 1/2 by 11 inch booklets. Reports must certify the compliance with performance requirements and follow the format of the required testing standard for the Chiller Performance Tests . Test report must include certified calibration report of all test instrumentation. Calibration report must include certification that all test instrumentation has been calibrated within 6 months prior to the test date, identification of all instrumentation, and certification that all instrumentation complies with requirements of the test standard. Test report must be submitted 1 week after completion of the factory test.

3.3 MANUFACTURER'S FIELD SERVICE

The services of a factory-trained representative must be provided for 3 days. The representative shall advise on the following:

a. Hermetic machines:

(1) Testing hermetic water-chilling unit under pressure for refrigerant leaks; evacuation and dehydration of machine to an absolute pressure of not over 300 micrometers.

(2) Charging the machine with refrigerant.

(3) Starting the machine.

b. Open Machines:

(1) Erection, alignment, testing, and dehydrating.

(2) Charging the machine with refrigerant.

(3) Starting the machine.

3.4 CLEANING AND ADJUSTING

Equipment must be wiped clean, with all traces of oil, dust, dirt, or paint spots removed. Provide temporary filters for all fans that are operated during construction. Perform and document that proper Indoor Air Quality During Construction procedures have been followed; this includes providing documentation showing that after construction ends, and prior to occupancy, new filters were provided and installed. System must be maintained in this clean condition until final acceptance. Bearings must be properly lubricated with oil or grease as recommended by the manufacturer. Belts must be tightened to proper tension. Control valves and other miscellaneous equipment requiring adjustment must be adjusted to setting indicated or directed. Fans must be adjusted to the speed indicated by the manufacturer to meet specified conditions. At least one week before the official equipment warranty start date, all condenser coils on air-cooled water chillers and split-system water chillers must be cleaned in accordance with the chiller manufacturer's instructions. This work covers two coil cleanings. The condenser coils must be cleaned with an approved coil cleaner by a service technician, factory trained by the chiller manufacturer. The condenser coil cleaner must not have any detrimental affect on the materials or protective coatings on the condenser coils. Testing, adjusting, and balancing must be as specified in Section 23 05 93 TESTING, ADJUSTING, AND BALANCING FOR HVAC.

3.5 SYSTEM PERFORMANCE TESTS

Six copies of the report must be provided in bound 8 1/2 by 11 inch booklets.

3.5.1 General Requirements

Before each refrigeration system is accepted, tests to demonstrate the general operating characteristics of all equipment must be conducted by the manufacturer's approved start-up representative experienced in system start-up and testing, at such times as directed. Tests must cover a period of not less than 48 hours for each system and must demonstrate that the entire system is functioning in accordance with the drawings and specifications. Corrections and adjustments must be made as necessary and tests must be re-conducted to demonstrate that the entire system is functioning as specified. Prior to acceptance, service valve seal caps and blanks over gauge points must be installed and tightened. Any refrigerant lost during the system startup must be replaced. If tests do not demonstrate satisfactory system performance, deficiencies must be corrected and the system must be retested. Tests must be conducted in the presence of the Contracting Officer. Water and electricity required for the tests will be furnished by the Government. Any material, equipment, instruments, and personnel required for the test must be provided by the Contractor. Field tests must be coordinated with Section 23 05 93 TESTING, ADJUSTING, AND BALANCING FOR HVAC.

3.5.2 Test Report

The report must document compliance with the specified performance criteria upon completion and testing of the system. The report must indicate the number of days covered by the tests and any conclusions as to the adequacy of the system. The report must also include the following information and must be taken at least three different times at outside dry-bulb temperatures that are at least 5 degrees F apart:

a. Date and outside weather conditions.

b. The load on the system based on the following:

   (1) The refrigerant used in the system.
   (2) Condensing temperature and pressure.
   (3) Suction temperature and pressure.
   (4) Running current, voltage and proper phase sequence for each phase of all motors.
   (5) The actual on-site setting of all operating and safety controls.
   (6) Chilled water pressure, flow and temperature in and out of the chiller.

3.6 DEMONSTRATIONS

Contractor must conduct a training course for the operating staff as designated by the Contracting Officer. The training period must consist of a total 8 hours of normal working time and start after the system is functionally completed but prior to final acceptance tests. The training course must cover all of the items contained in the approved operation and maintenance manuals as well as demonstrations of routine maintenance operations.

Provide a schedule, at least 2 weeks prior to the date of the proposed training course, which identifies the date, time, and location for the training.

-- End of Section --

SECTION 23 64 26

CHILLED, CHILLED-HOT, AND CONDENSER WATER PIPING SYSTEMS
08/09, CHG 6: 11/22

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI Z21.22/CSA 4.4	(2015; R 2020) Relief Valves for Hot Water Supply Systems

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME B1.20.1	(2013; R 2018) Pipe Threads, General Purpose (Inch)
ASME B16.1	(2020) Gray Iron Pipe Flanges and Flanged Fittings Classes 25, 125, and 250
ASME B16.3	(2021) Malleable Iron Threaded Fittings, Classes 150 and 300
ASME B16.9	(2018) Factory-Made Wrought Buttwelding Fittings
ASME B16.11	(2022) Forged Fittings, Socket-Welding and Threaded
ASME B16.18	(2021) Cast Copper Alloy Solder Joint Pressure Fittings
ASME B16.21	(2021) Nonmetallic Flat Gaskets for Pipe Flanges
ASME B16.22	(2021) Wrought Copper and Copper Alloy Solder Joint Pressure Fittings
ASME B16.26	(2018) Standard for Cast Copper Alloy Fittings for Flared Copper Tubes
ASME B16.39	(2020) Standard for Malleable Iron Threaded Pipe Unions; Classes 150, 250, and 300
ASME B31.9	(2020) Building Services Piping
ASME B40.100	(2022) Pressure Gauges and Gauge Attachments

AMERICAN SOCIETY OF SANITARY ENGINEERING (ASSE)

ASSE 1003	(2020) Performance Requirements for Water Pressure Reducing Valves for Domestic Water Distribution Systems - (ANSI approved 2010)

AMERICAN WATER WORKS ASSOCIATION (AWWA)

AWWA C606	(2015) Grooved and Shouldered Joints

AMERICAN WELDING SOCIETY (AWS)

AWS A5.8/A5.8M	(2019) Specification for Filler Metals for Brazing and Braze Welding
AWS BRH	(2007; 5th Ed) Brazing Handbook

ASTM INTERNATIONAL (ASTM)

ASTM A47/A47M	(1999; R 2022; E 2022) Standard Specification for Ferritic Malleable Iron Castings
ASTM A53/A53M	(2022) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM A106/A106M	(2019a) Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service
ASTM A183	(2014; R 2020) Standard Specification for Carbon Steel Track Bolts and Nuts
ASTM A536	(1984; R 2019; E 2019) Standard Specification for Ductile Iron Castings
ASTM A653/A653M	(2022) Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
ASTM A733	(2016; R 2022) Standard Specification for Welded and Seamless Carbon Steel and Austenitic Stainless Steel Pipe Nipples
ASTM B32	(2020) Standard Specification for Solder Metal
ASTM B42	(2020) Standard Specification for Seamless Copper Pipe, Standard Sizes
ASTM B62	(2017) Standard Specification for Composition Bronze or Ounce Metal Castings
ASTM B75/B75M	(2020) Standard Specification for Seamless Copper Tube

ASTM B88	(2022) Standard Specification for Seamless Copper Water Tube
ASTM B88M	(2020) Standard Specification for Seamless Copper Water Tube (Metric)
ASTM B117	(2019) Standard Practice for Operating Salt Spray (Fog) Apparatus
ASTM B813	(2016) Standard Specification for Liquid and Paste Fluxes for Soldering of Copper and Copper Alloy Tube
ASTM D520	(2000; R 2011) Zinc Dust Pigment
ASTM D596	(2001; R 2018) Standard Guide for Reporting Results of Analysis of Water
ASTM D2000	(2018) Standard Classification System for Rubber Products in Automotive Applications
ASTM D3308	(2012; R 2017) Standard Specification for PTFE Resin Skived Tape
ASTM E84	(2020) Standard Test Method for Surface Burning Characteristics of Building Materials
ASTM F1007	(2018; R 2022) Standard Specification for Pipeline Expansion Joints of the Packed Slip Type for Marine Application
ASTM F1120	(1987; R 2019) Standard Specification for Circular Metallic Bellows Type Expansion Joints for Piping Applications
ASTM F1199	(2021) Standard Specification for Cast (All Temperatures and Pressures) and Welded Pipe Line Strainers (150 psig and 150 degrees F Maximum)

EXPANSION JOINT MANUFACTURERS ASSOCIATION (EJMA)

EJMA Stds	(2015) (10th Ed) EJMA Standards

MANUFACTURERS STANDARDIZATION SOCIETY OF THE VALVE AND FITTINGS INDUSTRY (MSS)

MSS SP-25	(2018) Standard Marking System for Valves, Fittings, Flanges and Unions
MSS SP-58	(2018) Pipe Hangers and Supports - Materials, Design and Manufacture, Selection, Application, and Installation
MSS SP-67	(2022) Butterfly Valves
MSS SP-69	(2003; Notice 2012) Pipe Hangers and Supports - Selection and Application (ANSI

	Approved American National Standard)
MSS SP-70	(2011) Gray Iron Gate Valves, Flanged and Threaded Ends
MSS SP-71	(2018) Gray Iron Swing Check Valves, Flanged and Threaded Ends
MSS SP-72	(2010a) Ball Valves with Flanged or Butt-Welding Ends for General Service
MSS SP-80	(2019) Bronze Gate, Globe, Angle and Check Valves
MSS SP-110	(2010) Ball Valves Threaded, Socket-Welding, Solder Joint, Grooved and Flared Ends

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 90A	(2021) Standard for the Installation of Air Conditioning and Ventilating Systems

1.2 SYSTEM DESCRIPTION

Provide the water systems having the minimum service (design) temperature-pressure rating indicated. Provision of the piping systems, including materials, installation, workmanship, fabrication, assembly, erection, examination, inspection, and testing shall be in accordance with the required and advisory provisions of ASME B31.9 except as modified or supplemented by this specification section or design drawings. This specification section covers the water systems piping which is located within, on, and adjacent to building(s) within the building(s) 5 foot line.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Grooved Mechanical Connections For Steel; G

Grooved Mechanical Connections For Copper; G

Calibrated Balancing Valves; G

Automatic Flow Control Valves; G

Water Pressure Reducing Valve

Pressure Relief Valve

Combination Pressure and Temperature Relief Valves

Expansion Joints; G

Combination Strainer and Pump Suction Diffuser

Expansion Tanks

Air Separator Tanks

Water Treatment Systems; G

Proposed water treatment plan including a layout, control scheme, a list of existing make-up water conditions including the items listed in paragraph WATER ANALYSIS", a list of chemicals, the proportion of chemicals to be added, the final treated water conditions, and a description of environmental concerns for handling the chemicals.

SD-06 Test Reports

Pressure Tests Reports; G

Report shall be provided in bound 8-1/2 by 11 inch booklets. In the reports, document all phases of the tests performed. Include initial test summaries, all repairs/adjustments made, and the final test results.

SD-08 Manufacturer's Instructions

Lesson plan for the Instruction Course; G

SD-10 Operation and Maintenance Data

Requirements for data packages are specified Section 01 78 23 OPERATION AND MAINTENANCE DATA, except as supplemented and modified by this specification section.

Submit spare parts data for each different item of equipment specified, with operation and maintenance data packages. Include a complete list of parts and supplies, with current unit prices and source of supply, a recommended spare parts list for 1 year of operation, and a list of the parts recommended by the manufacturer to be replaced on a routine basis.

Submit a list of qualified permanent service organizations with operation and maintenance data packages. Include service organization addresses and service area or expertise. The service organizations shall be reasonably convenient to the equipment installation and be able to render satisfactory service to the equipment on a regular and emergency basis during the warranty period of the contract.

Water Treatment Systems; G

An operation manual in bound 8-1/2 by 11 inch booklets listing step-by-step procedures required for system startup, operation, abnormal shutdown, emergency shutdown, and normal shutdown. Include testing procedures used in determining water quality.

A maintenance manual in bound 8-1/2 by 11 inch booklets listing routine maintenance procedures, possible breakdowns and repairs, and a trouble shooting guide.

Calibrated Balancing Valves, Data Package 3; G

Automatic Flow Control Valves, Data Package 3; G

Water Pressure Reducing Valve, Data Package 3; G

Pressure Relief Valve, Data Package 2; G

Combination Pressure and Temperature Relief Valves, Data Package 2; G

Expansion Joints, Data Package 2; G

Combination Strainer and Pump Suction Diffuser, Data Package 2; G

Expansion Tanks, Data Package 2; G

Air Separator Tanks, Data Package 2; G

1.4 MODIFICATIONS TO REFERENCES

In each of the publications referred to herein, consider the advisory provisions to be mandatory, as though the word, "shall" had been substituted for "should" wherever it appears. Interpret references in these publications to the "authority having jurisdiction", or words of similar meaning, to mean the Contracting Officer.

1.4.1 Definitions

For the International Code Council (ICC) Codes referenced in the contract documents, advisory provisions shall be considered mandatory, the word "should" shall be interpreted as "shall." Reference to the "code official" shall be interpreted to mean the "Contracting Officer." For Navy owned property, references to the "owner" shall be interpreted to mean the "Contracting Officer." For leased facilities, references to the "owner" shall be interpreted to mean the "lessor." References to the "permit holder" shall be interpreted to mean the "Contractor."

1.4.2 Administrative Interpretations

For ICC Codes referenced in the contract documents, the provisions of Chapter 1, "Administrator," do not apply. These administrative requirements are covered by the applicable Federal Acquisition Regulations (FAR) included in this contract and by the authority granted to the Officer in Charge of Construction to administer the construction of this project. References in the ICC Codes to sections of Chapter 1, shall be applied appropriately by the Contracting Officer as authorized by his administrative cognizance and the FAR.

1.5 SAFETY REQUIREMENTS

Exposed moving parts, parts that produce high operating temperature, parts which may be electrically energized, and parts that may be a hazard to operating personnel shall be insulated, fully enclosed, guarded, or fitted with other types of safety devices. Safety devices shall be installed so that proper operation of equipment is not impaired.

1.6 DELIVERY, STORAGE, AND HANDLING

Protect stored items from the weather, humidity and temperature variations, dirt and dust, or other contaminants. Proper protection and care of all material both before and during installation shall be the Contractor's responsibility. Any materials found to be damaged shall be replaced at the Contractor's expense. During installation, cap piping and similar openings to keep out dirt and other foreign matter. Any porous materials found to be contaminated with mold or mildew will be replaced at the Contractor's expense. Non-porous materials found to be contaminated with mold or mildew will be disinfected and cleaned prior to installation.

1.7 PROJECT/SITE CONDITIONS

1.7.1 Verification of Dimensions

The Contractor shall become familiar with all details of the work, verify all dimensions in the field, and advise the Contracting Officer of any discrepancy before performing any work.

1.7.2 Drawings

Because of the small scale of the drawings, it is not possible to indicate all offsets, fittings, and accessories that may be required. The Contractor shall carefully investigate the plumbing, fire protection, electrical, structural and finish conditions that would affect the work to be performed and shall arrange such work accordingly, furnishing required offsets, fittings, and accessories to meet such conditions.

1.7.3 Accessibility

Install all work so that parts requiring periodic inspection, operation, maintenance, and repair are readily accessible. Install concealed valves, expansion joints, controls, dampers, and equipment requiring access, in locations freely accessible through access doors.

PART 2 PRODUCTS

2.1 STANDARD COMMERCIAL PRODUCTS

Materials and equipment shall be standard products of a manufacturer regularly engaged in the manufacturing of such products, which are of a similar material, design and workmanship. The standard products shall have been in satisfactory commercial or industrial use for 2 years prior to bid opening.

The two year use shall include applications of equipment and materials under similar circumstances and of similar size. The 2 years experience shall be satisfactorily completed by a product which has been sold or is offered for sale on the commercial market through advertisements, manufacturer's catalogs, or brochures.

Products having less than a 2 year field service record shall be acceptable if a certified record of satisfactory field operation, for not less than 6000 hours exclusive of the manufacturer's factory tests, can be shown. System components shall be environmentally suitable for the indicated locations.

The equipment items shall be supported by service organizations. These service organizations shall be reasonably convenient to the equipment installation and able to render satisfactory service to the equipment on a regular and emergency basis during the warranty period of the contract.

2.2 STEEL PIPING

Water piping shall be steel pipe or copper tubing. Provide steel piping with a ANSI/ASME Class 125 service rating, which for 150 degrees F, the pressure rating is 175 psig.

2.2.1 Pipe

Steel pipe, conform to ASTM A53/A53M, Schedule 40, Type E or S, Grades A or B. Do not use Type F pipe.

2.2.2 Fittings and End Connections (Joints)

Piping and fittings 1 inch and smaller shall have threaded connections. Piping and fittings larger than 1 inch and smaller than 3 inches shall have either threaded, grooved, or welded connections. Piping and fittings 3 inches and larger shall have grooved, welded, or flanged connections. The manufacturer of each fitting shall be permanently identified on the body of the fitting in accordance with MSS SP-25.

2.2.2.1 Threaded Connections

Use threaded valves and pipe connections conforming to ASME B1.20.1. Used threaded fitting conforming to ASME B16.3. Use threaded unions conforming to ASME B16.39. Use threaded pipe nipples conforming to ASTM A733.

2.2.2.2 Flanged Connections

Flanges shall conform to ASME B16.1, Class 125. Gaskets shall be nonasbestos compressed material in accordance with ASME B16.21, 1/16 inch thickness, full face or self-centering flat ring type. These gaskets shall contain aramid fibers bonded with styrene butadeine rubber (SBR) or nitrile butadeine rubber (NBR). Bolts, nuts, and bolt patterns shall conform to ASME B16.1.

2.2.2.3 Welded Connections

Welded valves and pipe connections (both butt-welds and socket-welds types) shall conform to ASME B31.9. Butt-welded fittings shall conform to ASME B16.9. Socket-welded fittings shall conform to ASME B16.11. Welded fittings shall be identified with the appropriate grade and marking symbol.

2.2.2.4 Grooved Mechanical Connections For Steel

Rigid grooved mechanical connections may only be used in serviceable aboveground locations where the temperature of the circulating medium does not exceed 230 degrees F. Flexible grooved connections shall be used only as a flexible connector with grooved pipe system. Unless otherwise specified, grooved piping components shall meet the corresponding criteria specified for the similar welded, flanged, or threaded component specified herein.

Each grooved mechanical joint shall be a system, including coupling housing, gasket, fasteners, all furnished by the same manufacturer. Joint installation shall be in compliance with joint manufacturer's written instructions.

Use fitting and coupling houses of malleable iron conforming to ASTM A47/A47M, Grade 32510; ductile iron conforming to ASTM A536, Grade 65-45-12; or steel conforming ASTM A106/A106M, Grade B or ASTM A53/A53M. Use gaskets of molded synthetic rubber with central cavity, pressure responsive configuration and conforming to ASTM D2000 Grade No. 2CA615A15B44F17Z for circulating medium up to 230 degrees F or Grade No. M3BA610A15B44Z for circulating medium up to 200 degrees F. Grooved mechanical connections shall conform to AWWA C606. Coupling nuts and bolts shall be steel and shall conform to ASTM A183. Pipe connections and fittings shall be the product of the same manufacturer. Provide joint installation be in compliance with joint manufacturer's written instructions.

2.2.2.5 Dielectric Waterways and Flanges

Provide dielectric waterways with a water impervious insulation barrier capable of limiting galvanic current to 1 percent of short circuit current in a corresponding bimetallic joint. When dry, insulation barrier shall be able to withstand a 600-volt breakdown test. Provide dielectric waterways constructed of galvanized steel and have threaded end connections to match connecting piping. Dielectric waterways shall be suitable for the required operating pressures and temperatures. Provide dielectric flanges with the same pressure ratings as standard flanges and provide complete electrical isolation between connecting pipe and/or equipment as described herein for dielectric waterways.

2.3 COPPER TUBING

Provide copper tubing and fittings with a ANSI/ASME Class 125 service rating, which for 150 degrees F., the pressure rating is 175 psig.

2.3.1 Tube

Use copper tube conforming to ASTM B88, Type L or M for aboveground tubing, and Type K for buried tubing.

2.3.2 Fittings and End Connections (Solder and Flared Joints)

Wrought copper and bronze solder joint pressure fittings, including unions ands flanges, shall conform to ASME B16.22 and ASTM B75/B75M. Provide adapters as required. Cast copper alloy solder-joint pressure fittings , including unions and flanges, shall conform to ASME B16.18. Cast copper alloy fittings for flared copper tube shall conform to ASME B16.26 and ASTM B62. ASTM B42 copper pipe nipples with threaded end connections shall conform to ASTM B42.

Copper tubing of sizes larger than 4 inches shall have brazed joints. Brass or bronze adapters for brazed tubing may be used for connecting tubing to flanges and to threaded ends of valves and equipment.

Extracted brazed tee joints may be used if produced with an acceptable tool and installed in accordance with tool manufacturer's written procedures.

2.3.3 Grooved Mechanical Connections For Copper

Rigid grooved mechanical connections may only be used in serviceable aboveground locations where the temperature of the circulating medium does not exceed 230 degrees F. Flexible grooved connections shall be used only as a flexible connector with grooved pipe system. Unless otherwise specified, grooved piping components shall meet the corresponding criteria specified for the similar welded, flanged, or threaded component specified herein.

Each grooved mechanical joint shall be a system, including coupling housing, gasket, fasteners, all furnished by the same manufacturer. Joint installation shall be in compliance with joint manufacturer's written instructions.

Grooved fitting and mechanical coupling housing shall be ductile iron conforming to ASTM A536. Provide gaskets for use in grooved joints shall constructed of molded synthetic polymer of pressure responsive design and shall conform to ASTM D2000 for circulating medium up to 230 degrees F. Provide grooved joints in conformance with AWWA C606.

2.3.4 Solder

Provide solder in conformance with ASTM B32, grade Sb5, tin-antimony alloy. Solder flux shall be liquid or paste form, non-corrosive and conform to ASTM B813.

2.3.5 Brazing Filler Metal

Filler metal shall conform to AWS A5.8/A5.8M, Type BAg-5 with AWS Type 3 flux, except Type BCuP-5 or BCuP-6 may be used for brazing copper-to-copper joints.

2.4 VALVES

Provide valves with a ANSI/ASME Class 125 service rating, which for 150 degrees F, the pressure rating is 175 psig.

Valves in sizes larger than 1 inch and used on steel pipe systems, may be provided with rigid grooved mechanical joint ends. Such grooved end valves shall be subject to the same requirements as rigid grooved mechanical joints and fittings and, shall be furnished by the same manufacturer as the grooved pipe joint and fitting system.

2.4.1 Gate Valve

Gate valves 2-1/2 inches and smaller shall conform to MSS SP-80 Class 125 and shall be bronze with wedge disc, rising stem and threaded, soldered, or flanged ends. Gate valves 3 inches and larger shall conform to MSS SP-70, Class 125, cast iron with bronze trim, outside screw and yoke, and flanged or threaded ends.

2.4.2 Check Valve

Check valves 2-1/2 inches and smaller shall conform to MSS SP-80. Check valves 3 inches and larger shall conform to MSS SP-71, Class 125.

2.4.3 Butterfly Valve

Butterfly valves shall conform to MSS SP-67, Type 1 and shall be either the wafer or lug type. Valves smaller than 8 inches shall have throttling handles with a minimum of seven locking positions. Valves 8 inches and larger shall have totally enclosed manual gear operators with adjustable balance return stops and position indicators.

2.4.4 Ball Valve

Full port design. Ball valves 1/2 inch and larger shall conform to MSS SP-72 or MSS SP-110 and shall be cast iron or bronze with threaded, soldered, or flanged ends. Valves 8 inches or larger shall be provided with manual gear operators with position indicators. Ball valves may be provided in lieu of gate valves.

2.4.5 Calibrated Balancing Valves

Copper alloy or cast iron body, copper alloy or stainless internal working parts. Provide valve calibrated so that flow can be determined when the temperature and pressure differential across valve is known. Valve shall have an integral pointer which registers the degree of valve opening. Valve shall function as a service valve when in fully closed position. Valve shall be constructed with internal seals to prevent leakage and shall be supplied with preformed insulation.

Provide valve bodies with tapped openings and pipe extensions with positive shutoff valves outside of pipe insulation. The pipe extensions shall be provided with quick connecting hose fittings for a portable differential pressure meter connections to verify the pressure differential. Provide metal tag on each valve showing the gallons per minute flow for each differential pressure reading.

2.4.6 Automatic Flow Control Valves

Valve shall automatically maintain the constant flow indicated on the design drawings. Valve shall modulate by sensing the pressure differential across the valve body. Valve shall be selected for the flow required and provided with a permanent nameplate or tag carrying a permanent record of the factory-determined flow rate and flow control pressure levels. Provide valve that controls the flow within 5 percent of the tag rating. Valve materials shall be the same as specified for the ball or plug valves.

Provide valve that are electric type as indicated. Valve shall be capable of positive shutoff against the system pump head, valve bodies shall be provided with tapped openings and pipe extensions with shutoff valves outside of pipe insulation. The pipe extensions shall be provided with quick connecting hose fittings and differential meter, suitable for the operating pressure specified. Provide the meter complete with hoses, vent, integral metering connections, and carrying case as recommended by the valve manufacturer.

2.4.7 Water Pressure Reducing Valve

Valve, ASSE 1003 for water service, copper alloy body.

2.4.8 Pressure Relief Valve

Valve shall prevent excessive pressure in the piping system when the piping system reaches its maximum heat buildup. Valve, ANSI Z21.22/CSA 4.4 and shall have cast iron bodies with corrosion resistant internal working parts. The discharge pipe from the relief valve shall be the size of the valve outlet unless otherwise indicated.

2.4.9 Combination Pressure and Temperature Relief Valves

ANSI Z21.22/CSA 4.4, copper alloy body, automatic re-seating, test lever, and discharge capacity based on AGA temperature steam rating.

2.4.10 Float Valve

Angle patternor Globe pattern. Valve bodies 3 inches nominal pipe size and smaller shall be bronze. Valve bodies larger than 3 inches shall be cast iron or bronze. Steel parts shall be corrosion resistant. Where float rods are extended for tank applications, extension shall be properly supported and guided to avoid bending of float rod or stressing of valve pilot linkage.

2.4.11 Drain Valves

Valves, MSS SP-80 gate valves. Valve shall be manually-operated, 3/4 inch pipe size and above with a threaded end connection. Provide valve with a water hose nipple adapter. Freeze-proof type valves shall be provided in installations exposed to freezing temperatures.

2.4.12 Air Venting Valves

Manually-operated general service type air venting valves, brass or bronze valves that are furnished with threaded plugs or caps. Air venting valves on water coils shall have not less than 1/8 inch threaded end connections. Air venting valves on water mains shall have not less than 3/4 inch threaded end connections. Air venting valves on all other applications shall have not less than 1/2 inch threaded end connections.

2.4.13 Vacuum Relief Valves

ANSI Z21.22/CSA 4.4

2.5 PIPING ACCESSORIES

2.5.1 Strainer

Strainer, ASTM F1199, except as modified and supplemented in this specification. Strainer shall be the cleanable, basket or "Y" type, the same size as the pipeline. Strainer bodies shall be fabricated of cast iron with bottoms drilled, and tapped. Provide blowoff outlet with pipe nipple, gate valve, and discharge pipe nipple. The bodies shall have arrows clearly cast on the sides indicating the direction of flow.

Provide strainer with removable cover and sediment screen. The screen shall be made of minimum 22 gauge corrosion-resistant steel, with small perforations numbering not less than 400 per square inch to provide a net free area through the basket of at least 3.30 times that of the entering pipe. The flow shall be into the screen and out through the perforations.

2.5.2 Cyclonic Separator

Metal- bodied, with removal capability of removing solids 45 microns/325 mesh in size and heavier than 1.20 specific gravity, maximum pressure drop of 5 psid, with cleanout connection.

2.5.3 Combination Strainer and Pump Suction Diffuser

Angle type body with removable strainer basket and internal straightening vanes, a suction pipe support, and a blowdown outlet and plug. Strainer shall be in accordance with ASTM F1199, except as modified and supplemented by this specification. Unit body shall have arrows clearly cast on the sides indicating the direction of flow.

Strainer screen shall be made of minimum 22 gauge corrosion-resistant steel, with small perforations numbering not less than 400 per square inch to provide a net free area through the basket of at least 3.30 times that of the entering pipe. Flow shall be into the screen and out through the perforations. Provide an auxiliary disposable fine mesh strainer which shall be removed 30 days after start-up. Provide warning tag for operator indicating scheduled date for removal.

Casing shall have connection sizes to match pump suction and pipe sizes, and be provided with adjustable support foot or support foot boss to relieve piping strains at pump suction. Provide unit casing with blowdown port and plug. Provide a magnetic insert to remove debris from system.

2.5.4 Flexible Pipe Connectors

Provide flexible bronze or stainless steel piping connectors with single braid. Equip flanged assemblies with limit bolts to restrict maximum travel to the manufacturer's standard limits. Unless otherwise indicated, the length of the flexible connectors shall be as recommended by the manufacturer for the service intended. Internal sleeves or liners, compatible with circulating medium, shall be provided when recommended by the manufacturer. Provide covers to protect the bellows where indicated.

2.5.5 Pressure and Vacuum Gauges

Gauges, ASME B40.100 with throttling type needle valve or a pulsation dampener and shut-off valve. Provide gauges with 4.5 inch dial, brass or aluminum case, bronze tube, and siphon. Gauge shall have a range from 0 psig to approximately 1.5 times the maximum system working pressure. Each gauge range shall be selected so that at normal operating pressure, the needle is within the middle-third of the range.

2.5.6 Temperature Gauges

Temperature gauges, shall be the industrial duty type and be provided for the required temperature range. Provide gauges with fixed thread connection, dial face gasketed within the case; and an accuracy within 2 percent of scale range. Gauges shall have Fahrenheit scale in 2 degree graduations scale (black numbers) on a white face. The pointer shall be adjustable. Rigid stem type temperature gauges shall be provided in thermal wells located within 5 feet of the finished floor. Universal adjustable angle type or remote element type temperature gauges shall be provided in thermal wells located 5 to 7 feet above the finished floor or in locations indicated. Remote element type temperature gauges shall be provided in thermal wells located 7 feet above the finished floor or in locations indicated.

2.5.6.1 Stem Cased-Glass

Stem cased-glass case shall be polished stainless steel or cast aluminum, 9 inches long, with clear acrylic lens, and non-mercury filled glass tube with indicating-fluid column.

2.5.6.2 Bimetallic Dial

Bimetallic dial type case shall be not less than 3-1/2 inches, stainless steel, and shall be hermetically sealed with clear acrylic lens. Bimetallic element shall be silicone dampened and unit fitted with external calibrator adjustment.

2.5.6.3 Liquid-, Solid-, and Vapor-Filled Dial

Liquid-, solid-, and vapor-filled dial type cases shall be not less than 3-1/2 inches, stainless steel or cast aluminum with clear acrylic lens. Fill shall be nonmercury, suitable for encountered cross-ambients, and connecting capillary tubing shall be double-braided bronze.

2.5.6.4 Thermal Well

Thermal well shall be identical size, 1/2 or 3/4 inch NPT connection, brass or stainless steel. Where test wells are indicated, provide captive plug-fitted type 1/2 inch NPT connection suitable for use with either engraved stem or standard separable socket thermometer or thermostat. Mercury shall not be used in thermometers. Extended neck thermal wells shall be of sufficient length to clear insulation thickness by 1 inch.

2.5.7 Pipe Hangers, Inserts, and Supports

Pipe hangers, inserts, guides, and supports: to MSS SP-58 and MSS SP-69. If ferrous materials are utilized provide hot-dipped galvanized hangers, inserts and supports.

2.5.8 Escutcheons

Provide one piece or split hinge metal plates for piping entering floors, walls, and ceilings in exposed spaces. Secure plates in place by internal spring tension or set screws. Provide polished stainless steel plates or chromium-plated finish on copper alloy plates in finished spaces. Provide paint finish on metal plates in unfinished spaces.

2.5.9 Expansion Joints

2.5.9.1 Slip-Tube Type

Slip-tube expansion joints, ASTM F1007, Class I or II. Joints shall be provided with internally-externally alignment guides, injected semi-plastic packing, and service outlets. End connections shall be flanged or beveled for welding as indicated. Initial settings shall be made in accordance with the manufacturer's recommendations to compensate for ambient temperature at time of installation. Pipe alignment guides shall be installed as recommended by the joint manufacturer.

2.5.9.2 Flexible Ball Type

Flexible ball expansion joints shall be capable of 360 degrees rotation plus 15 degrees angular flex movement. Joints shall be constructed of carbon steel with the exterior spherical surface of carbon steel balls plated with a minimum 5 mils of hard chrome in accordance with EJMA Stds. Joint end connections shall be threaded for piping 2 inches or smaller. Joint end connections larger than 2 inches shall be grooved, flanged, or beveled for welding. Provide joint with pressure-molded composition gaskets suitable for continuous operation at twice design temperature.

2.5.9.3 Bellows Type

Bellows expansion type joints, ASTM F1120 with Type 304 stainless steel corrugated bellows, reinforced with equalizing rings, internal sleeves, and external protective covers. Joint end connections shall be grooved, flanged, or beveled for welding. Guiding of piping on both sides of expansion joint shall be in accordance with the published recommendations of the manufacturer of the expansion joint.

2.6 EXPANSION TANKS

Tank shall be welded steel, constructed for, and tested to pressure-temperature rating of 125 psi at 150 degrees F. Provide tanks precharged to the minimum operating pressure. Tank shall have a replaceable polypropylene or butyl lined diaphragm which keeps the air charge separated from the water; shall be the captive air type.

Tanks shall accommodate expanded water of the system generated within the normal operating temperature range, limiting this pressure increase at all components in the system to the maximum allowable pressure at those components. Each tank air chamber shall be fitted with a drain, fill, an air charging valve, and system connections. Tank shall be supported by steel legs or bases for vertical installation or steel saddles for horizontal installations. The only air in the system shall be the permanent sealed-in air cushion contained within the expansion tank.

2.7 AIR SEPARATOR TANKS

Design to separate air from water and to direct released air to automatic air vent. Unit shall be of one piece cast-iron construction with internal baffles and two air chambers at top of unit; one air chamber shall have outlet to expansion tank and other air chamber shall be provided with automatic air release device. Tank shall be steel, constructed for, and tested to a ANSI Class 125 pressure-temperature rating.

2.8 WATER TREATMENT SYSTEMS

When water treatment is specified, the use of chemical-treatment products containing equivalent chromium (CPR) is prohibited.

2.8.1 Water Analysis

Conditions of make-up water to be supplied to the condenser and chilled water systems shall be sampled by the Contractor prior to system star up in accordance with ASTM D596. Provide the following information:

Date of Sample	_____
Temperature	_____ degrees F
Silica (Sino 2)	_____ pp (mg/1)
Insoluble	_____ pp (mg/1)

Iron and Aluminum Oxides	_____ pp (mg/1)
Calcium (Ca)	_____ pp (mg/1)
Magnesium (Mg)	_____ pp (mg/1)
Sodium and Potassium (Nan and AK)	_____ pp (mg/1)
Carbonate (HO 3)	_____ pp (mg/1)
Sulfate (SO 4)	_____ pp (mg/1)
Chloride (JCL)	_____ pp (mg/1)
Nitrate (NO 3	_____ pp (mg/1)
Turbidity	_____ unit
pH	_____
Residual Chlorine	_____ pp (mg/1)
Total Alkalinity	_____ PM (me/1
Non-Carbonate Hardness	_____ PM (me/1
Total Hardness	_____ PM (me/1
Dissolved Solids	_____ pp (mg/1)
Fluorine	_____ pp (mg/1)
Conductivity	_____ McMahon/cm

2.8.2 Chilled and Condenser Water

Water to be used in the chilled and condenser water systems shall be treated to maintain the conditions recommended by this specification as well as the recommendations from the manufacturers of the condenser and evaporator coils. Chemicals shall meet all required federal, state, and local environmental regulations for the treatment of evaporator coils and direct discharge to the sanitary sewer.

2.8.3 Chilled Water System

A shot feeder shall be provided on the chilled water piping as indicated. Size and capacity of feeder shall be based on local requirements and water analysis. The feeder shall be furnished with an air vent, gauge glass, funnel, valves, fittings, and piping.

2.9 PAINTING OF NEW EQUIPMENT

New equipment painting shall be factory applied or shop applied, and shall be as specified herein, and provided under each individual section.

2.9.1 Factory Painting Systems

Manufacturer's standard factory painting systems may be provided. The factory painting system applied will withstand 125 hours in a salt-spray fog test, except that equipment located outdoors shall withstand 500 hours in a salt-spray fog test.

Salt-spray fog test shall be in accordance with ASTM B117, and for that test, the acceptance criteria shall be as follows: immediately after completion of the test, the paint shall show no signs of blistering, wrinkling, or cracking, and no loss of 0.125 inch on either side of the scratch mark. The film thickness of the factory painting system applied on the equipment shall not be less than the film thickness used on the test specimen.

If manufacturer's standard factory painting system is being proposed for use on surfaces subject to temperatures above 120 degrees F, the factory painting system shall be designed for the temperature service.

2.9.2 Shop Painting Systems for Metal Surfaces

Clean, retreat, prime and paint metal surfaces; except aluminum surfaces need not be painted. Apply coatings to clean dry surfaces. Clean the surfaces to remove dust, dirt, rust, oil and grease by wire brushing and solvent degreasing prior to application of paint, except metal surfaces subject to temperatures in excess of 120 degrees F shall be cleaned to bare metal.

Where hot-dip galvanized steel has been cut, resulting surfaces with no galvanizing shall be coated with a zinc-rich coating conforming to ASTM D520, Type I.

Where more than one coat of paint is specified, apply the second coat after the preceding coat is thoroughly dry. Lightly sand damaged painting and retouch before applying the succeeding coat. Color of finish coat shall be aluminum or light gray.

a. Temperatures Less Than 120 Degrees F: Immediately after cleaning, the metal surfaces subject to temperatures less than 120 degrees F shall receive one coat of pretreatment primer applied to a minimum dry film thickness of 0.3 mil, one coat of primer applied to a minimum dry film thickness of one mil; and two coats of enamel applied to a minimum dry film thickness of one mil per coat.

b. Temperatures Between 120 and 400 degrees F: Metal surfaces subject to temperatures between 120 and 400 degrees F shall receive two coats of 400 degrees F heat-resisting enamel applied to a total minimum thickness of 2 mils.

2.10 FACTORY APPLIED INSULATION

Factory insulated items installed outdoors are not required to be fire-rated. As a minimum, factory insulated items installed indoors shall have a flame spread index no higher than 25 and a smoke developed index no higher than 150. Factory insulated items (no jacket) installed indoors and which are located in air plenums, in ceiling spaces, and in attic spaces shall have a flame spread index no higher than 25 and a smoke developed index no higher than 50. Flame spread and smoke developed indexes shall be determined by ASTM E84.

Insulation shall be tested in the same density and installed thickness as the material to be used in the actual construction. Material supplied by a manufacturer with a jacket shall be tested as a composite material. Jackets, facings, and adhesives shall have a flame spread index no higher than 25 and a smoke developed index no higher than 50 when tested in accordance with ASTM E84.

2.11 NAMEPLATES

Major equipment including pumps, pump motors, expansion tanks, and air separator tanks shall have the manufacturer's name, type or style, model or serial number on a plate secured to the item of equipment. The nameplate of the distributing agent will not be acceptable. Plates shall be durable and legible throughout equipment life and made of anodized aluminum or stainless steel. Plates shall be fixed in prominent locations with nonferrous screws or bolts.

2.12 RELATED COMPONENTS/SERVICES

2.12.1 Drain and Make-Up Water Piping

Requirements for drain and make-up water piping and backflow preventer is specified in Section 22 00 00 PLUMBING, GENERAL PURPOSE.

2.12.2 Field Applied Insulation

Requirements for field applied insulation is specified in Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS.

2.12.3 Field Applied Insulation

Requirements for field installed insulation is specified in Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS, except as supplemented and modified by this specification section.

PART 3 EXECUTION

3.1 INSTALLATION

Cut pipe accurately to measurements established at the jobsite, and work into place without springing or forcing, completely clearing all windows, doors, and other openings. Cutting or other weakening of the building structure to facilitate piping installation is not permitted without written approval. Cut pipe or tubing square, remove burrs by reaming, and fashion to permit free expansion and contraction without causing damage to the building structure, pipe, joints, or hangers.

Notify the Contracting Officer in writing at least 15 calendar days prior to the date the connections are required. Obtain approval before interrupting service. Furnish materials required to make connections into existing systems and perform excavating, backfilling, compacting, and other incidental labor as required. Furnish labor and tools for making actual connections to existing systems.

3.1.1 Directional Changes

Make changes in direction with fittings, except that bending of pipe 4 inches and smaller is permitted, provided a pipe bender is used and wide weep bends are formed. Mitering or notching pipe or other similar construction to form elbows or tees is not permitted. The centerline radius of bends shall not be less than 6 diameters of the pipe. Bent pipe showing kinks, wrinkles, flattening, or other malformations is not acceptable.

3.1.2 Functional Requirements

Pitch horizontal supply mains down in the direction of flow as indicated. The grade shall not be less than 1 inch in 40 feet. Reducing fittings shall be used for changes in pipe sizes. Cap or plug open ends of pipelines and equipment during installation to keep dirt or other foreign materials out of the system.

Pipe not otherwise specified shall be uncoated. Connections to appliances shall be made with malleable iron unions for steel pipe 2-1/2 inches or less in diameter, and with flanges for pipe 3 inches and above in diameter. Connections between ferrous and copper piping shall be electrically isolated from each other with dielectric waterways or flanges.

Piping located in air plenums shall conform to NFPA 90A requirements. Pipe and fittings installed in inaccessible conduits or trenches under concrete floor slabs shall be welded. Equipment and piping arrangements shall fit into space allotted and allow adequate acceptable clearances for installation, replacement, entry, servicing, and maintenance. Electric isolation fittings shall be provided between dissimilar metals.

3.1.3 Fittings and End Connections

3.1.3.1 Threaded Connections

Threaded connections shall be made with tapered threads and made tight with PTFE tape complying with ASTM D3308 or equivalent thread-joint compound applied to the male threads only. Not more than three threads shall show after the joint is made.

3.1.3.2 Brazed Connections

Brazing, AWS BRH, except as modified herein. During brazing, the pipe and fittings shall be filled with a pressure regulated inert gas, such as nitrogen, to prevent the formation of scale. Before brazing copper joints, both the outside of the tube and the inside of the fitting shall be cleaned with a wire fitting brush until the entire joint surface is bright and clean. Do not use brazing flux. Surplus brazing material shall be removed at all joints. Steel tubing joints shall be made in accordance with the manufacturer's recommendations. Piping shall be supported prior to brazing and not be sprung or forced.

3.1.3.3 Grooved Mechanical Connections

Prepare grooves in accordance with the coupling manufacturer's instructions. Pipe and groove dimensions shall comply with the tolerances specified by the coupling manufacturer. The diameter of grooves made in the field shall be measured using a "go/no-go" gauge, vernier or dial caliper, or narrow-land micrometer, or other method specifically approved by the coupling manufacturer for the intended application. Groove width and dimension of groove from end of pipe shall be measured and recorded for each change in grooving tool setup to verify compliance with coupling manufacturer's tolerances. Grooved joints shall not be used in concealed locations, such as behind solid walls or ceilings, unless an access panel is shown on the drawings for servicing or adjusting the joint.

3.1.3.4 Flanges and Unions

Except where copper tubing is used, union or flanged joints shall be provided in each line immediately preceding the connection to each piece of equipment or material requiring maintenance such as coils, pumps, control valves, and other similar items. Flanged joints shall be assembled square end tight with matched flanges, gaskets, and bolts. Gaskets shall be suitable for the intended application.

3.1.4 Valves

Isolation gate or ball valves shall be installed on each side of each piece of equipment, at the midpoint of all looped mains, and at any other points indicated or required for draining, isolating, or sectionalizing purpose. Each valve except check valves shall be identified. Valves in horizontal lines shall be installed with stems horizontal or above.

3.1.5 Air Vents

Air vents shall be provided at all high points, on all water coils, and where indicated to ensure adequate venting of the piping system.

3.1.6 Drains

Drains shall be provided at all low points and where indicated to ensure complete drainage of the piping. Drains shall be accessible, and shall consist of nipples and caps or plugged tees unless otherwise indicated.

3.1.7 Flexible Pipe Connectors

Connectors shall be attached to components in strict accordance with the latest printed instructions of the manufacturer to ensure a vapor tight joint. Hangers, when required to suspend the connectors, shall be of the type recommended by the flexible pipe connector manufacturer and shall be provided at the intervals recommended.

3.1.8 Temperature Gauges

Temperature gauges shall be located on coolant supply and return piping at each heat exchanger, on condenser water piping entering and leaving a condenser, at each automatic temperature control device without an integral thermometer, and where indicated or required for proper operation of equipment. Thermal wells for insertion thermometers and thermostats shall extend beyond thermal insulation surface not less than 1 inch.

3.1.9 Pipe Hangers, Inserts, and Supports

Pipe hangers, inserts, and supports shall conform to MSS SP-58 and MSS SP-69, except as supplemented and modified in this specification section. Pipe hanger types 5, 12, and 26 shall not be used. Hangers used to support piping 2 inches and larger shall be fabricated to permit adequate adjustment after erection while still supporting the load. Piping subjected to vertical movement, when operating temperatures exceed ambient temperatures, shall be supported by variable spring hangers and supports or by constant support hangers.

3.1.9.1 Hangers

Type 3 shall not be used on insulated piping. Type 24 may be used only on trapeze hanger systems or on fabricated frames.

3.1.9.2 Inserts

Type 18 inserts shall be secured to concrete forms before concrete is placed. Continuous inserts which allow more adjustments may be used if they otherwise meet the requirements for Type 18 inserts.

3.1.9.3 C-Clamps

Type 19 and 23 C-clamps shall be torqued per MSS SP-69 and have both locknuts and retaining devices, furnished by the manufacturer. Field-fabricated C-clamp bodies or retaining devices are not acceptable.

3.1.9.4 Angle Attachments

Type 20 attachments used on angles and channels shall be furnished with an added malleable-iron heel plate or adapter.

3.1.9.5 Saddles and Shields

Where Type 39 saddle or Type 40 shield are permitted for a particular pipe attachment application, the Type 39 saddle, connected to the pipe, shall be used on all pipe 4 inches and larger when the temperature of the medium is 60 degrees F or higher. Type 40 shields shall be used on all piping less than 4 inches and all piping 4 inches and larger carrying medium less than 60 degrees F. A high density insulation insert of cellular glass shall be used under the Type 40 shield for piping 2 inches and larger.

3.1.9.6 Horizontal Pipe Supports

Horizontal pipe supports shall be spaced as specified in MSS SP-69 and a support shall be installed not over 1 foot from the pipe fitting joint at each change in direction of the piping. Pipe supports shall be spaced not over 5 feet apart at valves.

3.1.9.7 Vertical Pipe Supports

Vertical pipe shall be supported at each floor, except at slab-on-grade, and at intervals of not more than 15 feet, not more than 8 feet from end of risers, and at vent terminations.

3.1.9.8 Pipe Guides

Type 35 guides using, steel, reinforced polytetrafluoroethylene (PTFE) or graphite slides shall be provided where required to allow longitudinal pipe movement. Lateral restraints shall be provided as required. Slide materials shall be suitable for the system operating temperatures, atmospheric conditions, and bearing loads encountered.

3.1.9.9 Steel Slides

Where steel slides do not require provisions for restraint of lateral movement, an alternate guide method may be used. On piping 4 inches and larger, a Type 39 saddle shall be used. On piping under 4 inches, a Type

40 protection shield may be attached to the pipe or insulation and freely rest on a steel slide plate.

3.1.9.10 Multiple Pipe Runs

In the support of multiple pipe runs on a common base member, a clip or clamp shall be used where each pipe crosses the base support member. Spacing of the base support members shall not exceed the hanger and support spacing required for an individual pipe in the multiple pipe run.

3.1.9.11 Structural Attachments

Attachment to building structure concrete and masonry shall be by cast-in concrete inserts, built-in anchors, or masonry anchor devices. Inserts and anchors shall be applied with a safety factor not less than 5. Supports shall not be attached to metal decking. Supports shall not be attached to the underside of concrete filled floors or concrete roof decks unless approved by the Contracting Officer. Masonry anchors for overhead applications shall be constructed of ferrous materials only. Structural steel brackets required to support piping, headers, and equipment, but not shown, shall be provided under this section.

3.1.10 Pipe Alignment Guides

Pipe alignment guides shall be provided where indicated for expansion loops, offsets, and bends and as recommended by the manufacturer for expansion joints, not to exceed 5 feet on each side of each expansion joint, and in lines 4 inches or smaller not more than 2 feet on each side of the joint.

3.1.11 Pipe Anchors

Anchors shall be provided where indicated. Unless indicated otherwise, anchors shall comply with the requirements specified. Anchors shall consist of heavy steel collars with lugs and bolts for clamping and attaching anchor braces, unless otherwise indicated. Anchor braces shall be installed in the most effective manner to secure the desired results using turnbuckles where required.

Supports, anchors, or stays shall not be attached where they will injure the structure or adjacent construction during installation or by the weight of expansion of the pipeline. Where pipe and conduit penetrations of vapor barrier sealed surfaces occur, these items shall be anchored immediately adjacent to each penetrated surface, to provide essentially zero movement within penetration seal.

3.1.12 Building Surface Penetrations

Sleeves shall not be installed in structural members except where indicated or approved. Except as indicated otherwise piping sleeves shall comply with requirements specified. Sleeves in nonload bearing surfaces shall be galvanized sheet metal, conforming to ASTM A653/A653M, Coating Class G-90, 20 gauge. Sleeves in load bearing surfaces shall be uncoated carbon steel pipe, conforming to ASTM A53/A53M, Standard weight. Sealants shall be applied to moisture and oil-free surfaces and elastomers to not less than 1/2 inch depth. Sleeves shall not be installed in structural members.

3.1.12.1 Refrigerated Space

Refrigerated space building surface penetrations shall be fitted with sleeves fabricated from hand-lay-up or helically wound, fibrous glass reinforced polyester or epoxy resin with a minimum thickness equal to equivalent size Schedule 40 steel pipe. Sleeves shall be constructed with integral collar or cold side shall be fitted with a bonded slip-on flange or extended collar.

In the case of masonry penetrations where sleeve is not cast-in, voids shall be filled with latex mixed mortar cast to shape of sleeve and flange/external collar type sleeve shall be assembled with butyl elastomer vapor barrier sealant through penetration to cold side surface vapor barrier overlap and fastened to surface with masonry anchors.

Integral cast-in collar type sleeve shall be flashed with not less than 4 inches of cold side vapor barrier overlap of sleeve surface. Normally noninsulated penetrating round surfaces shall be sealed to sleeve bore with mechanically expandable seals in vapor tight manner and remaining warm and cold side sleeve depth shall be insulated with not less than 4 inches of foamed-in-place rigid polyurethane or foamed-in-place silicone elastomer.

Vapor barrier sealant shall be applied to finish warm side insulation surface. Warm side of penetrating surface shall be insulated beyond vapor barrier sealed sleeve insulation for a distance which prevents condensation. Wires in refrigerated space surface penetrating conduit shall be sealed with vapor barrier plugs or compound to prevent moisture migration through conduit and condensation therein.

3.1.12.2 General Service Areas

Each sleeve shall extend through its respective wall, floor, or roof, and shall be cut flush with each surface. Pipes passing through concrete or masonry wall or concrete floors or roofs shall be provided with pipe sleeves fitted into place at the time of construction. Sleeves shall be of such size as to provide a minimum of 1/4 inch all-around clearance between bare pipe and sleeves or between jacketed-insulation and sleeves. Except in pipe chases or interior walls, the annular space between pipe and sleeve or between jacket over-insulation and sleeve shall be sealed.

3.1.12.3 Waterproof Penetrations

Pipes passing through roof or floor waterproofing membrane shall be installed through a .17 ounce copper sleeve, or a 0.032 inch thick aluminum sleeve, each within an integral skirt or flange.

Flashing sleeve shall be suitably formed, and skirt or flange shall extend not less than 8 inches from the pipe and be set over the roof or floor membrane in a troweled coating of bituminous cement. The flashing sleeve shall extend up the pipe a minimum of 2 inches above the roof or floor penetration. The annular space between the flashing sleeve and the bare pipe or between the flashing sleeve and the metal-jacket-covered insulation shall be sealed as indicated. Penetrations shall be sealed by either one of the following methods.

a. Waterproofing Clamping Flange: Pipes up to and including 10 inches in diameter passing through roof or floor waterproofing membrane may be installed through a cast iron sleeve with caulking recess, anchor lugs, flashing clamp device, and pressure ring with brass bolts. Waterproofing membrane shall be clamped into place and sealant shall be placed in the caulking recess.

b. Modular Mechanical Type Sealing Assembly: In lieu of a waterproofing clamping flange, a modular mechanical type sealing assembly may be installed. Seals shall consist of interlocking synthetic rubber links shaped to continuously fill the annular space between the pipe/conduit and sleeve with corrosion protected carbon steel bolts, nuts, and pressure plates. Links shall be loosely assembled with bolts to form a continuous rubber belt around the pipe with a pressure plate under each bolt head and each nut.

After the seal assembly is properly positioned in the sleeve, tightening of the bolt shall cause the rubber sealing elements to expand and provide a watertight seal rubber sealing elements to expand and provide a watertight seal between the pipe/conduit seal between the pipe/conduit and the sleeve. Each seal assembly shall be sized as recommended by the manufacturer to fit the pipe/conduit and sleeve involved. The Contractor electing to use the modular mechanical type seals shall provide sleeves of the proper diameters.

3.1.12.4 Fire-Rated Penetrations

Penetration of fire-rated walls, partitions, and floors shall be sealed as specified in Section 07 84 00 FIRESTOPPING.

3.1.12.5 Escutcheons

Finished surfaces where exposed piping, bare or insulated, pass through floors, walls, or ceilings, except in boiler, utility, or equipment rooms, shall be provided with escutcheons. Where sleeves project slightly from floors, special deep-type escutcheons shall be used. Escutcheon shall be secured to pipe or pipe covering.

3.1.13 Access Panels

Access panels shall be provided where indicated for all concealed valves, vents, controls, and additionally for items requiring inspection or maintenance. Access panels shall be of sufficient size and located so that the concealed items may be serviced and maintained or completely removed and replaced.

3.2 ELECTRICAL INSTALLATION

Install electrical equipment in accordance with NFPA 70 and manufacturers instructions.

3.3 CLEANING AND ADJUSTING

Pipes shall be cleaned free of scale and thoroughly flushed of all foreign matter. A temporary bypass shall be provided for all water coils to prevent flushing water from passing through coils. Strainers and valves shall be thoroughly cleaned. Prior to testing and balancing, air shall be removed from all water systems by operating the air vents. Temporary measures, such as piping the overflow from vents to a collecting vessel shall be taken to avoid water damage during the venting process. Air vents shall be plugged or capped after the system has been vented. Control valves and other miscellaneous equipment requiring adjustment shall be adjusted to setting indicated or directed.

3.4 FIELD TESTS

Field tests shall be conducted in the presence of the QC Manager or his designated representative to verify systems compliance with specifications. Any material, equipment, instruments, and personnel required for the test shall be provided by the Contractor.

3.4.1 Equipment and Component Isolation

Prior to testing, equipment and components that cannot withstand the tests shall be properly isolated.

3.4.2 Pressure Tests

Each piping system , except for polypropylene piping, shall be hydrostatically tested at a pressure not less than 188 psig for period of time sufficient to inspect every joint in the system and in no case less than 2 hours. Test pressure shall be monitored by a currently calibrated test pressure gauge. Leaks shall be repaired and piping retested until test requirements are met. No leakage or reduction in gage pressure shall be allowed.

Leaks shall be repaired by rewelding or replacing pipe or fittings. Caulking of joints will not be permitted. Concealed and insulated piping shall be tested in place before concealing.

Submit for approval pressure tests reports covering the above specified piping pressure tests; describe the systems tested, test results, defects found and repaired, and signature of the pressure tests' director. Obtain approval from the QC Manager before concealing piping or applying insulation to tested and accepted piping.

3.4.3 Related Field Inspections and Testing

3.4.3.1 Piping Welds

Examination of Piping Welds is specified in the paragraph EXAMINATION OF PIPING WELDS (above).

3.4.3.2 HVAC TAB

Requirements for testing, adjusting, and balancing (TAB) of HVAC water piping, and associated equipment is specified in Section 23 05 93 TESTING, ADJUSTING, AND BALANCING FOR HVAC. Coordinate with the TAB team, and provide support personnel and equipment as specified in Section 23 05 93 TESTING, ADJUSTING AND BALANCING FOR HVAC to assist TAB team to meet the TAB work requirements.

3.5 INSTRUCTION TO GOVERNMENT PERSONNEL

Furnish the services of competent instructors to give full instruction to the designated Government personnel in the adjustment, operation, and maintenance, including pertinent safety requirements, of the chilled water and condenser water piping system. Instructors shall be thoroughly familiar with all parts of the installation and shall be instructed in operating theory as well as practical operation and maintenance work. Submit a lesson plan for the instruction course for approval. The lesson plan and instruction course shall be based on the approved operation and maintenance data and maintenance manuals.

Conduct a training course for the operating staff and maintenance staff selected by the Contracting Officer. Give the instruction during the first regular work week after the equipment or system has been accepted and turned over to the Government for regular operation. The number of man-days (8 hours per day) of instruction furnished shall be one man-day.. Use approximately half of the time for classroom instruction and the other time for instruction at the location of equipment or system.

When significant changes or modifications in the equipment or system are made under the terms of the contract, provide additional instruction to acquaint the operating personnel with the changes or modifications.

-- End of Section --

SECTION 23 81 00

DECENTRALIZED UNITARY HVAC EQUIPMENT
05/18, CHG 1: 02/21

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AIR-CONDITIONING, HEATING AND REFRIGERATION INSTITUTE (AHRI)

AHRI 700	(2016) Specifications for Fluorocarbon Refrigerants
ANSI/AHRI 210/240	(2008; Add 1 2011; Add 2 2012) Performance Rating of Unitary Air-Conditioning & Air-Source Heat Pump Equipment
ANSI/AHRI 460	(2005) Performance Rating of Remote Mechanical-Draft Air-Cooled Refrigerant Condensers

AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS (ASHRAE)

ANSI/ASHRAE 15 & 34	(2013) ANSI/ASHRAE Standard 15-Safety Standard for Refrigeration Systems and ANSI/ASHRAE Standard 34-Designation and Safety Classification of Refrigerants
ASHRAE 15 & 34	(2013) ASHRAE Standard 34-2016 Safety Standard for Refrigeration Systems/ASHRAE Standard 34-2016 Designation and Safety Classification of Refrigerants-ASHRAE Standard 34-2016
ASHRAE 90.1 - IP	(2019; Errata 1 2019; Errata 2-5 2020; Addenda BY-CP 2020; Addenda AF-DB 2020; Addenda A-G 2020; Addenda F-Y 2021; Errata 6-8 2021; Interpretation 1-4 2020; Interpretation 5-8 2021 Addenda AS-AQ 2022) Energy Standard for Buildings Except Low-Rise Residential Buildings
ASHRAE 90.1 - SI	(2019; Errata 1-4 2020; Addenda BY-CP 2020; Addenda AF-DB 2020; Addenda A-G 2020; Addenda F-Y 2021; Errata 5-7 2021; Interpretation 1-4 2020; Interpretation 5-8 2021; Addenda AU-CM 2022) Energy Standard for Buildings Except Low-Rise

Residential Buildings

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME BPVC SEC IX	(2017; Errata 2018) BPVC Section IX-Welding, Brazing and Fusing Qualifications
ASME BPVC SEC VIII D1	(2019) BPVC Section VIII-Rules for Construction of Pressure Vessels Division 1

AMERICAN WELDING SOCIETY (AWS)

AWS Z49.1	(2021) Safety in Welding and Cutting and Allied Processes

ASTM INTERNATIONAL (ASTM)

ASTM B117	(2019) Standard Practice for Operating Salt Spray (Fog) Apparatus
ASTM D520	(2000; R 2011) Zinc Dust Pigment
ASTM E84	(2020) Standard Test Method for Surface Burning Characteristics of Building Materials

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA MG 1	(2021) Motors and Generators
NEMA MG 2	(2014) Safety Standard for Construction and Guide for Selection, Installation and Use of Electric Motors and Generators

U.S. DEPARTMENT OF DEFENSE (DOD)

MIL-DTL-5541	(2006; Rev F) Chemical Conversion Coatings on Aluminum and Aluminum Alloys

UNDERWRITERS LABORATORIES (UL)

UL 1995	(2015; Reprint Aug 2022) UL Standard for Safety Heating and Cooling Equipment

1.2 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Spare Parts

Posted Instructions

Coil Corrosion Protection

System Performance Tests

Training; G

Inventory

Supplied Products

Manufacturer's Standard Catalog Data

SD-06 Test Reports

System Performance Tests; G

SD-07 Certificates

Service Organizations

SD-10 Operation and Maintenance Data

Operation and Maintenance Manuals; G

SD-11 Closeout Submittals

Ozone Depleting Substances

1.3 QUALITY ASSURANCE

Carefully investigate the plumbing, fire protection, electrical, structural and finish conditions that would affect the work to be performed and arrange such work accordingly, furnishing required offsets, fittings, and accessories to meet such conditions. Submit drawings consisting of:

a. Equipment layouts which identify assembly and installation details.

b. Plans and elevations which identify clearances required for maintenance and operation.

c. Wiring diagrams which identify each component individually and interconnected or interlocked relationships between components.

d. Foundation drawings, bolt-setting information, and foundation bolts prior to concrete foundation construction for equipment indicated or required to have concrete foundations.

e. Details, if piping and equipment are to be supported other than as indicated, which include loadings and type of frames, brackets, stanchions, or other supports.

f. Automatic temperature control diagrams and control sequences.

g. Installation details which includes the amount of factory set superheat and corresponding refrigerant pressure/temperature.

h. Equipment schedules

1.4 DELIVERY, STORAGE, AND HANDLING

Protect stored items from the weather, humidity and temperature variations, dirt and dust, or other contaminants. Properly protect and care for all material both before and during installation. Submit an inventory of all the stored items. Replace any materials found to be damaged, at no additional cost to the Government. During installation, cap piping and similar openings capped to keep out dirt and other foreign matter.

1.5 WARRANTY

Provide equipment with the Manufacturer's Standard Warranty.

PART 2 PRODUCTS

2.1 ENERGY EFFICIENCY REQUIREMENTS

42 USC 8259b requires the procurement of energy efficient products in product categories covered by the Energy Star program or the Federal Energy Management Program for designated products. A list of covered product categories is available from the Federal Energy Management Web site at http://energy.gov/eere/femp/covered-product-categories.

Submit Material, Equipment, and Fixtures List of all supplied products within a covered product category, including manufacturer's catalog numbers, specification and drawing reference number, warranty information, fabrication site, and energy performance data. For product categories covered by the Federal Energy Management Program, submit documentation that the product meets or exceeds FEMP-designated efficiency requirements.

2.2 MATERIALS

Provide Manufacturer's standard catalog data, at least 5 weeks prior to the purchase or installation of a particular component, highlighted to show material, size, options, performance charts and curves, etc. in adequate detail to demonstrate compliance with contract requirements. Data includes manufacturer's recommended installation instructions and procedures. If vibration isolation is specified for a unit, include vibration isolator literature containing catalog cuts and certification that the isolation characteristics of the isolators provided meet the manufacturer's recommendations. Submit data for each specified component. Minimum efficiency requirements must be in accordance with ASHRAE 90.1 - IP.

2.2.1 Standard Products

Provide materials and equipment that are standard products of a manufacturer regularly engaged in the manufacturing of such products, which are of a similar material, design and workmanship. The standard products must have been in satisfactory commercial or industrial use for 2 years prior to request for proposal. The 2 year use includes applications of equipment and materials under similar circumstances and of similar size. The 2 years' experience must be satisfactorily completed by a product which has been sold or is offered for sale on the commercial market through advertisements, manufacturer's catalogs, or brochures. Products having less than a 2 year field service record will be acceptable if a certified record of satisfactory field operation, for not less than 6000 hours exclusive of the manufacturer's factory tests, can be shown.

Products must be supported by a service organization. Ensure system components are environmentally suitable for the indicated geographic locations.

2.2.2 Product Sustainability Criteria

2.2.2.1 Energy Efficient Equipment

Provide equipment meeting the efficiency requirements as stated within this section.

2.2.2.2 Electrical Equipment / Motors

Provide electrical equipment, motors, motor efficiencies, and wiring which are in accordance with Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Electrical motor driven equipment specified must be provided complete with motors, motor starters, and controls. Electrical characteristics must be as shown, and unless otherwise indicated, all motors of 1 horsepower and above with open, dripproof, totally enclosed, or explosion proof fan cooled enclosures, must be the premium efficiency type in accordance with NEMA MG 1. Field wiring must be in accordance with manufacturer's instructions. Each motor must conform to NEMA MG 1 and NEMA MG 2 and be of sufficient size to drive the equipment at the specified capacity without exceeding the nameplate rating of the motor. Motors must be continuous duty with the enclosure specified. Motor starters must be provided complete with thermal overload protection and other appurtenances necessary for the motor control indicated. Motors must be furnished with a magnetic across-the-line or reduced voltage type starter as required by the manufacturer. Motor duty requirements must allow for maximum frequency start-stop operation and minimum encountered interval between start and stop. Motors must be sized for the applicable loads. Motor torque must be capable of accelerating the connected load within 20 seconds with 80 percent of the rated voltage maintained at motor terminals during one starting period. Motor bearings must be fitted with grease supply fittings and grease relief to outside of enclosure. Manual or automatic control and protective or signal devices required for the operation specified and any control wiring required for controls and devices specified, but not shown, must be provided.

2.2.2.3 Ozone Depleting Substances

Unitary air conditioning equipment must not use CFC-based refrigerants. Refrigerant may be an approved alternative refrigerant in accordance with EPA's Significant New Alternative Policy (SNAP) listing.

2.2.3 Nameplates

Major equipment including compressors, condensers, receivers, heat exchanges, fans, and motors must have the manufacturer's name, address, type or style, model or serial number, and catalog number on a plate secured to the item of equipment. Plates must be durable and legible throughout equipment life and made of anodized aluminum. Fix plates in prominent locations with nonferrous screws or bolts.

2.2.4 Safety Devices

Exposed moving parts, parts that produce high operating temperature, parts which may be electrically energized, and parts that may be a hazard to operating personnel must be insulated, fully enclosed, guarded, or fitted with other types of safety devices. Safety devices must be installed so that proper operation of equipment is not impaired. Welding and cutting safety requirements must be in accordance with AWS Z49.1.

2.3 EQUIPMENT

2.3.1 Mini-Split-System Air Conditioners and Heat Pumps

2.3.1.1 Small-Capacity Split-System Air-Conditioners (Not Exceeding 65,000 Btu/hr)

Provide an air-cooled, split system which employs a remote condensing unit, a separate wall mounted indoor unit, and interconnecting refrigerant piping. Provide the heat pump type unit conforming to applicable Underwriters Laboratories (UL) standards including UL 1995. Unit must be rated in accordance with ANSI/AHRI 210/240. Provide indoor unit with necessary fans, air filters, and galvanized steel cabinet construction. The remote unit must be as specified in paragraph CONDENSING UNIT. Provide double-width, double inlet, forward curved backward inclined, or airfoil blade, centrifugal scroll type evaporator or supply fans. Provide the manufacturer's standard condenser or outdoor fans for the unit specified. Design unit to operate at outdoor ambient temperatures up to 115 degrees F.

2.3.1.1.1 Energy Efficiency

Provide unit with an Energy Star label.

2.3.1.1.2 Air-to-Refrigerant Coil

Provide condensing coils with copper or aluminum tubes of 3/8 inch minimum diameter with aluminum fins that are mechanically bonded or soldered to the tubes. Casing must be galvanized steel or aluminum. Avoid contact of dissimilar metals. Test coils in accordance with ASHRAE 15 & 34 at the factory and ensure suitability for the working pressure of the installed system. Dehydrate and seal each coil testing and prior to evaluation and charging.

Coat condenser coil with a uniformly applied epoxy electrodeposition, phenolic, or vinyl type coating to all coil surface areas without material bridging between fins. Apply coating at either the coil or coating manufacturer's factory. Coating process must ensure complete coil encapsulation and be capable of withstanding a minimum 500 hours exposure to the salt spray test specified in ASTM B117 using a 5 percent sodium chloride solution.

2.3.1.1.3 Compressor

Provide direct drive variable speed type compressor. Provide compressor with internal over temperature and pressure protector; sump heater; oil pump; high pressure and low pressure controls; and liquid line dryer.

2.3.1.1.4 Refrigeration Circuit

Refrigerant-containing components must comply with ASHRAE 15 & 34 and be factory tested, cleaned, dehydrated, charged, and sealed. Provide each unit with a factory operating charge of refrigerant and oil or a holding charge. Field charge unit shipped with a holding charge. Provide refrigerant charging valves. Provide filter-drier in liquid line.to prevent freeze-up in event of loss of water flow during heating cycle.

2.3.1.1.5 Unit Controls

Provide unit internally prewired with a control circuit powered by an internal transformer. Provide terminal blocks for power wiring and external control wiring. Internally protect unit by fuses or a circuit breaker in accordance with UL 1995. Equip units with three-phase power with phase monitoring protection to protect against problems caused by phase loss, phase imbalance and phase reversal. Control unit by a programmable electronic thermostat with heating setback and cooling setup with 7-day programming capability.

Communication networks between physically separate units in a split system must match the protocol used by the control system interface.

2.3.1.1.6 Condensing Coil

Provide coils with copper or aluminum tubes of 3/8 inch minimum diameter with aluminum fins that are mechanically bonded or soldered to the tubes. Protect coil in accordance with paragraph CORROSION PROTECTION. Provide galvanized steel or aluminum casing. Avoid contact of dissimilar metals. Test coils in accordance with ANSI/ASHRAE 15 & 34 at the factory and ensure suitability for the working pressure of the installed system. Dehydrate and seal each coil after testing and prior to evaluation and charging. Provide separate expansion devices for each compressor circuit.

2.3.1.1.7 Remote Condenser or Condensing Unit

Fit each remote condenser coil fitted with a manual isolation valve and an access valve on the coil side. Saturated refrigerant condensing temperature must not exceed 120 degrees F at 104 degrees F ambient. Provide unit with low ambient condenser controls to ensure proper operation in an ambient temperature of 32degrees F. Provide fan and cabinet construction as specified in paragraph UNITARY EQUIPMENT ACCESSORIES.

2.3.1.1.7.1 Air-Cooled Condenser

Provide Unit in accordance with ANSI/AHRI 460 and conform to the requirements of UL 1995. Provide factory fabricated, tested, packaged, and self-contained unit; complete with casing, propeller type fans, heat rejection coils, connecting piping and wiring, and all necessary accessories.

2.3.1.1.8 Primary/Supplemental Heat

Provide heating unit with internal thermal insulation having a fire hazard rating not to exceed 25 for flame spread and 50 for smoke developed as determined by ASTM E84.

2.4 COMPONENTS

2.4.1 Refrigerant and Oil

Refrigerant must be one of the fluorocarbon gases. Refrigerants must have number designations and safety classifications in accordance with ASHRAE 15 & 34. Refrigerants must meet the requirements of AHRI 700 as a minimum. Provide a complete charge of refrigerant for the installed system as recommended by the manufacturer. Lubricating oil must be of a type and grade recommended by the manufacturer for each compressor. Where color leak indicator dye is incorporated, charge must be in accordance with manufacturer's recommendation.

2.4.2 Fans

Fan wheel shafts must be supported by either maintenance-accessible lubricated antifriction block-type bearings, or permanently lubricated ball bearings. Unit fans must be selected to produce the cfm required at the fan total pressure. Motor starters, if applicable, must be magnetic across-the-line type with a totally enclosed enclosure. Thermal overload protection must be of the manual or automatic-reset type. Fan wheels or propellers must be constructed of aluminum or galvanized steel. Centrifugal fan wheel housings must be of galvanized steel, and both centrifugal and propeller fan casings must be constructed of aluminum or galvanized steel. Steel elements of fans, except fan shafts, must be hot-dipped galvanized after fabrication or fabricated of mill galvanized steel. Mill-galvanized steel surfaces and edges damaged or cut during fabrication by forming, punching, drilling, welding, or cutting must be recoated with an approved zinc-rich compound. Fan wheels or propellers must be statically and dynamically balanced.

2.5 FINISHES

2.5.1 Coil Corrosion Protection

Provide coil with a uniformly applied epoxy electrodeposition, phenolic, or vinyl type coating to all coil surface areas without material bridging between fins. Submit product data on the type coating selected, the coating thickness, the application process used, the estimated heat transfer loss of the coil, and verification of conformance with the salt spray test requirement. Coating must be applied at either the coil or coating manufacturer's factory. Coating process must ensure complete coil encapsulation. Coating must be capable of withstanding a minimum 1,000 hours exposure to the salt spray test specified in ASTM B117 using a 5 percent sodium chloride solution.

2.5.2 Equipment and Components Factory Coating

Unless otherwise specified, equipment and component items, when fabricated from ferrous metal, must be factory finished with the manufacturer's standard finish, except that items located outside of buildings must have weather resistant finishes that will withstand 500 hours exposure to the salt spray test specified in ASTM B117 using a 5 percent sodium chloride solution. Immediately after completion of the test, the specimen must show no signs of blistering, wrinkling, cracking, or loss of adhesion and no sign of rust creepage beyond 1/8 inch on either side of the scratch mark. Cut edges of galvanized surfaces where hot-dip galvanized sheet steel is used must be coated with a zinc-rich coating conforming to ASTM D520, Type I.

Where stipulated in equipment specifications of this section, coat finned tube coils of the affected equipment as specified below. Apply coating at the premises of a company specializing in such work. Degrease and prepare for coating in accordance with the coating applicator's procedures for the type of metals involved. Completed coating must show no evidence of softening, blistering, cracking, crazing, flaking, loss of adhesion, or "bridging" between the fins.

2.5.2.1 Phenolic Coating

Provide a resin base thermosetting phenolic coating. Apply coating by immersion dipping of the entire coil. Provide a minimum of two coats. Bake or heat dry coils following immersions. After final immersion and prior to final baking, spray entire coil with particular emphasis given to building up coating on sheared edges. Total dry film thickness must be 2.5 to 3.0 mils.

2.5.2.2 Chemical Conversion Coating with Polyelastomer Finish Coat

Dip coils in a chemical conversion solution to molecularly deposit a corrosion resistant coating by electrolysis action. Chemical conversion coatings must conform to MIL-DTL-5541, Class 1A. Cure conversion coating at a temperature of 110 to 140 degrees F for a minimum of 3 hours. Coat coil surfaces with a complex polymer primer with a dry film thickness of 1 mil. Cure primer coat for a minimum of 1 hour. Using dip tank method, provide three coats of a complex polyelastomer finish coat. After each of the first two finish coats, cure the coils for 1 hour. Following the third coat, spray a fog coat of an inert sealer on the coil surfaces. Total dry film thickness must be 2.5 to 3.0 mils. Cure finish coat for a minimum of 3 hours. Coating materials must have 300 percent flexibility, operate in temperatures of minus 50 to plus 220 degrees F, and protect against atmospheres of a pH range of 1 to 14.

2.5.2.3 Vinyl Coating

Apply coating using an airless fog nozzle. For each coat, make at least two passes with the nozzle. Materials to be applied are as follows:

a. Total dry film thickness, 6.5 mils maximum

b. Vinyl Primer, 24 percent solids by volume: One coat 2 mils thick

c. Vinyl Copolymer, 30 percent solids by volume: One coat 4.5 mils thick

2.5.3 Factory Applied Insulation

Refrigeration equipment must be provided with factory installed insulation on surfaces subject to sweating including the suction line piping. Where motors are the gas-cooled type, factory installed insulation must be provided on the cold-gas inlet connection to the motor in accordance with manufacturer's standard practice. Factory insulated items installed outdoors are not required to be fire-rated. As a minimum, factory insulated items installed indoors must have a flame spread index no higher than 75 and a smoke developed index no higher than 150. Factory insulated items (no jacket) installed indoors and which are located in air plenums, in ceiling spaces, and in attic spaces must have a flame spread index no higher than 25 and a smoke developed index no higher than 50. Flame spread and smoke developed indexes must be determined by ASTM E84. Insulation must be tested in the same density and installed thickness as the material to be used in the actual construction. Material supplied by a manufacturer with a jacket must be tested as a composite material. Jackets, facings, and adhesives must have a flame spread index no higher than 25 and a smoke developed index no higher than 50 when tested in accordance with ASTM E84.

2.6 TESTS, INSPECTIONS, AND VERIFICATIONS

All manufactured units must be inspected and tested, and documentation provided to demonstrate that each unit is in compliance with ANSI/AHRI and UL requirements and that the minimum efficiency requirements of ASHRAE 90.1 - IP have been met.

PART 3 EXECUTION

3.1 EXAMINATION

After becoming familiar with all details of the work, perform Verification of Dimensions in the field, and advise the Contracting Officer of any discrepancy before performing any work.

3.2 INSTALLATION

Perform work in accordance with the manufacturer's published diagrams, recommendations, and equipment warranty requirements. Where equipment is specified to conform to the requirements of ASME BPVC SEC VIII D1and ASME BPVC SEC IX, the design, fabrication, and installation of the system must conform to ASME BPVC SEC VIII D1 and ASME BPVC SEC IX.

3.2.1 Equipment

Provide refrigeration equipment conforming to ASHRAE 15 & 34. Provide necessary supports for all equipment, appurtenances, and pipe as required, including frames or supports for compressors, pumps, cooling towers, condensers, and similar items.

3.3 CLEANING AND ADJUSTING

Equipment must be wiped clean, with all traces of oil, dust, dirt, or paint spots removed. Temporary filters must be provided for all fans that are operated during construction, and new filters must be installed after all construction dirt has been removed from the building. System must be maintained in this clean condition until final acceptance. Bearings must be properly lubricated with oil or grease as recommended by the manufacturer. Belts must be tightened to proper tension. Control valves and other miscellaneous equipment requiring adjustment must be adjusted to setting indicated or directed. Fans must be adjusted to the speed indicated by the manufacturer to meet specified conditions. Testing, adjusting, and balancing must be as specified in Section 23 05 93 TESTING, ADJUSTING, AND BALANCING OF HVAC SYSTEMS.

3.4 TRAINING

Conduct a training course for the operating staff as designated by the Contracting Officer. The training period must consist of a total 4 hours of normal working time and start after the system is functionally completed but prior to final acceptance tests.

a. Submit a schedule, at least 2 weeks prior to the date of the proposed training course, which identifies the date, time, and location for the training.

b. Submit the field posted instructions, at least 2 weeks prior to construction completion, including equipment layout, wiring and control diagrams, piping, valves and control sequences, and typed condensed operation instructions. The condensed operation instructions must include preventative maintenance procedures, methods of checking the system for normal and safe operation, and procedures for safely starting and stopping the system. The posted instructions must be framed under glass or laminated plastic and be posted where indicated by the Contracting Officer.

c. The posted instructions must cover all of the items contained in the approved operation and maintenance manuals as well as demonstrations of routine maintenance operations. Submit 6 complete copies of an operation manual in bound 8-1/2 by 11 inch booklets listing step-by-step procedures required for system startup, operation, abnormal shutdown, emergency shutdown, and normal shutdown at least 2 weeks prior to the training course. The booklets must include the manufacturer's name, model number, and parts list. The manuals must include the manufacturer's name, model number, service manual, and a brief description of all equipment and their basic operating features.

d. Submit 6 complete copies of maintenance manual in bound 8-1/2 by 11 inch booklets listing routine maintenance procedures, possible breakdowns and repairs, and a trouble shooting guide. The manuals must include piping and equipment layouts and simplified wiring and control diagrams of the system as installed.

3.5 SYSTEM PERFORMANCE TESTS

Before each refrigeration system is accepted, conduct tests to demonstrate the general operating characteristics of all equipment by a registered professional engineer or an approved manufacturer's start-up representative experienced in system start-up and testing, at such times as directed. Six copies of the report provided in bound 8-1/2 by 11 inch booklets. The report must document compliance with the specified performance criteria upon completion and testing of the system. The report must indicate the number of days covered by the tests and any conclusions as to the adequacy of the system.

For equipment providing heating and cooling the system performance tests must be performed during the heating and cooling seasons.

a. Submit a schedule, at least 2 weeks prior to the start of related testing, for the system performance tests. The schedules must identify the proposed date, time, and location for each test. Tests must cover a period of not less than 48 hours for each system and must demonstrate that the entire system is functioning in accordance with the drawings and specifications.

b. Make corrections and adjustments, as necessary, tests must be re-conducted to demonstrate that the entire system is functioning as specified. Prior to acceptance, install and tighten service valve seal caps and blanks over gauge points. Replace any refrigerant lost during the system startup.

c. If tests do not demonstrate satisfactory system performance, correct deficiencies and retest the system. Conduct tests in the presence of the Contracting Officer. Water and electricity required for the tests will be furnished by the Government. Provide all material, equipment, instruments, and personnel required for the test.

d. Coordinate field tests with Section 23 05 93 TESTING, ADJUSTING, AND

BALANCING OF HVAC SYSTEMS. Submit 6 copies of the report provided in bound 8-1/2 by 11 inch booklets. The report must document compliance with the specified performance criteria upon completion and testing of the system. The report must indicate the number of days covered by the tests and any conclusions as to the adequacy of the system. Submit the report including the following information (where values are taken at least three different times at outside dry-bulb temperatures that are at least 5 degrees F apart):

(1) Date and outside weather conditions.

(2) The load on the system based on the following:

(a) The refrigerant used in the system.
(b) Condensing temperature and pressure.
(c) Suction temperature and pressure.
(d) Ambient, condensing and coolant temperatures.
(e) Running current, voltage and proper phase sequence for each phase of all motors.

(3) The actual on-site setting of operating and safety controls.

(4) Thermostatic expansion valve superheat - value as determined by field test.

(5) Subcooling.

(6) High and low refrigerant temperature switch set-points

(7) Low oil pressure switch set-point.

(8) Defrost system timer and thermostat set-points.

(9) Moisture content.

(10) Capacity control set-points.

(11) Field data and adjustments which affect unit performance and energy consumption.

(12) Field adjustments and settings which were not permanently marked as an integral part of a device.

3.6 MAINTENANCE

3.6.1 EXTRA MATERIALS

Submit spare parts data for each different item of equipment specified, after approval of detail drawings and not later than 2 months prior to the date of beneficial occupancy. Include in the data a complete list of parts and supplies, with current unit prices and source of supply, a recommended spare parts list for 1 year of operation, and a list of the parts recommended by the manufacturer to be replaced on a routine basis.

3.6.2 Maintenance Service

Submit a certified list of qualified permanent service organizations, which includes their addresses and qualifications, for support of the equipment. The service organizations must be reasonably convenient to the equipment installation and be able to render satisfactory service to the equipment on a regular and emergency basis during the warranty period of the contract.

-- End of Section --

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SECTION 25 05 11.01

CYBERSECURITY FOR FACILITY-RELATED CONTROL SYSTEMS - DDC and Metering
05/21, CHG 1: 08/23

PART 1 GENERAL

Many subparts in this Section contain text in curly braces ("{" and "}") indicating which cybersecurity control and control correlation identifier (CCI) the requirements of the subpart relate to. The text inside these curly braces is for Government reference only and enables coordination of the requirements of this Section with the RMF process throughout the design and construction process. Text in curly braces are not contractor requirements.

This Section refers to Security Requirements Guide (SRGs) and Security Technical Implementation Guide (STIGs). STIGs and SRGs are available online at the Information Assurance Support Environment (IASE) website at https://public.cyber.mil/stigs/downloads/ and an SRG/STIG Applicability Guide and Collection Tool is available at https://public.cyber.mil/stigs/SCAP/. Not all control system components have applicable STIGs or SRGs. The "Control Systems SRG" does not apply to work performed under this Section; all requirements within this section to apply applicable SRGs DO NOT include the "Control Systems SRG".

1.1 CONTROL SYSTEM APPLICABILITY

There are multiple versions of this Section associated with this project. Different versions have requirements applicable to different control systems. This specific Section applies only to the following control systems:

Direct Digital Control System (DDC/HVAC): L-L-L
Utility Metering Control System (Smart Metering): L-L-L

1.2 RELATED REQUIREMENTS

This section does not contain sufficient requirements to procure a control system and must be used in conjunction with other Sections which specify control systems. This Section adds cybersecurity requirements to the control systems specified in other Sections, and as these requirements are conditioned on the control system being provided, there may be requirements in this Section that will not apply to this project. All Sections containing facility-related control systems or control system components are related to the requirements of this Section. Review all specification sections to determine related requirements.

In cases where a requirement is specified in both this Section and in another Section, the more stringent requirement must be met. In cases where a requirement in this Section conflicts with the requirements of another Section such that both requirements cannot be met at the same time, request direction from the Contracting Officer Representative to determine which requirement applies to the project.

1.3 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 802.1x	(2010) Local and Metropolitan Area Networks - Port Based Network Access Control

NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY (NIST)

NIST FIPS 140-2	(2001) Security Requirements for Cryptographic Modules

U.S. DEPARTMENT OF DEFENSE (DOD)

DODI 8551.01	(2014) Ports, Protocols, and Services Management (PPSM)
DTM 08-060	(2008) Policy on Use of Department of Defense (DoD) Information Systems - Standard Consent Banner and User Agreement

1.4 DEFINITIONS

1.4.1 Administrator Account

An administrator account is an account with full permissions to a device, application, or operating system, including the ability to create and modify other user accounts.

Note that the operating system Administrator Account may be different than Administrator Accounts for applications hosted on that operating system. Also, most controllers will not have any support for accounts and will therefore not have an 'Administrator Account'.

1.4.2 Computer

A computer is one of the following:

a. a device running a non-embedded desktop or server version of Microsoft Windows

b. a device running a non-embedded version of MacOS

c. a device running a non-embedded version of Linux

d. a device running a version or derivative of the Android Operating System, where Android is considered separate from Linux

e. a device running a version of Apple iOS

Unless otherwise indicated or clear from context use of the word "device" in this Section includes computers.

1.4.3 Controller

A device other than a computer or Ethernet switch.

1.4.4 Mission Space

A device or media is in mission space if physical access to the device or media is controlled by the organization served by the device. For example, a VAV box controller in a suspended ceiling is in mission space if the VAV box serves that room; an electrical switchgear in an electrical room or an AHU in a mechanical room or on a rooftop may still be considered to be in mission space if the organization (mission) served by that switchgear or AHU controls access to the electrical room, mechanical room or rooftop.

1.4.5 Network

A network is a group of two or more devices that can communicate using a network protocol. Network protocols must provide a method for addressing devices on the network; a communication method that does not provide an addressing scheme is not a networked form of communication. Devices that communicate using a method of communication that does not support device addressing are not using a network.

1.4.6 Network Connected

A component is network connected (or "connected to a network") only when the device has a network transceiver which is directly connected to the network and implements the network protocol. A device lacking a network transceiver (and accompanying protocol implementation) can never be considered network connected. Note that (unlike many IT definitions of "Network Connected") a device connected to a non-IP network is still considered network connected (an IP connection or IP address is not required for a device to be network connected).

1.4.6.1 Wireless Network Connected

Any device that supports wireless network communication is network connected to a wireless network, regardless of whether the device is communicating using wireless. Unless physically disabled, devices with wireless transceivers support wireless, it is not sufficient to disable the wireless in software.

1.4.7 Network Media

The thing that provides the communication channel between the devices on a network. Typically wire, but might include wireless, fiber optic, or even power line (some network protocols allow sending network signals over power wiring).

1.4.8 User Account Support Levels

The support for user accounts is categorized in this Section as one of three levels:

1.4.8.1 FULLY Supported

Device supports configurable individual accounts. Accounts can be created, deleted, modified, etc. Privileges can be assigned to accounts. These devices support user-based (as opposed to role-based) authentication.

1.4.8.2 MINIMALLY Supported

Device supports a small, fixed number of accounts (perhaps only one). Accounts cannot be modified. A device with only a "User" and an "Administrator" account would fit this category. Similarly, a device with two PINs for logon - one for restricted and one for unrestricted rights would fit here (in other words, the accounts do not have to be the traditional "username and password" structure). These devices typically only support role-based authentication.

Examples of devices which MINIMALLY support accounts are a) a variable frequency drive with a single account which requires a PIN for access to configuration; and b) a room lighting control touchpad interface that has a single account.

1.4.8.3 NOT Supported

Device does not support any Access Enforcement therefore the whole concept of "account" is meaningless.

1.4.9 Manual Local Input

Manual Local Inputs are system analog or binary inputs that are adjustable by a person but are, by intrinsic hardware design, very limited in potential capabilities. Manual Local Inputs do not have touch screens or full keyboards, but may have a few buttons or dials to allow input. Manual Local Inputs do not have full graphic screens or dot-matrix displays, but may have simple lights (LEDs) or 7-segment displays. Manual Local Inputs do not have any sort of menu structure, each button has a single well-defined function.

Examples of Manual Local Inputs are H-O-A switches, simple thermostats, and disconnect switches.

1.4.10 Card Reader

A card reader is an input/output device whose primary function is to assist in two-factor authentication. A card reader must have an interface to read data from a card and may be able to write data to a card. A card reader may have a means (such as buttons, keypad, touchscreen, etc.) for a user to input a PIN or password, as well as a limited display.

1.4.11 User Interface

A User Interface (UI) is something other than a Manual Local Input or Card Reader that allows a person to interact with the system or device. Note that while a Card Reader is not by itself a User Interface, a User Interface may contain a Card Reader in order for it to authenticate its user. Within control systems, there are a wide range of User Interfaces.

Two important distinctions are 1) whether the user interface is Local or

Remote, and 2) the effective capabilities of the User Interface to alter data, which is the "privilege" of the user interface (where effective privilege available to a specific user at a specific user interface is the combination of the greatest privilege offered by the user interface and the specific account the user is logged into).

1.4.11.1 Local User Interface

A Local User Interface is a user interface where the physical hardware the user interacts with (keyboard, buttons, display, etc.) is physically part of the device being affected. All of the relevant characteristics of the user interface are embodied within a single device.

Note that a Local UI may be able to access data in a different device, Local versus Remote in this context refers to the user interface itself; the capability to access data in a different device is covered under "Full User Interface".

1.4.11.2 Remote User Interface

A Remote User Interface implements a Client/Server model where the physical hardware the user interacts with (Client) is physically distinct from the device being affected (Server). Most or all of the security and functionality characteristics of the user interface are defined by the Server, not the Client. The Client and Server communicate via a network connection. A common example of a remote user interface is a web-based interface where the browser (client) is generally on different hardware than the web server (server). A Remote UI remains a Remote UI even if the user happens to be at a Client on the same hardware as the Server. What is important is that a) the Client may be on different hardware than the Server and b) the majority of the security and functional characteristics of the interface are defined at the Server.

Note that this definition of "remote" is consistent with that generally used in the control industry but is not aligned with the NIST 800-53 definition of "Remote", which refers to "outside the system". The term "Remote" here better aligns with the NIST 800-53 definition of "Network" (remote from within the system) Access.

1.4.11.3 Types of User Interface (by capability)

User interfaces are also categorized by their capabilities as being Read Only, Limited, or Full.

1.4.11.3.1 Read-Only User Interface

A Read Only User Interface (also referred to as a View-Only User Interface) is a user interface that only allows for reading data, it does not allow (have the capability to) modify data. A Read Only User Interface may be either Local or Remote. A User Interface that is configured to be Read Only (by some other means than the interface itself, such as using configuration software on a laptop) is a Read-Only Interface. Note a Read Only User Interface may have buttons (or touch screen, etc.) allowing the user to navigate through the presentation of data.

Examples of a Read Only User Interfaces are a) a publicly viewable "energy dashboard" showing weather data and energy usage within a building and b) digital wayfinding signage.

1.4.11.3.2 Limited User Interface

A Limited User Interface is a user interface that - by design - can only alter information local to the user interface. Note that the determination of "alter" includes only direct interactions, it explicitly excludes interactions that might occur as secondary effects. For example, an interface changing the flow setpoint in a pump controller is a direct interaction, the subsequent change in flow (as well as any subsequent downstream changes in valve position) are not direct interactions.

Two examples of LIMITED UIs are: a) a variable speed drive has a Limited Local User Interface which allows the user to change properties within the drive, but does not allow affecting things outside the drive; and b) a typical home WiFi Router has a Limited Remote User Interface which allows configuration of the Router, but does not allow direct interaction with other devices.

1.4.11.3.3 Full User Interface

A Full User Interface can alter information in devices outside the device with the user interface. For example, a typical Local Display Panel is a Full Local User Interface while a browser-based front end is a Full Remote User Interface.

1.4.11.3.4 View-Only User Interface

See Read-Only User Interface

1.4.11.4 Other User Interface Terminology

In addition to defining whether a user interface is a Hardware Limited, Read-Only, Limited or Full, and whether it is Local or Remote, user interfaces are classified by whether they are writable or privileged.

1.4.11.4.1 Writable User Interface

Any User Interface that is not Read-Only is Writable. (Limited User Interfaces and Full User Interfaces are both writable user interfaces (as they are capable of changing a value)).

1.4.11.4.2 Privileged User Interface

A Privileged UI is a UI that has sufficient capabilities or functionality that it requires specific cybersecurity measures to be put in place to limit its unauthorized use. Ultimately, whether a specific user interface is considered a Privileged User Interface must be determined by usage. Unless otherwise specified, user interfaces can be determined to be privileged or not using the following:

a. Read-Only User Interfaces are not privileged user interfaces.

b. Full User Interfaces are privileged user interfaces.

c. User interfaces that allow for configuration of auditing or allows for modification or deletion of audit logs are privileged user interface.

d. User interfaces that allow for reprogramming a network connected device is a privileged user interface.

e. Except as specified above, a Limited User Interface must be determined to be privileged or not based on the specific capabilities and use case of the user interface. In general however, user interfaces that do not offer significant capabilities above and beyond those available at that location via other means (e.g. such as a disconnect switch, breaker, or hand-off-auto switch, or physical attack) are not privileged.

1.4.12 Wireless Network

Any network that communicates without using wires or fiber optics as the communication media. Wireless networks include: WiFi, Bluetooth, ZigBee, cellular, satellite, 900 MHz radio, 2.4 GHz, free space optical, point-to-point laser, and IR.

1.4.13 Wired Broadcast Network

Wired Broadcast Networks are any network, such as powerline carrier networks and modem (wired telephony), that use wire-based technologies where there is not a clearly defined boundary for signal propagation.

1.5 ADMINISTRATIVE REQUIREMENTS

1.5.1 Points of Contact

Coordinate with the following Points of Contact as indicated in this Section and as required. Not all projects will require coordination with all Points of Contact. When coordination is required and no Point of Contact is indicated, coordinate with The Contracting Office Representative (COR).

a. Government Computer Access Point of Contact: 1 SOCES Cybersecurity Team

1.5.2 Coordination

Coordinate the execution of this Section with the execution of all other Sections related to control systems as indicated in the paragraph RELATED REQUIREMENTS. Items that must be considered when coordinating project efforts include but are not limited to:

a. If requesting permission for wireless or wired broadcast communication, the Wireless and Wired Broadcast Communication Request submittal must be approved prior to control system device selection and installation.

b. If requesting permission for alternate account lock permissions, the Device Account Lock Exception Request must be approved prior to control system device selection and installation.

c. If requesting permission for the use of a device with multiple physical connections to IP networks, the Multiple IP Connection Device Request must be approved prior to control system device selection and installation.

d. Wireless testing may be required as part of the control system testing. See requirements for the Wireless Communication Test Report submittal.

e. If the Device Audit Record Upload Software is to be installed on a computer not being provided as part of the control system, coordination is required to identify the computer on which to install the software.

f. The Cybersecurity Interconnection Schedule must be coordinated with other work that will be interconnected to, and interconnections must be approved by the Government before relying on them for system functionality.

g. Cybersecurity testing support must be coordinated across control systems and with the Government cybersecurity testing schedule.

h. Passwords must be coordinated with the indicated contact for the project site.

i. If applicable, HTTPS web server certificates must be obtained from the indicated HTTPS Certificate Point of Contact.

j. Contractor Computer Cybersecurity Compliance Statements must be provided for each contractor using contractor owned computers.

1.6 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Wireless and Wired Broadcast Communication Request; G

Device Account Lock Exception Request; G

Multiple Ethernet Connection Device Request; G

Contractor Computer Cybersecurity Compliance Statements; G

Contractor Temporary Network Cybersecurity Compliance Statements; G

Cybersecurity Interconnection Schedule; G

Proposed STIG and SRG Applicability Report; G

SD-02 Shop Drawings

Network Communication Report; G

Cybersecurity Riser Diagram; G

SD-03 Product Data

Control System Cybersecurity Documentation; G

SD-06 Test Reports

Wireless Communication Test Report; G

Control System Cybersecurity Testing Procedures; G

Control System Cybersecurity Testing Report; G

SD-07 Certificates

Software Licenses; G

SD-11 Closeout Submittals

Confidential Password Report; G

Enclosure Keys; G

Software and Configuration Backups; G

Auditing Front End Software; G

Device Audit Record Upload Software; G

System Maintenance Tool Software; G

Control System Scanning Tools; G

STIG, SRG and Vendor Guide Compliance Result Report; G

Control System Inventory Report; G

1.7 CYBERSECURITY DOCUMENTATION

{For Government Reference Only: This subpart (and its subparts) relates to PL-7; CCI-003071}

1.7.1 Proposed STIG and SRG Applicability Report

For each model of network connected or network infrastructure device, use the DISA SRG/STIG Applicability Guide and Collection Tool (available at https://public.cyber.mil/stigs/SCAP/to identify applicable STIGs or SRGs and provide a report indicating applicable STIGs and SRGs for each model.

1.7.2 Cybersecurity Interconnection Schedule

{For Government Reference Only: This subpart relates to CA-3(b), PL-8, SC-7(9), SC-7(11); CCI-000258, CCI-003072, CCI-003073, CCI-003075, CCI-002398, CCI-002399, CCI-002401, CCI-002402, CCI-002403.}

Provide a completed Cybersecurity Interconnection Schedule documenting network connections between the installed system and other systems. Provide the following information for each device directly communicating between systems: Device Identifier, Device Description, Transport layer Protocol, Network Address, Port (if applicable), MAC (Layer 2) address (if applicable), Media, Application Protocol, Service (if applicable), Descriptive Purpose of communication. For communication with other authorized systems also provide the Foreign Destination and POC for Destination. If other control system Sections used on this project include submittals documenting this information, provide copies of those submittals to meet this requirement.

In addition to the requirements of Section 01 33 00 SUBMITTAL PROCEDURES, provide the Cybersecurity Interconnection Schedule as an editable Microsoft Excel file (a template Cybersecurity Interconnection Schedule in Excel format is available at https://www.wbdg.org/ffc/dod/unified-facilities-guide-specifications-ufgs/ufgs-25-05-1

1.7.3 Network Communication Report

{For Government Reference Only: This subpart (and its subparts) relates to CA-9, PL-8; CCI-002102, CCI-002103, CCI-002104, CCI-002105, CCI-003072, CCI-003073, CCI-003075 and also the submittal requirements associated with CM-6, CM-7, SC-8 and SC-41 including CM-7(3), CCI-000388.}

Provide a network communication report. For each networked device, document the communication characteristics of the device including communication protocols, services used, encryption employed, and a general description of what information is communicated over the network. For each device using IP, document all TCP and UDP ports used. For non-IP communications, document communication protocol and media used. If other control system Sections used on this project include submittals documenting this information, provide copies of those submittals to meet this requirement.

In addition to the requirements of Section 01 33 00 SUBMITTAL PROCEDURES, provide the Network Communication Report as an editable Microsoft Excel file.

1.7.4 Control System Inventory Report

{For Government Reference Only: This subpart (and its subparts) relates to CM-8(a), SI-17, IA-3; CCI-000389, CCI-000392, CCI-000398, CCI-002773, CCI-002774, CCI-002775, CCI-000777, CCI-000778, CCI-001958}

Provide a Control System Inventory report using the Inventory Spreadsheet listed under this Section at https://www.wbdg.org/ffc/dod/unified-facilities-guide-specifications-ufgs/ufgs-25-05-1 documenting all networked devices, including network infrastructure devices. For each device provide all applicable information for which there is a field on the spreadsheet in accordance with the instructions on the spreadsheet.

In addition to the requirements of Section 01 33 00 SUBMITTAL PROCEDURES, provide the Control System Inventory Report as an editable Microsoft Excel file.

1.7.5 Software and Configuration Backups

{For Government Reference Only: This subpart (and its subparts) relates to CP-10; CCI-000550, CCI-000551, CCI-000552}

For each computer on which software is installed under this project, provide a recovery image of the final as-built computer. This image must allow for bare-metal restore such that restoration of the image is sufficient to restore system operation to the imaged state without the need for re-installation of software. If additional user permissions are required to meet this requirement, coordinate the creation of the image with the identified Government Computer Access Point of Contact.

For all ethernet switches provide a backup of the switch configuration. For all controllers, provide a backup of the controller configuration and the source code for all loaded application programs (all software that is not common to every controller of the same manufacturer and model).

If any or all of these are provided under another Section, provide documentation indicating this and referencing those submittals.

1.7.6 Cybersecurity Riser Diagram

{For Government Reference Only: This subpart (and its subparts) relates to PL-2(a), PL-8; CCI-003051, CCI-003053, CCI-003072, CCI-003073, CCI-003075}

Provide a cybersecurity riser diagram of the complete control system including all network and device hardware. If the control system specifications require a riser diagram submittal, provide a copy of that submittal as the cybersecurity riser diagram. Otherwise, provide a riser diagram in tabular format.

1.7.7 STIG, SRG and Vendor Guide Compliance Result Report

For every component (device or software) with an applicable STIG or SRG in the Proposed STIG and SRG Applicability Report, provide a result report documenting compliance with the STIG or SRG requirements. For components which are scannable by the SCAP (security content automation protocol) tool (available online at https://public.cyber.mil/stigs/scap), provide the SCAP report and raw scan results.

For every component (device or software) with manufacturer provided cybersecurity documentation, procedure, or method for secure configuration or installation, provide a report documenting how the component was configured and any deviation from the manufacturer instructions.

1.7.8 Control System Cybersecurity Documentation

{For Government Reference Only: This subpart (and its subparts) relates to SA-5(a),SA-5(b),SA-5(c), SA-22(b); CCIs: CCI-003124, CCI-003125, CCI-003126, CCI-003127, CCI-003128, CCI-003129, CCI-003130, CCI-003131, CCI-003374}

Provide a Control System Cybersecurity Documentation submittal containing the indicated information for each device and software application.

1.7.8.1 Software Applications

For all software applications running on computers provide:

a. administrator documentation that describes secure configuration of the software {For Government Reference Only: relates to CCI-003124}

b. administrator documentation that describes secure installation of the software and software updates. {For Government Reference Only: relates to CCI-003125}

c. administrator documentation that describes secure operation of the software {For Government Reference Only: relates to CCI-003124}

d. administrator documentation that describes effective use and maintenance of security functions or mechanisms for the software {For Government Reference Only: relates to CCI-003127}

e. administrator documentation that describes known vulnerabilities regarding configuration and use of administrative (i.e. privileged) functions for the software {For Government Reference Only: relates to CCI-003128}

f. user documentation that describes user-accessible security functions or mechanisms in the software and how to effectively use those security functions or mechanisms {For Government Reference Only: relates to CCI-003129}

g. user documentation that describes methods for user interaction which enables individuals to use the software in a more secure manner {For Government Reference Only: relates to CCI-003130}

h. user documentation that describes user responsibilities in maintaining the security of the software {For Government Reference Only: relates to CCI-003131}

1.7.8.2 For HVAC Control System Devices

1.7.8.2.1 HVAC Control System Devices FULLY Supporting User Accounts

For all HVAC Control System Devices which FULLY support user accounts, provide:

a. Documentation that describes secure configuration of the device {For Government Reference Only: relates to CCI-003124}

b. Documentation that describes secure operation of the device {For Government Reference Only: relates to CCI-003124}

c. Documentation that describes effective use and maintenance of security functions or mechanisms for the device {For Government Reference Only: relates to CCI-003127}

d. Documentation that describes known vulnerabilities regarding configuration and use of administrative (i.e. privileged) functions for the device {For Government Reference Only: relates to CCI-003128}

e. Documentation that describes user-accessible security functions or mechanisms in the device and how to effectively use those security functions or mechanisms; or a specific indication that there are no user-accessible security functions or mechanisms in the device {For Government Reference Only: relates to CCI-003129}

f. Documentation that describes methods for user interaction which enables individuals to use the device in a more secure manner {For Government Reference Only: relates to CCI-003130}

1.7.8.2.2 All Other HVAC Control System Devices

For all HVAC Control System Devices which do not FULLY support user accounts, provide:

a. Documentation that describes secure configuration of the device; or a specific indication that there are no secure configuration steps that apply {For Government Reference Only: relates to CCI-003124}

b. Documentation that describes effective use and maintenance of security functions or mechanisms for the device; or a specific indication that there are no security functions or mechanisms in the device {For Government Reference Only: relates to CCI-003127}

c. For devices which include a user interface, documentation that describes methods for user interaction which enables individuals to use the device in a more secure manner {For Government Reference Only: relates to CCI-003130}

1.7.8.3 Default Requirements for Control System Devices

For control system devices where Control System Cybersecurity Documentation requirements are not otherwise indicated in this Section, provide:

a. Documentation that describes secure configuration of the device {For Government Reference Only: relates to CCI-003124}

b. Documentation that describes secure installation of the device {For Government Reference Only: relates to CCI-003125}

c. Documentation that describes secure operation of the device {For Government Reference Only: relates to CCI-003124}

d. Documentation that describes effective use and maintenance of security functions or mechanisms for the device {For Government Reference Only: relates to CCI-003127}

e. Documentation that describes known vulnerabilities regarding configuration and use of administrative (i.e. privileged) functions for the device {For Government Reference Only: relates to CCI-003128}

f. Documentation that describes user-accessible security functions or mechanisms in the device and how to effectively use those security functions or mechanisms {For Government Reference Only: relates to CCI-003129}

g. Documentation that describes methods for user interaction which enables individuals to use the device in a more secure manner {For Government Reference Only: relates to CCI-003130}

h. Documentation that describes user responsibilities in maintaining the security of the device {For Government Reference Only: relates to CCI-003131}

i. Documentation of the published last date of support by the manufacturer or indication that a published date is not available. {For Government Reference Only: relates to CCI-003374}

1.8 SOFTWARE LICENSING

{For Government Reference Only: This subpart (and its subparts) relates to SI-2(a), SI-2(c), SI-7(14); CCI-001227, CCI-002605, CCI-002737}

For all software provided that has not already been licensed to the government or project site, provide a license to the Government for a period of no less than 5 years, and the license must also include the following software updates:

a. Security and bug-fix patches issued by the software manufacturer.

b. Security patches to address any vulnerability identified in the National Vulnerability Database at http://nvd.nist.gov with a Common Vulnerability Scoring System (CVSS) severity rating of MEDIUM or higher.

Provide a single Software Licenses submittal with documentation of the software licenses for all software provided

1.9 CYBERSECURITY DURING CONSTRUCTION

{For Government Reference Only: This subpart (and its subparts) relates to AC-18, SA-3; CCI-000258}

In addition to the control system cybersecurity requirements indicated in this section, meet following requirement throughout the construction process.

1.9.1 Contractor Computer Equipment

Contractor owned computers may be used for construction. Contractor computers connected to the control system, control system network, or a control system component at any point during construction must meet the following requirements:

1.9.1.1 Operating System

The operating system must be an operating system currently supported by the manufacturer of the operating system. The operating system must be current on security patches and operating system manufacturer required updates.

1.9.1.2 Anti-Malware Software

The computer must run anti-malware software from a reputable software manufacturer. Anti-malware software must be a version currently supported by the software manufacturer, must be current on all patches and updates, and must use the latest definitions file. Computers used on this project must be scanned using the installed software at least once per day.

1.9.1.3 Passwords and Passphrases

The passwords and passphrases for computers, applications, and web-based applications supporting passwords must be changed from their default values. Passwords must be a minimum of eight characters with a minimum of one uppercase letter, one lowercase letter, one number and one special character.

1.9.1.4 User-Based Authentication

Each user must have a unique account; sharing of a single account between multiple users is prohibited.

1.9.1.5 Demonstration of Compliance

The Government has the right to require demonstration of computer compliance with these requirements at any time during the project.

1.9.1.6 Contractor Computer Cybersecurity Compliance Statements

Provide a single submittal containing completed Contractor Computer Cybersecurity Compliance Statements for each company using contractor owned computers. Contractor Computer Cybersecurity Compliance Statements must use the template published at https://www.wbdg.org/ffc/dod/unified-facilities-guide-specifications-ufgs/ufgs-25-05-1 Each Statement must be signed by a cybersecurity representative for the relevant company.

1.9.2 Temporary IP Networks

Temporary contractor-installed IP networks may be used during construction. When used, temporary contractor-installed IP networks connected to the control system, control system network, or a control system component at any point during construction must meet the following requirements:

1.9.2.1 Network Boundaries and Connections

The network must not extend outside the project site and must not connect to any IP network other than those specifically provided or furnished for this project. Any and all access to the network from outside the project site is prohibited.

1.9.3 Government Access to Network

Government personnel must be allowed to have complete and immediate access to the network at any time in order to verify compliance with this specification.

1.9.4 Temporary Wireless IP Networks

In addition to the other requirements on temporary IP networks, temporary wireless IP (WiFi) networks, when permitted, must not interfere with existing wireless networks, must use WPA2 security and must not broadcast the network name (SSID). Network names (SSID) for wireless networks must be changed from their default values.

1.9.5 Passwords and Passphrases

The passwords and passphrases for all network devices and network access must be changed from their default values. Passwords must be a minimum 8 characters with a minimum of one uppercase letter, one lowercase letter, one number and one special character.

1.9.6 Contractor Temporary Network Cybersecurity Compliance Statements

Provide a single submittal containing completed Contractor Temporary Network Cybersecurity Compliance Statements for each company implementing a temporary IP network. Contractor Temporary Network Cybersecurity Compliance Statements must use the template published at https://www.wbdg.org/ffc/dod/unified-facilities-guide-specifications-ufgs/ufgs-25-05-1 Each Statement must be signed by a cybersecurity representative for the relevant company. If no temporary IP networks will be used, provide a single copy of the Statement indicating this.

1.10 CYBERSECURITY DURING WARRANTY PERIOD

All work performed on the control system after acceptance must be performed using Government Furnished Equipment or equipment specifically and individually approved by the Government.

PART 2 PRODUCTS

This section intentionally left blank

PART 3 EXECUTION

3.1 CYBERSECURITY HARDENING AND CONFIGURATION GUIDES

Install, configure, and harden all hardware and software furnished on this project in accordance with manufacturer provided documentation, procedures, or methods for secure configuration or installation. Do not implement specific hardening actions if that action would conflict with required functionality or another requirement of this Section.

3.2 NETWORK REQUIREMENTS

3.2.1 Wireless and Wired Broadcast Communication

{For Government Reference Only: This subpart (and its subparts) relates to AC-18, AC-18(3); CCI-001438, CCI-001439, CCI-002323, CCI-001441, CCI-001449}

Unless explicitly authorized by the Government, do not use any wireless or wired broadcast communication. If requesting authorization for wireless or wired broadcast communication, wired broadcast media such as powerline carrier is preferred to wireless.

3.2.1.1 Wireless and Wired Broadcast IP Communications

Do not install wireless or wired broadcast IP networks, including: do not install a wireless access point; do not install or configure an ad-hoc wireless network; do not install or configure a WiFi Direct communication.

When explicitly authorized by the Government, wireless IP communication may be used to communicate with an existing wireless network.

3.2.1.2 Non-IP Wireless Communication

For LOW Impact Systems: When non-IP wireless communication is explicitly authorized by the Government, use the maximum level of encryption supported by the specific protocol employed and select signal strength and radiated power to the minimum necessary for reliable communication.

3.2.1.3 Wireless and Wired Broadcast Communication Request

Provide a report documenting the proposed use of wireless or wired broadcast communication prior to device selection using the Wireless and Wired Broadcast Communication Request Schedule at https://www.wbdg.org/ffc/dod/unified-facilities-guide-specifications-ufgs/ufgs-25-05-1 If there is no proposed use of wireless or wired broadcast communication, provide a document indicating this instead of the Request Schedule.

For each device proposed to use wireless or wired broadcast communication show: the device identifier, a description of the device, the location of the device, the device identifiers of other devices communicating with the device, the protocol used for communication, encryption type and strength. For wireless communication, also show: RF Frequency, Radiated Power in dBm (decibel with a milliwatt reference), free-space range, and the expected as-installed range.

3.2.1.4 Wireless Communication Testing

As part of Functional Performance Testing {FPT}, conduct testing of wireless communication for all devices indicated on the approved Wireless and Wired Broadcast Communication Request as requiring testing.

To test wireless communication, test for wireless network reception at multiple points along the wireless test boundary in the vicinity of the wireless device, and record whether a network connection can be established at each point. The wireless test boundary is the building exterior walls. If wireless testing is required, provide a Wireless Communication Test Report documenting the testing points and results at each point for each wireless device.

3.2.2 Non-IP Control Networks

When control system specifications require particular communication protocols, use only those communication protocols and only as specified. Do not implement any other communication protocol.

When control system specifications do not indicate requirements for communication protocols, use only those protocols required for operation of the system as specified.

3.2.3 IP Control Networks

{For Government Reference Only: This subpart relates to CM-6(a), CM-7(a), CM-7(b), CM-7(1)(b), SC-41; CCI-001588, CCI-000381, CCI-000380, CCI-000381, CCI-000382, CCI-001761, CCI-001762, CCI-002544, CCI-002545, CCI-002546.}

IP Networks must be Ethernet networks and must use switches which are

Ethernet Switches or Daisy Chain IP Controllers as defined in this Section. Do not use nonsecure functions, ports, protocols and services as defined in DODI 8551.01 unless those ports, protocols and services are specifically required by the control system specifications or otherwise specifically authorized by the Government. Do not use ports, protocols and services that are not specified in the control system specifications or required for operation of the control system.

3.2.3.1 IP Network Routers

Do not install any device that performs IP routing.

3.2.3.2 IP Devices With Multiple Ethernet Connection

Except for Ethernet Switches and Daisy Chain IP Controllers, devices must not have more than one Ethernet connection to IP networks unless doing so is required by the project specifications and the specific application is approved. If a device with Multiple Ethernet Connections to IP networks is required, provide a Multiple Ethernet Connection Device Request using the Multiple Ethernet Connection Device Request Template at https://www.wbdg.org/ffc/dod/unified-facilities-guide-specifications-ufgs/ufgs-25-05-1 to request approval for each device. If a device with Multiple Ethernet Connections to IP networks is not required, instead provide a document stating that no approval is being requested.

3.2.4 Cryptographic Protection

{For Government Reference Only: This subpart relates to IA-2(9), IA-3(1), SC-8, SC-13, SC-23(1), SC-23(3); CCI-001942, CCI-001959, CCI-001967, CCI-002418, CCI-002449, CCI-002450, CCI-001185, CCI-001188, CCI-001664.}

All remote user interfaces must use HTTPS for all traffic between the user interface client and user interface server.

3.2.5 Device Identification and Authentication

{For Government Reference Only: This subpart (and its subparts) relates to IA-3; CCI-000777, CCI-000778, CCI-001958.}

All computers must support IEEE 802.1x for device authentication to the network.

3.2.5.1 For HVAC Control System Devices

Devices using HTTP as a control protocol must use HTTPS instead. Devices using Ethernet must support IEEE 802.1x.

3.2.6 Cryptographic Module Authentication

{For Government Reference Only: This subpart (and its subparts) relates to IA-7; CCI-000803}

For devices (including but not limited to NIST FIPS 140-2 compliant radios) that have STIG/SRGs related to cryptographic module authentication (CCI-000803), comply with the requirements of those STIG/SRGs.

3.3 ACCESS CONTROL REQUIREMENTS

3.3.1 User Accounts

{For Government Reference Only: This subpart (and its subparts) relate to AC-2(a), AC-3, AC-6(1), AC-6(10), AC-6(2), AC-6(9), CM-11(2), and IA-2; CCI-002110, CCI-000213, CCI-001558, CCI-002221, CCI-002222, CCI-002223, CCI-002235, CCI-000039, CCI-001419, CCI-002234, CCI-001812, and CCI-000764.}

Any user interface supporting user accounts (either FULLY or MINIMALLY) must limit access according to specified limitations for each account. Install and configure any device having a STIG or SRG in accordance with that STIG or SRG.

All user interfaces FULLY supporting accounts must implement user-based authentication where each account is uniquely assigned to a specific user. User interfaces FULLY supporting accounts must implement at least three (3) levels of user account privilege including: 1) an account with read-only permissions 2) an account with full permissions including account creation and modification and 3) an account with greater permissions than read-only but without account creation and modification.

3.3.1.1 Computers

All computer operating systems must FULLY support user accounts and implement accounts for access. Each control system software application not supporting accounts and running on a computer must be installed such that use of the software is restricted by the computer operating system to specific users.

Applications running on computers must not require the user be logged in to a computer operating system administrator account for normal operation. It is permissible to require the computer operating system administrator account for initial application installation and configuration.

3.3.1.2 Controllers

For user interfaces provided by controllers, provide access control in accordance with the User Interface Requirements table for the applicable control system and user interface type.

a. For table entries of "NA": NA means Not Applicable, there are no interfaces in this category.

b. For table entries of "None Required": The user interface is not required to support user accounts.

c. For table entries of "MINIMALLY": The user interface must at least MINIMALLY support user accounts.

d. For table entries of "FULLY": The user interface must at FULLY support user accounts.

e. For table entries of "KEY": The user interface must have physical security in the form of either a key lock on the interface itself or be furnished inside a locked enclosure. Where this is required for a read only interface, this lock must prevent viewing of data on the interface; for other interfaces, this lock must prevent using the interface to alter data.

f. For table entries of "Physical Security": For Local FULL interfaces, the interface must be located inside mission space. For Local Limited (not FULL) interfaces, the user interface must either a) be located within mission space or b) be protected by physical security at least as good as the control devices (and equipment controlled by the control devices) affected by the interface. For purposes of this requirement, 'affected' includes controllers with data that can be directly altered by the interface, as well as mechanical and/or electrical equipment directly controlled by those controllers, but does not include other interactions.

g. Entries of the form "X and Y" must meet both the requirement indicated for X and the requirement indicated for Y. For example, an entry of "MINIMALLY and Physical Security" indicates the user interface must both MINIMALLY support accounts and have physical security.

h. Entries of the form "X or Y" must meet either the requirement indicated for X or the requirement indicated for Y.

3.3.1.2.1 HVAC Control Systems

User Interface Requirements for LOW Impact HVAC Control Systems	
User Interface Type	**Access Control Requirement**
Local Read Only (see note 1)	None Required
Local Limited, Non-privileged	MINIMALLY
Local Limited, Privileged	MINIMALLY
Local Full	MINIMALLY
Remote Read Only	None Required
Remote Limited, Non-Privileged	MINIMALLY
Remote Limited, Privileged AND Remote Full (see note 2)	FULLY
Notes: 1)Local Read Only User Interfaces are always Non-Privileged 2)Remote Full User Interfaces are always Privileged	

3.3.2 Unsuccessful Logon Attempts

{For Government Reference Only: This subpart (and its subparts) relate to AC-7 (a), AC-7 (b); CCI-000043, CCI-000044, CCI-001423, CCI-002236, CCI-002237, CCI-002238}

Except for high availability user interfaces indicated as exempt, devices must meet the indicated requirements for handling unsuccessful logon attempts. If a device cannot meet these requirements, document device capabilities to protect from subsequent logon attempts and propose alternate protections in a Device Account Lock Exception Request submittal. Do not implement alternate protection measures in lieu of the indicated requirements without explicit permission from the Government. If no Device Account Lock Exceptions are requested, provide a document stating that no approval is being requested as the Device Account Lock Exception Request.

3.3.2.1 Devices MINIMALLY Supporting Accounts

For LOW Impact Systems: Devices which MINIMALLY (but not FULLY) support accounts are not required to lock based on unsuccessful logon attempts.

3.3.2.2 Devices FULLY Supporting Accounts

Devices which FULLY support accounts must meet the following requirements.

a. It must lock the user account when three unsuccessful logon attempts occur within a 15 minute interval.

b. Once an account is locked, the account must stay locked until unlocked by an administrator. If the account being locked is the sole administrator account on the device, the account must stay locked for 1 hour and then automatically unlock.

c. Once the indicated number of unsuccessful logon attempts occurs, delay further logon prompts by 5 seconds.

3.3.3 System Use Notification

{For Government Reference Only: This subpart (and its subparts) relates to AC-8; CCI-000048, CCI-002247, CCI-002243, CCI-002244, CCI-002245, CCI-002246, CCI-000050, CCI-002248}

3.3.3.1 System Use Notification for Remote User Interfaces

Remote user interfaces must display a warning banner meeting the requirements of DTM 08-060 on screen.

3.3.3.2 System Use Notification for Local User Interfaces

Devices which are connected to a network and have a local user interface must display a warning banner meeting the requirements of DTM 08-060 on the user interface screen if capable of doing so and must have a permanently affixed label with an approved banner from DTM 08-060 if unable to display the warning banner on the screen. Where it is impractical (perhaps due to device size) to affix the label to the device, affix the label to the device enclosure.

Labels must be machine printed or engraved, plastic or metal, designed for permanent installation, must use a font no smaller than 14 point, and must provide a high contrast between font and background colors.

3.3.4 Permitted Actions Without Identification or Authentication

{For Government Reference Only: This subpart (and its subparts) relates to AC-14; CCI-000061, CCI-000232}

The control system must require identification and authentication before allowing any actions except read-only actions by a user acting from a user interface which MINIMALLY or FULLY supports accounts.

3.3.5 Enclosures

Prior to final acceptance of the system, lock all lockable enclosures. Submit an Enclosure Keys submittal with all copies of keys for all enclosures and a key inventory list documenting all keys. Label each key with the matching enclosure identifier.

3.4 USER IDENTIFICATION AND AUTHENTICATION

{For Government Reference Only: This subpart (and its subparts) relates to IA-2, IA-2(1),IA-2(12), IA-5 IA-5(b), IA-5(c), IA-5(e), IA-5(g), IA-5(1), IA-5(11); CCI-000764, CCI-000765, CCI-001953, CCI-001954, CCI-001544, CCI-001989, CCI-000182, CCI-001610, CCI-000192, CCI-000193, CCI-000194, CCI-000205, CCI-001619, CCI-001611, CCI-001612, CCI-001613, CCI-001614, CCI-000195, CCI-001615, CCI-000196, CCI-000197, CCI-000199, CCI-000198, CCI-001616, CCI-001617, CCI-000200, CCI-001618, CCI-002041, CCI-002002, CCI-002003. }

This subpart indicates requirements for specific methods of identification and authentication for users and user accounts. Where these requirements conflict apply the following order of precedence: 1) If present, Device Specific Requirements take precedence over any other requirements; and then 2) multifactor authentication requirements take precedence over password requirements.

3.4.1 User Identification and Authentication for All System Types

Unless otherwise indicated, all user interfaces supporting accounts (either FULLY or MINIMALLY) must implement Identification and Authorization via passwords.

3.4.2 User Identification and Authentication for Specific System Types

System specific requirements are in addition to and supersede those indicated for all system types. When no additional requirements are indicated for a specific system type the requirements for all systems still apply to that system type.

3.4.2.1 HVAC Control Systems Devices

No additional system specific requirements apply.

3.4.3 Implementation of Identification and Authorization Requirements

Identification and Authorization must be met by one of the following methods:

a. Direct implementation in the user interface.

b. For user interfaces on a computer: inheriting the Identification and Authorization from the computer operating system, either by the operating system limiting access to specific applications by user, or by the application itself having permissions based on the user logged into the computer.

c. For remote interfaces: an implementation shared between the remote user interface server and the remote user interface client. For example, a requirement for PIV authentication may be met on a remote user interface by a PIV reader on a web browser client which sends the authentication information via HTTPS to the remote server.

3.4.4 Password-Based Authentication Requirements

3.4.4.1 Passwords for Software and Applications Running on Computers

All software and applications running on computers supporting password-based authentication must enforce the following requirements:

a. Minimum password length of 12 characters

b. Password must contain at least one uppercase character.

c. Password must contain at least one lowercase character.

d. Password must contain at least one numeric character.

e. Password must contain at least one special character. The list of supported special characters must include at least 4 separate characters.

f. Password must have a minimum lifetime of 24 hours.

g. Password must have a maximum lifetime of 60 days. When passwords expire, prompt users to change passwords. Do not lock accounts due to expired passwords.

h. Password must differ from previous five passwords, where differ is defined as changing at least 50 percent of the characters (where location is significant, a character may be reused if it is in a different position).

i. Passwords must be cryptographically protected during storage and transmission.

3.4.4.2 Passwords for Controllers FULLY Supporting Accounts

All controllers FULLY supporting accounts and supporting password-based authentication must enforce the following requirements:

a. Minimum password length of twelve (12) characters

b. Password must contain at least one uppercase character.

c. Password must contain at least one lowercase character.

d. Password must contain at least one numeric character.

e. Password must contain at least one special character. The list of supported special characters must include at least 4 separate characters.

f. Password must have a maximum lifetime of sixty (60) days. When passwords expire, prompt users to change passwords. Do not lock accounts due to expired passwords.

g. Password must differ from previous five (5) passwords, where differ is defined as changing at least fifty percent of the characters.

h. Passwords must be cryptographically protected during storage and transmission.

3.4.4.3 Passwords for Remote Interfaces

Passwords for connecting to a Remote User Interface supporting password-based authentication must enforce the following requirements:

a. Minimum password length of twelve (12) characters

b. Password must contain at least one uppercase character.

c. Password must contain at least one lowercase character.

d. Password must contain at least one numeric character.

e. Password must contain at least one special character. The list of supported special characters must include at least 4 separate characters.

f. Password must have a maximum lifetime of 60 days. When passwords expire, prompt users to change passwords. Do not lock accounts due to expired passwords.

g. Password must differ from previous five passwords, where differ is defined as changing at least 50 percent of the characters (where location is significant, a character may be reused if it is in a different position).

h. Passwords must be cryptographically protected during storage and transmission.

3.4.4.4 Passwords for Devices Minimally Supporting Accounts

Devices MINIMALLY supporting accounts must support passwords with a minimum length of four characters.

3.4.4.5 Password Configuration and Reporting

For all devices with a password, change the password from the default password. Coordinate selection of passwords with the Password Point of Contact. Do not use the same password for more than one device unless specifically instructed to do so. Provide a Confidential Password Report documenting the password for each device and describing the procedure to change the password for each device.

Do not provide the Password Summary Report in electronic format. Provide two hardcopies of the Password Summary Report, each copy in its own sealed envelope.

3.4.5 Authenticator Feedback

{For Government Reference Only: This subpart relates to IA-6; CCI-000206}

Devices must never show authentication information, including passwords, on a display. Devices that momentarily display a character as it is entered, and then obscure the character, are acceptable. For devices that have STIGs or SRGs related to obscuring of authenticator feedback (CCI-000206), comply with the requirements of those STIGS/SRGs.

3.5 CYBERSECURITY AUDITING

Where an auditing requirement exists for email notification, notify via email the application administrator and Information System Security Officer (ISSO) of the event. Coordinate with the Email Address Point of Contact for email addresses. If outgoing email is not available to the system, configure the system for these notifications for future support of outgoing email.

3.5.1 Audit Events, Content of Audit Records, and Audit Generation

{For Government Reference Only: This subpart (and its subparts) relates to AU-2(a), AU-2(c), AU-2(d), AU-3, AU-10, AU-12, AU-13(3), AU-14(b), AU-14(1), AU-14(2), AU-14(3), CM-5(1), SC-7 (9); CCI-000123, CCI-001571, CCI-000125, CCI-001485, CCI-000130, CCI-000131, CCI-000132, CCI-001230, CCI-000133, CCI-000134, CCI-001487, CCI-000166, CCI-001899, CCI-000169, CCI-001459, CCI-000171, CCI-000172, CCI-001910, CCI-001914, CCI-001919, CCI-001464, CCI-001462, CCI-001920, CCI-001814, CCI-002400. }

For devices that have STIG/SRGs related to audit events, content of audit records or audit generation, comply with the requirements of those STIG/SRGs.

If auditing requirements can be met using existing control system alarm or event capabilities, those existing capabilities may be used to meet these requirements.

3.5.1.1 Computers

For each computer, provide the capability to select audited events and the content of audit logs. Configure computers to audit the indicated events, and to record the indicated information for each auditable event

3.5.1.1.1 Audited Events

Configure each computer to audit the following events:

a. Successful and unsuccessful attempts to access, modify, or delete privileges, security objects, security levels, or categories of information (e.g. classification levels)

b. Successful and unsuccessful logon attempts

c. Successful logouts

d. Privileged activities or other system level access

e. Concurrent logons from different workstations

f. Successful and unsuccessful accesses to objects

g. All program initiations

h. All direct access to the information system

i. All account creations, modifications, disabling, and terminations.

j. All kernel module load, unload, and restart

3.5.1.1.2 Audit Event Information To Record

Configure each computer to record, for each auditable event, the following information (where applicable to the event):

a. What type of event occurred

b. When the event occurred

c. Where the event occurred

d. The source of the event

e. The outcome of the event

f. The identity of any individuals or subjects associated with the event

3.5.1.2 For HVAC Control System Controllers

3.5.1.2.1 HVAC Control System Controllers FULLY Supporting User Accounts

For each controller which FULLY supports accounts, provide the capability to select audited events and the content of audit logs. Configure controllers to audit the indicated events, and to record the indicated information for each auditable event.

3.5.1.2.1.1 Audited Events

Configure each controller to audit the following events:

a. Successful and unsuccessful logon attempts to the controller

b. Successful logouts

c. All account creations, modifications, disabling, and terminations.

d. All controller shutdown and startup

3.5.1.2.1.2 Audit Event Information To Record

Configure each controller to record, for each auditable event, the following information (where applicable to the event):

a. what type of event occurred

b. when the event occurred

c. the identity of any individuals or subjects associated with the event

3.5.1.2.2 Other HVAC Control System Controllers

There are no requirements to perform auditing at HVAC field controllers that do not FULLY support accounts.

3.5.1.3 Default Requirements for Control System Controllers

For control system controllers where Audit Events, Content of Audit Records, and Audit Generation are not otherwise indicated in this Section:

3.5.1.3.1 Controllers Which FULLY Support Accounts

For each controller which FULLY supports accounts, provide the capability to select audited events and the content of audit logs. Configure controllers to audit the indicated events, and to record the indicated information for each auditable event.

3.5.1.3.1.1 Audited Events

Configure each controller to audit the following events:

a. Successful and unsuccessful attempts to access, modify, or delete privileges, security objects, security levels, or categories of information (e.g. classification levels)

b. Successful and unsuccessful logon attempts

c. Successful logouts

d. Concurrent logons from different workstations

e. All account creations, modifications, disabling, and terminations.

f. All kernel module load, unload, and restart

3.5.1.3.1.2 Audit Event Information To Record

Configure each controller to record, for each auditable event, the following information (where applicable to the event):

a. what type of event occurred

b. when the event occurred

c. where the event occurred

d. the source of the event

e. the outcome of the event

f. the identity of any individuals or subjects associated with the event

3.5.1.3.2 Controllers Which Do Not FULLY Support Accounts

For each controller which does not FULLY support accounts configure the controller to audit all controller shutdown and startup events and to record for each event the type of event and when the event occurred.

3.5.2 Audit Time Stamps

{For Government Reference Only: This subpart (and its subparts) relates to AU-8; CCI-000159, CCI-001889, CCI-001890.}

Any device (computer or controller) generating audit records must have an internal clock capable of providing time with a resolution of one second. Clocks must not drift more than 10 seconds per day. Configure the system so that each device (computer or controller) generating audit records maintains accurate time to within 1 second. Note that if the control system specifications include requirement for clocks, the most stringent requirement applies.

3.5.3 Auditing Front End Software

The project site currently has the following software to support control system auditing: none. If there is no existing auditing front end software or the software is not compatible with the provided control systems, provide Auditing Front End Software with audit log import and upload, export, notification, and analysis functionality. The Auditing Front End Software may be provided as a component of the control system front end or as a separate software package, and a single package may serve multiple control systems provided under the same projects if they are sharing a cybersecurity authorization.

3.5.3.1 Import and Upload Requirements

Auditing Front End Software must be capable of importing audit logs from the Device Audit Record Upload Software and of uploading audit logs over the network from all control system devices supporting network upload of audit logs.

3.5.3.2 Export Requirements

Auditing Front End Software must be capable of exporting to a file format supported by Microsoft Excel.

3.6 REQUIREMENTS FOR LEAST FUNCTIONALITY

{For Government Reference Only: This subpart (and its subparts), along with the network communication report submittal specified elsewhere in this section, relates to CM-6(a), CM-6(c), CM-7, CM-7(1)(b), SC-41; CCI-000363, CCI-000364, CCI-000365, CCI-001588, CCI-001755, CCI-000381, CCI-000380, CCI-000382, CCI-001761, CCI-001762, CCI-002544, CCI-002545, CCI-002546. }

For devices that have a STIG or SRG related to Requirements for Least Functionality (such as configuration settings and port and device I/O access for least functionality), install and configure the device in accordance with that STIG or SRGs.

3.6.1 Device Capabilities

For HVAC Control Systems: Do not provide devices with remote user interfaces or with full user interfaces where one was not required. Do not use a networked sensor or actuator where a non-networked sensor or actuator would suffice.

3.6.2 Software

For software that has a STIG or SRG related to Requirements for Least Functionality (such as configuration settings and port access for least functionality), install and configure the software in accordance with that STIG or SRG.

3.7 SYSTEM AND COMMUNICATION PROTECTION

3.7.1 Collaborative Computing

{For Government Reference Only: This subpart relates to SC-15(a), SC-15(b); CCI-001150, CCI-001152.}

Without explicit approval from the project site, control systems must not use collaborative computing technologies.

3.7.2 Denial of Service Protection

{For Government Reference Only: This subpart relates to SC-5, SC-39, SC-7(a); CCI-001093, CCI-002385, CCI-002386, CCI-002430, CCI-001097. }

To the greatest extent practical, implement control logic without reliance on the network. Except when required to meet the requirements of the control system Section (where the requirement can only be met using computer hardware), do not implement control logic in computers.

3.7.2.1 Default Requirements for MODERATE Impact Control Systems

Except for networked input and outputs on input-output buses specifically designed to provide high reliability or redundancy, sensors and actuators must not rely on the network to exchange data with the controller executing the sequence of operation which uses the sensor value or determines the actuator command.

Sensor values required by multiple devices may be shared over the network provided they are connected to a controller requiring the value for execution of the sequence and that controller shares the value on the network.

3.8 SAFE MODE AND FAIL SAFE OPERATION

{For Government Reference Only: This subpart (and its subparts) relates to CP-12, SI-10(3), SI-17; CCI-002855, CCI-002856, CCI-002857, CCI-002754, CCI-002773, CCI-002774, CCI-002775}

For all control system components with an applicable STIG or SRG, configure the component in accordance with all applicable STIGs and SRGs.

3.9 SYSTEM MAINTENANCE TOOL SOFTWARE

{For Government Reference Only: This subpart (and its subparts) relates to MA-3; CCI-000865.}

Submit and license to the Government all software required to operate, maintain and modify the control system such the Government or their agents are able to perform repair, replacement, upgrades, and expansions of the system without subsequent or future dependence on the Contractor, Vendor or Manufacturer. Submit hard copies of user manuals for each software with the software submittal.

For software provided and licensed to the Government under the requirements of another Section, submit a statement indicating the Section and Submittal under which the software was provided. For software provided to meet the requirements of this Section and not provided and licensed under another Section, submit software and software user manuals on DVD or CD as a Technical Data Package and submit one hard copy of the software user manual for each piece of software.

3.10 DEVICE POWER

{For Government Reference Only: This subpart (and its subparts) relates to PE-11, PE-11(1); CCI-002955, CCI-000961. }

3.11 VULNERABILITY SCANNING

{For Government Reference Only: This subpart (and its subparts) relates to RA-5 RA-5(a),RA-5(b),RA-5(c),RA-5(d); CCI-001054, CCI-001055, CCI-000156, CCI-001641, CCI-001643, CCI-001057, CCI-001058, CCI-001059. }

All IP devices must be scannable, such that the device can be scanned by industry standard IP network scanning utilities without harm to the device, application, or functionality.

3.11.1 Computers and Software Running on Computers

Computers and applications running on computers must meet relevant vulnerability scanning STIGs/SRGs and respond to approved DoD vulnerability scanning tools.

3.11.2 Controllers

Provide controllers that are scannable by standard control system discovery tools or control system browsers and return meaningful status information including the network inputs and outputs for the controller. This information must contain sufficient detail to detect vulnerabilities or exploits of the controller.

Provide all software needed to scan the control system as the Control System Scanning Tools submittal. If the software required to scan the system is already installed at the project site or is provided under a separate section instead provide a statement indicating this.

3.12 SYSTEM AND INTEGRATION INTEGRITY

3.12.1 Malicious Code Protection

{For Government Reference Only: This subpart (and its subparts) relates to SI-3(c); CCI-001241, CCI-002623}

For all computers installed under this project, provide malware protection software media, provide licenses, and install and configure malware protection software as indicated. Coordinate with the Government Computer Access Point of Contact as required.

a. Malware protection software licenses will be Government furnished.

b. Malware protection software media will be Government furnished.

c. Malware protection software will be Government installed.

3.13 CONTROL SYSTEM CYBERSECURITY TESTING

3.13.1 Control System Cybersecurity Testing Procedures

Prepare Control System Cybersecurity Testing Procedures explaining step-by-step, the actions and expected results that will demonstrate that the control system meets the requirements of this Section.

Submit 2 copies of the Control System Cybersecurity Testing Procedures. The Control System Cybersecurity Testing Procedures may be submitted as a Technical Data Package.

3.13.2 Control System Cybersecurity Testing Execution

Using the Control System Cybersecurity Testing Procedures verify that the control system meets the requirements of this Section. UNLESS GOVERNMENT WITNESSING OF A TEST IS SPECIFICALLY WAIVED BY THE GOVERNMENT, PERFORM ALL TESTS WITH A GOVERNMENT WITNESS. If testing reveals deficiencies in the system, correct the deficiency and retest until successful.

3.13.3 Control System Cybersecurity Testing Report

Prepare and submit a Control System Cybersecurity Testing Report documenting all tests performed and their results. Include all tests in the Control System Cybersecurity Testing Procedures and any additional tests performed during testing. Document test failures and repairs conducted with the test results.

Submit 2 copies of the Control System Cybersecurity Testing Report. The Control System Cybersecurity Testing Report may be submitted as a Technical Data Package.

3.14 FIELD QUALITY CONTROL, CYBERSECURITY VALIDATION SUPPORT

In addition to testing and testing support required by other Sections, provide a minimum of 2 hours of technical support for cybersecurity testing of control systems to support the DoD Risk Management Framework process Cybersecurity assessment of the control system. This support is independent of (and in addition to) the Control System Cybersecurity Testing specified in this section.

3.15 CYBERSECURITY TRAINING

Provide 2 hours of classroom training for six Government personnel on the cybersecurity operation and maintenance of the control system provided. This training is in addition to and must be coordinated with control system training specified in other Sections.

The Government will provide the training location. Training must cover, at a minimum: (a) applying software and firmware updates, (b) user account creation, modification and deletion, (c) audit log upload procedures and (d) identification of privileged user interfaces and system impact of those interfaces. Training session must include a question and answer period during which government staff questions about cybersecurity aspects of the control system are answered.

-- End of Section --

SECTION 26 05 73

POWER SYSTEM STUDIES
08/23

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 1584	(2018; E 2019) Guide for Performing Arc-Flash Hazard Calculations
IEEE 1584.1	(2022) Guide for the Specification of Scope and Deliverable Requirements for an Arc-Flash Hazard Calculation Study
IEEE 3002.3	(2018) Recommended Practice for Conducting Short-Circuit Studies and Analysis of Industrial and Commercial Power Systems

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70E	(2024) Standard for Electrical Safety in the Workplace

U.S. DEPARTMENT OF DEFENSE (DOD)

UFC 3-560-01	(2017; with Change 2, 2019) Operations and Maintenance: Electrical Safety

1.2 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. When used, a code following the "G" classification identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Arc Flash Label Formats; G

SD-11 Closeout Submittals

Fault Current Study; G

System Coordination Study; G

Arc Flash Hazard Study; G

1.3 QUALITY ASSURANCE

1.3.1 System Analyzer

The System Analyzer must perform the power system studies. The System Analyzer must be a registered professional electrical engineer with a minimum of 3 years of experience with power system studies. Include the license number and state of the registered Professional Engineer.

PART 2 PRODUCTS

Not used.

PART 3 EXECUTION

3.1 FIELD EXAMINATION

3.1.1 Application of Arc Flash Labels

Install arc flash warning labels using Qualified Personnel as necessary after the setting and inspection is complete. For new equipment, install labels before the equipment is energized for the first time after installation/modification or setting changes. Schedule the label placement with the Contracting Officer at least 5 business days before label placement. Furnish all materials, labor, and equipment necessary to place the labels. Maintain a written record of the all equipment that received labels, personnel involved, and the date labels were placed.

3.2 POWER SYSTEM STUDIES

Perform power system studies to demonstrate that the equipment selected and system constructed meet the contract requirements for fault current and interrupt ratings, coordination, protection, and Arc Flash Hazard. Submit reports of the studies along with protective device equipment submittals. Apply Arc Flash Hazard labels to equipment after the studies are approved. Update and resubmit the studies after any changes to the equipment or systems which may affect the study results, and re-apply Arc Flash Hazard labels to equipment after the resubmitted studies are approved. The Government is not responsible for any changes to equipment, device ratings, settings, or additional labor for installation of equipment or devices or labels ordered and/or procured before approval of the study.

3.2.1 Scope of Studies

The scope of the studies must begin at the source bus and extend down to system buses where fault current availability is 5,000 amperes or less (symmetrical) and at most 600 volts for facility-level distribution buses.

The "source bus" is the source of energy for system being analyzed. This may be the energy feed from a utility, the first bus upstream of the work, generators within the work or upstream of the work, or any other source capable of contributing significant energy into the system being analyzed.

In the systems model for the studies, incorporate all existing and new equipment within the scope of the studies. Incorporate any additional sources or load equipment necessary to accurately model the system's performance.

3.2.2 Determination of Facts

Determine and document the time-current characteristics, features, ratings, ampacities, and nameplate data for each existing protective device, electrical equipment, and feeder cables. Obtain the available fault current from CHELCO.

3.2.3 Single Line Diagram

Provide a single line diagram showing the electrical system buses, devices, transformation points, and all sources of load current and fault current, including generator and motor contributions. Provide a diagram from the system model. Each bus, device must have a unique identifier. Show the location of switches, breakers, and circuit interrupting devices on the diagram together with available fault data, and the device interrupting rating.

The naming of existing components within the system model and single line diagram must match existing installed equipment names. The naming of new components within the system model and single line diagram must use unique identifiers and be coordinated with the Government.

3.2.4 Fault Current Study

Use the results of the load flow study to perform the fault current study in accordance with IEEE 3002.3. Provide balanced three-phase fault, bolted line-to-line fault, and single line-to-ground fault current values at each voltage transformation point and at each power distribution bus. For each location, show in tabular form on the diagram or in the report the maximum and minimum available fault currents of all modes of operation for that location.

Where the available fault current at the source bus is not available, describe how the fault contribution from the source bus was determined and why this method is reasonable for the study.

3.2.5 System Coordination Study

Use the results of the load flow study and fault current study. For normal modes of operation, demonstrate that selectivity has been obtained between the devices within the scope of the project. Demonstrate the equipment, machines, and conductors are protected from damage from overloads and fault conditions. Include a description of the coordination of the protective devices in this project. Provide a written narrative describing which devices may operate in the event of a fault at each bus; due to the nature of the facility complete system coordination is not required. Use the types of breakers listed on the drawings and select the settings to achieve the best coordination results.

3.2.6 Arc Flash Hazard Study

Perform the arc flash hazard study in accordance with IEEE 1584.1. Utilize the data from the fault current study to determine the worst case incident energy per IEEE 1584, and OSHA 29 CFR 1910.269 Appendix E. Use identified modes of operation to determine the worst case arc flash energy. If not included in another study, include a description of the devices and device settings for the operating modes that provided the highest arc flash energy.

3.2.7 Study report(s)

a. Include a narrative describing the studies performed; the bases and methods used; and the desired method of coordinated protection of the power system.

b. Include descriptive and technical data protective devices proposed. Include manufacturers published data, nameplate data, and definition of the fixed or adjustable features of the existing or new protective devices. For existing devices, included statements on the condition of the equipment based upon field inspections and owner's statements and reports.

c. For each bus in the system, provide fully coordinated composite time-current characteristics (TCC) curves as required to ensure coordinated power system protection between protective devices and equipment. In a tabular format, provide recommended ratings and settings of all protective devices.

d. Provide an arc flash study report in accordance with IEEE 1584.1.

e. Provide the calculations performed for the studies, including computer programs utilized. Provide the name of the software package, developer, and version number.

3.2.8 Arc Flash Labels

Provide arc flash warning labels on electrical equipment likely to require examination, servicing, or maintenance while energized. Typical types of equipment include panelboards, disconnect switches, meter socket enclosures . The arc flash label naming must match the naming used in the system modeling and the single line diagram.

Comply with the label requirements specified in UFC 3-560-01NFPA 70E. Obtain approval of arc flash label formats before printing.

a. Provide a 3.5 inch x 5 inch to 4 inch x 6 inch thermal transfer type label of high adhesion polyester for each location device analyzed. The label must remain in place and be legible for at least 5 years in the installed environment.

b. Labels must be machine printed with no field markings. Provide arc flash labels in the following manner. All labels must be based on implemented overcurrent devices and settings.

   1. Provide at least one arc flash label for each 208 volt panelboards.

c. Use the worst case hazard of all operating scenarios unless mitigation procedures are used. If mitigation procedures are used, explain the procedures on the label.

3.3 MODELING

Develop a software model of the electrical system identified in the scope of the studies. Use the latest version of EasyPower(TM)tools. Develop the model with accurate, verified information. Model existing electrical equipment, machines, devices, and conductors directly connected to, altered by, or otherwise affected by the work. This includes, but is not limited to generators, transformers, switchgear, switchboards, panelboards, motor control centers, motors, voltage regulators, tap changers, protective relays, circuit breakers, switches, fuses, conductors, capacitors, reactors, grounding system, and control equipment.

Provide the final model files in their native editable formats for future use by the Government. Include device information for devices not in the software vendor's standard distribution.

-- End of Section --

SECTION 26 20 00

INTERIOR DISTRIBUTION SYSTEM
08/23

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI C12.1 (2014; Errata 2016) Electric Meters - Code for Electricity Metering

ASTM INTERNATIONAL (ASTM)

ASTM B1 (2013) Standard Specification for Hard-Drawn Copper Wire

ASTM B8 (2011; R 2017) Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft

ASTM D709 (2017) Standard Specification for Laminated Thermosetting Materials

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 81 (2012) Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System

IEEE Stds Dictionary (2009) IEEE Standards Dictionary: Glossary of Terms & Definitions

INTERNATIONAL ELECTRICAL TESTING ASSOCIATION (NETA)

NETA ATS (2021) Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems

NATIONAL ELECTRICAL CONTRACTORS ASSOCIATION (NECA)

NECA NEIS 1 (2015) Standard for Good Workmanship in Electrical Construction

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

ANSI C80.1 (2020) American National Standard for Electrical Rigid Steel Conduit (ERSC)

ANSI C80.3 (2020) American National Standard for Electrical Metallic Tubing (EMT)

ANSI C80.5	(2020) American National Standard for Electrical Rigid Aluminum Conduit
NEMA 250	(2020) Enclosures for Electrical Equipment (1000 Volts Maximum)
NEMA ICS 1	(2022) Standard for Industrial Control and Systems: General Requirements
NEMA ICS 6	(1993; R 2016) Industrial Control and Systems: Enclosures
NEMA KS 1	(2013) Enclosed and Miscellaneous Distribution Equipment Switches (600 V Maximum)
NEMA TC 2	(2020) Standard for Electrical Polyvinyl Chloride (PVC) Conduit
NEMA TC 3	(2021) Polyvinyl Chloride (PVC) Fittings for Use With Rigid PVC Conduit and Tubing
NEMA VE 2	(2018; ERTA 1-2 2018) Cable Tray Installation Guidelines
NEMA WD 1	(1999; R 2020) Standard for General Color Requirements for Wiring Devices
NEMA WD 6	(2021) Wiring Devices Dimensions Specifications
NEMA Z535.4	(2011; R 2017) Product Safety Signs and Labels

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2023; ERTA 4 2023) National Electrical Code
NFPA 70E	(2024) Standard for Electrical Safety in the Workplace
NFPA 780	(2023) Standard for the Installation of Lightning Protection Systems

TELECOMMUNICATIONS INDUSTRY ASSOCIATION (TIA)

TIA-568.1	(2020e) Commercial Building Telecommunications Infrastructure Standard
TIA-569	(2019e; Add 1 2022) Telecommunications Pathways and Spaces
TIA-607	(2019d) Generic Telecommunications Bonding and Grounding (Earthing) for Customer Premises

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

29 CFR 1910.147	The Control of Hazardous Energy (Lock Out/Tag Out)
29 CFR 1910.303	Electrical, General

UNDERWRITERS LABORATORIES (UL)

UL 1	(2005; Reprint Jan 2022) UL Standard for Safety Flexible Metal Conduit
UL 6	(2022) UL Standard for Safety Electrical Rigid Metal Conduit-Steel
UL 6A	(2008; Reprint Mar 2021) UL Standard for Safety Electrical Rigid Metal Conduit - Aluminum, Red Brass, and Stainless Steel
UL 20	(2018; Reprint May 2023) UL Standard for Safety General-Use Snap Switches
UL 44	(2018; Reprint May 2021) UL Standard for Safety Thermoset-Insulated Wires and Cables
UL 50	(2015) UL Standard for Safety Enclosures for Electrical Equipment, Non-Environmental Considerations
UL 67	(2018; Reprint Aug 2023) UL Standard for Safety Panelboards
UL 83	(2017; Reprint Mar 2020) UL Standard for Safety Thermoplastic-Insulated Wires and Cables
UL 360	(2013; Reprint Apr 2023) UL Standard for Safety Liquid-Tight Flexible Metal Conduit
UL 467	(2022) UL Standard for Safety Grounding and Bonding Equipment
UL 486A-486B	(2018; Reprint Jul 2023) UL Standard for Safety Wire Connectors
UL 486C	(2018; Reprint May 2021) UL Standard for Safety Splicing Wire Connectors
UL 489	(2016; Rev 2019) UL Standard for Safety Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures
UL 498	(2017; Reprint May 2023) UL Standard for Safety Attachment Plugs and Receptacles
UL 510	(2020; Dec 2022) UL Standard for Safety Polyvinyl Chloride, Polyethylene and Rubber Insulating Tape

UL 514A	(2013; Reprint Jun 2022) UL Standard for Safety Metallic Outlet Boxes
UL 514B	(2012; Reprint May 2020) Conduit, Tubing and Cable Fittings
UL 514C	(2014; Reprint Feb 2020) UL Standard for Safety Nonmetallic Outlet Boxes, Flush-Device Boxes, and Covers
UL 651	(2011; Reprint May 2022) UL Standard for Safety Schedule 40, 80, Type EB and A Rigid PVC Conduit and Fittings
UL 797	(2007; Reprint Apr 2023) UL Standard for Safety Electrical Metallic Tubing -- Steel
UL 869A	(2006; Reprint Jun 2020) Reference Standard for Service Equipment
UL 943	(2016; Reprint Sep 2023) UL Standard for Safety Ground-Fault Circuit-Interrupters
UL 1242	(2006; Reprint Apr 2022) UL Standard for Safety Electrical Intermediate Metal Conduit -- Steel
UL 1449	(2021; Reprint Dec 2022) UL Standard for Safety Surge Protective Devices
UL 1660	(2019; Reprint Jan 2022) Liquid-Tight Flexible Nonmetallic Conduit

1.2 DEFINITIONS

Unless otherwise specified or indicated, electrical and electronics terms used in these specifications, and on the drawings, are as defined in IEEE Stds Dictionary.

1.3 RELATED REQUIREMENTS

Section 25 05 11 CYBERSECURITY FOR FACILITY-RELATED CONTROL SYSTEMS applies to this section, with the additions and modifications specified herein.

1.4 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval.for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Panelboards; G

Cable Trays; G

Wireways; G

Marking Strips Drawings; G

SD-03 Product Data

Receptacles; G

Circuit Breakers; G

Switches; G

Surface Metal Raceways, G

Metering; G

CAT 6 Cable and Outlets (Commercial internet equipment); G

Secondary Bonding Busbar; G

Surge Protective Devices; G

Cable Trays; G

SD-05 Design Data

Cable Tray Design; G

SD-06 Test Reports

600-volt Wiring Test; G

Grounding System Test; G

Ground-fault Receptacle Test; G

SD-10 Operation and Maintenance Data

Electrical Systems, Data Package 5; G

Metering, Data Package 5; G

1.5 QUALITY ASSURANCE

1.5.1 Regulatory Requirements

In each of the publications referred to herein, consider the advisory provisions to be mandatory, as though the word, "must" had been substituted for "should" wherever it appears. Interpret references in these publications to the "authority having jurisdiction," or words of similar meaning, to mean the Contracting Officer. Provide equipment, materials, installation, and workmanship in accordance with NFPA 70 unless more stringent requirements are specified or indicated. NECA NEIS 1 shall be considered the minimum standard for workmanship.

1.5.2 Standard Products

Provide materials and equipment that are products of manufacturers regularly engaged in the production of such products which are of equal material, design and workmanship and:

a. Have been in satisfactory commercial or industrial use for 2 years prior to bid opening including applications of equipment and materials under similar circumstances and of similar size.

b. Have been on sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 2-year period.

c. Where two or more items of the same class of equipment are required, provide products of a single manufacturer; however, the component parts of the item need not be the products of the same manufacturer unless stated in this section.

1.5.2.1 Alternative Qualifications

Products having less than a 2-year field service record will be acceptable if a certified record of satisfactory field operation for not less than 6000 hours, exclusive of the manufacturers' factory or laboratory tests, is furnished.

1.5.2.2 Material and Equipment Manufacturing Date

Products manufactured more than 3 years prior to date of delivery to site are not acceptable.

1.6 MAINTENANCE

1.6.1 Electrical Systems

Submit operation and maintenance data in accordance with Section 01 78 23, OPERATION AND MAINTENANCE DATA and as specified herein. Submit operation and maintenance manuals for electrical systems that provide basic data relating to the design, operation, and maintenance of the electrical distribution system for the building. Include the following:

a. Single line diagram of the "as-built" building electrical system.

b. Schematic diagram of electrical control system (other than HVAC, covered elsewhere).

c. Manufacturers' operating and maintenance manuals on active electrical equipment.

1.7 WARRANTY

Provide equipment items supported by service organizations that are reasonably convenient to the equipment installation in order to render satisfactory service to the equipment on a regular and emergency basis during the warranty period of the contract.

PART 2 PRODUCTS

2.1 MATERIALS AND EQUIPMENT

As a minimum, meet requirements of UL, where UL standards are established for those items, and requirements of NFPA 70 for all materials, equipment, and devices.

2.2 CONDUIT AND FITTINGS

Conform to the following:

2.2.1 Rigid Metallic Conduit

2.2.1.1 Rigid, Threaded Zinc-Coated Steel Conduit

ANSI C80.1, UL 6.

2.2.1.2 Rigid Aluminum Conduit

ANSI C80.5, UL 6A.

2.2.2 Rigid Nonmetallic Conduit

PVC Type EPC-40, and EPC-80 in accordance with NEMA TC 2,UL 651.

2.2.3 Intermediate Metal Conduit (IMC)

UL 1242, zinc-coated steel only.

2.2.4 Electrical, Zinc-Coated Steel Metallic Tubing (EMT)

UL 797, ANSI C80.3.

2.2.5 Flexible Metal Conduit

UL 1, limited to 6 feet.

2.2.5.1 Liquid-Tight Flexible Metal Conduit, Steel

UL 360, limited to 6 feet.

2.2.6 Fittings for Metal Conduit, EMT, and Flexible Metal Conduit

UL 514B. Ferrous fittings: cadmium- or zinc-coated in accordance with UL 514B.

2.2.6.1 Fittings for Rigid Metal Conduit and IMC

Threaded-type. Split couplings unacceptable.

2.2.6.2 Fittings for EMT

Steel compression type.

2.2.7 Fittings for Rigid Nonmetallic Conduit

NEMA TC 3 for PVC, and UL 514B.

2.2.8 Liquid-Tight Flexible Nonmetallic Conduit

UL 1660.

2.3 CABLE TRAYS

NEMA VE 2. Provide the following:

a. Cable trays: form a wireway system, with a nominal3 depth.

b. Cable trays: constructed of aluminum.

c. Cable trays: include splice and end plates, dropouts, and miscellaneous hardware.

d. Edges, fittings, and hardware: finished free from burrs and sharp edges.

e. Fittings: ensure not less than load-carrying ability of straight tray sections and have manufacturer's minimum standard radius.

f. Radius of bends:12inches.

2.3.1 Ladder-Type Cable Trays

Provide size as indicatedwith maximum rung spacing of 6inches. Cable tray must be suitable for use as an equipment grounding conductor.

2.3.2 Surface Metal Raceways

a. Painted steel over floor raceway system with outlets as indicated. See drawings for specific requirements.

2.4 OUTLET BOXES AND COVERS

UL 514A, cadmium- or zinc-coated, if ferrous metal. UL 514C, if nonmetallic.

2.4.1 Outlet Boxes for Telecommunications System

Provide the following:

a. Standard type.

b. Depth of boxes: large enough to allow manufacturers' recommended conductor bend radii.

2.5 CABINETS, JUNCTION BOXES, AND PULL BOXES

UL 50; volume greater than 100 cubic inches, NEMA Type 1 enclosure; sheet steel, hot-dip, zinc-coated. Where exposed to wet, damp, or corrosive environments, NEMA Type 3R.

2.6 WIRES AND CABLES

Provide wires and cables in accordance applicable requirements of NFPA 70 and UL for type of insulation, jacket, and conductor specified or indicated. Do not use wires and cables manufactured more than 24 months prior to date of delivery to site.

2.6.1 Conductors

Provide the following:

a. Conductor sizes and capacities shown are based on copper, unless indicated otherwise.

b. Conductors No. 8 AWG and larger diameter: stranded.

c. Conductors No. 10 AWG and smaller diameter: solid.

d. Conductors for remote control, alarm, and signal circuits, classes 1, 2, and 3: stranded unless specifically indicated otherwise.

e. All conductors: copper.

2.6.1.1 Minimum Conductor Sizes

Provide minimum conductor size in accordance with the following:

a. Branch circuits: No. 12 AWG.

b. Class 1 remote-control and signal circuits: No. 14 AWG.

c. Class 2 low-energy, remote-control and signal circuits: No. 16 AWG.

d. Class 3 low-energy, remote-control, alarm and signal circuits: No. 22 AWG.

e. Digital low voltage lighting control (DLVLC) system at 24 Volts or less: with DLVLC system manufacturer requirements.

2.6.2 Color Coding

Provide color coding for service, feeder, branch, control, and signaling circuit conductors.

2.6.2.1 Ground and Neutral Conductors

Provide color coding of ground and neutral conductors as follows:

a. Grounding conductors: Green.

b. Neutral conductors: White.

c. Exception, where neutrals of more than one system are installed in same raceway or box, other neutrals color coding: white with a different colored (not green) stripe for each.

2.6.2.2 Ungrounded Conductors

Provide color coding of ungrounded conductors in different voltage systems as follows:

a. 208/120 volt, three-phase

(1) Phase A - black

(2) Phase B - red

(3) Phase C - blue

2.6.3 Insulation

Unless specified or indicated otherwise or required by NFPA 70, provide power and lighting wires rated for 600-volts, Type THWN/THHN conforming to UL 83 or Type XHHW or RHW conforming to UL 44, except that grounding wire may be type TW conforming to UL 83; remote-control and signal circuits: Type TW or TF, conforming to UL 83. Where equipment or devices require 90-degree Centigrade (C) conductors, provide only conductors with 90-degree C insulation or better.

2.6.4 Bonding Conductors

ASTM B1, solid bare copper wire for sizes No. 8 AWG and smaller diameter; ASTM B8, Class B, stranded bare copper wire for sizes No. 6 AWG and larger diameter.

2.6.4.1 Telecommunications Bonding Backbone (TBB)

Provide a copper conductor TBB in accordance with TIA-607 with No. 6 AWG minimum size, and sized at 2 kcmil per linear foot of conductor length up to a maximum size of 750 kcmil.

2.6.4.2 Bonding Conductor for Telecommunications

Provide a copper conductor Bonding Conductor for Telecommunications between the telecommunications main grounding busbar (PBB) and the electrical service ground in accordance with TIA-607. Size the bonding conductor for telecommunications the same as the TBB.

2.7 SPLICES AND TERMINATION COMPONENTS

UL 486A-486B for wire connectors and UL 510 for insulating tapes. Connectors for No. 10 AWG and smaller diameter wires: insulated, pressure-type in accordance with UL 486A-486B or UL 486C (twist-on splicing connector). Provide solderless terminal lugs on stranded conductors.

2.8 DEVICE PLATES

Provide the following:

a. UL listed, one-piece device plates for outlets to suit the devices installed.

b. For metal outlet boxes, plates on unfinished walls: zinc-coated sheet steel or cast metal having round or beveled edges.

c. Plates on finished walls: satin finish stainless steel or brushed-finish aluminum, minimum 0.03 inch thick.

d. Screws: machine-type with countersunk heads in color to match finish of plate.

e. Sectional type device plates are not be permitted.

f. Plates installed in wet locations: gasketed and UL listed for "wet locations."

2.9 SWITCHES

2.9.1 Toggle Switches

NEMA WD 1, UL 20, single pole, double pole, three-way, and four-way, totally enclosed with bodies of thermoplastic or thermoset plastic and mounting strap with grounding screw. Include the following:

a. Handles: grey thermoplastic.

b. Wiring terminals: screw-type, side-wired.

c. Contacts: silver-cadmium and contact arm - one-piece copper alloy.

d. Switches: rated quiet-type ac only, 120/277 volts, with current rating and number of poles indicated.

2.9.2 Disconnect Switches

NEMA KS 1. Provide heavy duty-type switches . Provide horsepower rated for switches serving as the motor-disconnect means. Provide switches in NEMA, enclosure indicated per NEMA ICS 6.

2.10 RECEPTACLES

Provide the following:

a. UL 498, general purpose specification grade, grounding-type. Residential grade receptacles are not acceptable.

b. Ratings and configurations: as indicated.

c. Bodies: grey as per NEMA WD 1.

d. Face and body: thermoplastic supported on a metal mounting strap.

e. Dimensional requirements: per NEMA WD 6.

f. Screw-type, side-wired wiring terminals or of the solderless pressure type having suitable conductor-release arrangement.

g. Grounding pole connected to mounting strap.

h. The receptacle: containing triple-wipe power contacts and double or triple-wipe ground contacts.

2.10.1 Weatherproof Receptacles

Provide receptacles, UL listed for use in "wet locations" with integral GFCI protection. Include cast metal box with gasketed, hinged, lockable and weatherproof while-in-use,die-cast metal/aluminum extra-duty rated hood.

2.10.2 Ground-Fault Circuit Interrupter Receptacles

UL 943, duplex type for mounting in standard outlet box. Provide device capable of detecting current leak when the current to ground is 6 milliamperes or higher, and tripping per requirements of UL 943 for Class A ground-fault circuit interrupter devices. Provide screw-type, side-wired wiring terminals or pre-wired (pigtail) leads.

2.10.3 Dryer Receptacles

NEMA 14-30 configuration, rated 30 amperes, 125/250 volts. Furnish one matching plug with each receptacle.

2.11 PANELBOARDS

Provide panelboards in accordance with the following:

a. UL 67 and UL 50 having a short-circuit current rating as indicated .

b. Panelboards for use as service disconnecting means: additionally conform to UL 869A.

c. Panelboards: circuit breaker-equipped.

d. Designed such that individual breakers can be removed without disturbing adjacent units or without loosening or removing supplemental insulation supplied as means of obtaining clearances as required by UL.

e. "Specific breaker placement" is required in panelboards to match the breaker placement indicated in the panelboard schedule on the design drawings. If it is not possible to match "specific breaker placement" during construction, obtain Government approval prior to device installation.

f. Use of "Subfeed Breakers" is not acceptable.

g. Main breaker: "separately" mounted"above" or "below" branch breakers.

h. Where "space only" is indicated, make provisions for future installation of breakers.

i. Directories: indicate load served by each circuit in panelboard.

j. Directories: indicate source of service to panelboard (e.g., Panel PA served from Panel MDP).

k. Type directories and mount in holder behind transparent protective covering.

l. Panelboards: listed and labeled for their intended use.

m. Panelboard nameplates: provided in accordance with paragraph FIELD FABRICATED NAMEPLATES.

2.11.1 Enclosure

Provide panelboard enclosure in accordance with the following:

a. UL 50.

b. Front edges of cabinets: form-flanged or fitted with structural shapes welded or riveted to the sheet steel, for supporting the panelboard front.

c. All cabinets: fabricated such that no part of any surface on the finished cabinet deviates from a true plane by more than 1/8 inch.

d. Holes: provided in the back of indoor surface-mounted cabinets, with outside spacers and inside stiffeners, for mounting the cabinets with a 1/2 inch clear space between the back of the cabinet and the wall surface.

e. Flush doors: mounted on hinges that expose only the hinge roll to view when the door is closed.

f. Each door: fitted with a combined catch and lock latch.

g. Keys: two provided with each lock, with all locks keyed alike.

h. Finished-head cap screws: provided for mounting the panelboard fronts on the cabinets.

2.11.2 Panelboard Buses

Support bus bars on bases independent of circuit breakers. Design main buses and back pans so that breakers may be changed without machining, drilling, or tapping. Provide isolated neutral bus in each panel for connection of circuit neutral conductors. Provide separate ground bus identified as equipment grounding bus per UL 67 for connecting grounding conductors; bond to steel cabinet.

2.11.3 Circuit Breakers

UL 489, thermal magnetic-type or (unless specifically noted as electronic trip on the drawings) having a minimum short-circuit current rating equal to the short-circuit current rating of the panelboard in which the circuit breaker will be mounted. Breaker terminals: UL listed as suitable for type of conductor provided. Series rated circuit breakers and plug-in circuit breakers are unacceptable.

2.11.3.1 Multipole Breakers

Provide common trip-type with single operating handle. Design breaker such that overload in one pole automatically causes all poles to open. Maintain phase sequence throughout each panel so that any three adjacent breaker poles are connected to Phases A, B, and C, respectively.

2.11.3.2 Circuit Breaker With Ground-Fault Circuit Interrupter

UL 943 and NFPA 70. Provide with auto-monitoring (self-test) and lockout features, "push-to-test" button, visible indication of tripped condition, and ability to detect and trip when current imbalance is 6 milliamperes or higher per requirements of UL 943 for Class A ground-fault circuit interrupter devices.

2.12 LOCKOUT REQUIREMENTS

Provide circuit breakers, disconnecting means, and other devices that are electrical energy-isolating capable of being locked out for machines and other equipment to prevent unexpected startup or release of stored energy in accordance with 29 CFR 1910.147, NFPA 70E and 29 CFR 1910.303. Comply with requirements of Division 23, "Heating, Ventilating, and Air Conditioning (HVAC)" for mechanical isolation of machines and other equipment.

2.13 TELECOMMUNICATIONS SYSTEM

Provide system of telecommunications wire-supporting structures (pathway), including: outlet boxes, conduits with pull wires cable trays, and other accessories for telecommunications outlets and pathway in accordance with TIA-569 and as specified herein. Additional telecommunications requirements are specified in Section 27 10 00 BUILDING TELECOMMUNICATIONS CABLING SYSTEM.

2.14 GROUNDING AND BONDING EQUIPMENT

2.14.1 Ground Rods

UL 467. Ground rods: cone pointed copper-clad steel with minimum diameter of 3/4 inch and minimum length 10 feet. Sectional type rods may be used for rods 20 feet or longer.

2.15 MANUFACTURER'S NAMEPLATE

Provide on each item of equipment a nameplate bearing the manufacturer's name, address, model number, and serial number securely affixed in a conspicuous place; the nameplate of the distributing agent will not be acceptable.

2.16 FIELD FABRICATED NAMEPLATES

Provide field fabricated nameplates in accordance with the following:

a. ASTM D709.

b. Provide laminated plastic nameplates for each equipment enclosure, relay, switch, and device; as specified or as indicated on the drawings.

c. Each nameplate inscription: identify the function and, when applicable, the position.

d. Nameplates: melamine plastic, 0.125 inch thick, white with black center core.

e. Surface: matte finish. Corners: square. Accurately align lettering and engrave into the core.

f. Minimum size of nameplates: one by 2.5 inches.

g. Lettering size and style: a minimum of 0.25 inch high normal block style.

2.17 WARNING SIGNS

Provide warning signs for flash protection in accordance with NFPA 70E and NEMA Z535.4 for switchboards, panelboards, industrial control panels, and motor control centers that are in other than dwelling occupancies and are likely to require examination, adjustment, servicing, or maintenance while energized. Provide field installed signs to warn qualified persons of potential electric arc flash hazards when warning signs are not provided by the manufacturer. Provide marking that is clearly visible to qualified persons before examination, adjustment, servicing, or maintenance of the equipment.

2.18 FIRESTOPPING MATERIALS

Provide firestopping around electrical penetrations in accordance with Section 07 84 00 FIRESTOPPING.

2.19 METERING

ANSI C12.1. Provide a self-contained, electronic programmable outdoor watthour meter. Meter: either programmed at the factory or programmed in the field. Turn field programming device over to the Contracting Officer at completion of project. Coordinate meter to system requirements. Coordinate meter, system components, and meter location to be compatible with the Activity's central advanced metering system. See drawings for requirements.

2.20 SURGE PROTECTIVE DEVICES

Provide parallel type surge protective devices (SPD) which comply with UL 1449 at the locations indicated. Provide surge protectors in a NEMA 1 enclosure per NEMA ICS 6. Do not install SPD inside a panelboard or switchboard enclosure. SPD must have the same short-circuit current rating as the protected equipment and must not be installed at a point of system where the available fault current is in excess of that rating. Use Type 1 or Type 2 SPD and connect on the load side of a dedicated circuit breaker. Submit performance and characteristic curves.

Provide the following modes of protection:

FOR SINGLE PHASE AND THREE PHASE WYE CONNECTED SYSTEMS-
- Phase to phase (L-L)
- Each phase to neutral (L-N)
- Neutral to ground (N-G)
- Phase to ground (L-G)

SPDs at the service entrance: provide with a minimum surge current rating of 80,000 amperes for L-L mode minimum and 40,000 amperes for other modes (L-N, L-G, and N-G) and downstream SPDs rated 40,000 amperes for L-L mode minimum and 20,000 amperes for other modes (L-N, L-G, and N-G).

Provide SPDs per NFPA 780 for the lightning protection system.

Maximum L-N, and N-G Voltage Protection Rating:

- 700V for 208Y/120V, three phase system
- 1,200V for 480Y/277V, three phase system

Maximum L-G Protection Rating:

- 700V for 208Y/120V, three phase system

The minimum MCOV (Maximum Continuous Operating Voltage) rating for L-N and L-G modes of operation: 120 percent of nominal voltage for 240 volts and below; 115 percent of nominal voltage above 240 volts to 480 volts.

2.21 FACTORY APPLIED FINISH

Provide factory-applied finish on electrical equipment in accordance with the following:

a. NEMA 250 corrosion-resistance test and the additional requirements as specified herein.

b. Interior and exterior steel surfaces of equipment enclosures: thoroughly cleaned followed by a rust-inhibitive phosphatizing or equivalent treatment prior to painting.

c. Exterior surfaces: free from holes, seams, dents, weld marks, loose scale or other imperfections.

d. Interior surfaces: receive not less than one coat of corrosion-resisting paint in accordance with the manufacturer's standard practice.

e. Exterior surfaces: primed, filled where necessary, and given not less than two coats baked enamel with semigloss finish.

f. Equipment located indoors: ANSI Light Gray, and equipment located outdoors: ANSI Light Gray or Dark Gray.

g. Provide manufacturer's coatings for touch-up work and as specified in paragraph FIELD APPLIED PAINTING.

PART 3 EXECUTION

3.1 INSTALLATION

Electrical installations, including weatherproof and hazardous locations and ducts, plenums and other air-handling spaces: conform to requirements of NFPA 70 and to requirements specified herein.

3.1.1 Underground Service

Underground service conductors and associated conduit: continuous from service entrance equipment to outdoor power system connection.

3.1.2 Service Entrance Identification

Service entrance disconnect devices, switches, and enclosures: labeled and identified as such.

3.1.2.1 Labels

Wherever work results in service entrance disconnect devices in more than one enclosure, as permitted by NFPA 70, label each enclosure, new and existing, as one of several enclosures containing service entrance disconnect devices. Label, at minimum: indicate number of service disconnect devices housed by enclosure and indicate total number of enclosures that contain service disconnect devices. Provide laminated plastic labels conforming to paragraph FIELD FABRICATED NAMEPLATES. Use lettering of at least 0.25 inch in height, and engrave on black-on-white matte finish. Service entrance disconnect devices in more than one enclosure: provided only as permitted by NFPA 70.

3.1.3 Wiring Methods

Provide insulated conductors installed in rigid steel conduit, IMC, rigid nonmetallic conduit, or EMT, except where specifically indicated or specified otherwise or required by NFPA 70 to be installed otherwise. Grounding conductor: separate from electrical system neutral conductor. Provide insulated green equipment grounding conductor for circuit(s) installed in conduit and raceways. Minimum conduit size: 1/2 inch in diameter for low voltage lighting and power circuits. Vertical distribution in multiple story buildings: made with metal conduit in fire-rated shafts, with metal conduit extending through shafts for minimum distance of 6 inches. Firestop conduit which penetrates fire-rated walls, fire-rated partitions, or fire-rated floors in accordance with Section 07 84 00 FIRESTOPPING.

3.1.3.1 Pull Wire

Install pull wires in empty conduits. Pull wire: plastic having minimum 200-pound force tensile strength. Leave minimum 36 inches of slack at each end of pull wire.

3.1.4 Conduit Installation

Unless indicated otherwise, conceal conduit under floor slabs and within finished walls, ceilings, and floors. Keep conduit minimum 6 inches away from parallel runs of flues and steam or hot water pipes. Install conduit parallel with or at right angles to ceilings, walls, and structural members where located above accessible ceilings and where conduit will be visible after completion of project.

3.1.4.1 Restrictions Applicable to Aluminum Conduit

a. Do not install underground or encase in concrete or masonry.

b. Do not use brass or bronze fittings.

c. Do not use when the enclosed conductors must be shielded from the effects of High-altitude Electromagnetic Pulse (HEMP).

3.1.4.2 Restrictions Applicable to EMT

a. Do not install underground.

b. Do not encase in concrete, mortar, grout, or other cementitious materials.

c. Do not use in areas subject to physical damage including but not limited to equipment rooms where moving or replacing equipment could physically damage the EMT.

d. Do not use outdoors.

e. Do not use when the enclosed conductors must be shielded from the effects of High-altitude Electromagnetic Pulse (HEMP).

3.1.4.3 Restrictions Applicable to Nonmetallic Conduit

a. PVC Schedule 40.

(1) Do not use where subject to physical damage, including but not limited to, mechanical equipment rooms, electrical equipment rooms, fire pump rooms, and where restrictions are applying to both PVC Schedule 40 and PVC Schedule 80.

(2) Do not use above grade, except where allowed in this section for rising through floor slab or indicated otherwise.

b. PVC Schedule 80.

(1) Do not use where subject to physical damage, including but not limited to, hospitals, power plant, missile magazines, and other such areas.

(2) Do not use in hazardous (classified) areas.

(3) Do not use in penetrating fire-rated walls or partitions, or fire-rated floors.

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3.1.4.4 Restrictions Applicable to Flexible Conduit

Use only as specified in paragraph FLEXIBLE CONNECTIONS. Do not use when the enclosed conductors must be shielded from the effects of High-altitude Electromagnetic Pulse (HEMP).

3.1.4.5 Underground Conduit

Plastic-coated rigid steel; plastic-coated steel IMC; PVC, Type EPC-40. Convert nonmetallic conduit, other than PVC Schedule 40 or 80, to plastic-coated rigid, or IMC, steel conduit before rising through floor slab. Plastic coating: extend minimum 6 inches above floor.

3.1.4.6 Conduit Installed Under Floor Slabs

Conduit run under floor slab: located a minimum of 12_____ inches below the vapor barrier. Seal around conduits at penetrations thru vapor barrier. Use NECA NEIS 1 Table 2a (Minimum Raceway Spacing) to determine under floor slab conduit spacing unless greater spacing is required elsewhere in this section.

3.1.4.7 Conduit Through Floor Slabs

Where conduits rise through floor slabs, do not allow curved portion of bends to be visible above finished slab. Where conduit rises through slab-on grade, seal all electrical penetrations to address radon mitigation and prevent infiltration of air, insects, and vermin.

3.1.4.8 Conduit Support

Support conduit by pipe straps, wall brackets, threaded rod conduit hangers, or ceiling trapeze. Plastic cable ties are not acceptable. Fasten by wood screws to wood; by toggle bolts on hollow masonry units; by concrete inserts or expansion bolts on concrete or brick; and by machine screws, welded threaded studs, or spring-tension clamps on steel work. Threaded C-clamps may be used on rigid steel conduit only. Do not weld conduits or pipe straps to steel structures. Do not exceed one-fourth proof test load for load applied to fasteners. Provide vibration resistant and shock-resistant fasteners attached to concrete ceiling. Do not cut main reinforcing bars for any holes cut to depth of more than 1

1/2 inches in reinforced concrete beams or to depth of more than 3/4 inch in concrete joints. Fill unused holes. In partitions of light steel construction, use sheet metal screws. In suspended-ceiling construction, run conduit above ceiling. Do not support conduit by ceiling support system. Conduit and box systems: supported independently of both (a) tie wires supporting ceiling grid system, and (b) ceiling grid system into which ceiling panels are placed. Do not share supporting means between electrical raceways and mechanical piping or ducts. Identify independent conduit support in both fire and non-fire rated assemblies per NFPA 70. Coordinate installation with above-ceiling mechanical systems to assure maximum accessibility to all systems. Spring-steel fasteners may be used for lighting branch circuit conduit supports in suspended ceilings in dry locations. Where conduit crosses building expansion joints, provide suitable watertight expansion fitting that maintains conduit electrical continuity by bonding jumpers or other means. For conduits greater than 2 1/2 inches inside diameter, provide supports to resist forces of 0.5 times the equipment weight in any direction and 1.5 times the equipment weight in the downward direction.

3.1.4.9 Directional Changes in Conduit Runs

Make changes in direction of runs with symmetrical bends or cast-metal fittings. Make field-made bends and offsets with hickey or conduit-bending machine. Do not install crushed or deformed conduits. Avoid trapped conduits. Prevent plaster, dirt, or trash from lodging in conduits, boxes, fittings, and equipment during construction. Free clogged conduits of obstructions.

3.1.4.10 Locknuts and Bushings

Fasten conduits to sheet metal boxes and cabinets with two locknuts where required by NFPA 70, where insulated bushings are used, and where bushings cannot be brought into firm contact with the box; otherwise, use at least minimum single locknut and bushing. Provide locknuts with sharp edges for digging into wall of metal enclosures. Install bushings on ends of conduits, and provide insulating type where required by NFPA 70.

3.1.4.11 Flexible Connections

Provide flexible steel conduit between 3 and 6 feet in length for recessed and semirecessed lighting fixtures; for equipment subject to vibration, noise transmission, or movement; and for motors. Install flexible conduit to allow 20 percent slack. Minimum flexible steel conduit size: 1/2 inch diameter. Provide liquid tight flexible conduit in wet and damp locations and in fire pump rooms for equipment subject to vibration, noise transmission, movement or motors. Provide separate ground conductor across flexible connections. Plastic cable ties are not acceptable as a support method.

3.1.4.12 Telecommunications and Signal System Pathway

Install telecommunications pathway in accordance with TIA-569.

a. Horizontal Pathway: Telecommunications pathways from the work area to the telecommunications room: installed and cabling length requirements in accordance with TIA-568.1. Size conduits as indicated.

3.1.5 Cable Tray Installation

Install and ground in accordance with NFPA 70. In addition, install and ground telecommunications cable tray in accordance with TIA-569, and TIA-607. Install cable trays parallel with or at right angles to ceilings, walls, and structural members. Cable tray and tray supports must not partially nor completely obstruct access to the room. Adjacent cable tray sections: bonded together by connector plates of an identical type as the cable tray sections. For grounding of cable tray system provide No. 2 AWG bare copper wire throughout cable tray system, and bond to each section, except use No. 1/0 aluminum wire if cable tray is aluminum. Terminate cable trays 10 inches from both sides of smoke and fire partitions. Install conductors run through smoke and fire partitions in 4 inch rigid steel conduits with grounding bushings, extending 12 inches beyond each side of partitions. Seal conduit on both ends to maintain smoke and fire ratings of partitions. Firestop penetrations in accordance with Section 07 84 00, FIRESTOPPING. Provide supports to resist forces of 0.5 times the equipment weight in any direction and 1.5 times the equipment weight in the downward direction.

In addition, install and ground telecommunications cable tray in accordance with TIA-569, and TIA-607. Ensure edges, fittings, and hardware are finished free from burrs and sharp edges. Use No. 1/0 aluminum wire if cable tray is aluminum.

3.1.6 Boxes, Outlets, and Supports

Provide boxes in wiring and raceway systems wherever required for pulling of wires, making connections, and mounting of devices or fixtures. Boxes for metallic raceways: cast-metal, hub-type when located in wet locations, when surface mounted on outside of exterior surfaces, when surface mounted on interior walls exposed up to 7 feet above floors and walkways, and when specifically indicated. Boxes in other locations: sheet steel, except that aluminum boxes may be used with aluminum conduit . Provide each box with volume required by NFPA 70 for number of conductors enclosed in box. Boxes for mounting lighting fixtures: minimum 4 inches square, or octagonal, except that smaller boxes may be installed as required by fixture configurations, as approved. Boxes for use in masonry-block or tile walls: square-cornered, tile-type, or standard boxes having square-cornered, tile-type covers. Provide gaskets for cast-metal boxes installed in wet locations and boxes installed flush with outside of exterior surfaces. Provide separate boxes for flush or recessed fixtures when required by fixture terminal operating temperature; provide readily removable fixtures for access to boxes unless ceiling access panels are provided. Support boxes and pendants for surface-mounted fixtures on suspended ceilings independently of ceiling supports. Fasten boxes and supports with wood screws on wood, with bolts and expansion shields on concrete or brick, with toggle bolts on hollow masonry units, and with machine screws or welded studs on steel. Threaded studs driven in by powder charge and provided with lock washers and nuts or nail-type nylon anchors may be used in lieu of wood screws, expansion shields, or machine screws. In open overhead spaces, cast boxes threaded to raceways need not be separately supported except where used for fixture support; support sheet metal boxes directly from building structure or by bar hangers. Where bar hangers are used, attach bar to raceways on opposite sides of box, and support raceway with approved-type fastener maximum 24 inches from box. When penetrating reinforced concrete members, avoid cutting reinforcing steel.

3.1.6.1 Boxes

Boxes for use with raceway systems: minimum 1 1/2 inches deep, except where shallower boxes required by structural conditions are approved. Boxes for other than lighting fixture outlets: minimum 4 inches square, except that 4 by 2 inch boxes may be used where only one raceway enters outlet.

3.1.6.2 Pull Boxes

Construct of at least minimum size required by NFPA 70 of code-gauge aluminum or galvanized sheet steel, except where cast-metal boxes are required in locations specified herein. Provide boxes with screw-fastened covers. Where several feeders pass through common pull box, tag feeders to indicate clearly electrical characteristics, circuit number, and panel designation.

3.1.6.3 Extension Rings

Extension rings are not permitted for new construction. Use only on existing boxes in concealed conduit systems where wall is furred out for new finish.

3.1.7 Mounting Heights

Mount panelboards, circuit breakers, and disconnecting switches so height of center of grip of the operating handle of the switch or circuit breaker at its highest position is maximum 79 inches above floor or working platform or as allowed in Section 404.8 per NFPA 70. Mount lighting switches 48 inches above finished floor. Mount receptacles and telecommunications outlets 18 inches above finished floor, unless otherwise indicated Mount other devices as indicated. Measure mounting heights of wiring devices and outlets in non-hazardous areas to center of device or outlet.

3.1.8 Conductor Identification

Provide conductor identification within each enclosure where tap, splice, or termination is made. For conductors No. 6 AWG and smaller diameter, provide color coding by factory-applied, color-impregnated insulation. For conductors No. 4 AWG and larger diameter, provide color coding by plastic-coated, self-sticking markers; colored nylon cable ties and plates; or heat shrink-type sleeves. Provide telecommunications system conductor identification as specified in Section 27 10 00 BUILDING TELECOMMUNICATIONS CABLING SYSTEMS.

3.1.8.1 Marking Strips

Provide marking strips for identification of power distribution, control, data, and communications cables in accordance with the following:

a. Provide white or other light-colored plastic marking strips, fastened by screws to each terminal block, for wire designations.

b. Use permanent ink for the wire numbers

c. Provide reversible marking strips to permit marking both sides, or provide two marking strips with each block.

d. Size marking strips to accommodate the two sets of wire numbers.

e. Assign a device designation in accordance with NEMA ICS 1 to each device to which a connection is made. Mark each device terminal to which a connection is made with a distinct terminal marking corresponding to the wire designation used on the Contractor's schematic and connection diagrams.

f. The wire (terminal point) designations used on the Contractor's wiring diagrams and printed on terminal block marking strips may be according to the Contractor's standard practice; however, provide additional wire and cable designations for identification of remote (external) circuits for the Government's wire designations.

g. Prints of the marking strips drawings submitted for approval will be so marked and returned to the Contractor for addition of the designations to the terminal strips and tracings, along with any rearrangement of points required.

3.1.9 Electrical Penetrations

Seal openings around electrical penetrations through fire resistance-rated walls, partitions, floors, or ceilings in accordance with Section 07 84 00 FIRESTOPPING.

3.1.10 Grounding and Bonding

Provide in accordance with NFPA 70 and NFPA 780. Ground exposed, non-current-carrying metallic parts of electrical equipment, metallic raceway systems, grounding conductor in metallic and nonmetallic raceways, telecommunications system grounds, and neutral conductor of wiring systems. Make ground connection at main service equipment, and extend grounding conductor to point of entrance of metallic water service. Make connection to water pipe by suitable ground clamp or lug connection to plugged tee. If flanged pipes are encountered, make connection with lug bolted to street side of flanged connection. Supplement metallic water service grounding system with additional made electrode in compliance with NFPA 70. Interconnect all grounding media in or on the structure to provide a common ground potential. This includes lightning protection, electrical service, telecommunications system grounds, as well as underground metallic piping systems. Make interconnection to the gas line on the customer's side of the meter. Use main size lightning conductors for interconnecting these grounding systems to the lightning protection system. In addition to the requirements specified herein, provide telecommunications grounding in accordance with TIA-607. Where ground fault protection is employed, ensure that connection of ground and neutral does not interfere with correct operation of fault protection.

3.1.10.1 Ground Rods

Provide ground rods and measure the resistance to ground using the fall-of-potential method described in IEEE 81. Do not exceed 25 ohms under normally dry conditions for the maximum resistance of a driven ground. If this resistance cannot be obtained with a single rod, 3 additional rods, spaced on center. Spacing for additional rods must be a minimum of 10 feet, or if sectional type rods are used, 3 additional sections may be coupled and driven with the first rod. If the resultant resistance exceeds 25 ohms measured not less than 48 hours after rainfall, notify the Contracting Officer who will decide on the number of ground rods to add.

3.1.10.2 Grounding Connections

Make grounding connections which are buried or otherwise normally inaccessible, excepting specifically those connections for which access for periodic testing is required, by exothermic weld or high compression connector.

a. Make exothermic welds strictly in accordance with the weld manufacturer's written recommendations. Welds which are "puffed up" or which show convex surfaces indicating improper cleaning are not acceptable. Mechanical connectors are not required at exothermic welds.

b. Make high compression connections using a hydraulic or electric compression tool to provide the correct circumferential pressure. Provide tools and dies as recommended by the manufacturer. Use an embossing die code or other standard method to provide visible indication that a connector has been adequately compressed on the ground wire.

3.1.10.3 Resistance

Maximum resistance-to-ground of grounding system: do not exceed 25 ohms under dry conditions. Where resistance obtained exceeds 25ohms, contact Contracting Officer for further instructions.

3.1.10.4 Telecommunications System

Provide telecommunications grounding in accordance with the following:

a. Telecommunications Grounding Busbars: Provide a Primary bonding busbar (PBB) in the telecommunications entrance facility.

b. Telecommunications Bonding Conductors: Provide main telecommunications service equipment ground consisting of separate bonding conductor for telecommunications, between the PBB and readily accessible grounding connection of the electrical service. Grounding and bonding conductors should not be placed in ferrous metallic conduit. If it is necessary to place grounding and bonding conductors in ferrous metallic conduit that exceeds 3 feet in length, bond the conductors to each end of the conduit using a grounding bushing or a No. 6 AWG conductor, minimum.

c. Telecommunications Grounding Connections: Telecommunications grounding connections to the PBB: utilize listed compression two-hole lugs, exothermic welding, suitable and equivalent one hole non-twisting lugs, or other irreversible compression type connections. Bond all metallic pathways, cabinets, and racks for telecommunications cabling and interconnecting hardware located within the comm room to the PBB. In a metal frame (structural steel) building, where the steel framework is readily accessible within the room; bond each PBB to the vertical steel metal frame using a minimum No. 6 AWG conductor. All connectors used for bonding to the metal frame of a building must be listed for the intended purpose.

3.1.11 Equipment Connections

Provide power wiring for the connection of motors and control equipment under this section of the specification. Except as otherwise specifically noted or specified, automatic control wiring, control devices, and protective devices within the control circuitry are not included in this section of the specifications and are provided under the section specifying the associated equipment.

3.1.12 Government-Furnished Equipment

Contractor make connections to Government-furnished equipment to make equipment operate as intended, including providing miscellaneous items such as plugs, receptacles, wire, cable, conduit, flexible conduit, and outlet boxes or fittings.

3.1.13 Repair of Existing Work

Perform repair of existing work, demolition, and modification of existing electrical distribution systems as follows:

3.1.13.1 Workmanship

Lay out work in advance. Exercise care where cutting, channeling, chasing, or drilling of floors, walls, partitions, ceilings, or other surfaces is necessary for proper installation, support, or anchorage of conduit, raceways, or other electrical work. Repair damage to buildings, piping, and equipment using skilled craftsmen of trades involved.

3.1.13.2 Existing Concealed Wiring to be Removed

Disconnect existing concealed wiring to be removed from its source. Remove conductors; cut conduit flush with floor, underside of floor, and through walls; and seal openings.

3.1.13.3 Removal of Existing Electrical Distribution System

Removal of existing electrical distribution system equipment includes equipment's associated wiring, including conductors, cables, exposed conduit, surface metal raceways, boxes, and fittings,as indicated.

3.1.14 Watthour Meters

ANSI C12.1.

3.1.15 Surge Protective Devices

Connect the surge protective devices in parallel to the power source, keeping the conductors as short and straight as practically possible. Maximum allowed lead length is 3 feet avoiding 90 degree bends. Do not locate surge protective devices inside a panelboard or switchboard enclosure.

3.2 FIELD FABRICATED NAMEPLATE MOUNTING

Provide number, location, and letter designation of nameplates as indicated. Fasten nameplates to the device with a minimum of two sheet-metal screws or two rivets. Provide nameplate on all equipment in access controlled spaces and areas.

3.3 WARNING SIGN MOUNTING

Provide the number of signs required to be readable from each accessible side. Space the signs in accordance with NFPA 70E.

3.4 FIELD APPLIED PAINTING

Paint electrical equipment as required to match finish of adjacent surfaces or to meet the indicated or specified safety criteria. Painting: as specified in Section 09 90 00 PAINTS AND COATINGS.

3.5 FIELD QUALITY CONTROL

Furnish test equipment and personnel and submit written copies of test results. Give Contracting Officer 5 working days notice prior to each test. Where applicable, test electrical equipment in accordance with NETA ATS.

3.5.1 Devices Subject to Manual Operation

Operate each device subject to manual operation at least five times, demonstrating satisfactory operation each time.

3.5.2 600-Volt Wiring Test

Test wiring rated 600 volt and less to verify that no short circuits or accidental grounds exist. Perform insulation resistance tests on wiring No. 6 AWG and larger diameter using instrument which applies voltage of 1,000 volts DC for 600 volt rated wiring and 500 volts DC for 300 volt rated wiring per NETA ATS to provide direct reading of resistance. All existing wiring to be reused must also be tested.

3.5.3 Ground-Fault Receptacle Test

Test ground-fault receptacles with a "load" (such as a plug in light) to verify that the "line" and "load" leads are not reversed. Press the TEST button and then the RESET button to verify by LED status that the device is a self-test model as specified in UL 943.

3.5.4 Grounding System Test

Test grounding system to ensure continuity, and that resistance to ground is not excessive. Test each ground rod for resistance to ground before making connections to rod; tie grounding system together and test for resistance to ground. Make resistance measurements in dry weather, not earlier than 48 hours after rainfall. Submit written results of each test to Contracting Officer, and indicate location of rods as well as resistance and soil conditions at time measurements were made.

3.5.5 Watthour Meter

a. Visual and mechanical inspection

   (1) Examine for broken parts, shipping damage, and tightness of connections.

   (2) Verify that meter type, scales, and connections are in accordance with approved shop drawings.

b. Electrical tests

(1) Determine accuracy of meter.

(2) Calibrate watthour meters to one-half percent.

(3) Verify that correct multiplier has been placed on face of meter, where applicable.

3.5.6 Phase Rotation Test

Perform phase rotation test to ensure proper rotation of service power prior to operation of new or reinstalled equipment using a phase rotation meter. Follow the meter manual directions performing the test.

-- End of Section --

SECTION 26 29 23

ADJUSTABLE SPEED DRIVE (ASD) SYSTEMS UNDER 600 VOLTS
02/20, CHG 1: 05/21

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

EUROPEAN COMMITTEE FOR STANDARDIZATION (CEN/CENELEC)

EN 61800-3	(2017) Requirements for the Control of Electromagnetic Interference Characteristics of Subsystems and Equipment

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 519	(2014) Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems
IEEE C62.41.1	(2002; R 2008) Guide on the Surges Environment in Low-Voltage (1000 V and Less) AC Power Circuits
IEEE C62.41.2	(2002) Recommended Practice on Characterization of Surges in Low-Voltage (1000 V and Less) AC Power Circuits

INTERNATIONAL ELECTROTECHNICAL COMMISSION (IEC)

IEC 61000-3-12	(2012) Electromagnetic Compatibility (EMC) - Part 3-12: Limits - Limits for harmonic currents produced by equipment connected to public low-voltage systems with input current >16 A and </=75 A per phase

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA 250	(2020) Enclosures for Electrical Equipment (1000 Volts Maximum)
NEMA ICS 1	(2000; R 2015) Standard for Industrial Control and Systems: General Requirements
NEMA ICS 3.1	(2019) Guide for the Application, Handling, Storage, Installation and Maintenance of Medium-Voltage AC Contactors, Controllers and Control Centers
NEMA ICS 6	(1993; R 2016) Industrial Control and Systems: Enclosures
NEMA ICS 7	(2020) Adjustable-Speed Drives

NEMA ICS 7.2	(2015) Application Guide for AC Adjustable Speed Drive Systems
NEMA MG 1	(2021) Motors and Generators

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2020; TIA 22-1; ERTA 1 2022) National Electrical Code

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

47 CFR 15	Radio Frequency Devices

UNDERWRITERS LABORATORIES (UL)

UL 489	(2016; Rev 2019) UL Standard for Safety Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures
UL 61800-5-1	(2016) Adjustable Speed Electrical Power Drive Systems - Part 5-1: Safety Requirements - Electrical, Thermal and Energy

1.2 RELATED REQUIREMENTS

Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM applies to this section with additions and modifications specified herein.

1.3 SYSTEM DESCRIPTION

1.3.1 Performance Requirements

1.3.1.1 Electromagnetic Interference Suppression

Computing devices, as defined by 47 CFR 15 and EN 61800-3 rules and regulations, must be certified to comply with the requirements for class A computing devices and labeled.

1.3.1.2 Electromechanical and Electrical Components

Ensure electrical and electromechanical components of the Adjustable Speed Drive (ASD) do not cause electromagnetic interference to adjacent electrical or electromechanical equipment while in operation.

1.3.2 Electrical Requirements

1.3.2.1 Power Line Surge Protection

IEEE C62.41.1 and IEEE C62.41.2, IEEE 519, IEC 61000-3-12 Control panel must have surge protection, included within the panel to protect the unit from damaging transient voltage surges. Surge protective device must be mounted near the incoming power source and properly wired to all three phases and ground. Fuses must not be used for surge protection.

1.3.2.2 Sensor and Control Wiring Surge Protection

I/O functions as specified must be protected against surges induced on control and sensor wiring installed outdoors and as shown. Test the inputs and outputs in both normal mode and common mode using the following two waveforms:

a. A 10 microsecond by 1000 microsecond waveform with a peak voltage of 1500 volts and a peak current of 60 amperes.

b. An 8 microsecond by 20 microsecond waveform with a peak voltage of 1000 volts and a peak current of 500 amperes.

1.4 SUBMITTALS

Government approval is required for submittals with a "G" classification. Submittals not having a "G" classification are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Schematic Diagrams; G

Interconnecting Diagrams; G

Installation Drawings; G

As-Built Drawings; G

SD-03 Product Data

Adjustable Speed Drives; G

Wires and Cables

Equipment Schedule

SD-06 Test Reports

ASD Test

Performance Verification Tests

Endurance Test

SD-07 Certificates

Testing Agency's Field Supervisor NETA Certificate; G

SD-08 Manufacturer's Instructions

Installation instructions

SD-09 Manufacturer's Field Reports

ASD Test Plan; G

Standard Products

SD-10 Operation and Maintenance Data

Adjustable Speed Drives, Data Package 4

1.5 QUALITY ASSURANCE

1.5.1 Schematic Diagrams

Submit diagrams showing circuits and device elements for each replaceable module. Schematic diagrams of printed circuit boards are permitted to group functional assemblies as devices, provided that sufficient information is provided for government maintenance personnel to verify proper operation of the functional assemblies.

1.5.2 Interconnecting Diagrams

Show interconnections between equipment assemblies, and external interfaces, including power and signal conductors. Include for enclosures and external devices.

1.5.3 Installation Drawings

Show floor plan of each site, with ASD's and motors indicated. Indicate ventilation requirements, adequate clearances, and cable routes. Submit drawings for government approval prior to equipment construction or integration. Immediately record modifications to original drawings made during installation for inclusion into the as-built drawings.

1.5.4 Equipment Schedule

Provide schedule of equipment supplied. Schedule must provide a cross reference between manufacturer data and identifiers indicated in shop drawings. Schedule must include the total quantity of each item of equipment supplied and data indicating compatibility with motors being driven. For complete assemblies, such as ASD's, provide the serial numbers of each assembly, and a sub-schedule of components within the assembly. Provide recommended spare parts listing for each assembly or component.

1.5.5 Installation Instructions

Provide installation instructions issued by the manufacturer of the equipment, including notes and recommendations, prior to shipment to the site. Provide operation instructions prior to acceptance testing.

1.5.6 Standard Products

Provide materials and equipment that are products of manufacturers regularly engaged in the production of such products which are of equal material, design and workmanship and:

a. Have been in satisfactory commercial or industrial use for 2 years prior to bid opening including applications of equipment and materials under similar circumstances and of similar size.

b. Have been on sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 2-year period.

c. Where two or more items of the same class of equipment are required, provide products of a single manufacturer; however, the component parts of the item need not be the products of the same manufacturer unless stated in this section.

1.6 DELIVERY AND STORAGE

Store delivered equipment to protect from the weather, humidity and temperature variations, dirt and dust, or other contaminants.

1.7 WARRANTY

The complete system must be warranted by the manufacturer for a period of one year. Repair or replace any component failing to perform its function as specified and documented at no additional cost to the Government. Items repaired or replaced must be warranted for an additional period of at least one year from the date that it becomes functional again, as specified in FAR 52.246-21 Warranty of Construction.

1.8 MAINTENANCE

1.8.1 Spare Parts

Manufacturers provide spare parts in accordance with recommended spare parts list.

1.8.2 Operation and Maintenance Data

Provide in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA. Provide service and maintenance information including preventive maintenance, assembly, and disassembly procedures. Include electrical drawings from electrical general sections. Provide additional information necessary to provide complete operation, repair, and maintenance information, detailed to the smallest replaceable unit. Include copies of as-built submittals. Provide routine preventative maintenance instructions, and equipment required. Provide instructions on how to modify program settings, and modify the control program. Provide instructions on drive adjustment, trouble-shooting, and configuration. Provide instructions on process tuning and system calibration.

1.8.3 Maintenance Support

During the warranty period, provide on-site, on-call maintenance services by drive manufacturer's personnel on the following basis: The service must be on a per-call basis with 36 hour response. Contractor is responsible for the maintenance of all hardware and software of the system during the warranty period. Various personnel of different expertise must be sent on-site depending on the nature of the maintenance service required. Costs must include travel, local transportation, living expenses, and labor rates of the service personnel while responding to the service request. The provisions of this Section are not in lieu of, nor relieve the Contractor of, warranty responsibilities covered in this specification. Should the result of the service request be the uncovering of a system defect covered under the warranty provisions, all costs for the call, including the labor necessary to identify the defect, must be borne by the Contractor.

1.8.4 Technical Support

Provide the ASDs with manufacturer's technical telephone support in English, readily available during normal working hours.

PART 2 PRODUCTS

2.1 ADJUSTABLE SPEED DRIVES (ASD)

Provide adjustable speed drive to control the speed of induction motor(s). The ASD must include the following minimum functions, features and ratings.

a. Input circuit breaker per UL 489 with a minimum of 10,000 amps symmetrical interrupting capacity and door interlocked external operator.

b. A converter stage per UL 61800-5-1 must change fixed voltage, fixed frequency, ac line power to a fixed dc voltage. The converter must utilize a full wave bridge design incorporating diode rectifiers. Silicon Controlled Rectifiers (SCR) are not acceptable. The converter must be insensitive to three phase rotation of the ac line and must not cause displacement power factor of less than .95 lagging under any speed and load condition.

c. An inverter stage must change fixed dc voltage to variable frequency, variable ac voltage for application to a standard NEMA MG 1 Part 30 motor designed for use with adjustable frequency power supplies. Switch the inverter to produce a sine coded pulse width modulated (PWM) output waveform.

d. The ASD shall be capable of supplying 110 percent of rated full load current for one minute at maximum ambient temperature.

e. The ASD must be designed to operate from a 480 volt, plus or minus 10 percent, three phase, 60 Hz supply, and control motors with a corresponding voltage rating.

f. Acceleration and deceleration time must be independently adjustable from one second to 60 seconds.

Required deceleration time may be achieved using not only dynamic braking resistor but with other methods described in NEMA ICS 7.2-2015 paragraph 5.2.5.

g. Adjustable full-time current limiting must limit the current to a preset value which must not exceed 110 percent of the controller rated current. The current limiting action must maintain the V/Hz ratio constant so that variable torque can be maintained. Short time starting override must allow starting current to reach 175 percent of controller rated current to maximum starting torque.

h. The controllers must be capable of producing an output frequency over the range of 3 Hz to 60 Hz (20 to one speed range), without low speed cogging. Over frequency protection must be included such that a failure in the controller electronic circuitry must not cause frequency to exceed 110 percent of the maximum controller output frequency selected.

i. Minimum and maximum output frequency must be adjustable over the following ranges: 1) Minimum frequency 3 Hz to 50 percent of maximum selected frequency; 2) Maximum frequency 40 Hz to 60 Hz.

j. The controller efficiency at any speed must not be less than 96 percent.

k. The controllers must be capable of being restarted into a motor coasting in the forward direction without tripping.

l. Protection of power semiconductor components must be accomplished without the use of fast acting semiconductor output fuses. Subjecting the controllers to any of the following conditions must not result in component failure or the need for fuse replacement:

(1) Short circuit at controller output

(2) Ground fault at controller output

(3) Open circuit at controller output

(4) Input undervoltage

(5) Input overvoltage

(6) Loss of input phase

(7) AC line switching transients

(8) Instantaneous overload

(9) Sustained overload exceeding 115 percent of controller rated current

(10) Over temperature

(11) Phase reversal

m. Solid state motor overload protection must be included such that current exceeding an adjustable threshold must activate a 60 second timing circuit. Should current remain above the threshold continuously for the timing period, the controller will automatically shut down.

n. Include slip compensation circuit that will sense changing motor load conditions and adjust output frequency to provide speed regulation of NEMA MG 1 Part 30 designed for use with adjustable frequency power supplies motors to within plus or minus 0.5 percent of maximum speed without the necessity of a tachometer generator.

o. The ASD must be factory set for manual restart after the first protective circuit trip for malfunction (overcurrent, undervoltage, overvoltage or overtemperature) or an interruption of power. The ASD must be capable of being set for automatic restart after a selected time delay. If the drive faults again within a specified time period (adjustable 0-60 seconds), a manual restart will be required. Provide Bidirectional Autospeed Search capable of starting the ASD into rotating loads spinning in either direction and returning motor to set speed in proper direction, without causing damage to drive, motor, or load.

p. The ASD must include external fault reset capability. All the necessary logic to accept an external fault reset contact must be included.

q. Provide critical speed lockout circuitry to prevent operating at frequencies with critical harmonics that cause resonant vibrations. The ASD must have a minimum of three user selectable bandwidths.

r. Provide preperly sized NEMA rated by-pass and isolation contactors to enable operation of motor in the event of ASD failure and for safety transfers motor between power converter output and bypass circuit using a field-selectable automatic and manual bypass mode. Install mechanical and electrical interlocks between the by-pass and isolation contactors. Provide a selector switch and transfer delay timer. Motor overload and short circuit protective features must remain in use during the bypass mode.

s. Each individual ASD must meet the following Total Harmonic Distortion (THD) requirements at the input terminals to the factory assembly of the ASD or at the load disconnecting means serving the ASD and filter assembly. These measurements should be taken with the drive set at 90 percent frequency (rpms) and the motor under a minimum of 50 percent demand.

(1) The Voltage THD should not exceed 2.0 percent THD.

(2) The Current THD should not exceed 15.0 percent THD.

(3) If the standard factory ASD does not meet or exceed these requirements the factory must install appropriate equipment (Harmonic Traps, Filters, different Drive technology, etc.) to mitigate the distortion to assure performance of the VFD is within the limits.

(4) These tests should be performed at the Manufacturers Laboratory facilities and submitted as part of the Product Data Submittals, in order to prevent the necessity of adding mitigation equipment in the field. If the requirements listed above are met, IEEE 519 will also be met.

t. Minimum Operating Conditions. Designed and constructed ASD's to operate within the following service conditions:

(1) Ambient Temperature Rating: 0 to 120 degrees F.

(2) Non-condensing relative humidity rating: less than 95 percent.

(3) Ambient rating: Not exceed 3,300 feet.

2.1.1 ASD for HVAC Application

ASDs must have the following features:

a. A local operator control providing the following functions:

(1) Remote/Local operator selection with password access.

(2) Run/Stop and manual speed commands.

(3) All programming functions.

(4) Scrolling through all display functions.

b. A local operator control panel with the following data displayed:

(1) ASD status.

(2) Frequency.

(3) Motor RPM.

(4) Phase current.

(5) Scrolling through all display functions.

(6) Fault diagnostics in descriptive text.

(7) All programmed parameters.

c. Standard PI loop controller with input terminal for controlled variable and parameter settings.

d. User interface terminals for remote control of ASD speed, speed feedback, and an isolated form C SPDT relay, which energizes on a drive fault condition.

e. An isolated form C SPDT auxiliary relay which energizes on a run command.

f. An adjustable carrier frequency with 16 KHz minimum upper limit.

g. A built-in or external line reactor with 3 percent minimum impedance to protect the DC bus capacitors and rectifier section diodes, reduce power line transient voltage, line notching, DC bus over-voltage tripping and improve the inverter over-current and over-voltage conditions.

h. Historical logging information and displays:

(1) Real-time clock with current time and date.

(2) Running log of total power versus time.

(3) Total run time.

(4) Fault log, maintaining last four faults with time and data stamp for each.

i. The ASD must be capable of automatic control by a remote 0 to 10 VDC signal, by DDC network command, or manually by the ASD control panel.

j. ASDs must include the following operator programmable parameters:

(1) Upper and lower limit frequency.

(2) Acceleration and deceleration rate.

(3) Variable torque volts per Hertz curve.

(4) Starting voltage level.

(5) Starting frequency level.

(6) Display speed scaling.

(7) Enable/disable soft stall feature.

(8) Motor overload level.

(9) Motor stall level.

(10) Jump frequency and hysteresis band.

(11) PWM carrier frequency.

k. ASD must have the following protective features:

(1) An electronic adjustable inverse time current limit with consideration for additional heating of the motor at frequencies below 45Hz, for the protection of the motor.

(2) An electronic adjustable soft stall feature, allowing the ASD to lower the frequency to a point where the motor will not exceed the full-load amperage when an overload ASD will automatically return to the requested frequency when load conditions permit.

(3) A separate electronic stall at 110 percent ASD rated current, and a separate hardware trip at 190 percent current.

(4) The ability to shut down if inadvertently started into a rotating load without damaging the ASD or the motor.

(5) The ability to keep a log of a minimum of four previous fault conditions, indicating the fault type and time of occurrence in descriptive text.

(6) The ability to sustain 110 percent rated current for 60 seconds.

(7) The ability to shutdown safely or protect against and record the following fault conditions:

(a) Over current (and an indication if the over current was during acceleration, deceleration, or running).

(b) Over current internal to the drive.

(c) Motor overload at start-up.

(d) Over voltage from utility power.

(e) Motor running overload.

(f) Over voltage during deceleration.

(g) ASD over heat.

(h) Load and ground fault.

(h) Abnormal parameters or data in ASD EEPROM.

2.2 ENCLOSURES

Provide equipment enclosures conforming to NEMA 250, NEMA ICS 7, and NEMA ICS 6, with a heater if located outdoors. An HMCP device shall provide the disconnecting means. The operating handle shall protrude through the door, but the disconnect shall not be mounted on the door. The handle shall indicate ON, OFF, and tripped conditions. The handle shall have provisions to accommodate a minimum of three padlocks in the OFF position. Interlocks shall prevent unauthorized opening or closing of the ASD door with the disconnect handle in the ON position. The door handle interlock should have provisions to be defeated by qualified maintenance personnel.

2.3 WIRES AND CABLES

All wires and cables must conform to NEMA 250, NEMA ICS 7, NFPA 70.

2.4 NAMEPLATES

Nameplates external to NEMA enclosures must conform with the requirements of Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Provide manufacturer's standard, permanent nameplates for internal areas of enclosures.

2.5 SOURCE QUALITY CONTROL

2.5.1 ASD Test Plan

To ensure quality, each ASD must be subject to a series of in-plant quality control inspections before approval for shipment from the manufacturer's facilities. Provide test plans.

2.5.2 ASD Test Report

To ensure quality, each ASD must be subject to a series of in-plant quality control inspections before approval for shipment from the manufacturer's facilities. Provide test reports.

PART 3 EXECUTION

3.1 INSTALLATION

Per NEMA ICS 3.1, install equipment in accordance with the approved manufacturer's printed installation drawings, instructions, wiring diagrams, and as indicated on project drawings and the approved shop drawings. A field representative of the drive manufacturer must supervise the installation of all equipment, and wiring.

3.2 GROUNDING

Per NEMA ICS 7.2, ASD must be solidly grounded to the main distribution.

3.3 FIELD QUALITY CONTROL

Specified products must be tested as a system for conformance to specification requirements prior to scheduling the acceptance tests. Conduct performance verification tests in the presence of Government representative, observing and documenting complete compliance of the system to the specifications. Submit a signed copy of the test results, certifying proper system operation before scheduling tests.

3.3.1 ASD Test

A proposed test plan must be submitted to the contracting officer at least 28 calendar days prior to proposed testing for approval. The tests must conform to NEMA ICS 1, NEMA ICS 7, and all manufacturer's safety regulations. The Government reserves the right to witness all tests and review any documentation. Inform the Government at least 14 working days prior to the dates of testing. Perform the ASD test engaging a qualified testing agency's field supervisor currently certified by NETA to supervise on-site testing.

3.3.2 Performance Verification Tests

"Performance Verification Test" plan must provide the step by step procedure required to establish formal verification of the performance of the ASD. Compliance with the specification requirements must be verified by inspections, review of critical data, demonstrations, and tests. The Government reserves the right to witness all tests, review data, and request other such additional inspections and repeat tests as necessary to ensure that the system and provided services conform to the stated requirements. Inform the Government 14 calendar days prior to the date the test is to be conducted.

3.3.3 Endurance Test

Immediately upon completion of the performance verification test, the endurance test must commence. The system must be operated at varying rates for not less than 192 consecutive hours, at an average effectiveness level of 0.9998, to demonstrate proper functioning of the complete PCS. Continue the test on a day-to-day basis until performance standard is met. The contractor is not allowed in the building during the endurance test. The system must respond as designed.

3.4 DEMONSTRATION

3.4.1 Training

Coordinate training requirements with the Contracting Officer. Provide video tapes, if available, of all training provided to the Government for subsequent use in training new personnel. Provide all training aids, texts, and expendable support material for a self-sufficient presentation shall be provided, the amount of which to be determined by the contracting officer.

3.4.1.1 Instructions to Government Personnel

Provide the services of competent instructors with minimum two-year field experience with the operation and maintenance of similar ASDs who will give full instruction to designated personnel in operation, maintenance, calibration, configuration, and programming of the complete control system. Orient the training specifically to the system installed. Instructors must be thoroughly familiar with the subject matter they are to teach. The number of training days of instruction furnished must be as specified. A training day is defined as eight hours of instruction, including two 15-minute breaks and excluding lunch time; Monday through Friday. Provide a training manual for each student at each training phase which describes in detail the material included in each training program. Provide one additional copy for archiving. Provide equipment and materials required for classroom training. Provide a list of additional related courses, and offers, noting any courses recommended. List each training course individually by name, including duration, approximate cost per person, and location of course. Unused copies of training manuals must be turned over to the Government at the end of last training session.

3.4.1.2 Operating Personnel Training Program

Provide one 2-hour training session at the site at a time and place mutually agreeable between the Contractor and the Government. Provide session to train 4 operation personnel in the functional operations of the system and the procedures that personnel will follow in system operation. This training shall include:

a. System overview

b. General theory of operation

c. System operation

d. Alarm formats

e. Failure recovery procedures

f. Troubleshooting

3.4.1.3 Engineering/Maintenance Personnel Training

Accomplish the training program as specified. Training must be conducted on site at a location designated by the Government. Provide a one-day training session to train four engineering personnel in the functional operations of the system. This training must include:

a. System overview

b. General theory of operation

c. System operation

d. System configuration

e. Alarm formats

f. Failure recovery procedures

g. Troubleshooting and repair

h. Maintenance and calibration

i. System programming and configuration

-- End of Section --

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SECTION 26 41 00

LIGHTNING PROTECTION SYSTEM
08/23

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 81	(2012) Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2023; ERTA 4 2023; ERTA 5 2023; ERTA 6 2023) National Electrical Code
NFPA 780	(2023) Standard for the Installation of Lightning Protection Systems

U.S. AIR FORCE (USAF)

DAFMAN 32-1065	(2020) Grounding and Electrical Systems

U.S. DEPARTMENT OF DEFENSE (DOD)

UFC 3-575-01	(2012; with Change 1, 2021) Lightning and Static Electricity Protection Systems

UNDERWRITERS LABORATORIES (UL)

UL 96	(2016; May 2023) UL Standard for Safety Lightning Protection Components
UL 96A	(2023) UL Standard for Safety Installation Requirements for Lightning Protection Systems
UL Electrical Construction	(2012) Electrical Construction Equipment Directory

1.2 RELATED REQUIREMENTS

1.2.1 Verification of Dimensions

Confirm all details of work, verify all dimensions in field, and advise Contracting Officer of any discrepancy before performing work. Obtain prior approval of Contracting Officer after engineering approval and before making any departures from the design.

1.2.2 System Requirements

Provide a system furnished under this specification consisting of the latest products of a manufacturer regularly engaged in production of lightning protection system components. Products must be UL listed for use on lightning protection systems unless this rating does not exist for items in question.

Comply with NFPA 70, NFPA 780, UL 96, and UFC 3-575-01.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. When used, a code following the "G" classification identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-06 Test Reports

Lightning Protection and Grounding System Test Plan; G

Grounding Systems Testing; G

SD-07 Certificates

Component UL Listed and Labeled; G

Lightning Protection System Inspection Certificate; G

Roof Manufacturer's Warranty; G

1.4 QUALITY ASSURANCE

In each standard referred to herein, consider the advisory provisions to be mandatory, as though the word "shall" or "must" has been substituted for "should," wherever it appears. Interpret references that require LPS expertise in these standards to mean Base Civil Engineer (BCE) or BCE-designated representative with LPS training certification.

1.4.1 Component UL Listed and Labeled

Submit proof of compliance that components are UL Listed and Labeled for use on lightning protection systems. Listing alone in UL Electrical Construction, which is the UL Electrical Construction Directory, is not acceptable evidence. In lieu of Listed and Labeled, submit written certificate from an approved, nationally-recognized testing organization equipped to perform such services, stating that items have been tested and conform to requirements and testing methods of Underwriters Laboratories (UL).

1.4.2 Lightning Protection and Grounding System Test Plan

Provide lightning protection system and grounding system test plans in compliance with NFPA 780

1.4.3 Lightning Protection System Inspection Certificate of Qualifications

Provide an approved third-party inspector who meets training certification requirements for final acceptance of the LPS. Inspection and certification of the LPS must be completed and certified in writing, before occupancy of the building. Compliance requirements are in UFC 3-575-01. Signed Certificate of Qualifications must be placed in the LPS records.

Note that the Contracting Officer may not accept the LPS system without a recommendation from a qualified person identified in the project documents.

1.5 SITE CONDITIONS

Confirm all details of work, verify all dimensions in the field, and advise the Contracting Officer of any discrepancy before starting any work, if known at that time, or when it becomes known while performing work. Obtain prior approval of the BCE or BCE-designated representative with LPS training certification before design changes are made.

PART 2 PRODUCTS

2.1 MATERIALS

See NFPA 70, NFPA 780, UFC 3-575-01. Do not use a combination of materials that forms an electrolytic couple of such nature that corrosion is accelerated in the presence of moisture unless moisture is permanently excluded from the junction of such metals. Where unusual conditions exist which would cause corrosion of conductors, provide conductors with protective coatings, such as tin or lead, or oversize conductors. Where a mechanical hazard is involved, increase conductor size to compensate for the hazard or protect conductors. When metallic conduit or tubing is provided, electrically bond conductor to conduit or tubing at the upper and lower ends by clamp type connectors or welds (including exothermic). All lightning protection components, such as bonding plates, air terminals, air terminal supports and braces, chimney bands, clips, connector fittings, and fasteners are to comply with the requirements of UL 96 classes, as applicable.

2.1.1 Main and Bonding Conductors

Main and Bonding Conductors should be NFPA 780 and UL 96 Class I or Class II materials, as applicable. For explosives, Class II materials are in accordance with NFPA 780, Chapter 8.

2.1.2 Conductors

Provide copper or aluminum conductors, as applicable. See NFPA 780, UFC 3-575-01.

2.2 COMPONENTS

2.2.1 Air Terminals on Integral Systems

Provide solid air terminals. Tubular air terminals are not permitted. Support air terminals more than 24 inches in length by suitable brace, supported at not less than one-half the height of the terminal.

2.2.2 Ground Rods

Provide ground rods conforming to NFPA 780. Provide ground rods that are not less than 5/8 inch in diameter and 8 feet in length. Do not mix ground rods of copper-clad steel and solid copper on the job.

2.2.3 Connections and Terminations

Provide connectors for splicing conductors that conform to UL 96, class as applicable. Conductor connections can be made by compression clamps or welds (including exothermic). Provide style and size connectors required for the installation.

2.2.4 Connector Fittings

Provide connector fittings for "end-to-end", "Tee", or "Y" splices that conform to NFPA 780 and UL 96.

PART 3 EXECUTION

3.1 LIGHTNING PROTECTION SYSTEMS

Provide a lightning protection system that meets the requirements of NFPA 780 and UFC 3-575-01.

3.1.1 Integral Lightning Protection System

The integral type lightning protection system consists of air terminals, roof conductors, down conductors, ground connections, grounding electrodes and ground ring electrode conductor for the purpose of carrying lightning current from a direct strike to ground in a manner that will protect assets and personnel. Expose all conductors on the structures except where exterior down conductors are required to be in protective sleeves for prevention of mechanical damage (6 feet above grade level). Integral systems are the least preferred, especially for explosives and communications facilities. When use of integral systems is determined by the designer or site conditions to be necessary, do not run down conductors inside columns or other methods which will prevent visual access for required inspections. Visual access is required by NFPA 780 so that the annual visual inspection may be performed on all LPS components.

Make interconnections within side-flash distances between down conductors and metallic equipment mounted on the exterior or interior of a facility, at or below the level of the grounded metallic parts. Calculate side-flash distances in accordance with NFPA 780. Be aware of side flashes that may occur through exterior walls.

Note that integral systems should be avoided as LPS for Explosives and Communications facilities and is discouraged for general facilities. Installation and maintenance costs of an integral system are excessive and this method is maintenance intensive. The complexity and number of test points dictates frequent interruption to missions and daily operations for required annual inspections and testing. Integral systems require fall protection and maintenance of that fall protection system. For fall protection, maintain NFPA 780-compliant separation distance between the integral system and metallic fall protection.

3.1.1.1 Roof-Mounted Components

Coordinate with the roofing manufacturer and provide certification that the roof manufacturer's warranty is not violated by the installation methods for air terminals and roof conductors. Adhesive fasteners may be used on the roof if the installation is observed by base-qualified personnel to be compliant with manufacturer's instructions. Installation must be observed until the observer is satisfied that the proper methods for preparing the surface are being performed. These fasteners will be added and considered a test point in Base records and must be part of the annual inspection. Observer must date and sign the test record.

No connection or physical attachment is allowed to any coping system on the roof as this violates the integrity and warranty of the coping system.

3.1.1.2 Air Terminals

Use of adhesive fasteners, when installing air terminals on "rubber" (EPDM) type roofs, should be in accordance with adhesive and roof manufactures’ recommendations. See paragraph ROOF-MOUNTED COMPONENTS.

3.1.1.3 Roof Conductors

Roof conductors should comply with NFPA 780.

3.1.2 Down Conductors

A minimum of two paths to ground shall be provided on any system. This may be by two down conductors or with a down conductor in combination with other metallic connections to ground. Protect exposed down conductors from physical damage from ground level up to 6 feet. If this protection is a metal conduit, both ends must be bonded to the down conductor passing through it. For Schedule 80 conduit providing this protection, no bonding at both ends is necessary. Schedule 80 conduit or metallic conduit may be painted to match the surrounding surface. NO CONNECTIONS OR FASTENERS OF ANY LIGHTNING PROTECTION SYSTEM MAY BE PAINTED because this affects the ease with which lightning current can pass to ground.

3.1.3 Ground Connections

Attach each down conductor and ground ring electrode to a ground rod below grade by exothermic weld for all buried connections and exothermic weld or compression connectors for connections inside test wells. Terminate all down conductors to a grounding electrode inside a test well. Test connections and record resistances and continuity readings prior to covering.

Accessible connections above ground level and in test wells can be grounded with mechanical clamping, meeting installation requirements in NFPA 780.

3.1.4 Installation of Grounding Electrodes (Ground Rods)

Extend driven ground rods vertically into the existing undisturbed earth for a distance of not-less-than 8 feet if exothermic welds are used for bonds. Inside test wells, the 5/8 in. by 8 ft rod may be driven to a point above the base of the test well, that will provide working/testing access to the mechanically-fastened bond. Set ground rods not less than 3 feet nor more than 6 feet (see NFPA 780) from the structural foundation, and at least 3 feet beyond the drip line for the facility. After the completed installation, measure the total resistance to ground using the fall-of-potential method described in IEEE 81. Maximum allowed resistance of a single driven ground rod is 25 ohms (NFPA 70). If resistance-to-ground of a single ground rod for the lightning protection system exceeds 25 ohms and another ground rod is driven in accordance with NFPA 780, 25 ohms does not apply to this test point. See NFPA 70 exception to Article 250.53.

3.2 APPLICATIONS

3.2.1 Personnel Ramps and Covered Passageways

Lightning Protection is required in accordance with NFPA 780 and UFC 3-575-01.

3.3 INTERFACE WITH OTHER STRUCTURES

3.3.1 Fences

Bond metal fence and gate systems to the lightning protection system at the point where the fence, any fence post, or gate is within 6 feet of any part of the lightning protection system (usually a down conductor) in accordance with ANSI C2 and NFPA 780 and UFC 3-575-01.

3.4 RESTORATION

Where sod has been removed, replace sod as soon as possible after completing the backfilling. Restore areas disturbed by trenching, storing of dirt, cable laying, and other work, to original condition. Overfill the trench to accommodate for settling. Include necessary topsoil, fertilizing, liming, seeding, sodding, sprigging or mulching in any restoration, to match existing. Maintain disturbed surfaces and replacements until final acceptance. Return to site after six months to fill in compacted surface.

3.5 FIELD QUALITY CONTROL

3.5.1 Lightning Protection Systems Testing

A 100 percent test point test and inspection is required by all services. Identify test points for lightning protection system connections and bonds. Provide a sketch (NTS) with identified test points as part of the contract acceptance. Number points in a manner consistent with the installation (Base or Post) nomenclature for existing lightning protection systems; for example, use letters or numbers to track the test results. Test each lightning protection system connection to ensure continuity across each connection or bond is 1 ohm or less, and record the value indicated on a copy of the test form located at the back of DAFMAN 32-1065, Attachment 7.

a. LPS testing must also be accomplished on smaller projects, such as roofing and HVAC projects, where lightning protection systems are installed on any facility with existing LPS, to ensure the LPS is not damaged or reconfigured during construction.

b. Comply with UL 96A. A third-party inspector (not the designer and not the installer) must be present for the 100 percent inspection and data documentation by the contractor. This is to take place prior to project acceptance. Note that in many cases Air Force personnel have been trained to inspect and accept projects as the third-party inspector. Verify this before contract award.

3.5.2 Grounding Systems Testing

A 100 percent test point resistance test and inspection is required. Identify all test points for grounding system connections and bonds. Provide a sketch (NTS) with identified test points as part of the contract acceptance. Number points in a manner consistent with the installation (Base or Post) nomenclature for existing grounding systems; for example, use letters or numbers to track the test results. Test each grounding system connection or bond to ensure resistance-to-ground is 25 ohms or less or as excepted by NFPA 70 or NFPA 780. Record the resistance measurement on a copy of the test form located at the back of DAFMAN 32-1065 for Air Force or a similar form provided by the Army or Navy. Test the ground rod for resistance to ground before making connections to the rod. Tie the grounding system together and test for resistance to ground. Make resistance measurements in dry weather, and not earlier than 48 hours after rainfall. Include in the written report: locations of test points, measured values for continuity and ground resistances, and soil conditions at the time that measurements were made. Submit results of each test to the Contracting Officer.

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SECTION 26 51 00

INTERIOR LIGHTING
05/20, CHG 2: 11/21

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

EUROPEAN UNION (EU)

Directive 2011/65/EU	(2011) Restriction of the Use of Certain Hazardous Substances in Electrical and Electronic Equipment

ILLUMINATING ENGINEERING SOCIETY (IES)

ANSI/IES LM-79	(2019) Approved Method: Electrical and Photometric Measurements of Solid State Lighting Products
ANSI/IES LM-80	(2020) Approved Method: Measuring Luminous Flux and Color Maintenance of LED Packages, Arrays and Modules
ANSI/IES LS-1	(2020) Lighting Science: Nomenclature and Definitions for Illuminating Engineering
ANSI/IES TM-21	(2021) Technical Memorandum: Projecting Long-TermLuminous, Photon, and Radiant Flux Maintenance of LED Light Sources
ANSI/IES TM-30	(2020) Technical Memorandum: IES Method for Evaluating Light Source Color Rendition
IES Lighting Library	IES Lighting Library

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 100	(2000; Archived) The Authoritative Dictionary of IEEE Standards Terms
IEEE C2	(2023) National Electrical Safety Code

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA C82.77-10	(2020) Harmonic Emission Limits - Related Power Quality Requirements
NEMA SSL 1	(2016) Electronic Drivers for LED Devices, Arrays, or Systems

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2023; ERTA 4 2023) National Electrical Code
NFPA 101	(2024) Life Safety Code
NFPA 110	(2022) Standard for Emergency and Standby Power Systems

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

47 CFR 15	Radio Frequency Devices

UNDERWRITERS LABORATORIES (UL)

UL 924	(2016; Reprint Dec 2022) UL Standard for Safety Emergency Lighting and Power Equipment
UL 1598	(2021; Reprint Jun 2021) Luminaires
UL 8750	(2015; Reprint Sep 2021) UL Standard for Safety Light Emitting Diode (LED) Equipment for Use in Lighting Products

1.2 RELATED REQUIREMENTS

Materials not considered to be luminaires, luminaire accessories, or lighting equipment are specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Luminaires and accessories that are mounted in exterior environments and not attached to the exterior of the building are specified in Section 26 56 00 EXTERIOR LIGHTING. Cybersecurity requirements are specified in Section 25 05 11. CYBERSECURITY FOR FACILITY-RELATED CONTROL SYSTEMS. Emergency lighting requirements are specified in Section 26 52 00.00 40 EMERGENCY LIGHTING.

1.3 DEFINITIONS

a. Unless otherwise specified or indicated, electrical and electronics terms used in these specifications and on the drawings, must be as defined in IEEE 100 and ANSI/IES LS-1.

b. For LED luminaire light sources, "Useful Life" is the operating hours before reaching 70 percent of the initial rated lumen output (L70) with no catastrophic failures under normal operating conditions. This is also known as 70 percent "Rated Lumen Maintenance Life" as defined in ANSI/IES LM-80.

c. For LED luminaires, "Luminaire Efficacy" (LE) is the appropriate measure of energy efficiency, measured in lumens/watt. This is gathered from LM-79 data for the luminaire, in which absolute photometry is used to measure the lumen output of the luminaire as one entity, not the source separately and then the source and housing together.

d. Total harmonic distortion (THD) is the root mean square (RMS) of all the harmonic components divided by the total fundamental current.

1.4 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval.. When used, a code following the "G" classification identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Luminaire Drawings; G

Occupancy/Vacancy Sensor Coverage Layout; G; S

Emergency Inverters; G

Lighting Control System One-Line Diagram; G

Sequence of Operation for Lighting Control System; G

SD-03 Product Data

Luminaires; G

Light Sources; G

LED Drivers; G

Luminaire Warranty; G

Lighting Controls Warranty; G

Lighting Contactor; G

Switches; G

Occupancy/Vacancy Sensors; G

Photosensors; G

Room Controllers; G

Emergency Inverters; G

Exit Signs; G

Emergency Drivers; G,

SD-05 Design Data

Luminaire Design Data; G

SD-06 Test Reports

ANSI/IES LM-79 Test Report; G

ANSI/IES LM-80 Test Report; G

ANSI/IES TM-21 Test Report; G

ANSI/IES TM-30 Test Report; G

Occupancy/Vacancy Sensor Verification Test; G

Photosensor Verification Test; G

SD-10 Operation and Maintenance Data

Lighting Control System, Data Package 5; G

Maintenance Staff Training Plan; G,

End-User Training Plan; G

1.5 QUALITY ASSURANCE

Data, drawings, and reports must employ the terminology, classifications and methods prescribed by the IES Lighting Library as applicable, for the lighting system specified.

1.5.1 Luminaire Drawings

Include dimensions, accessories installation details, and construction details. Photometric data, including CRI, CCT, LED driver type, zonal lumen data, and candlepower distribution data must accompany shop drawings.

1.5.2 Luminaire Design Data

a. Provide safety certification and file number for the luminaire family that must be listed, labeled, or identified in accordance with the NFPA 70. Applicable testing bodies are determined by the US Occupational Safety Health Administration (OSHA) as Nationally Recognized Testing Laboratories (NRTL) and include: CSA (Canadian Standards Association), ETL (Edison Testing Laboratory), and UL (Underwriters Laboratories).

b. Provide long term lumen maintenance projections for each LED luminaire in accordance with ANSI/IES TM-21. Data used for projections must be obtained from testing in accordance with ANSI/IES LM-80.

1.5.3 ANSI/IES LM-79 Test Report

Submit test report on manufacturer's standard production model of specified luminaire. Testing must be performed at the same operating drive current as specified luminaire. Include all applicable and required data in IES format as outlined under "14.0 Test Report" in ANSI/IES LM-79.

1.5.4 ANSI/IES LM-80 Test Report

Submit report on manufacturer's standard production LED light source (package, array, or module) of specified luminaire. Testing must be performed at the same operating drive current as specified luminaire. Include all applicable and required data as outlined under "8.0 Test Report" in ANSI/IES LM-80.

1.5.5 ANSI/IES TM-21 Test Report

Submit test report on manufacturer's standard production LED light source (package, array, or module) of specified luminaire. Testing must be performed at the same operating drive current as specified luminaire. Include all applicable and required data, as well as required interpolation information as outlined under "7.0 Report" in ANSI/IES TM-21.

1.5.6 ANSI/IES TM-30 Test Report

Submit color vector graphic in accordance with ANSI/IES TM-30 on manufacturer's standard production LED light source (package, array, or module) of specified luminaire. Include spectral distribution of test LED light source.

1.5.7 Test Laboratories

Test laboratories for the ANSI/IES LM-79 and ANSI/IES LM-80 test reports must be one of the following:

a. National Voluntary Laboratory Accreditation Program (NVLAP) accredited for solid-state lighting testing as part of the Energy-Efficient Lighting Products laboratory accreditation program for both LM-79 and LM-80 testing.

b. One of the qualified labs listed on the Department of Energy - LED Lighting Facts Approved Testing Laboratories List for LM-79 testing.

c. One of the EPA-Recognized Laboratories listed for LM-80 testing.

1.5.8 Regulatory Requirements

Equipment, materials, installation, and workmanship must be in accordance with the mandatory and advisory provisions of NFPA 70, unless more stringent requirements are specified or indicated. Provide luminaires and assembled components that are approved by and bear the label of UL for the applicable location and conditions unless otherwise specified.

1.5.9 Standard Products

Provide materials and equipment that are products of manufacturers regularly engaged in the production of such products which are of equal material, design, and workmanship. Products must have been in satisfactory commercial or industrial use for six months prior to bid opening. The six-month period must include applications of equipment and materials under similar circumstances and of similar size. The product must have been on sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the six-month period. Where two or more items of the same class of equipment are required, these items must be products of a single manufacturer; however, the component parts of the item need not be the products of the same manufacturer unless stated in this section.

1.5.9.1 Alternative Qualifications

Products having less than a six-month field service record will be acceptable if a certified record of satisfactory field operation for not less than 6000 hours, exclusive of the manufacturers' factory or laboratory tests, is furnished.

1.5.9.2 Material and Equipment Manufacturing Date

Do not use products manufactured more than six months prior to date of delivery to site, unless specified otherwise.

1.6 WARRANTY

Support all equipment items by service organizations which are reasonably convenient to the equipment installation in order to render satisfactory service to the equipment on a regular and emergency basis during the warranty period of the contract.

1.6.1 Luminaire Warranty

Provide and transfer to the government the original LED luminaire manufacturers standard commercial warranty for each different luminaire manufacturer used in the project.

a. Provide a written five year minimum replacement warranty for material, luminaire finish, and workmanship. Provide written warranty document that contains all warranty processing information needed, including customer service point of contact, whether or not a return authorization number is required, return shipping information, and closest return location to the luminaire location.

   (1) Finish warranty must include failure and substantial deterioration such as blistering, cracking, peeling, chalking, or fading.

   (2) Material warranty must include:

      (a) All LED drivers and integral control equipment.

      (b) Replacement when more than 15 percent of LED sources in any lightbar or subassembly(s) are defective, non-starting, or operating below 70 percent of specified lumen output.

      (c) Replacement when more than 15 percent of LED sources in any lightbar or subassembly(s) show a color shift greater than 0.003 delta u'v' from the zero hour measurement stated in the ANSI/IES LM-79 Test Report.

b. Warranty period must begin in accordance with the manufacturer's standard warranty starting date.

c. Provide replacements that are promptly shipped, without charge, to the using Government facility point of contact and that are identical to or an improvement upon the original equipment. All replacements must include testing of new components and assembly.

1.6.2 Lighting Controls Warranty

Provide and transfer to the government the original lighting controls manufacturers standard commercial warranty for each different lighting controls manufacturer used in the project. Warranty coverage must begin from date of final system commissioning or three months from date of delivery, whichever is the earliest. Warranty service must be performed by a factory-trained engineer or technician.

a. Unless otherwise noted, provide a written five year minimum warranty on the complete system for all systems with factory commissioning. Provide warranty that covers 100 percent of the cost of any replacement parts and services required over the five years which are directly attributable to the product failure. Failures include, but are not limited to, the following:

(1) Software: Failure of input/output to execute switching or dimming commands.

(2) Damage of electronic components due to transient voltage surges.

(3) Failure of control devices, including but not limited to occupancy sensors, photosensors, and manual wall station control devices.

b. Provide a written five year minimum warranty on all input devices against defect in workmanship or materials provided by device manufacturer.

c. Provide a written five year minimum warranty on all control components attached to luminaires against defect in workmanship or materials.

1.7 OPERATION AND MAINTENANCE MANUALS

1.7.1 Lighting Control System

Provide operation and maintenance manuals for the lighting control system in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA that provide basic data relating to the design, operation, and maintenance of the lighting control system for the building. Include the following:

a. Lighting control system layout and wiring plan.

b. Lighting control system one-line diagram.

c. Product data for all devices, including installation and programming instructions.

d. Occupancy/vacancy sensor coverage layout.

e. Training materials, such as videos or in-depth manuals, that cover basic operation of the lighting control system and instructions on modifying the lighting control system. Training materials must include calibration, adjustment, troubleshooting, maintenance, repair, and replacement.

f. Sequence of operation descriptions for each typical room type, including final programming, schedules, and calibration settings.

PART 2 PRODUCTS

2.1 PRODUCT COORDINATION

2.2 LUMINAIRES

UL 1598, NEMA C82.77-10. Provide luminaires as indicated in the luminaire schedule and NL plates or details on project plans, complete with light source, wattage, and lumen output indicated. All luminaires of the same type must be provided by the same manufacturer. Luminaires must be specifically designed for use with the driver and light source provided.

2.2.1 Luminaires

UL 8750, ANSI/IES LM-79, ANSI/IES LM-80. For all luminaires, provide:

a. Complete system with LED drivers and light sources.

b. Housings constructed of non-corrosive materials. All new aluminum housings must be anodized or powder-coated. All new steel housings must be treated to be corrosion resistant.

c. ANSI/IES TM-21, ANSI/IES LM-80. Minimum L70 lumen maintenance value of 50,000 hours unless otherwise indicated in the luminaire schedule. Luminaire drive current value must be identical to that provided by test data for luminaire in question.

d. Minimum efficacy as specified in the luminaire schedule. Theoretical models of initial lamp lumens per watt are not acceptable. If efficacy values are not listed in the luminaire schedule, provide luminaires that meet the following minimum values:

Luminaire Style	Minimum Luminaire Efficacy
Recessed 1 by 4, 2 by 4, and 2 by 2	100 LPW
Recessed Downlight (fixed, adjustable, wallwash)	80 LPW
Linear, Accent (undercabinet, cove)	45 LPW
Linear, Ambient (indirect wall mount, linear pendent)	100 LPW
High Bay, Low Bay, and Industrial Locations	100 LPW
Food Service and Hazardous Locations	60 LPW
Other (track, residential diffusers)	50 LPW
Exterior Wall Sconce	50 LPW
Steplight	30 LPW
Parking Garage Luminaire	100 LPW

e. UL listed for dry or damp location typical of interior installations. Any luminaire mounted on the exterior of the building must be UL listed for wet location typical of exterior installations.

f. LED driver and light source package, array, or module are accessible for service or replacement without removal or destruction of luminaire.

g. Lenses constructed of heat tempered borosilicate glass, UV-resistant acrylic, or silicone.

2.3 LED DRIVERS

NEMA SSL 1, UL 8750. Provide LED drivers that are electronic, UL Class 1 or Class 2, constant-current type and that comply with the following requirements:

a. The combined driver and LED light source system does not exceed the minimum luminaire efficacy values as listed in the luminaire schedule provided.

b. Operates at a voltage of 120-277 volts at 50/60 hertz, with input voltage fluctuations of plus/minus 10 percent.

c. Power Factor (PF) greater than or equal to 0.90 at full input power and across specified dimming range.

d. Maximum Total Harmonic Distortion (THD) less than 20 percent at full input power and across specified dimming range.

e. Operates for at least 50,000 hours at maximum case temperature and 90 percent non-condensing relative humidity.

f. Withstands Category A surges of 2 kV without impairment of performance. Provide surge protection that is integral to the driver.

g. Integral thermal protection that reduces the output power to protect the driver and light source from damage if the case temperature approaches or exceeds the driver's maximum operating temperature.

h. 47 CFR 15. Complies with the requirements of the Federal Communications Commission (FCC) rules and regulations, Non-Consumer (Class A) for EMI/RFI (conducted and radiated).

i. Class A sound rating.

j. Directive 2011/65/EU. Restriction of Hazardous Substances (RoHS) compliant.

2.4 EXIT AND EMERGENCY LIGHTING EQUIPMENT

2.4.1 Exit Signs

UL 924, NFPA 101. Provide wattage as indicated in the luminaire schedule on project plans. Provide LED Exit Signs that meet the following criteria:

a. Housing constructed of UV-stable, thermo-plastic

b. UL listed for damp location.

c. Configured for universal mounting.

d. 6 inch high, 3/4 inch stroke red lettering on face of sign with chevrons on either side of lettering to indicate direction.

e. Single or double face as indicated in project plans and luminaire schedule.

2.4.1.1 Exit Signs with Battery Backup

Equip with automatic power failure device, test switch, and pilot light, and fully automatic high/low trickle charger in a self-contained power pack. Battery must be sealed, maintenance free nickel-cadmium type, and must operate unattended for a period of not less than five years. Emergency run time must be a minimum of 1-1/2 hours. LEDs must have a minimum rated life of 10 years. Provide self-diagnostic circuitry integral to emergency LED driver.

2.4.2 LED Emergency Drivers

UL 924, NFPA 101. Provide LED emergency driver with automatic power failure detection, test switch and LED indicator (or combination switch/indicator) located on luminaire exterior, and fully-automatic solid-state charger, battery and inverter integral to a self-contained housing. Provide self-diagnostic function integral to emergency driver. Integral nickel-cadmium or lead-calcium battery is required to supply a minimum of 90 minutes of emergency power at 10watts, 10-50VDCcompatible with LED forward voltage requirements, constant output. Driver must be RoHS compliant, rated for installation in plenum-rated spaces and damp locations, and be warranted for a minimum of five years.

2.4.3 Self-Diagnostic Circuitry for LED Drivers

UL 924, NFPA 101. Provide emergency lighting unit with fully-automatic, integral self-testing/diagnostic electronic circuitry. Circuitry must provide for a one minute diagnostic test every 28 days, and a 30 minute diagnostic test every six months, minimum. Any malfunction of the unit must be indicated by LED(s) visible from the exterior of the luminaire. A manual test switch must also be provided to perform a diagnostic test at any given time.

2.4.4 Central Emergency Lighting System

UL 924, NFPA 101, NFPA 110 level 1, NFPA 70. Provide a central power system providing emergency power at 120 volts, 60 hertz, for a minimum period of 90 minutes. Design the system to handle surges during loss and recovery of the voltage, and to deliver its full rated output to the designated lamp load.

2.4.4.1 Operation

Provide system such that when the lighting system loses normal supply voltage, it automatically disengages itself from the normal input line, and switches to a self-contained inverter with built-in protection when the output is shorted or overloaded. Ensure that, when normal line voltage resumes, the emergency system automatically switches back to normal operation. Size the transfer switch for this function to handle 125 percent of full load. Provide the battery system with self-contained inverters with overload protection.

2.4.4.2 Charger

Provide a completely automatic battery charger that maintains the batteries in a fully charged condition and recharges the batteries to full capacity within 24 hours after full discharge in accordance with UL 924.

2.4.4.3 Batteries

Provide sealed lead-acid or nickel-cadmium batteries, maintenance-free for a period of not less than 10 years under normal operating conditions.

2.4.4.4 Accessories

Provide visual indicators to indicate normal power, inverter power, and battery-charger operation. Provide a low-voltage test switch to simulate power failure by interrupting the input line, voltage meter, electrolyte level detector to automatically disable the charging circuit in the event of a fault, and low-voltage cutoff to prevent extreme battery power dissipation.

2.5 LUMINAIRE MOUNTING ACCESSORIES

2.5.1 Suspended Luminaires

a. Provide hangers capable of supporting twice the combined weight of luminaires supported by hangers.

b. Hangers must allow luminaires to swing within an angle of 45 degrees. Brace pendents 4 feet or longer to limit swinging. Provide with swivel hangers to ensure a plumb installation for rigid stem pendents. Provide cadmium-plated steel with a swivel-ball tapped for the conduit size indicated.

2.6 LIGHTING CONTROLS

Provide lighting control systems that do not switch off battery-opreated or emergency backup luminaires or exit signs in path of egress.

2.6.1 System

Provide lighting control system that operates the lighting system as described in the lighting control details in the project plans. Submit Sequence of Operation for Lighting Control System describing the operation of the proposed lighting control system and devices. Sequence of Operation must provide the strategies identified in the lighting control strategies.

2.6.2 Localized Control Systems

Provide room lighting control system capable of manual control, and receiving input from occupancy/vacancy sensors. See drawings for requirements.

2.7 EQUIPMENT IDENTIFICATION

2.7.1 Manufacturer's Nameplate

Each item of equipment must have a nameplate bearing the manufacturer's name, address, model number, and serial number securely affixed in a conspicuous place; the nameplate of the distributing agent will not be acceptable.

2.7.2 Labels

All luminaires must be clearly marked for operation of specific light sources and LED drivers. The labels must be easy to read when standing next to the equipment, and durable to match the life of the equipment to which they are attached. Note the following light source characteristics in the format "Use Only _____".

a. Correlated Color Temperature (CCT) and Color Rendering Index (CRI) for all luminaires.

b. Driver and dimming protocol.

All markings related to light source type must be clear and located to be readily visble to service personnel, but unseen from normal viewing angles when light sources are in place. LED drivers must have clear markings indicating dimming type and indicate proper terminals for the various outputs.

PART 3 EXECUTION

3.1 INSTALLATION

IEEE C2, NFPA 70.

3.1.1 Light Sources

When light sources are not provided as an integral part of the luminaire, deliver light sources of the type, wattage, lumen output, color temperature (CCT), color rendering index (CRI), and voltage rating indicated to the project site and install just prior to project completion, if not already installed in the luminaires from the factory.

3.1.2 Luminaires

Set luminaires plumb, square, and level with ceiling and walls, in alignment with adjacent luminaires and secure in accordance with manufacturers' directions and approved drawings. Provide accessories as required for ceiling construction type indicated on Finish Schedule. Luminaire catalog numbers do not necessarily denote specific mounting accessories for type of ceiling in which a luminaire may be installed. Provide wires, straps, or rods for luminaire support in this section. Install luminaires with vent holes free of air blocking obstacles.

3.1.2.1 Suspended Luminaires

Measure mounting heights from the bottom of the luminaire for ceiling-mounted luminaires and to center of luminaire for wall-mounted luminaires. Obtain architect approval of the exact mounting height on the job before commencing installation and, where applicable, after coordinating with the type, style, and pattern of the ceiling being installed. Support suspended luminaires from structural framework of ceiling or from inserts cast into slab.

a. Provide suspended luminaires with 45 degree swivel hangers so that they hang plumb and level.

b. Locate so that there are no obstructions within the 45 degree range in all directions.

c. The stem, canopy and luminaire must be capable of 45 degree swing.

d. Rigid pendent stem, aircraft cable, rods, or chains 4 feet or longer excluding luminaire must be braced to prevent swaying using three cables at 120 degree separation.

e. Suspended luminaires in continuous rows must have internal wireway systems for end to end wiring and must be properly aligned to provide a straight and continuous row without bends, gaps, light leaks or filler pieces.

f. Utilize aligning splines on extruded aluminum luminaires to assure minimal hairline joints.

g. Support steel luminaires to prevent "oil-canning" effects.

h. Match supporting pendents with supported luminaire. Aircraft cable must be stainless steel.

i. Match finish of canopies to match the ceiling, and provide low profile canopies unless otherwise shown.

j. Maximum distance between suspension points must be 10 feet or as recommended by the manufacturer, whichever is less.

3.1.2.2 Recessed and Semi-Recessed Luminaires

a. Support recessed and semi-recessed luminaires independently from the building structure by a minimum of two wires, straps or rods per luminaire and located near opposite corners of the luminaire. Secure horizontal movement with clips provided by manufacturer. Ceiling grid clips are not allowed as an alternative to independently supported luminaires.

b. Support round luminaires or luminaires smaller in size than the ceiling grid independently from the building structure by a minimum of four wires, straps or rods per luminaire, spaced approximately equidistant around.

c. Do not support luminaires by acoustical tile ceiling panels.

d. Where luminaires of sizes less than the ceiling grid are indicated to be centered in the acoustical panel, support each independently and provide at least two 3/4 inch metal channels spanning, and secured to, the ceiling tees for centering and aligning the luminaire.

e. Luminaires installed in suspended ceilings must also comply with the requirements of Section 09 51 00 ACOUSTICAL CEILINGS.

f. Adjust aperture rings on all applicable ceiling recessed luminaires to accommodate various ceiling material thickness. Coordinate cut-out size in ceiling to ensure aperture covers cut-out entirely. Install aperture rings such that the bottom of the ring is flush with finished ceiling or not more than 1/16 inch above. Do not install luminaires such that the aperture ring extends below the finished ceiling surface.

3.1.3 Exit Signs

NFPA 101. Wire exit signs and emergency lighting units ahead of the local switch, to the normal lighting circuit located in the same room or area.

3.1.4 Lighting Controls

3.1.4.1 Occupancy/Vacancy Sensors

a. Provide quantity of sensor units indicated as a minimum. Provide additional units to give full coverage over controlled area. Full coverage must provide hand and arm motion detection for office and administration type areas and walking motion for industrial areas, warehouses, storage rooms and hallways.

b. Locate ceiling-mounted sensors no closer than 6 feet from the nearest HVAC supply or return diffuser.

c. Locate the sensor(s) as indicated and in accordance with the manufacturer's recommendations.

3.1.4.2 Photosensors

Locate and aim sensor as indicated and in accordance with the manufacturer's recommendations. Adjust sensor set-point in accordance with the manufacturer's recommendations and for the indicated light level of the area of coverage, measured at the work plane.

3.2 FIELD QUALITY CONTROL

3.2.1 Tests

3.2.1.1 Lighting Control Verification Tests

Verify lighting control system and devices operate according to approved sequence of operations. Verification tests are to be completed after commissioning.

a. Verify occupancy/vacancy sensors operate as described in sequence of operations. Provide testing of sensor coverage, sensitivity, and time-out settings in all spaces where sensors are placed. This is to be completed only after all furnishings have been installed. Submit occupancy/vacancy sensor verification test.

b. Verify photosensors operate as described in sequence of operations. Provide testing of sensor coverage, aiming, and calibration in all spaces where sensors are placed. This is to be completed only after all furnishings have been installed. Submit photosensor verification test.

c. Verify wall box dimmers and scene wallstations operate as described in sequence of operations.

3.2.1.2 Emergency Lighting Test

Interrupt power supply to demonstrate proper operation of emergency lighting. If adjustments are made to the lighting system, re-test system to show compliance with standards.

3.3 CLOSEOUT ACTIVITIES

3.3.1 Commissioning

NFPA 101. Commission all components of the lighting system and lighting control system in accordance with Section 01 91 00.15 BUILDING COMMISSIONING. Factory Trained Field Service Technician is responsible for calibration and programming sequences for input devices and systems in accordance with the requirements described in the sequence of operation.

3.3.2 Training

3.3.2.1 Maintenance Staff Training

Submit a Maintenance Staff Training Plan at least 30 calendar days prior to training session that describes training procedures for Owner's personnel in the operation and maintenance of lighting and lighting control system. Provide on-site training which demonstrates full system functionality, assigning schedules, calibration adjustments for light levels and sensor sensitivity, integration procedures for connecting to third-party devices, and manual override including information on appropriate use. Provide protocols for troubleshooting, maintenance, repair, and replacement, and literature on available system updates and process for implementing updates.

3.3.2.2 End-User Training

Submit an End-User Training Plan at least 30 calendar days prior to training session that describes training procedures for end-users on the lighting control system. Provide users with a list of control devices located within user-occupied spaces, such as photosensors and occupancy and vacancy sensors, including information on the proper operation and schedule for each device. Provide demonstration for each type of interface. Provide users with the building schedule as currently commissioned, including conditional programming based on astronomic time clock functionality. Provide users with the correct contact information for maintenance personnel who will be available to address any lighting control issues.

Provide laminated instructions to the user at each scene wallstation. Provide only instructions relevant to the functionality of the specific scene wallstation. Provide a description of each labeled scene control button. If the room utilizes occupancy/vacancy sensors or photosensors, include a description of this functionality on the instruction sheet.

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SECTION 27 10 00

BUILDING TELECOMMUNICATIONS CABLING SYSTEM
08/11

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM D709	(2017) Standard Specification for Laminated Thermosetting Materials

ELECTRONIC COMPONENTS INDUSTRY ASSOCIATION (ECIA)

ECIA EIA/ECA 310-E	(2005) Cabinets, Racks, Panels, and Associated Equipment

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 100	(2000; Archived) The Authoritative Dictionary of IEEE Standards Terms

INSULATED CABLE ENGINEERS ASSOCIATION (ICEA)

ICEA S-83-596	(2021) Indoor Optical Cable
ICEA S-90-661	(2021) Category 3 and 5E Individually Unshielded Twisted Pairs, Indoor Cables (With or Without an Overall Shield) for Use in General Purpose and LAN Communications Wiring Systems

NATIONAL ELECTRICAL CONTRACTORS ASSOCIATION (NECA)

NECA/BICSI 568	(2006) Standard for Installing Building Telecommunications Cabling

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

ANSI/NEMA WC 66	(2019) Performance Standard for Category 6 and Category 7 100 Ohm Shielded and Unshielded Twisted Pairs

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2023; ERTA 4 2023) National Electrical Code

TELECOMMUNICATIONS INDUSTRY ASSOCIATION (TIA)

TIA-568.0	(2020e) Generic Telecommunications Cabling for Customer Premises

TIA-568.1	(2020e) Commercial Building Telecommunications Infrastructure Standard
TIA-568.2	(2018d) Balanced Twisted-Pair Telecommunications Cabling and Components Standards
TIA-568.3	(2022e) Optical Fiber Cabling Components Standard
TIA-569	(2019e; Add 1 2022) Telecommunications Pathways and Spaces
TIA-606	(2021d) Administration Standard for Telecommunications Infrastructure
TIA-607	(2019d) Generic Telecommunications Bonding and Grounding (Earthing) for Customer Premises
TIA-1152	(2016; R 2021) Requirements for Field Test Instruments and Measurements for Balanced Twisted-Pair Cabling

U.S. FEDERAL COMMUNICATIONS COMMISSION (FCC)

FCC Part 68	Connection of Terminal Equipment to the Telephone Network (47 CFR 68)

UNDERWRITERS LABORATORIES (UL)

UL 50	(2015) UL Standard for Safety Enclosures for Electrical Equipment, Non-Environmental Considerations
UL 444	(2017; Reprint Jun 2021) UL Standard for Safety Communications Cables
UL 467	(2022) UL Standard for Safety Grounding and Bonding Equipment
UL 514C	(2014; Reprint Feb 2020) UL Standard for Safety Nonmetallic Outlet Boxes, Flush-Device Boxes, and Covers
UL 969	(2017; Reprint May 2023) UL Standard for Safety Marking and Labeling Systems
UL 1286	(2022; Reprint Aug 2023) UL Standard for Safety Office Furnishings
UL 1863	(2004; Reprint Oct 2019) UL Standard for Safety Communication Circuit Accessories

1.2 RELATED REQUIREMENTS

Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM and Section 33 82 00 TELECOMMUNICATIONS, OUTSIDE PLANT (OSP), apply to this section with additions and modifications specified herein.

1.3 DEFINITIONS

Unless otherwise specified or indicated, electrical and electronics terms used in this specification shall be as defined in TIA-568.1, TIA-568.2, TIA-568.3, TIA-569, TIA-606 and IEEE 100 and herein.

1.3.1 Campus Distributor (CD)

A distributor from which the campus backbone cabling emanates. (International expression for main cross-connect (MC).)

1.3.2 Building Distributor (BD)

A distributor in which the building backbone cables terminate and at which connections to the campus backbone cables may be made. (International expression for intermediate cross-connect (IC).)

1.3.3 Floor Distributor (FD)

A distributor used to connect horizontal cable and cabling subsystems or equipment. (International expression for horizontal cross-connect (HC).)

1.3.4 Telecommunications Room (TR)

An enclosed space for housing telecommunications equipment, cable, terminations, and cross-connects. The room is the recognized cross-connect between the backbone cable and the horizontal cabling.

1.3.5 Entrance Facility (EF) (Telecommunications)

An entrance to the building for both private and public network service cables (including wireless) including the entrance point at the building wall and continuing to the equipment room.

1.3.6 Equipment Room (ER) (Telecommunications)

An environmentally controlled centralized space for telecommunications equipment that serves the occupants of a building. Equipment housed therein is considered distinct from a telecommunications room because of the nature of its complexity.

1.3.7 Open Cable

Cabling that is not run in a raceway as defined by NFPA 70. This refers to cabling that is "open" to the space in which the cable has been installed and is therefore exposed to the environmental conditions associated with that space.

1.3.8 Open Office

A floor space division provided by furniture, moveable partitions, or other means instead of by building walls.

1.3.9 Pathway

A physical infrastructure utilized for the placement and routing of telecommunications cable.

1.4 SYSTEM DESCRIPTION

The building telecommunications cabling and pathway system shall include permanently installed backbone and horizontal cabling, horizontal and backbone pathways, service entrance facilities, work area pathways, telecommunications outlet assemblies, conduit, raceway, and hardware for splicing, terminating, and interconnecting cabling necessary to transport telephone and data (including LAN) between equipment items in a building. The horizontal system shall be wired in a star topology from the telecommunications work area to the floor distributor or campus distributor at the center or hub of the star. The backbone cabling and pathway system includes intrabuilding and interbuilding interconnecting cabling, pathway, and terminal hardware. The intrabuilding backbone provides connectivity from the floor distributors to the building distributors or to the campus distributor and from the building distributors to the campus distributor as required. The backbone system shall be wired in a star topology with the campus distributor at the center or hub of the star. The interbuilding backbone system provides connectivity between the campus distributors and is specified in Section 33 82 00 TELECOMMUNICATIONS OUTSIDE PLANT (OSP). Provide telecommunications pathway systems referenced herein as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM.

1.5 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. When used, a code following the "G" classification identifies the office that will review the submittal for the Government. See also specific 96CS requirements included in the appendix. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Telecommunications Drawings; G

Telecommunications Space Drawings; G

In addition to Section 01 33 00 SUBMITTAL PROCEDURES, provide shop drawings in accordance with paragraph SHOP DRAWINGS.

SD-03 Product Data

Telecommunications Cabling (backbone and horizontal); G

Patch Panels; G

Telecommunications Outlet/Connector Assemblies; G

Communications Cabinet; G

Connector Blocks; G

Spare Parts; G

Submittals shall include the manufacturer's name, trade name, place of manufacture, and catalog model or number. Include performance and characteristic curves. Submittals shall also include applicable federal, military, industry, and technical society publication references. Should manufacturer's data require supplemental information for clarification, the supplemental information shall be submitted as specified in paragraph REGULATORY REQUIREMENTS and as required in Section 01 33 00 SUBMITTAL PROCEDURES.

SD-06 Test Reports

Telecommunications Cabling Testing; G

SD-07 Certificates

Telecommunications Contractor Qualifications; G

Key Personnel Qualifications; G

Manufacturer Qualifications; G

Test Plan; G

SD-09 Manufacturer's Field Reports

Factory Reel Tests; G

SD-10 Operation and Maintenance Data

Telecommunications Cabling and Pathway System Data Package 5; G

SD-11 Closeout Submittals

Record Documentation; G

1.6 QUALITY ASSURANCE

1.6.1 96CS Requirements See Appendix

1.6.2 Shop Drawings

In exception to Section 01 33 00 SUBMITTAL PROCEDURES, submitted plan drawings shall be a minimum of 11 by 17 inches in size using a minimum scale of 1/8 inch per foot. Include wiring diagrams and installation details of equipment indicating proposed location, layout and arrangement, control panels, accessories, piping, ductwork, and other items that must be shown to ensure a coordinated installation. Wiring diagrams shall identify circuit terminals and indicate the internal wiring for each item of equipment and the interconnection between each item of equipment. Drawings shall indicate adequate clearance for operation, maintenance, and replacement of operating equipment devices. Submittals shall include the nameplate data, size, and capacity. Submittals shall also include applicable federal, military, industry, and technical society publication references.

1.6.2.1 Telecommunications Drawings

Provide drawings in accordance with TIA-606. The identifier for each termination and cable shall appear on the drawings. Drawings shall depict final telecommunications installed wiring system infrastructure in accordance with TIA-606. The drawings should provide details required to prove that the distribution system shall properly support connectivity from the EF telecommunications and ER telecommunications, CD's, BD's, and FD's to the telecommunications work area outlets. Provide a plastic laminated schematic of the as-installed telecommunications cable system showing cabling, CD's, BD's, FD's, and the EF and ER for telecommunications keyed to floor plans by room number. Mount the laminated schematic in the EF telecommunications space as directed by the Contracting Officer. The following drawings shall be provided as a minimum:

a. T1 - Layout of complete building per floor - Building Area/Serving Zone Boundaries, Backbone Systems, and Horizontal Pathways. Layout of complete building per floor. The drawing indicates location of building areas, serving zones, vertical backbone diagrams, telecommunications rooms, access points, pathways, grounding system, and other systems that need to be viewed from the complete building perspective.

b. T2 - Serving Zones/Building Area Drawings - Drop Locations and Cable Identification (ID’S). Shows a building area or serving zone. These drawings show drop locations, telecommunications rooms, access points and detail call outs for common equipment rooms and other congested areas.

c. T4 - Typical Detail Drawings - Faceplate Labeling, Firestopping, Americans with Disabilities Act (ADA), Safety, Department of Transportation (DOT). Detailed drawings of symbols and typicals such as faceplate labeling, faceplate types, faceplate population installation procedures, detail racking, and raceways.

1.6.2.2 Telecommunications Space Drawings

Provide T3 drawings in accordance with TIA-606 that include telecommunications rooms plan views, pathway layout (cable tray, racks, ladder-racks, etc.), mechanical/electrical layout, and rack backboard and wall elevations. Drawings shall show layout of applicable equipment including incoming cable stub or connector blocks, building protector assembly, outgoing cable connector blocks, patch panels and equipment spaces and cabinet/racks. Drawings shall include a complete list of equipment and material, equipment rack details, proposed layout and anchorage of equipment and appurtenances, and equipment relationship to other parts of the work including clearance for maintenance and operation. Drawings may also be an enlargement of a congested area of T1 or T2 drawings.

1.6.3 Telecommunications Qualifications

Work under this section shall be performed by and the equipment shall be provided by the approved telecommunications contractor and key personnel. Qualifications shall be provided for: the telecommunications system contractor, the telecommunications system installer, and the supervisor (if different from the installer). A minimum of 30 days prior to installation, submit documentation of the experience of the telecommunications contractor and of the key personnel.

1.6.3.1 Telecommunications Contractor

The telecommunications contractor shall be a firm which is regularly and professionally engaged in the business of the applications, installation, and testing of the specified telecommunications systems and equipment. The telecommunications contractor shall demonstrate experience in providing successful telecommunications systems within the past 3 years of similar scope and size. Submit documentation for a minimum of three and a maximum of five successful telecommunication system installations for the telecommunications contractor.

1.6.3.2 Key Personnel

Provide key personnel who are regularly and professionally engaged in the business of the application, installation and testing of the specified telecommunications systems and equipment. There may be one key person or more key persons proposed for this solicitation depending upon how many of the key roles each has successfully provided. Each of the key personnel shall demonstrate experience in providing successful telecommunications systems within the past 3 years. System shop drawings/design drawings shall be by BICSI registered communications designer (RCDD).

Supervisors and installers assigned to the installation of this system or any of its components shall be Building Industry Consulting Services International (BICSI) Registered Cabling Installers, Technician Level. Submit documentation of current BICSI certification for each of the key personnel.

In lieu of BICSI certification, supervisors and installers assigned to the installation of this system or any of its components shall have a minimum of 3 years experience in the installation of the specified copper and fiber optic cable and components. They shall have factory or factory approved certification from each equipment manufacturer indicating that they are qualified to install and test the provided products. Submit documentation for a minimum of three and a maximum of five successful telecommunication system installations for each of the key personnel. Documentation for each key person shall include at least two successful system installations provided that are equivalent in system size and in construction complexity to the telecommunications system proposed for this solicitation. Include specific experience in installing and testing telecommunications systems and provide the names and locations of at least two project installations successfully completed using copper telecommunications cabling systems. All of the existing telecommunications system installations offered by the key persons as successful experience shall have been in successful full-time service for at least 18 months prior to the issuance date for this solicitation. Provide the name and role of the key person, the title, location, and completed installation date of the referenced project, the referenced project owner point of contact information including name, organization, title, and telephone number, and generally, the referenced project description including system size and construction complexity.

Indicate that all key persons are currently employed by the telecommunications contractor, or have a commitment to the telecommunications contractor to work on this project. All key persons shall be employed by the telecommunications contractor at the date of issuance of this solicitation, or if not, have a commitment to the telecommunications contractor to work on this project by the date that the bid was due to the Contracting Officer.

Note that only the key personnel approved by the Contracting Officer in the successful proposal shall do work on this solicitation's telecommunications system. Key personnel shall function in the same roles in this contract, as they functioned in the offered successful experience. Any substitutions for the telecommunications contractor's key personnel requires approval from The Contracting Officer.

1.6.3.3 Minimum Manufacturer Qualifications

Cabling, equipment and hardware manufacturers shall have a minimum of 3 years experience in the manufacturing, assembly, and factory testing of components which comply with TIA-568.1, TIA-568.2 and TIA-568.3.

1.6.4 Test Plan

Provide a complete and detailed test plan for the telecommunications cabling system including a complete list of test equipment for the components and accessories for each cable type specified, 60 days prior to the proposed test date. Include procedures for certification, validation, and testing.

1.6.5 Regulatory Requirements

In each of the publications referred to herein, consider the advisory provisions to be mandatory, as though the word, "shall" had been substituted for "should" wherever it appears. Interpret references in these publications to the "authority having jurisdiction," or words of similar meaning, to mean the Contracting Officer. Equipment, materials, installation, and workmanship shall be in accordance with the mandatory and advisory provisions of NFPA 70 unless more stringent requirements are specified or indicated.

1.6.6 Standard Products

Provide materials and equipment that are products of manufacturers regularly engaged in the production of such products which are of equal material, design and workmanship. Products shall have been in satisfactory commercial or industrial use for 2 years prior to bid opening. The 2-year period shall include applications of equipment and materials under similar circumstances and of similar size. The product shall have been on sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 2-year period. Where two or more items of the same class of equipment are required, these items shall be products of a single manufacturer; however, the component parts of the item need not be the products of the same manufacturer unless stated in this section.

1.6.6.1 Alternative Qualifications

Products having less than a 2-year field service record will be acceptable if a certified record of satisfactory field operation for not less than 6000 hours, exclusive of the manufacturers' factory or laboratory tests, is furnished.

1.6.6.2 Material and Equipment Manufacturing Date

Products manufactured more than 1 year prior to date of delivery to site shall not be used, unless specified otherwise.

1.7 DELIVERY AND STORAGE

Provide protection from weather, moisture, extreme heat and cold, dirt, dust, and other contaminants for telecommunications cabling and equipment placed in storage.

1.8 ENVIRONMENTAL REQUIREMENTS

Connecting hardware shall be rated for operation under ambient conditions of 32 to 140 degrees F and in the range of 0 to 95 percent relative humidity, noncondensing.

1.9 WARRANTY

The equipment items shall be supported by service organizations which are reasonably convenient to the equipment installation in order to render satisfactory service to the equipment on a regular and emergency basis during the warranty period of the contract.

1.10 MAINTENANCE

1.10.1 Operation and Maintenance Manuals

Commercial off the shelf manuals shall be furnished for operation, installation, configuration, and maintenance of products provided as a part of the telecommunications cabling and pathway system, Data Package 5. Submit operations and maintenance data in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA and as specified herein not later than 2 months prior to the date of beneficial occupancy. In addition to requirements of Data Package 5, include the requirements of paragraphs TELECOMMUNICATIONS DRAWINGS, TELECOMMUNICATIONS SPACE DRAWINGS, and RECORD DOCUMENTATION. Ensure that these drawings and documents depict the as-built configuration.

1.10.2 Record Documentation

Provide T5 drawings including documentation on cables and termination hardware in accordance with TIA-606. T5 drawings shall include schedules to show information for cut-overs and cable plant management, patch panel layouts and cover plate assignments, cross-connect information and connecting terminal layout as a minimum. T5 drawings shall be provided in hard copy format and on electronic media using Windows based computer cable management software. A licensed copy of the cable management software including documentation, shall be provided. Provide the following T5 drawing documentation as a minimum:

a. Cables - A record of installed cable shall be provided in accordance with TIA-606. The cable records shall include only the required data fieldsinclude the required data fields for each cable and complete end-to-end circuit report for each complete circuit from the assigned outlet to the entry facility in accordance with TIA-606. Include manufacture date of cable with submittal.

b. Termination Hardware - A record of installed patch panels, cross-connect points, distribution frames, terminating block arrangements and type, and outlets shall be provided in accordance with TIA-606. Documentation shall include the required data fields as a minimum in accordance with TIA-606.

1.10.3 Spare Parts

In addition to the requirements of Section 01 78 23 OPERATION AND MAINTENANCE DATA, provide a complete list of parts and supplies, with current unit prices and source of supply, and a list of spare parts recommended for stocking.

PART 2 PRODUCTS

2.1 COMPONENTS

Components shall be UL or third party certified. Where equipment or materials are specified to conform to industry and technical society reference standards of the organizations, submit proof of such compliance. The label or listing by the specified organization will be acceptable evidence of compliance. In lieu of the label or listing, submit a certificate from an independent testing organization, competent to perform testing, and approved by the Contracting Officer. The certificate shall state that the item has been tested in accordance with the specified organization's test methods and that the item complies with the specified organization's reference standard. Provide a complete system of telecommunications cabling and pathway components using star topology. Provide support structures and pathways, complete with outlets, cables, connecting hardware and telecommunications cabinets/racks. Cabling and interconnecting hardware and components for telecommunications systems shall be UL listed or third party independent testing laboratory certified, and shall comply with NFPA 70 and conform to the requirements specified herein.

2.2 TELECOMMUNICATIONS PATHWAY

Provide telecommunications pathways in accordance with TIA-569 and as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Provide system furniture pathways in accordance with UL 1286.

2.3 TELECOMMUNICATIONS CABLING

Cabling shall be UL listed for the application and shall comply with TIA-568.0, TIA-568.1, TIA-568.2, TIA-568.3 and NFPA 70. Provide a labeling system for cabling as required by TIA-606 and UL 969. Ship cable on reels or in boxes bearing manufacture date for for unshielded twisted pair (UTP) in accordance with ICEA S-90-661 and optical fiber cables in accordance with ICEA S-83-596 for all cable used on this project. Cabling manufactured more than 12 months prior to date of installation shall not be used.

2.3.1 Horizontal Cabling

Provide horizontal cable in compliance with NFPA 70 and performance characteristics in accordance with TIA-568.1.

2.3.1.1 Horizontal Copper

Provide horizontal copper cable, UTP, 100 ohm in accordance with TIA-568.2, UL 444, ANSI/NEMA WC 66, ICEA S-90-661 . Provide four each individually twisted pair, minimum size 24 AWG conductors, Category 6, with a thermoplastic jacket. Cable shall be imprinted with manufacturers name or identifier, flammability rating, gauge of conductor, transmission performance rating (category designation) and length marking at regular intervals in accordance with ICEA S-90-661. Provide plenum (CMP), riser (CMR), or general purpose (CM or CMG) communications rated cabling in accordance with NFPA 70. Substitution of a higher rated cable shall be permitted in accordance with NFPA 70. Cables installed in conduit within and under slabs shall be UL listed and labeled for wet locations in accordance with NFPA 70.

2.4 TELECOMMUNICATIONS SPACES

Provide connecting hardware and termination equipment in the telecommunications entrance facility and telecommunication equipment room to facilitate installation as shown on design drawings for terminating and cross-connecting permanent cabling. Provide telecommunications interconnecting hardware color coding in accordance with TIA-606.

2.4.1 Backboards

Provide void-free, interior grade A-C plywood 3/4 inch thick size as indicated. Backboards shall be fire rated by manufacturing process. Fire stamp shall be clearly visible. Backboards shall be provided on a minimum of two adjacent walls in the telecommunication spaces.

2.4.2 Equipment Support Frame

Provide in accordance with ECIA EIA/ECA 310-E and UL 50.

a. Cabinets, freestanding modular type, 16 gauge steel or 11 gauge aluminum construction, minimum, treated to resist corrosion. Cabinet shall have removable and lockable side panels, front and rear doors, and have adjustable feet for leveling. Cabinetshall be vented in the roof and rear door. Cabinet shall have cable access in the roof and base and be compatible with 19 inches panel mounting. Provide cabinet with grounding bar protected power strip with 6. See drawings for specific requirements.

2.4.3 Cable Guides

Provide cable guides specifically manufactured for the purpose of routing cables, wires and patch cords horizontally and vertically on 19 inches equipment racks and cabinets and telecommunications backboards. Cable guides of ring or bracket type devices mounted on rack panels for horizontal cable management and individually mounted for vertical cable management. Mount cable guides with screws, and or nuts and lockwashers.

2.4.4 Patch Panels

Provide ports for the number of horizontal and backbone cables terminated on the panel plus 25 percent spare. Provide pre-connectorized copper patch cords for patch panels.

2.4.4.1 Modular to 110 Block Patch Panel

Provide in accordance with TIA-568.1 and TIA-568.2. Panels shall be third party verified and shall comply with EIA/TIA Category 6 requirements. Panel shall be constructed of 0.09 inches minimum aluminum and shall be rack mounted and compatible with an ECIA EIA/ECA 310-E19 inchesequipment rack. Panel shall provide 48 non-keyed, 8-pin modular ports, wired to T568A or T568B as indicated. Patch panels shall terminate the building cabling on Type 110 IDCs and shall utilize a printed circuit board interface. The rear of each panel shall have incoming cable strain-relief and routing guides. Panels shall have each port factory numbered and be equipped with laminated plastic nameplates above each port.

2.4.4.2 Fiber Optic Patch Panel

Twenty four (24) port FODP with LC connections (basis of design Corning premium fiber optic patch panel with LC connectors). Splice centers are also required at each termination point.

2.5 TELECOMMUNICATIONS OUTLET/CONNECTOR ASSEMBLIES

2.5.1 Outlet/Connector Copper

Outlet/connectors shall comply with FCC Part 68, TIA-568.1, and TIA-568.2. UTP outlet/connectors shall be UL 1863 listed, non-keyed, 8-pin modular, constructed of high impact rated thermoplastic housing and shall be third party verified and shall comply with TIA-568.2 Category 6 requirements. Outlet/connectors provided for UTP cabling shall meet or exceed the requirements for the cable provided. Outlet/connectors shall be terminated using a Type 110 IDC PC board connector, color-coded for both T568A and T568B wiring. Each outlet/connector shall be wired T568A or T568Bas indicated. UTP outlet/connectors shall comply with TIA-568.2 for 200 mating cycles.

2.5.2 Cover Plates

Telecommunications cover plates shall comply with UL 514C, and TIA-568.1, flush design constructed of high impact thermoplastic material colorto match color of receptacle/switch cover plates specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Provide labeling in accordance with the paragraph LABELING in this section.

2.6 GROUNDING AND BONDING PRODUCTS

Provide in accordance with UL 467, TIA-607, and NFPA 70. Components shall be identified as required by TIA-606. Provide ground rods, bonding conductors, and grounding busbars as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM.

2.7 FIRESTOPPING MATERIAL

Provide as specified in Section 07 84 00 FIRESTOPPING.

2.8 MANUFACTURER'S NAMEPLATE

Each item of equipment shall have a nameplate bearing the manufacturer's name, address, model number, and serial number securely affixed in a conspicuous place; the nameplate of the distributing agent will not be acceptable.

2.9 FIELD FABRICATED NAMEPLATES

ASTM D709. Provide laminated plastic nameplates for each equipment enclosure, relay, switch, and device; as specified or as indicated on the drawings. Each nameplate inscription shall identify the function and, when applicable, the position. Nameplates shall be melamine plastic, 0.125 inches thick, white with black center core. Surface shall be matte finish. Corners shall be square. Accurately align lettering and engrave into the core. Minimum size of nameplates shall be one by 2.5 inches. Lettering shall be a minimum of 0.25 inches high normal block style.

2.10 TESTS, INSPECTIONS, AND VERIFICATIONS

2.10.1 Factory Reel Tests

Provide documentation of the testing and verification actions taken by manufacturer to confirm compliance with TIA-568.1, TIA-568.2.

PART 3 EXECUTION

3.1 INSTALLATION

Install telecommunications cabling and pathway systems, including the horizontal and backbone cable, pathway systems, telecommunications outlet/connector assemblies, and associated hardware in accordance with NECA/BICSI 568, TIA-568.1, TIA-568.2, NFPA 70, and UL standards as applicable. Provide cabling in a star topology network. Pathways and outlet boxes shall be installed as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Install telecommunications cabling with copper media in accordance with the following criteria to avoid potential electromagnetic interference between power and telecommunications equipment. The interference ceiling shall not exceed 3.0 volts per meter measured over the usable bandwidth of the telecommunications cabling.

3.1.1 Cabling

Install UTP, telecommunications cabling system as detailed in TIA-568.1,. Screw terminals shall not be used except where specifically indicated on plans. Use an approved insulation displacement connection (IDC) tool kit for copper cable terminations. Do not exceed manufacturers' cable pull tensions for copper and optical fiber cables. Provide a device to monitor cable pull tensions. Do not exceed 25 pounds pull tension for four pair copper cables. Do not chafe or damage outer jacket materials. Use only lubricants approved by cable manufacturer. Do not over cinch cables, or crush cables with staples. For UTP cable, bend radii shall not be less than four times the cable diameter. Cables shall be terminated; no cable shall contain unterminated elements. Cables shall not be spliced. Label cabling in accordance with paragraph LABELING in this section.

3.1.1.1 Horizontal Cabling

Install horizontal cabling as indicated on drawings Do not untwist Category 6 UTP cables more than one half inch from the point of termination to maintain cable geometry. Provide slack cable in the form of a figure eight (not a service loop) on each end of the cable, 10 feet in the telecommunications room, and 12 inches in the work area outlet.

3.1.2 Pathway Installations

Provide in accordance with TIA-569 and NFPA 70. Provide building pathway as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM.

3.1.3 Cable Tray Installation

Install cable tray as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. .

3.1.4 Work Area Outlets

3.1.4.1 Terminations

Terminate UTP cable in accordance with TIA-568.1, TIA-568.2 and wiring configuration as specified.

3.1.4.2 Cover Plates

As a minimum, each outlet/connector shall be labeled as to its function and a unique number to identify cable link in accordance with the paragraph LABELING in this section.

3.1.4.3 Cables

Unshielded twisted pair and fiber optic cables shall have a minimum of 12 inches of slack cable loosely coiled into the telecommunications outlet boxes. Minimum manufacturer's bend radius for each type of cable shall not be exceeded.

3.1.4.4 Pull Cords

Pull cords shall be installed in conduit serving telecommunications outlets that do not have cable installed.

3.1.5 Telecommunications Space Termination

Install termination hardware required for Category 6 system. An insulation displacement tool shall be used for terminating copper cable to insulation displacement connectors.

3.1.5.1 Patch Panels

Patch panels shall be mountedracks with sufficient ports to accommodate the installed cable plant plus 25 percent spares.

a. Copper Patch Panel. Copper cable entering a patch panel shall be secured to the panelas recommended by the manufacturer to prevent movement of the cable.

3.1.5.2 Equipment Support Frames

Install in accordance with TIA-569:

a. Permanently anchor cabling to the floor in accordance with manufacturer's recommendations.

3.1.6 Electrical Penetrations

Seal openings around electrical penetrations through fire resistance-rated wall, partitions, floors, or ceilings as specified in Section 07 84 00 FIRESTOPPING.

3.1.7 Grounding and Bonding

Provide in accordance with TIA-607, NFPA 70 and as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM.

3.2 LABELING

3.2.1 Labels

Provide labeling in accordance with TIA-606. Handwritten labeling is unacceptable. Stenciled lettering for voice and data circuits shall be provided using thermal ink transfer process or laser printer.

3.2.2 Cable

Cables shall be labeled using color labels on both ends with identifiers in accordance with TIA-606.

3.2.3 Termination Hardware

Workstation outlets and patch panel connections shall be labeled using color coded labels with identifiers in accordance with TIA-606.

3.3 FIELD APPLIED PAINTING

Paint electrical equipment as required to match finish of adjacent surfaces or to meet the indicated or specified safety criteria. Painting shall be as specified in Section 09 90 00 PAINTS AND COATINGS.

3.3.1 Painting Backboards

If backboards are required to be painted, then the manufactured fire retardant backboard must be painted with fire retardant paint, so as not to increase flame spread and smoke density and must be appropriately labeled. Label and fire rating stamp must be unpainted.

3.4 FIELD FABRICATED NAMEPLATE MOUNTING

Provide number, location, and letter designation of nameplates as indicated. Fasten nameplates to the device with a minimum of two sheet-metal screws or two rivets.

3.5 TESTING

3.5.1 Telecommunications Cabling Testing

Perform telecommunications cabling inspection, verification, and performance tests in accordance with TIA-568.1. Test equipment shall conform to TIA-1152. Perform optical fiber field inspection tests via attenuation measurements on factory reels and provide results along with manufacturer certification for factory reel tests. Remove failed cable reels from project site upon attenuation test failure.

3.5.1.1 Inspection

Visually inspect UTP and optical fiber jacket materials for UL or third party certification markings. Inspect cabling terminations in telecommunications rooms and at workstations to confirm color code for T568A or T568B pin assignments, and inspect cabling connections to confirm compliance with TIA-568.1, TIA-568.2. Visually confirm Category 6, marking of outlets, cover plates, outlet/connectors, and patch panels.

3.5.1.2 Verification Tests

UTP backbone copper cabling shall be tested for DC loop resistance, shorts, opens, intermittent faults, and polarity between conductors, and between conductors and shield, if cable has overall shield. Test operation of shorting bars in connection blocks. Test cables after termination but prior to being cross-connected.

3.5.1.3 Performance Tests

Perform testing for each outlet as follows:

a. Perform Category 6 link tests in accordance with TIA-568.1 and TIA-568.2. Tests shall include wire map, length, insertion loss, NEXT, PSNEXT, ELFEXT, PSELFEXT, return loss, propagation delay, and delay skew.

3.5.1.4 Final Verification Tests

Perform verification tests for UTP systems after the complete telecommunications cabling and workstation outlet/connectors are installed.

a. Voice Tests. These tests assume that dial tone service has been installed. Connect to the network interface device at the demarcation point. Go off-hook and listen and receive a dial tone. If a test number is available, make and receive a local, long distance, and DSN telephone call.

b. Data Tests. These tests assume the Information Technology Staff has a network installed and are available to assist with testing. Connect to the network interface device at the demarcation point. Log onto the network to ensure proper connection to the network.

-- End of Section --

SECTION 31 00 00

EARTHWORK

PART 1 GENERAL

1.1 CRITERIA FOR BIDDING

Base bids on the following criteria:

a. Surface elevations are as indicated.

b. Pipes or other artificial obstructions, except those indicated, will not be encountered.

c. Ground water elevations indicated by the boring log were those existing at the time subsurface investigations were made and do not necessarily represent ground water elevation at the time of construction.

d. Material character is indicated by the boring logs.

1.2 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only. Publications used shall be the most current issue.

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO)

AASHTO T 180 (2017) Standard Method of Test for Moisture-Density Relations of Soils Using a 4.54-kg (10-lb) Rammer and a 457-mm (18-in.) Drop

AASHTO T 224 (2010) Standard Method of Test for Correction for Coarse Particles in the Soil Compaction Test

AMERICAN WATER WORKS ASSOCIATION (AWWA)

AWWA C600 (2017) Installation of Ductile-Iron Mains and Their Appurtenances

AMERICAN WELDING SOCIETY (AWS)

AWS D1.1/D1.1M (2020; Errata 1 2021) Structural Welding Code - Steel

ASTM INTERNATIONAL (ASTM)

ASTM A139/A139M (2022) Standard Specification for Electric-Fusion (ARC)-Welded Steel Pipe (NPS 4 and over)

ASTM A252	(2010) Standard Specification for Welded and Seamless Steel Pipe Piles
ASTM C136	(2006) Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates
ASTM C33/C33M	(2018) Standard Specification for Concrete Aggregates
ASTM D1140	(2017) Standard Test Methods for Determining the Amount of Material Finer than 75-µm (No. 200) Sieve in Soils by Washing
ASTM D1556	(2007) Density and Unit Weight of Soil in Place by the Sand-Cone Method
ASTM D1557	(2012; E 2015) Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft3) (2700 kN-m/m3)
ASTM D2167	(2015) Density and Unit Weight of Soil in Place by the Rubber Balloon Method
ASTM D2487	(2017; E 2020) Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)
ASTM D4318	(2017; E 2018) Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils
ASTM D4944	(2018) Standard Test Method for Field Determination of Water (Moisture) Content of Soil by the Calcium Carbide Gas Pressure Tester Method
ASTM D6938	(2017a) Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)
ASTM D7928	(2017) Standard Test Method for Particle-Size Distribution (Gradation) of Fine-Grained Soils Using the Sedimentation (Hydrometer) Analysis

1.3 DEFINITIONS

1.3.1 Satisfactory Materials

Satisfactory materials comprise any materials classified by ASTM D2487 as GW, GP, GM, GP-GM, GW-GM, GC, GP-GC, GM-GC, SW, SP, SM, SP-SM. Satisfactory materials for grading comprise stones less than 8 inches. To be considered satisfactory, any offsite soils imported for use as backfill shall be tested and certified as meeting local, state, and federal regulation for clean fill prior to bringing to the site. Provide at least one borrow site testing from each borrow site used.

1.3.2 Unsatisfactory Materials

Materials which do not comply with the requirements for satisfactory materials are unsatisfactory. Unsatisfactory materials also include man-made fills; trash; refuse; backfills from previous construction; and material classified as satisfactory which contains root and other organic matter or frozen material. Notify the Contracting Officer when encountering any contaminated materials.

1.3.3 Cohesionless and Cohesive Materials

Cohesionless materials include materials classified in ASTM D2487 as GW, GP, SW, and SP. Cohesive materials include materials classified as GC, SC, ML, CL, MH, and CH. Materials classified as GM and SM will be identified as cohesionless only when the fines are nonplastic. Perform testing, required for classifying materials, in accordance with ASTM D4318, ASTM C136, ASTM D1140 and ASTM D7928.

1.3.4 Degree of Compaction

Degree of compaction required, except as noted in the second sentence, is expressed as a percentage of the maximum density obtained by the test procedure presented in ASTM D1557 abbreviated as a percent of laboratory maximum density. Since ASTM D1557 applies only to soils that have 30 percent or less by weight of their particles retained on the 3/4 inch sieve, express the degree of compaction for material having more than 30 percent by weight of their particles retained on the 3/4 inch sieve as a percentage of the maximum density in accordance with AASHTO T 180 and corrected with AASHTO T 224. To maintain the same percentage of coarse material, use the "remove and replace" procedure as described in NOTE 8 of Paragraph 7.2 in AASHTO T 180.

1.3.5 Topsoil

Material suitable for topsoils obtained from offsite areas is defined as: Natural, friable soil representative of productive, well-drained soils in the area, free of subsoil, stumps, rocks larger than one inch diameter, brush, weeds, toxic substances, and other material detrimental to plant growth. Amend topsoil pH range to obtain a pH of 5.5 to 7.

1.3.6 Hard/Unyielding Materials

Hard/Unyielding materials comprise weathered rock, dense consolidated deposits, or conglomerate materials which are not included in the definition of "rock" with stones greater than 3 inch in any dimension or as defined by the pipe manufacturer, whichever is smaller. These materials usually require the use of heavy excavation equipment, ripper teeth, or jack hammers for removal.

1.3.7 Unstable Material

Unstable materials are too wet to properly support the utility pipe, conduit, or appurtenant structure.

1.3.8 Select Granular Material

1.3.8.1 General Requirements

Select granular material consist of materials classified as GW, GP, SW, or SP, by ASTM D2487 where indicated. The liquid limit of such material must not exceed 15 percent when tested in accordance with ASTM D4318. The plasticity index must not be greater than 12 percent when tested in accordance with ASTM D4318, and not more than 30 percent by weight may be finer than No. 200 sieve, and not more than 65 percent by weight finer than a No. 40 sieve when tested in accordance with ASTM C136.

1.3.9 Initial Backfill Material

Initial backfill consists of select granular material or satisfactory materials free from rocks 3 inches or larger in any dimension or free from rocks of such size as recommended by the pipe manufacturer, whichever is smaller. When the pipe is coated or wrapped for corrosion protection, free the initial backfill material of stones larger than 1 inch in any dimension or as recommended by the pipe manufacturer, whichever is smaller.

1.4 SYSTEM DESCRIPTION

Subsurface soil boring logs are included on plan sheet C002. These data represent the best subsurface information available; however, variations may exist in the subsurface between boring locations.

1.4.1 Classification of Excavation

No consideration will be given to the nature of the materials, and all excavation will be designated as unclassified excavation.

1.4.2 Blasting

Blasting will not be permitted.

1.4.3 Dewatering Work Plan

Submit procedures for accomplishing dewatering work.

1.5 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Dewatering Work Plan

SD-03 Product Data

Utilization of Excavated Soils

SD-06 Test Reports

Testing

Borrow Site Testing Within 24 hours of conclusion of physical tests, submit digital copies of test results, including calibration curves and results of calibration tests, and certification that imported material is free of contamination and meets all local, state, and federal regulations for clean fill.

SD-07 Certificates

Testing

Qualifications of the Corps validated commercial testing laboratory or the contractor's validated testing facilities.

PART 2 PRODUCTS

2.1 BURIED WARNING AND IDENTIFICATION TAPE

Provide metallic core or metallic-faced, acid- and alkali-resistant, polyethylene plastic warning tape manufactured specifically for warning and identification of buried utility lines. Provide tape on rolls, 3 inches minimum width, color coded as specified below for the intended utility with warning and identification imprinted in bold black letters continuously over the entire tape length. Warning and identification to read, "CAUTION, BURIED (intended service) LINE BELOW" or similar wording. Provide permanent color and printing, unaffected by moisture or soil.

Warning Tape Color Codes	
Red	Electric
Yellow	Gas
Orange	Telephone and Other Communications
Blue	Water Systems
Green	Sewer Systems

2.1.1 Warning Tape for Metallic Piping

Provide acid and alkali-resistant polyethylene plastic tape conforming to the width, color, and printing requirements specified above, with a minimum thickness of 0.003 inch and a minimum strength of 1500 psi lengthwise, and 1250 psi crosswise, with a maximum 350 percent elongation.

2.1.2 Detectable Warning Tape for Non-Metallic Piping

Provide polyethylene plastic tape conforming to the width, color, and printing requirements specified above, with a minimum thickness of 0.004 inch, and a minimum strength of 1500 psi lengthwise and 1250 psi crosswise. Manufacture tape with integral wires, foil backing, or other means of enabling detection by a metal detector when tape is buried up to 3 feet deep. Encase metallic element of the tape in a protective jacket or provide with other means of corrosion protection.

2.2 MATERIAL FOR RIP-RAP

Provide filter fabric and rock conforming to these requirements for construction indicated.

2.2.1 Rock

Provide rock fragments sufficiently durable to ensure permanence in the structure and the environment in which it is to be used. Use rock fragments free from cracks, seams, and other defects that would increase the risk of deterioration from natural causes. Provide fragments sized so that no individual fragment exceeds a weight of 150 pounds and that no more than 10 percent of the mixture, by weight, consists of fragments weighing 2 pounds or less each. Provide rock with a minimum specific gravity of 2.50.

2.3 CAPILLARY WATER BARRIER

Provide capillary water barrier of clean, poorly graded crushed rock, crushed gravel, or uncrushed gravel placed beneath a building slab with or without a vapor barrier to cut off the capillary flow of pore water to the area immediately below. Conform to ASTM C33/C33M for fine aggregate grading with a maximum of 3 percent by weight passing ASTM D1140, No. 200 sieve.

2.4 PIPE CASING

2.4.1 Casing Pipe

ASTM A139/A139M, Grade B, or ASTM A252, Grade 2, smooth wall pipe. Match casing size to the outside diameter and wall thickness as indicated. Protective coating is not required on casing pipe.

PART 3 EXECUTION

3.1 STRIPPING OF TOPSOIL

Where indicated or directed, strip topsoil to a depth of 4 inches. Spread topsoil on areas already graded and prepared for topsoil, or transported and deposited in stockpiles convenient to areas that are to receive application of the topsoil later, or at locations indicated or specified. Keep topsoil separate from other excavated materials, brush, litter, objectionable weeds, roots, stones larger than 1 inch in diameter, and other materials that would interfere with planting and maintenance operations. Remove from the site any surplus of topsoil from excavations and gradings.

3.2 GENERAL EXCAVATION

Perform excavation of every type of material encountered within the limits of the project to the lines, grades, and elevations indicated and as specified. Perform the grading in accordance with the typical sections shown and the tolerances specified in paragraph FINISHING. Transport satisfactory excavated materials and place in fill or embankment within the limits of the work. Excavate unsatisfactory materials encountered within the limits of the work below grade and replace with satisfactory materials as directed. Include such excavated material and the satisfactory material ordered as replacement in excavation. Dispose surplus satisfactory excavated material not required for fill or embankment in areas approved for surplus material storage or designated waste areas. Dispose unsatisfactory excavated material in designated waste or spoil areas. During construction, perform excavation and fill in a manner and sequence that will provide proper drainage at all times. Excavate material required for fill or embankment in excess of that produced by excavation within the grading limits from the borrow areas indicated or from other approved areas selected by the Contractor as specified.

3.2.1 Ditches, Gutters, and Channel Changes

Finish excavation of ditches, gutters, and channel changes by cutting accurately to the cross sections, grades, and elevations shown. Do not excavate ditches and gutters below grades shown. Backfill the excessive open ditch or gutter excavation with satisfactory, thoroughly compacted, material or with suitable stone or cobble to grades shown. Dispose excavated material as shown or as directed, except in no case allow material be deposited a maximum 4 feet from edge of a ditch. Maintain excavations free from detrimental quantities of leaves, brush, sticks, trash, and other debris until final acceptance of the work.

3.2.2 Drainage Structures

Make excavations to the lines, grades, and elevations shown, or as directed. Provide trenches and foundation pits of sufficient size to permit the placement and removal of forms for the full length and width of structure footings and foundations as shown. Clean rock or other hard foundation material of loose debris and cut to a firm, level, stepped, or serrated surface. Remove loose disintegrated rock and thin strata. Do not disturb the bottom of the excavation when concrete or masonry is to be placed in an excavated area. Do not excavate to the final grade level until just before the concrete or masonry is to be placed.

3.2.3 Drainage

Provide for the collection and disposal of surface and subsurface water encountered during construction. Completely drain construction site during periods of construction to keep soil materials sufficiently dry. Construct storm drainage features at the earliest stages of site development, and throughout construction grade the construction area to provide positive surface water runoff away from the construction activity and or provide temporary ditches, swales, and other drainage features and equipment as required to maintain dry soils. When unsuitable working platforms for equipment operation and unsuitable soil support for subsequent construction features develop, remove unsuitable material and provide new soil material as specified herein. It is the responsibility of the Contractor to assess the soil and ground water conditions presented by the plans and specifications and to employ necessary measures to permit construction to proceed.

3.2.4 Dewatering

Control groundwater flowing toward or into excavations to prevent sloughing of excavation slopes and walls, boils, uplift and heave in the excavation and to eliminate interference with orderly progress of construction. Do not permit French drains, sumps, ditches or trenches within 3 feet of the foundation of any structure, except with specific written approval, and after specific contractual provisions for restoration of the foundation area have been made. Take control measures by the time the excavation reaches the water level in order to maintain the integrity of the in situ material. While the excavation is open, maintain the water level continuously, at least 2 foot below the working level. Operate dewatering system continuously until construction work below existing water levels is complete.

3.2.5 Trench Excavation Requirements

Excavate the trench as recommended by the manufacturer of the pipe to be installed. Slope trench walls below the top of the pipe, or make vertical, and of such width as recommended in the manufacturer's printed installation manual. Provide vertical trench walls where no manufacturer's printed installation manual is available. Shore trench walls more than 5 feet high, cut back to a stable slope, or provide with equivalent means of protection for employees who may be exposed to moving ground or cave in. Shore vertical trench walls more than 4 feet high. Excavate trench walls which are cut back to at least the angle of repose of the soil. Give special attention to slopes which may be adversely affected by weather or moisture content. Do not exceed the trench width below the pipe top of 24 inches plus pipe outside diameter (O.D.) for pipes of less than 24 inches inside diameter, and do not exceed 36 inches plus pipe outside diameter for sizes larger than 24 inches inside diameter. Where recommended trench widths are exceeded, provide redesign, stronger pipe, or special installation procedures by the Contractor. The Contractor is responsible for the cost of redesign, stronger pipe, or special installation procedures without any additional cost to the Government.

3.2.5.1 Bottom Preparation

Grade the bottoms of trenches accurately to provide uniform bearing and support for the bottom quadrant of each section of the pipe. Excavate bell holes to the necessary size at each joint or coupling to eliminate point bearing. Remove stones of 3 inch or greater in any dimension, or as recommended by the pipe manufacturer, whichever is smaller, to avoid point bearing.

3.2.5.2 Removal of Unyielding Material

Where unyielding material is encountered in the bottom of the trench, remove such material 12 inch below the required grade and replaced with suitable materials as provided in paragraph BACKFILLING AND COMPACTION.

3.2.5.3 Removal of Unstable Material

Where unstable material is encountered in the bottom of the trench, remove such material to the depth directed and replace it to the proper grade with select granular material as provided in paragraph BACKFILLING AND COMPACTION. When removal of unstable material is required due to the Contractor's fault or neglect in performing the work, the Contractor is responsible for excavating the resulting material and replacing it without additional cost to the Government.

3.2.5.4 Excavation for Appurtenances

Provide excavation for manholes, catch-basins, inlets, or similar structures sufficient to leave at least 12 inches clear between the outer structure surfaces and the face of the excavation or support members.

Specify removal of unstable material. When concrete or masonry is to be placed in an excavated area, take special care not to disturb the bottom of the excavation. Do not excavate to the final grade level until just before the concrete or masonry is to be placed.

3.2.5.5 Jacking, Boring, and Tunneling

Unless otherwise indicated, provide excavation by open cut except that sections of a trench may be jacked, bored, or tunneled if, in the opinion of the Contracting Officer, the pipe, cable, or duct can be safely and properly installed and backfill can be properly compacted in such sections.

3.2.6 Underground Utilities

The Contractor is responsible for movement of construction machinery and equipment over pipes and utilities during construction. Perform work adjacent to utilities as indicated in accordance with procedures outlined by utility provider. For work immediately adjacent to or for excavations exposing a utility or other buried obstruction, excavate by hand. Start hand excavation on each side of the indicated obstruction and continue until the obstruction is uncovered or until clearance for the new grade is assured. Support uncovered lines or other existing work affected by the contract excavation until approval for backfill is granted by the Contracting Officer. Report damage to utility lines or subsurface construction immediately to the Contracting Officer.

3.2.7 Structural Excavation

Ensure that footing subgrades have been inspected and approved by the Contracting Officer prior to concrete placement.

3.3 SELECTION OF BORROW MATERIAL

Select borrow material to meet the requirements and conditions of the particular fill or embankment for which it is to be used. Obtain borrow material from approved private sources. Unless otherwise provided in the contract, the Contractor is responsible for obtaining the right to procure material, pay royalties and other charges involved, and bear the expense of developing the sources, including rights-of-way for hauling from the owners.Unless specifically provided, do not obtain borrow within the limits of the project site without prior written approval. Consider necessary clearing, grubbing, and satisfactory drainage of borrow pits and the disposal of debris thereon related operations to the borrow excavation.

3.4 SHORING

3.4.1 General Requirements

Finish shoring, including sheet piling, and install as necessary to protect workmen, banks, adjacent paving, structures, and utilities. Remove shoring, bracing, and sheeting as excavations are backfilled, in a manner to prevent caving.

3.5 FINAL GRADE OF SURFACES TO SUPPORT CONCRETE

Do not excavate to final grade until just before concrete is to be placed. Roughen the level surfaces, and cut the sloped surfaces, as indicated, into rough steps or benches to provide a satisfactory bond. Protect all surfaces from erosion resulting from ponding or water flow.

3.6 GROUND SURFACE PREPARATION

3.6.1 General Requirements

Remove and replace unsatisfactory material with satisfactory materials, as directed by the Contracting Officer, in surfaces to receive fill or in excavated areas. Scarify the surface to a depth of 6 inches before the fill is started. Plow, step, bench, or break up sloped surfaces steeper than 1 vertical to 4 horizontal so that the fill material will bond with the existing material. When subgrades are less than the specified density, break up the ground surface to a minimum depth of 6 inches, pulverizing, and compacting to the specified density. When the subgrade is part fill and part excavation or natural ground, scarify the excavated or natural ground portion to a depth of 12 inches and compact it as specified for the adjacent fill.

3.6.2 Frozen Material

Do not place material on surfaces that are muddy, frozen, or contain frost. Finish compaction by sheepsfoot rollers, pneumatic-tired rollers, steel-wheeled rollers, or other approved equipment well suited to the soil being compacted. Moisten material as necessary to provide the moisture content that will readily facilitate obtaining the specified compaction with the equipment used.

3.7 UTILIZATION OF EXCAVATED SOILS

3.7.1 Soil Reuse

Satisfactory materials may be re-used on the job site. Unsatisfactory materials, if encountered, shall be spread uniformly in non-structural areas.

3.8 BURIED TAPE AND DETECTION WIRE

3.8.1 Buried Warning and Identification Tape

Provide buried utility lines with utility identification tape. Bury tape 12 inches below finished grade; under pavements and slabs, bury tape 6 inches below top of subgrade.

3.8.2 Buried Detection Wire

Bury detection wire directly above non-metallic piping at a distance not to exceed 12 inches above the top of pipe. Extend the wire continuously and unbroken, from manhole to manhole. Terminate the ends of the wire inside the manholes at each end of the pipe, with a minimum of 3 feet of wire, coiled, remaining accessible in each manhole. Furnish insulated wire over it's entire length. Install wires at manholes between the top of the corbel and the frame, and extend up through the chimney seal between the frame and the chimney seal. For force mains, terminate the wire in the valve pit at the pump station end of the pipe.

3.9 BACKFILLING AND COMPACTION

Place backfill adjacent to any and all types of structures, and compact to at least 95 percent laboratory maximum density for cohesionless materials, to prevent wedging action or eccentric loading upon or against the structure. Prepare ground surface on which backfill is to be placed and provide compaction requirements for backfill materials in conformance with the applicable portions of paragraphs GROUND SURFACE PREPARATION. Finish compaction by pneumatic-tired rollers, steel-wheeled rollers, vibratory compactors, or other approved equipment.

3.9.1 Trench Backfill

Backfill trenches to the grade shown.

3.9.1.1 Replacement of Unyielding Material

Replace unyielding material removed from the bottom of the trench with select granular material or initial backfill material.

3.9.1.2 Replacement of Unstable Material

Replace unstable material removed from the bottom of the trench or excavation with select granular material placed in layers not exceeding 6 inches loose thickness.

3.9.1.3 Bedding and Initial Backfill

Place initial backfill material,(in compacted lifts of 8" or less for mechanical compaction and 4" or less for manual compaction), and compact it with approved tampers to a height of at least one foot above the utility pipe or conduit. Bring up the backfill evenly on both sides of the pipe for the full length of the pipe. Take care to ensure thorough compaction of the fill under the haunches of the pipe. Except as specified otherwise in the individual piping section, provide bedding for buried piping in accordance with AWWA C600, Type 4, except as specified herein. Compact backfill to top of pipe to 95 percent of ASTM D1557 maximum density. Provide plastic piping with bedding to spring line of pipe. Provide materials as follows:

3.9.1.3.1 Class I

Angular, 0.25 to 1.5 inch, graded stone, including a number of fill materials that have regional significance such as coral, slag, cinders, crushed stone, and crushed shells.

3.9.1.3.2 Class II

Coarse sands and gravels with maximum particle size of 1.5 inch, including various graded sands and gravels containing small percentages of fines, generally granular and noncohesive, either wet or dry. Soil Types GW, GP, SW, and SP are included in this class as specified in ASTM D2487.

3.9.1.4 Final Backfill

Fill the remainder of the trench, except for special materials for roadways, railroads and airfields, with satisfactory material. Place backfill material and compact as follows:

3.9.1.4.1 Roadways

Place backfill up to the required elevation as specified. Do not permit water flooding or jetting methods of compaction.

3.9.1.4.2 Sidewalks, Turfed or Seeded Areas and Miscellaneous Areas

Deposit backfill in layers of a maximum of 12 inches loose thickness, and compact it to 90 percent maximum density for cohesionless soils.

3.9.2 Backfill for Appurtenances

After the manhole, catchbasin, inlet, or similar structure has been constructed and the concrete has been allowed to cure for 7 days, place backfill in such a manner that the structure is not be damaged by the shock of falling earth. Deposit the backfill material, compact it as specified for final backfill, and bring up the backfill evenly on all sides of the structure to prevent eccentric loading and excessive stress.

3.10 SPECIAL REQUIREMENTS

Special requirements for both excavation and backfill relating to the specific utilities are as follows:

3.10.1 Gas Distribution

Excavate trenches to a depth that will provide a minimum 24 inch of cover in other excavation.

3.10.2 Water Lines

Excavate trenches to a depth that provides a minimum cover of 3 feet from the existing ground surface, or from the indicated finished grade, whichever is lower, to the top of the pipe.

3.10.3 Electrical Distribution System

Provide a minimum cover of 24 inches from the finished grade to direct burial cable and conduit or duct line, unless otherwise indicated.

3.10.4 Pipeline Casing

Provide new smooth wall steel pipeline casing under new existing pavement by the boring and jacking method of installation. Provide each new pipeline casing, where indicated and to the lengths and dimensions shown, complete and suitable for use with the new piped utility as indicated. Install pipeline casing by dry boring and jacking method as follows:

3.10.4.1 Bore Holes

Mechanically bore holes and case through the soil with a cutting head on a continuous auger mounted inside the casing pipe. Weld lengths of pipe together in accordance with AWS D1.1/D1.1M. Do not use water or other fluids in connection with the boring operation.

3.10.4.2 Cleaning

Clean inside of the pipeline casing of dirt, weld splatters, and other foreign matter which would interfere with insertion of the piped utilities by attaching a pipe cleaning plug to the boring rig and passing it through the pipe.

3.10.4.3 End Seals

After installation of piped utilities in pipeline casing, provide watertight end seals at each end of pipeline casing between pipeline casing and piping utilities.

3.10.5 Rip-Rap Construction

Construct rip-rap on filter fabric in the areas indicated. Trim and dress indicated areas to conform to cross sections, lines and grades shown within a tolerance of 0.1 foot.

3.10.5.1 Bedding Placement

Spread filter fabric on prepared subgrade as indicated.

3.10.5.2 Stone Placement

Place rock for rip-rap on filter fabric to produce a well graded mass with the minimum practicable percentage of voids in conformance with lines and grades indicated. Distribute larger rock fragments, with dimensions extending the full depth of the rip-rap throughout the entire mass and eliminate "pockets" of small rock fragments. Rearrange individual pieces by mechanical equipment or by hand as necessary to obtain the distribution of fragment sizes specified above.

3.11 EMBANKMENTS

3.11.1 Earth Embankments

Construct earth embankments from satisfactory materials free of organic or frozen material and rocks with any dimension greater than 3 inches. Place the material in successive horizontal layers of loose material not more than 8 inches in depth. Spread each layer uniformly on a soil surface that has been moistened or aerated as necessary, and scarified or otherwise broken up so that the fill will bond with the surface on which it is placed. After spreading, plow, disk, or otherwise brake up each layer; moisten or aerate as necessary; thoroughly mix; and compact to at least 95 percent laboratory maximum density for cohesionless materials. Compaction requirements for the upper portion of earth embankments forming subgrade for pavements are identical with those requirements specified in paragraph SUBGRADE PREPARATION. Finish compaction by pneumatic-tired rollers, steel-wheeled rollers, vibratory compactors, or other approved equipment.

3.12 SUBGRADE PREPARATION

3.12.1 Proof Rolling

Finish proof rolling on an exposed subgrade free of surface water (wet conditions resulting from rainfall) which would promote degradation of an otherwise acceptable subgrade. After stripping, proof roll the existing subgrade of the roadway and parking lots with six passes of a 15 ton (min) vibratory roller. Operate the roller in a systematic manner to ensure the number of passes over all areas, and at speeds between 2-1/2 to 3-1/2 mph. Notify the Contracting Officer a minimum of 3 days prior to proof rolling. Undercut rutting or pumping of material as directed by the Contracting Officer and replace with fill and backfill material.

3.12.2 Construction

Shape subgrade to line, grade, and cross section, and compact as specified. Include plowing, disking, and any moistening or aerating required to obtain specified compaction for this operation. Remove soft or otherwise unsatisfactory material and replace with satisfactory excavated material or other approved material as directed. Bring up low areas resulting from removal of unsatisfactory material to required grade with satisfactory materials, and shape the entire subgrade to line, grade, and cross section and compact as specified. After rolling, the surface of the subgrade for roadways shall not show deviations greater than 1/2 inch when tested with a 12-foot straightedge applied both parallel and at right angles to the centerline of the area. Do not vary the elevation of the finish subgrade more than 0.05 foot from the established grade and cross section.

3.12.3 Compaction

Finish compaction by pneumatic-tired rollers, steel-wheeled rollers, vibratory compactors, or other approved equipment. Except for paved areas compact each layer of the embankment to at least 90 percent of laboratory maximum density.

3.12.3.1 Subgrade for Pavements and Building Pads

Compact subgrade for pavements and building pads to at least 98 percentage laboratory maximum density for the depth below the surface of the pavement shown. When more than one soil classification is present in the subgrade, thoroughly blend, reshape, and compact the top 12 inch of subgrade.

3.13 FINISHING

Finish the surface of excavations, embankments, and subgrades to a smooth and compact surface in accordance with the lines, grades, and cross sections or elevations shown. Provide the degree of finish for graded areas within 0.1 foot of the grades and elevations indicated except that the degree of finish for subgrades specified in paragraph SUBGRADE PREPARATION. Finish gutters and ditches in a manner that will result in effective drainage. Finish the surface of areas to be turfed from settlement or washing to a smoothness suitable for the application of turfing materials. Repair graded, topsoiled, or backfilled areas prior to acceptance of the work, and re-established grades to the required elevations and slopes.

3.13.1 Subgrade and Embankments

During construction, keep embankments and excavations shaped and drained. Maintain ditches and drains along subgrade to drain effectively at all times. Do not disturb the finished subgrade by traffic or other operation. Protect and maintain the finished subgrade in a satisfactory condition until ballast, subbase, base, or pavement is placed. Do not permit the storage or stockpiling of materials on the finished subgrade. Do not lay subbase, base course, ballast, or pavement until the subgrade has been checked and approved, and in no case place subbase, base, surfacing, pavement, or ballast on a muddy, spongy, or frozen subgrade.

3.13.2 Grading Around Structures

Construct areas within 5 feet outside of each building and structure line true-to-grade, shape to drain, and maintain free of trash and debris until final inspection has been completed and the work has been accepted.

3.14 PLACING TOPSOIL

On areas to receive topsoil, prepare the compacted subgrade soil to a 2 inches depth for bonding of topsoil with subsoil. Spread topsoil evenly to a thickness of 3 inch and grade to the elevations and slopes shown. Do not spread topsoil when frozen or excessively wet or dry. Obtain material required for topsoil in excess of that produced by excavation within the grading limits from offsite areas.

3.15 TESTING

Perform testing by a Corps validated commercial testing laboratory or the Contractor's validated testing facility. Submit qualifications of the Corps validated commercial testing laboratory or the Contractor's validated testing facilities. If the Contractor elects to establish testing facilities, do not permit work requiring testing until the Contractor's facilities have been inspected, Corps validated and approved by the Contracting Officer.

a. Determine field in-place density in accordance with ASTM D1556 ASTM D2167 or ASTM D6938. When ASTM D6938 is used, check the calibration curves and adjust using only the sand cone method as described in ASTM D1556. ASTM D6938 results in a wet unit weight of soil in determining the moisture content of the soil when using this method.

b. Check the calibration curves furnished with the moisture gauges along with density calibration checks as described in ASTM D6938; check the calibration of both the density and moisture gauges at the beginning of a job on each different type of material encountered and at intervals as directed by the Contracting Officer. When test results indicate, as determined by the Contracting Officer, that compaction is not as specified, remove the material, replace and recompact to meet specification requirements.

c. Perform tests on recompacted areas to determine conformance with specification requirements. The following number of tests, if performed at the appropriate time, will be the minimum acceptable for each type operation.

3.15.1 Fill and Backfill Material Gradation

One test per 1000 cubic yards stockpiled or in-place source material. Test each visually different material separately. Determine gradation of fill and backfill material in accordance with ASTM C136 or ASTM D1140.

3.15.2 In-Place Densities

a. One test per 2500 square feet, or fraction thereof, of each lift of fill or backfill areas compacted by other than hand-operated machines.

b. One test per 1000 square feet, or fraction thereof, of each lift of fill or backfill areas compacted by hand-operated machines.

c. Refer to Geotechnical Report for testing requirement within the limits of the building.

3.15.3 Check Tests on In-Place Densities

If ASTM D6938 is used, check in-place densities by ASTM D1556 as follows:

a. One check test per lift for each 5000 square feet, or fraction thereof, of each lift of fill or backfill compacted by other than hand-operated machines.

b. One check test per lift for each 2000 square feet, of fill or backfill areas compacted by hand-operated machines.

3.15.4 Moisture Contents

In the stockpile, excavation, or borrow areas, perform a minimum of two tests per day per type of material or source of material being placed during stable weather conditions. During unstable weather, perform tests as dictated by local conditions and approved by the Contracting Officer. Determine soil moisture per ASTM D4944.

3.15.5 Optimum Moisture and Laboratory Maximum Density

Perform tests for each type material or source of material including borrow material to determine the optimum moisture and laboratory maximum density values per ASTM D1557. One representative test per 1000 cubic yards of fill and backfill, or when any change in material occurs which may affect the optimum moisture content or laboratory maximum density.

3.15.6 Tolerance Tests for Subgrades

Perform continuous checks on the degree of finish specified in paragraph SUBGRADE PREPARATION during construction of the subgrades.

3.15.7 Displacement of Sewers

After other required tests have been performed and the trench backfill compacted to 1, foot above the top of the pipe, inspect the pipe to determine whether significant displacement has occurred. Conduct this inspection in the presence of the Contracting Officer. Inspect pipe by shining a light or laser between manholes or manhole locations, or by the use of television cameras passed through the pipe. If, in the judgment of the Contracting Officer, the interior of the pipe shows poor alignment or any other defects that would cause improper functioning of the system, replace or repair the defects as directed at no additional cost to the Government.

3.16 DISPOSITION OF SURPLUS MATERIAL

Dispose surplus soil materials off government property in a legal manner.

-- End of Section --

SECTION 31 11 00

CLEARING AND GRUBBING
11/18

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

U.S. DEPARTMENT OF DEFENSE (DOD)

DODI 4150.07	(2019) DOD Pest Management Program

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Herbicide Application Plan

SD-03 Product Data

Herbicide

SD-11 Closeout Submittals

Pest Management Report

1.3 QUALITY CONTROL

1.3.1 Regulatory Requirements

Comply with DODI 4150.07 for requirements on Contractor's licensing, certification, and record keeping. Maintain daily records using the Pest Management Maintenance Record, DD Form 1532-1, or a computer generated equivalent. These forms may be obtained from the main web site: http://www.dtic.mil/whs/directives/forms/eforms/dd1532-1.pdf

1.3.2 Qualifications

For the application of herbicides, use the services of an applicator who is commercially certified in the state where the work is to be performed as required by DODI 4150.07.

1.4 DELIVERY, STORAGE, AND HANDLING

Deliver materials to the site, and handle in a manner which will maintain the materials in their original manufactured or fabricated condition until ready for use.

1.4.1 Storage

Storage of herbicides on the installation will not be permitted unless it is written into the contract.

1.4.2 Handling

Handle herbicides in accordance with the manufacturer's label and Safety Data Sheet (SDS), preventing contamination by dirt, water, and organic material. Protect herbicides from weather elements as recommended by the manufacturer's label and SDS. Spill kits must be maintained on herbicide control vehicles. Mixing of herbicides on the installation will not be permited unless it is written into the contract.

PART 2 PRODUCTS

2.1 MATERIALS

2.1.1 Tree Wound Paint

Use bituminous based paint from standard manufacture specially formulated for tree wounds.

2.1.2 Herbicide

If used, provide herbicides currently registered by the EPA or approved for such use by the appropriate agency of the host county and approved by the Contracting Officer. Select a herbicide that is suitable for the climatic conditions at the project site. Submit manufacturer's label and SDS for herbicides proposed for use.

PART 3 EXECUTION

3.1 PREPARATION

3.1.1 Herbicide Application Plan

Prior to commencing application of herbicide, submit a herbicide application plan with proposed sequence of treatment work including dates and times of application. Include the herbicide trade name, EPA registration number, chemical composition, formulation, application rate of active ingredients, method of application, area or volume treated, and amount applied. Include a copy of the pesticide applicator certificates.

3.1.2 Protection

3.1.2.1 Roads and Walks

Keep roads and walks free of dirt and debris at all times.

3.1.2.2 Trees, Shrubs, and Existing Facilities

Provide protection in accordance with Section 01 57 19 TEMPORARY ENVIRONMENTAL CONTROLS. Protect trees and vegetation to be left standing from damage incident to clearing, grubbing, and construction operations by the erection of barriers or by such other means as the circumstances require.

3.1.2.3 Utility Lines

Protect existing utility lines that are indicated to remain from damage. Notify the Contracting Officer immediately of damage to or an encounter with an unknown existing utility line. The Contractor is responsible for the repair of damage to existing utility lines that are indicated or made known to the Contractor prior to start of clearing and grubbing operations. When utility lines which are to be removed are encountered within the area of operations, notify the Contracting Officer in ample time to minimize interruption of the service. Refer to Section 01 30 00 ADMINISTRATIVE REQUIREMENTS and Section 01 57 19 TEMPORARY ENVIRONMENTAL CONTROLS for additional utility protection.

3.2 Application

3.2.1 Herbicide Application

Adhere to safety precautions as recommended by the manufacturer concerning handling and application of the herbicide.

3.2.1.1 Clean Up, Disposal, And Protection

Once application has been completed, proceed with clean up and protection of the site without delay. Clean the site of all material associated with the treatment measures, according to label instructions, and as indicated. Remove and dispose of excess and waste material off Government property.

3.2.1.1.1 Disposal of Herbicide

Dispose of residual herbicides and containers off Government property, and in accordance with the approved disposal plan, label instructions and EPA requirements.

3.3 CLEARING

Clearing consists of the felling, trimming, and cutting of trees into sections and the satisfactory disposal of the trees and other vegetation designated for removal, including downed timber, snags, brush, and rubbish occurring within the areas to be cleared. Cut off flush with or below the original ground surface trees, stumps, roots, brush, and other vegetation in areas to be cleared, except such trees and vegetation as may be indicated or directed to be left standing. Trim dead branches 1-1/2 inches or more in diameter on trees designated to be left standing within the cleared areas and trim all branches to the heights indicated or directed. Neatly cut close to the bole of the tree or main branches, limbs and branches to be trimmed. Paint, with an approved tree-wound paint, cuts more than 1-1/2 inches in diameter. Apply herbicide in accordance with the manufacturer's label to the top surface of stumps designated not to be removed.

3.3.1 Tree Removal

Where indicated or directed, trees and stumps that are designated as trees shall be removed from areas outside those areas designated for clearing and grubbing. This work includes the felling of such trees and the removal of their stumps and roots as specified in paragraph GRUBBING.

Dispose of trees as specified in paragraph DISPOSAL OF MATERIALS.

3.3.2 PruningPrune trees designated to be left standing within the cleared areas of dead branches 1-1/2 inches or more in diameter. Neatly cut limbs and branches to be trimmed close to the bole of the tree or main branches. Paint cuts more than 1-1/4 inches in diameter with an approved tree wound paint.

3.3.3 Grubbing

Grubbing consists of the removal and disposal of stumps, roots larger than 3 inches in diameter, and matted roots from the designated grubbing areas. Remove material to be grubbed, together with logs and other organic or metallic debris not suitable for foundation purposes, to a depth of not less than 18 inches below the original surface level of the ground in areas indicated to be grubbed and in areas indicated as construction areas under this contract, such as areas for buildings, and areas to be paved. Fill depressions made by grubbing with suitable material and compact to make the surface conform with the original adjacent surface of the ground.

3.4 DISPOSAL OF MATERIALS

Dispose of excess materials in accordance with the approved solid waste management permit and include those materials in the solid waste management report.

All wood or wood like materials, except for salable timber, remaining from clearing, prunning or grubbing such as limbs, tree tops, roots, stumps, logs, rotten wood, and other similiar materials shall become the property of the Contractor and disposed of as specified. All timber and wood or wood like materials remaining from timber harvesting such as limbs, tree tops, roots, stumps, logs, rotten wood, and other similiar materials shall become the property of the Contractor and disposed as specified.

3.5 CLOSEOUT ACTIVITIES

3.5.1 Herbicides

Upon completion of this work, submit the Pest Management Report DD Form 1532, or an equivalent computer product, to the Integrated Pest Management Coordinator. This form identifies the type of operation, brand name and manufacturer of herbicide, formulation, concentration or rate of application used.

-- End of Section --

SECTION 32 16 19

CONCRETE CURBS, GUTTERS AND SIDEWALKS
05/18

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO)

AASHTO M 182	(2005; R 2017) Standard Specification for Burlap Cloth Made from Jute or Kenaf and Cotton Mats

ASTM INTERNATIONAL (ASTM)

ASTM A1064/A1064M	(2022) Standard Specification for Carbon-Steel Wire and Welded Wire Reinforcement, Plain and Deformed, for Concrete
ASTM A615/A615M	(2022) Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement
ASTM C143/C143M	(2020) Standard Test Method for Slump of Hydraulic-Cement Concrete
ASTM C171	(2020) Standard Specification for Sheet Materials for Curing Concrete
ASTM C172/C172M	(2017) Standard Practice for Sampling Freshly Mixed Concrete
ASTM C173/C173M	(2016) Standard Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method
ASTM C231/C231M	(2022) Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method
ASTM C309	(2019) Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete
ASTM C31/C31M	(2022) Standard Practice for Making and Curing Concrete Test Specimens in the Field
ASTM C920	(2018) Standard Specification for Elastomeric Joint Sealants

ASTM D1751	(2018) Standard Specification for Preformed Expansion Joint Filler for Concrete Paving and Structural Construction (Nonextruding and Resilient Bituminous Types)
ASTM D1752	(2018) Standard Specification for Preformed Sponge Rubber, Cork and Recycled PVC Expansion Joint Fillers for Concrete Paving and Structural Construction
ASTM D5893/D5893M	(2016) Standard Specification for Cold Applied, Single Component, Chemically Curing Silicone Joint Sealant for Portland Cement Concrete Pavements

INTERNATIONAL CODE COUNCIL (ICC)

ICC A117.1 COMM	(2017) Standard And Commentary Accessible and Usable Buildings and Facilities

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Concrete

Biodegradable Form Release Agent

SD-06 Test Reports

Field Quality Control

1.3 EQUIPMENT, TOOLS, AND MACHINES

1.3.1 General Requirements

Plant, equipment, machines, and tools used in the work will be subject to approval and must be maintained in a satisfactory working condition at all times. Use equipment capable of producing the required product, meeting grade controls, thickness control and smoothness requirements as specified. Discontinue using equipment that produces unsatisfactory results. Allow the Contracting Officer access at all times to the plant and equipment to ensure proper operation and compliance with specifications.

1.3.2 Slip Form Equipment

Slip form paver or curb forming machines, will be approved based on trial use on the job and must be self-propelled, automatically controlled, crawler mounted, and capable of spreading, consolidating, and shaping the plastic concrete to the desired cross section in one pass.

1.4 ENVIRONMENTAL REQUIREMENTS

1.4.1 Placing During Cold Weather

Do not place concrete when the air temperature reaches 40 degrees F and is falling, or is already below that point. Placement may begin when the air temperature reaches 35 degrees F and is rising, or is already above 40 degrees F. Make provisions to protect the concrete from freezing during the specified curing period.

1.4.2 Placing During Warm Weather

The temperature of the concrete as placed must not exceed 85 degrees F except where an approved retarder is used. Cool the mixing water and aggregates as necessary to maintain a satisfactory placing temperature. The placing temperature must not exceed 95 degrees F at any time.

PART 2 PRODUCTS

2.1 CONCRETE

Provide concrete consisting of portland cement Type I or II and mix design appropriate for the application. Concrete must have a minimum compressive strength of 3500 psi at 28 days. Size of aggregate must not exceed 1-1/2 inches. Submit copies of certified delivery tickets for all concrete used in the construction.

2.1.1 Air Content

Use concrete mixtures that have an air content by volume of concrete of 3 to 6 percent, based on measurements made immediately after discharge from the mixer.

2.1.2 Slump

Use concrete with a slump of 2 inches plus or minus 1 inch for hand placed concrete or 1 inch plus or minus 1/2 inch for slipformed concrete as determined in accordance with ASTM C143/C143M.

2.1.3 Reinforcement Steel

Use reinforcement bars conforming to ASTM A615/A615M. Use wire mesh reinforcement conforming to ASTM A1064/A1064M.

2.2 CONCRETE CURING MATERIALS

2.2.1 Impervious Sheet Materials

Use impervious sheet materials conforming to ASTM C171, type optional, except that polyethylene film, if used, must be white opaque.

2.2.2 Burlap

Use burlap conforming to AASHTO M 182.

2.2.3 White Pigmented Membrane-Forming Curing Compound

Use white pigmented membrane-forming curing compound conforming to ASTM C309, Type 2.

2.3 CONCRETE PROTECTION MATERIALS

Use concrete protection materials consisting of a linseed oil mixture of equal parts, by volume, of linseed oil and either mineral spirits, naphtha, or turpentine. At the option of the Contractor, commercially prepared linseed oil mixtures, formulated specifically for application to concrete to provide protection against the action of deicing chemicals may be used, except that emulsified mixtures are not acceptable.

2.4 JOINT FILLER STRIPS

2.4.1 Contraction Joint Filler for Curb and Gutter

Use hard-pressed fiberboard contraction joint filler for curb and gutter.

2.4.2 Expansion Joint Filler, Premolded

Onless otherwise indicated, use 1/2 inch thick premolded expansion joint filler conforming to ASTM D1751 or ASTM D1752.

2.5 JOINT SEALANTS

Use cold-applied joint sealant conforming to ASTM C920 or ASTM D5893/D5893M.

2.6 FORM WORK

Design and construct form work to ensure that the finished concrete will conform accurately to the indicated dimensions, lines, and elevations, and within the tolerances specified. Use wood or steel forms that are straight and of sufficient strength to resist springing during depositing and consolidating concrete.

2.6.1 Wood Forms

Use forms that are surfaced plank, 2 inches nominal thickness, straight and free from warp, twist, loose knots, splits or other defects. Use forms with a nominal length of 10 feet. Radius bends may be formed with 3/4 inch boards, laminated to the required thickness.

2.6.2 Steel Forms

Use channel-formed sections with a flat top surface and welded braces at each end and at not less than two intermediate points. Use forms with interlocking and self-aligning ends. Provide flexible forms for radius forming, corner forms, form spreaders, and fillers as needed. Use forms with a nominal length of 10 feet and that have a minimum of 3 welded stake pockets per form. Use stake pins consisting of solid steel rods with chamfered heads and pointed tips designed for use with steel forms.

2.6.3 Sidewalk Forms

Use sidewalk forms that are of a height equal to the full depth of the finished sidewalk.

2.6.4 Curb and Gutter Forms

Use curb and gutter outside forms that have a height equal to the full depth of the curb or gutter. Use rigid forms for curb returns, except that benders or thin plank forms may be used for curb or curb returns with a radius of 10 feet or more, where grade changes occur in the return, or where the central angle is such that a rigid form with a central angle of 90 degrees cannot be used. Back forms for curb returns may be made of 1-1/2 inch benders, for the full height of the curb, cleated together. In lieu of inside forms for curbs, a curb "mule" may be used for forming and finishing this surface, provided the results are approved.

2.6.5 Biodegradable Form Release Agent

Where practicable, use form release agent that is colorless and biodegradableand that is composed of at least 87 percent biobased material. Provide product that does not bond with, stain, or adversely affect concrete surfaces and does not impair subsequent treatments of concrete surfaces. Provide form release agent that does not contain diesel fuel, petroleum-based lubricating oils, waxes, or kerosene.

2.7 Detectable Warning System

Detectable Warning Systems shown on the Contract plans are to meet requirements of ICC A117.1 COMM - Section 705.

PART 3 EXECUTION

3.1 SUBGRADE PREPARATION

Construct subgrade to the specified grade and cross section prior to concrete placement.

3.1.1 Sidewalk Subgrade

Place and compact the subgrade in accordance with Section 31 00 00 EARTHWORK. Test the subgrade for grade and cross section with a template extending the full width of the sidewalk and supported between side forms.

3.1.2 Curb and Gutter Subgrade

Place and compact the subgrade in accordance with Section 31 00 00 EARTHWORK. Test the subgrade for grade and cross section by means of a template extending the full width of the curb and gutter. Use subgrade materials equal in bearing quality to the subgrade under the adjacent pavement.

3.1.3 Maintenance of Subgrade

Maintain subgrade in a smooth, compacted condition in conformity with the required section and established grade until the concrete is placed. The subgrade must be in a moist condition when concrete is placed. Prepare and protect subgrade so that it is free from frost when the concrete is deposited.

3.2 FORM SETTING

Set forms to the indicated alignment, grade and dimensions. Hold forms rigidly in place by a minimum of 3 stakes per form placed at intervals not to exceed 4 feet. Use additional stakes and braces at corners, deep sections, and radius bends, as required. Use clamps, spreaders, and braces where required to ensure rigidity in the forms. Remove forms in a manner that will not injure the concrete. Do not use bars or heavy tools against the concrete when removing the forms. Promptly and satisfactorily repair concrete found to be defective after form removal. Clean forms and coat with form oil or biodegradable form release agent each time before concrete is placed. Wood forms may, instead, be thoroughly wetted with water before concrete is placed, except that with probable freezing temperatures, oiling is mandatory.

3.2.1 Sidewalks

Set forms for sidewalks with the upper edge true to line and grade with an allowable tolerance of 1/8 inch in any 10 foot long section. After forms are set, grade and alignment must be checked with a 10 foot straightedge. Sidewalks must have a transverse slope as indicated or of 1/4 inch per foot where not indicated as the plans. Unless otherwise indicated, construct sidewalks that are located adjacent to curbs with the low side adjacent to the curb. Do not remove side forms less than 12 hours after finishing has been completed.

3.2.2 Curbs and Gutters

Remove forms used along the front of the curb not less than 2 hours nor more than 6 hours after the concrete has been placed. Do not remove forms used along the back of curb until the face and top of the curb have been finished, as specified for concrete finishing. Do not remove gutter forms while the concrete is sufficiently plastic to slump in any direction.

3.3 SIDEWALK CONCRETE PLACEMENT AND FINISHING

3.3.1 Formed Sidewalks

Place concrete in the forms in one layer. When consolidated and finished, the sidewalks must be of the thickness indicated. Use a strike-off guided by side forms after concrete has been placed in the forms to bring the surface to proper section to be compacted. Consolidate concrete by tamping and spading or with an approved vibrator. Finish the surface to grade with a strike off.

3.3.2 Concrete Finishing

After straightedging, when most of the water sheen has disappeared, and just before the concrete hardens, finish the surface with a wood or magnesium float or darby to a smooth and uniformly fine granular or sandy texture free of waves, irregularities, or tool marks. Produce a scored surface by brooming with a fiber-bristle brush in a direction transverse to that of the traffic, followed by edging.

3.3.3 Edge and Joint Finishing

Finish all slab edges, including those at formed joints, with an edger having a radius of 1/8 inch. Edge transverse joints before brooming. Eliminate the flat surface left by the surface face of the edger with brooming. Clean and solidly fill corners and edges which have crumbled and areas which lack sufficient mortar for proper finishing with a properly proportioned mortar mixture and then finish.

3.3.4 Surface and Thickness Tolerances

Finished surfaces must not vary more than 5/16 inch from the testing edge of a 10-foot straightedge. Permissible deficiency in section thickness will be up to 1/4 inch.

3.4 CURB AND GUTTER CONCRETE PLACEMENT AND FINISHING

3.4.1 Formed Curb and Gutter

Place concrete to the required section in a single lift. Consolidate concrete using approved mechanical vibrators. Curve shaped gutters must be finished with a standard curb "mule".

3.4.2 Curb and Gutter Finishing

Approved slipformed curb and gutter machines may be used in lieu of hand placement.

3.4.3 Concrete Finishing

Float and finish exposed surfaces with a smooth wood float until true to grade and section and uniform in texture. Brush floated surfaces with a fine-hair brush using longitudinal strokes. Round the edges of the gutter and top of the curb with an edging tool to a radius of 1/2 inch. Immediately after removing the front curb form, rub the face of the curb with a wood or concrete rubbing block and water until blemishes, form marks, and tool marks have been removed. Brush the front curb surface, while still wet, in the same manner as the gutter and curb top. Finish the top surface of gutter and entrance to grade with a wood float.

3.4.4 Joint Finishing

Finish curb edges at formed joints as indicated.

3.4.5 Surface and Thickness Tolerances

Finished surfaces must not vary more than 1/4 inch from the testing edge of a 10-foot straightedge. Permissible deficiency in section thickness will be up to 1/4 inch.

3.5 SIDEWALK JOINTS

Construct sidewalk joints to divide the surface into rectangular areas. Space transverse contraction joints at a distance equal to the sidewalk width or 5 feet on centers, whichever is less, and continuous across the slab. Construct longitudinal contraction joints along the centerline of all sidewalks 10 feet or more in width. Construct transverse expansion joints at sidewalk returns and opposite expansion joints in adjoining curbs. Where the sidewalk is not in contact with the curb, install transverse expansion joints as indicated. Form expansion joints around structures and features which project through or into the sidewalk pavement, using joint filler of the type, thickness, and width indicated. Expansion joints are not required between sidewalks and curb that abut the sidewalk longitudinally.

3.5.1 Sidewalk Contraction Joints

Form contraction joints in the fresh concrete by cutting a groove in the top portion of the slab to a depth of at least one-fourth of the sidewalk slab thickness. Unless otherwise approved or indicated, either use a jointer to cut the groove or saw a groove in the hardened concrete with a power-driven saw. Construct sawed joints by sawing a groove in the concrete with a 1/8 inch blade. Provide an ample supply of saw blades on the jobsite before concrete placement is started. Provide at least one standby sawing unit in good working order at the jobsite at all times during the sawing operations.

3.5.2 Sidewalk Expansion Joints

Form expansion joints using 1/2 inch joint filler strips. Joint filler in expansion joints surrounding structures and features within the sidewalk may consist of preformed filler material conforming to ASTM D1752 or building paper. Hold joint filler in place with steel pins or other devices to prevent warping of the filler during floating and finishing. Immediately after finishing operations are completed, round joint edges using an edging tool having a radius of 1/8 inch. Remove any concrete over the joint filler. At the end of the curing period, clean the top of expansion joints and fill with cold-applied joint sealant. Use joint sealant that is gray or stone in color. Thoroughly clean the joint opening before the sealing material is placed. Do not spill sealing material on exposed surfaces of the concrete. Apply joint sealing material only when the concrete at the joint is surface dry and atmospheric and concrete temperatures are above 50 degrees F. Immediately remove any excess material on exposed surfaces of the concrete and clean the concrete surfaces.

3.6 CURB AND GUTTER JOINTS

Construct curb and gutter joints at right angles to the line of curb and gutter.

3.6.1 Contraction Joints

Construct contraction joints directly opposite contraction joints in abutting portland cement concrete pavements and spaced so that monolithic sections between curb returns will not be less than 5 feet nor greater than 15 feet in length.

a. Construct contraction joints (except for slip forming) by means of 1/8 inch thick separators and of a section conforming to the cross section of the curb and gutter. Remove separators as soon as practicable after concrete has set sufficiently to preserve the width and shape of the joint and prior to finishing.

b. When slip forming is used, cut the contraction joints in the top portion of the gutter/curb hardened concrete in a continuous cut across the curb and gutter, using a power-driven saw. Cut the contraction joint to a depth of at least one-fourth of the gutter/curb depth using a 1/8 inch saw blade.

3.6.2 Expansion Joints

Form expansion joints by means of preformed expansion joint filler material cut and shaped to the cross section of curb and gutter. Construct expansion joints in curb and gutter directly opposite expansion joints of abutting portland cement concrete pavement using the same type and thickness of joints as joints in the pavement. Where curb and gutter do not abut portland cement concrete pavement, provide expansion joints at least 1/2 inch in width at intervals not less than 30 feet nor greater than 120 feet. Seal expansion joints immediately following curing of the concrete or as soon thereafter as weather conditions permit. Seal expansion joints and the top 1 inch depth of curb and gutter contraction-joints with joint sealant. Thoroughly clean the joint opening before the sealing material is placed. Do not spill sealing material on exposed surfaces of the concrete. Concrete at the joint must be surface dry and atmospheric and concrete temperatures must be above 50 degrees F at the time of application of joint sealing material. Immediately remove excess material on exposed surfaces of the concrete and clean concrete surfaces.

3.7 CURING AND PROTECTION

3.7.1 General Requirements

Protect concrete against loss of moisture and rapid temperature changes for at least 7 days from the beginning of the curing operation. Protect unhardened concrete from rain and flowing water. All equipment needed for adequate curing and protection of the concrete must be on hand and ready for use before actual concrete placement begins. Protect concrete as necessary to prevent cracking of the pavement due to temperature changes during the curing period.

3.7.1.1 Mat Method

Cover the entire exposed surface with two or more layers of burlap. Overlap mats at least 6 inches. Thoroughly wet the mat with water prior to placing on concrete surface and keep the mat continuously in a saturated condition and in intimate contact with concrete for not less than 7 days.

3.7.1.2 Impervious Sheeting Method

Wet the entire exposed surface with a fine spray of water and then cover with impervious sheeting material. Lay sheets directly on the concrete surface with the light-colored side up and overlapped 12 inches when a continuous sheet is not used. Use sheeting that is not less than 18-inches wider than the concrete surface to be cured. Secure sheeting using heavy wood planks or a bank of moist earth placed along edges and laps in the sheets. Satisfactorily repair or replace sheets that are torn or otherwise damaged during curing. Sheeting must remain on the concrete surface to be cured for not less than 7 days.

3.7.1.3 Membrane Curing Method

Apply a uniform coating of white-pigmented membrane-curing compound to the entire exposed surface of the concrete as soon after finishing as the free water has disappeared from the finished surface. Coat formed surfaces immediately after the forms are removed and in no case longer than 1 hour after the removal of forms. Do not allow concrete surface to dry before application of the membrane. If drying has occurred, moisten the surface of the concrete with a fine spray of water and apply the curing compound as soon as the free water disappears. Apply curing compound in two coats by hand-operated pressure sprayers at a coverage of approximately 200 square feet/gallon for the total of both coats. Apply the second coat in a direction approximately at right angles to the direction of application of the first coat. The compound must form a uniform, continuous, coherent film that will not check, crack, or peel and must be free from pinholes or other imperfections. If pinholes, abrasion, or other discontinuities exist, apply an additional coat to the affected areas within 30 minutes. Respray concrete surfaces that are subjected to heavy rainfall within 3 hours after the curing compound has been applied by the method and at the coverage specified above. Respray areas where the curing compound is damaged by subsequent construction operations within the curing period. Take precautions necessary to ensure that the concrete is properly cured at sawed joints, and that no curing compound enters the joints. Tightly seal the top of the joint opening and the joint groove at exposed edges before the concrete in the region of the joint is resprayed with curing compound. Use a method used for sealing the joint groove that prevents loss of moisture from the joint during the entire specified curing period. Provide approved standby facilities for curing concrete pavement at a location accessible to the jobsite for use in the event of mechanical failure of the spraying equipment or other conditions that might prevent correct application of the membrane-curing compound at the proper time. Adequately protect concrete surfaces to which membrane-curing compounds have been applied during the entire curing period from pedestrian and vehicular traffic, except as required for joint-sawing operations and surface tests, and from other possible damage to the continuity of the membrane.

3.7.2 Backfilling

After curing, remove debris and backfill, grade, and compact the area adjoining the concrete to conform to the surrounding area in accordance with lines and grades indicated.

3.7.3 Protection

Protect completed concrete from damage until accepted. Repair damaged concrete and clean concrete discolored during construction. Remove and reconstruct concrete that is damaged for the entire length between regularly scheduled joints. Refinishing the damaged portion will not be acceptable. Dispose of removed material as directed.

3.8 FIELD QUALITY CONTROL

Submit copies of all test reports within 24 hours of completion of the test.

3.8.1 General Requirements

Perform the inspection and tests described and meet the specified requirements for inspection details and frequency of testing. Based upon the results of these inspections and tests, take the action and submit reports as required below, and additional tests to ensure that the requirements of these specifications are met.

3.8.2 Concrete Testing

3.8.2.1 Strength Testing

Take concrete samples in accordance with ASTM C172/C172M not less than once a day nor less than once for every 250 cubic yards of concrete placed. Mold cylinders in accordance with ASTM C31/C31M for strength testing by an approved laboratory. Each strength test result must be the average of 2 test cylinders from the same concrete sample tested at 28 days, unless otherwise specified or approved. Concrete specified on the basis of compressive strength will be considered satisfactory if the averages of all sets of three consecutive strength test results equal or exceed the specified strength, and no individual strength test result falls below the specified strength by more than 500 psi.

3.8.2.2 Air Content

Determine air content in accordance with ASTM C173/C173M or ASTM C231/C231M. Use ASTM C231/C231M with concretes and mortars made with relatively dense natural aggregates. Make two tests for air content on randomly selected batches of each class of concrete placed during each shift. Make additional tests when excessive variation in concrete workability is reported by the placing foreman or the Government inspector. Notify the placing forman if results are out of tolerance. The placing foreman must take appropriate action to have the air content corrected at the plant. Additional tests for air content will be performed on each truckload of material until such time as the air content is within the tolerance specified.

3.8.2.3 Slump Test

Perform two slump tests on randomly selected batches of each class of concrete for every 250 cubic yards, or fraction thereof, of concrete placed during each shift. Perform additional tests when excessive variation in the workability of the concrete is noted or when excessive crumbling or slumping is noted along the edges of slip-formed concrete.

3.8.3 Thickness Evaluation

Determine the anticipated thickness of the concrete prior to placement by passing a template through the formed section or by measuring the depth of opening of the extrusion template of the curb forming machine. If a slip form paver is used for sidewalk placement, construct the subgrade true to grade prior to concrete placement. The thickness will be determined by measuring each edge of the completed slab.

3.8.4 Surface Evaluation

Provide finished surfaces for each category of the completed work that are uniform in color and free of blemishes and form or tool marks.

3.9 SURFACE DEFICIENCIES AND CORRECTIONS

3.9.1 Thickness Deficiency

When measurements indicate that the completed concrete section is deficient in thickness by more than 1/4 inch the deficient section will be removed, between regularly scheduled joints, and replaced.

3.9.2 High Areas

In areas not meeting surface smoothness and plan grade requirements, reduce high areas either by rubbing the freshly finished concrete with carborundum brick and water when the concrete is less than 36 hours old or by grinding the hardened concrete with an approved surface grinding machine after the concrete is 36 hours old or more. The area corrected by grinding the surface of the hardened concrete must not exceed 5 percent of the area of any integral slab, and the depth of grinding must not exceed

1/4 inch. Remove and replace pavement areas requiring grade or surface smoothness corrections in excess of the limits specified.

3.9.3 Appearance

Exposed surfaces of the finished work will be inspected by the Contracting Officer and deficiencies in appearance will be identified. Remove and replace areas which exhibit excessive cracking, discoloration, form marks, or tool marks or which are otherwise inconsistent with the overall appearances of the work.

3.10 DETECTABLE WARNING SYSTEM

Install Detectable Warning Systems required by Contract plans in accordance with ICC A117.1 COMM, Section 705, and by manufacturers' installation instructions.

-- End of Section --

SECTION 32 92 23

SODDING
04/06

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only. Publications used shall be the most current issue.

ASTM INTERNATIONAL (ASTM)

ASTM C602	(2020) Agricultural Liming Materials
ASTM D4427	(2018) Standard Classification of Peat Samples by Laboratory Testing
ASTM D4972	(2018) Standard Test Methods for pH of Soils

TURFGRASS PRODUCERS INTERNATIONAL (TPI)

TPI GSS	(1995) Guideline Specifications to Turfgrass Sodding

U.S. DEPARTMENT OF AGRICULTURE (USDA)

DOA SSIR 42	(1996) Soil Survey Investigation Report No. 42, Soil Survey Laboratory Methods Manual, Version 3.0

1.2 DEFINITIONS

1.2.1 Stand of Turf

100 percent ground cover of the established species.

1.3 RELATED REQUIREMENTS

Section 31 00 00 EARTHWORK applies to this section for pesticide use and plant establishment requirements, with additions and modifications herein.

1.4 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Fertilizer

Include physical characteristics, and recommendations.

SD-06 Test Reports

Topsoil composition tests (reports and recommendations).

SD-07 Certificates

Sod farm certification for sods. Indicate type of sod in accordance with TPI GSS.

1.5 DELIVERY, STORAGE, AND HANDLING

1.5.1 Delivery

1.5.1.1 Sod Protection

Protect from drying out and from contamination during delivery, on-site storage, and handling.

1.5.1.2 Fertilizer and Lime Delivery

Deliver to the site in original, unopened containers bearing manufacturer's chemical analysis, name, trade name, trademark, and indication of conformance to state and federal laws. Instead of containers, fertilizer and lime may be furnished in bulk with certificate indicating the above information.

1.5.2 Storage

1.5.2.1 Sod Storage

Lightly sprinkle with water, cover with moist burlap, straw, or other approved covering; and protect from exposure to wind and direct sunlight until planted. Provide covering that will allow air to circulate so that internal heat will not develop. Do not store sod longer than 24 hours. Do not store directly on concrete or bituminous surfaces.

1.5.2.2 Topsoil

Clear and grub existing vegetation three to four weeks prior to stockpiling topsoil.

1.5.2.3 Handling

Do not drop or dump materials from vehicles.

1.6 TIME RESTRICTIONS AND PLANTING CONDITIONS

1.6.1 Restrictions

Do not plant when the ground is muddy, or when air temperature exceeds 90 degrees Fahrenheit.

1.7 TIME LIMITATIONS

1.7.1 Sod

Place sod a maximum of thirty six hours after initial harvesting, in accordance with TPI GSS as modified herein.

PART 2 PRODUCTS

2.1 SODS

2.1.1 Classification

Nursery grown, certified as classified in the TPI GSS. Machine cut sod at a uniform thickness of 3/4 inch within a tolerance of 1/4 inch, excluding top growth and thatch. Each individual sod piece shall be strong enough to support its own weight when lifted by the ends. Broken pads, irregularly shaped pieces, and torn or uneven ends will be rejected.Wood pegs and wire staples for anchorage shall be as recommended by sod supplier.

2.1.2 Purity

Sod species shall be genetically pure, free of weeds, pests, and disease.

2.1.3 Planting Dates

Lay sod from February to August for warm season spring planting and from September to November for cool season fall planting.

2.1.4 Composition

2.1.4.1 Proportion

Proportion grass species as indicated on plans.

2.2 TOPSOIL

2.2.1 On-Site Topsoil

Surface soil stripped and stockpiled on site and modified as necessary to meet the requirements specified for topsoil in paragraph entitled "Composition." When available topsoil shall be existing surface soil stripped and stockpiled on-site in accordance with Section 31 00 00 EARTHWORK.

2.2.2 Off-Site Topsoil

Conform to requirements specified in paragraph entitled "Composition." Additional topsoil shall be furnished by the Contractor, if required.

2.2.3 Composition

Containing from 5 to 10 percent organic matter as determined by the topsoil composition tests of the Organic Carbon, 6A, Chemical Analysis Method described in DOA SSIR 42. Maximum particle size, 3/4 inch, with maximum 3 percent retained on 1/4 inch screen. The pH shall be tested in accordance with ASTM D4972. Topsoil shall be free of sticks, stones, roots, and other debris and objectionable materials. Other components shall conform to the following limits:

Silt	7 to 17 percent
Clay	4 to 12 percent
Sand	70 to 82 percent
pH	5.5 to 7.0
Soluble Salts	600 ppm maximum

2.3 SOIL CONDITIONERS

Add conditioners to topsoil as required to bring into compliance with "composition" standard for topsoil as specified herein.

2.3.1 Lime

Commercial grade hydrate or burnt limestone containing a calcium carbonate equivalent (C.C.E.) as specified in ASTM C602 of not less than 110 percent.

2.3.2 Iron

100 percent elemental

2.3.3 Peat

Natural product of peat moss derived from a freshwater site and conforming to ASTM D4427. Shred and granulate peat to pass a 1/2 inch mesh screen and condition in storage pile for minimum 6 months after excavation.

2.3.4 Sand

Clean and free of materials harmful to plants.

2.3.5 Perlite

Horticultural grade.

2.3.6 Composted Derivatives

Ground bark, nitrolized sawdust, humus or other green wood waste material free of stones, sticks, and soil stabilized with nitrogen and having the following properties:

2.3.6.1 Particle Size

Minimum percent by weight passing:

No. 4 mesh screen	95
No. 8 mesh screen	80

2.3.6.2 Nitrogen Content

Minimum percent based on dry weight:

Fir Sawdust	0.7
Fir or Pine Bark	1.0

2.4 FERTILIZER

2.4.1 Granular Fertilizer

Synthetic, granular controlled release fertilizer containing the following minimum percentages, by weight, of plant food nutrients:

12 percent available nitrogen
8 percent available phosphorus
8 percent available potassium

2.5 WATER

Source of water shall be approved by Contracting Officer and of suitable quality for irrigation containing no element toxic to plant life.

PART 3 EXECUTION

3.1 PREPARATION

3.1.1 Extent Of Work

Provide soil preparation (including soil conditioners), fertilizing, and sodding of all newly graded finished earth surfaces, unless indicated otherwise, and at all areas inside or outside the limits of construction that are disturbed by the Contractor's operations.

3.1.2 Soil Preparation

Provide 4 inches of topsoil to meet indicated finish grade. After areas have been brought to indicated finish grade, incorporate fertilizer pH adjusters and soil conditioners into soil a minimum depth of 3 inches by disking, harrowing, tilling or other method approved by the Contracting Officer. Remove debris and stones larger than 3/4 inch in any dimension remaining on the surface after finish grading. Correct irregularities in finish surfaces to eliminate depressions. Protect finished topsoil areas from damage by vehicular or pedestrian traffic.

3.1.2.1 Soil Conditioner and Fertilizer Application Rates

Apply soil conditioners at rates as determined by laboratory soil analysis of the soils at the job site.

3.2 SODDING

3.2.1 Finished Grade and Topsoil

Prior to the commencement of the sodding operation, the Contractor shall verify that finished grades are as indicated on drawings; the placing of topsoil, smooth grading, and compaction requirements have been completed in accordance with Section 31 00 00 EARTHWORK.

The prepared surface shall be a maximum 1 inch below the adjoining grade of any surfaced area. New surfaces shall be blended to existing areas. The prepared surface shall be completed with a light raking to remove from the surface debris and stones over a minimum 5/8 inch in any dimension.

3.2.2 Placing

Place sod a maximum of 36 hours after initial harvesting, in accordance with TPI GSS as modified herein.

3.2.3 Sodding Slopes and Ditches

For slopes 2:1 and greater, lay sod with long edge perpendicular to the contour. For V-ditches and flat bottomed ditches, lay sod with long edge perpendicular to flow of water. Anchor each piece of sod with wood pegs or wire staples maximum 2 feet on center. On slope areas, start sodding at bottom of the slope.

3.2.4 Finishing

After completing sodding, blend edges of sodded area smoothly into surrounding area. Air pockets shall be eliminated and a true and even surface shall be provided. Frayed edges shall be trimmed and holes and missing corners shall be patched with sod.

3.2.5 Rolling

Immediately after sodding, firm entire area except for slopes in excess of 3 to 1 with a roller not exceeding 90 pounds for each foot of roller width.

3.2.6 Watering

Start watering areas sodded as required by daily temperature and wind conditions. Apply water at a rate sufficient to ensure thorough wetting of soil to minimum depth of 4 inches. Run-off, puddling, and wilting shall be prevented. Unless otherwise directed, watering trucks shall not be driven over turf areas. Watering of other adjacent areas or plant material shall be prevented.

Water sufficiently to ensure that sod receives at least 2 inches of water per week (including rainfall). Continue watering until sod is well-rooted. Minimum watering time shall be sixty (60) days from placement.

3.3 PROTECTION OF TURF AREAS

Immediately after turfing, protect area against traffic and other use.

3.4 ESTABLISHMENT PERIOD

Contractor shall monitor and maintain sod until such time that all sod is well-rooted and no bare spots exist exceeding 1 square foot in dimension. All rills and areas of erosion shall be promptly repaired during the maintenance period. Monitoring period shall be a minimum of sixty (60) days following installation.

-- End of Section --

SECTION 33 11 00

WATER UTILITY DISTRIBUTION PIPING

PART 1 GENERAL

American States Utility Services, Inc. (ASUS) requirements and specifications shall govern the construction of Water Utility Distribution Piping related components. See ASUS specifications.

-- End of Section --

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SECTION 33 30 00

SANITARY SEWERS

PART 1 GENERAL

1.1 SUMMARY

1.1.1 Sanitary Sewer

American States Utility Services, Inc. (ASUS) requirements and specifications shall govern the construction of Sanitary Sewer related components. See ASUS specifications attached.

-- End of Section --

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SECTION 33 40 00

STORM DRAINAGE UTILITIES
02/10

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO)

AASHTO M 294	(2021) Standard Specification for Corrugated Polyethylene Pipe, 300- to 1500-mm (12- to 60-in.) Diameter

ASTM INTERNATIONAL (ASTM)

ASTM A48/A48M	(2003; R 2021) Standard Specification for Gray Iron Castings
ASTM A536	(1984; R 2019; E 2019) Standard Specification for Ductile Iron Castings
ASTM B26/B26M	(2018; E 2018) Standard Specification for Aluminum-Alloy Sand Castings
ASTM C1433	(2020) Standard Specification for Precast Reinforced Concrete Monolithic Box Sections for Culverts, Storm Drains, and Sewers
ASTM C1433M	(2022) Standard Specification for Precast Reinforced Concrete Monolithic Box Sections for Culverts, Storm Drains, and Sewers (Metric)
ASTM C425	(2021) Standard Specification for Compression Joints for Vitrified Clay Pipe and Fittings
ASTM C443	(2021) Standard Specification for Joints for Concrete Pipe and Manholes, Using Rubber Gaskets
ASTM C443M	(2021) Standard Specification for Joints for Concrete Pipe and Manholes, Using Rubber Gaskets (Metric)
ASTM C478	(2018) Standard Specification for Circular Precast Reinforced Concrete Manhole Sections

ASTM C478M	(2018) Standard Specification for Precast Reinforced Concrete Manhole Sections (Metric)
ASTM C76	(2022a) Standard Specification for Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe
ASTM C76M	(2022a) Standard Specification for Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe (Metric)
ASTM C877	(2021) Standard Specification for External Sealing Bands for Concrete Pipe, Manholes, and Precast Box Sections
ASTM C877M	(2021) Standard Specification for External Sealing Bands for Concrete Pipe, Manholes, and Precast Box Sections (Metric)
ASTM C923	(2008; R 2013; E 2016) Standard Specification for Resilient Connectors Between Reinforced Concrete Manhole Structures, Pipes and Laterals
ASTM C923M	(2008b; R 2013) Standard Specification for Resilient Connectors Between Reinforced Concrete Manhole Structures, Pipes and Laterals (Metric)
ASTM C990	(2009; R 2019) Standard Specification for Joints for Concrete Pipe, Manholes, and Precast Box Sections Using Preformed Flexible Joint Sealants
ASTM D1056	(2020) Standard Specification for Flexible Cellular Materials - Sponge or Expanded Rubber
ASTM D1171	(2018) Standard Test Method for Rubber Deterioration - Surface Ozone Cracking Outdoors (Triangular Specimens)
ASTM D1557	(2012; E 2015) Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft3) (2700 kN-m/m3)
ASTM D1784	(2020) Standard Specification for Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds
ASTM D2167	(2015) Density and Unit Weight of Soil in Place by the Rubber Balloon Method
ASTM D2321	(2020) Standard Practice for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity-Flow Applications

ASTM D3034	(2016) Standard Specification for Type PSM Poly(Vinyl Chloride) (PVC) Sewer Pipe and Fittings
ASTM D6938	(2017a) Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)
ASTM F477	(2014; R 2021) Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-04 Samples

Pipe for Culverts and Storm Drains

SD-07 Certificates

Resin Certification

Oil Resistant Gasket

Determination of Density

Frame and Cover for Gratings

SD-08 Manufacturer's Instructions

Placing Pipe

1.3 DELIVERY, STORAGE, AND HANDLING

1.3.1 Delivery and Storage

Materials delivered to site shall be inspected for damage, unloaded, and stored with a minimum of handling. Materials shall not be stored directly on the ground. The inside of pipes and fittings shall be kept free of dirt and debris. Before, during, and after installation, plastic pipe and fittings shall be protected from any environment that would result in damage or deterioration to the material. Keep a copy of the manufacturer's instructions available at the construction site at all times and follow these instructions unless directed otherwise by the Contracting Officer. Solvents, solvent compounds, lubricants, elastomeric gaskets, and any similar materials required to install plastic pipe shall be stored in accordance with the manufacturer's recommendations and shall be discarded if the storage period exceeds the recommended shelf life. Solvents in use shall be discarded when the recommended pot life is exceeded.

1.3.2 Handling

Materials shall be handled in a manner that ensures delivery to the trench in sound, undamaged condition. Pipe shall be carried to the trench, not dragged.

PART 2 PRODUCTS

2.1 PIPE FOR CULVERTS AND STORM DRAINS

Pipe for culverts and storm drains shall be of the sizes indicated and shall conform to the requirements specified.

2.1.1 Concrete Pipe (If required)

Manufactured in accordance with and conforming to ASTM C76, Class III.

2.1.2 Poly Vinyl Chloride (PVC) Pipe

PVC pipe and fittings may be used for roof leader collection system. Submit the pipe manufacturer's resin certification, indicating the cell classification of PVC used to manufacture the pipe, prior to installation of the pipe.

2.1.2.1 Type PSM PVC Pipe

ASTM D3034, Type PSM, maximum SDR 35, produced from PVC certified by the Manufacturer as meeting the requirements of ASTM D1784, minimum cell class 12454-B.

2.1.3 Polyethylene (PE) Pipe

2.1.3.1 Corrugated PE Pipe (Double Wall)

AASHTO M 294, Type S. For slow crack growth resistance, acceptance of resins shall be determined by using the notched constant ligament-stress (NCLS) test meeting the requirements of AASHTO M 294. Pipe walls shall have minimum OD (inch) 22 inches for 18 inch nominal pipe and 28 inches for 24 inch nominal pipe.

2.2 DRAINAGE STRUCTURES

2.2.1 Precast Reinforced Concrete Box

Manufactured in accordance with and conforming to ASTM C1433.

2.3 MISCELLANEOUS MATERIALS

2.3.1 Precast Reinforced Concrete Manholes

Conform to ASTM C478. Joints between precast concrete risers and tops shall be made with flexible watertight, rubber-type gaskets meeting the requirements of paragraph JOINTS.

2.3.2 Frame and Cover for Gratings

Submit certification on the ability of frame and cover or gratings to carry the imposed live load. Frame and cover for gratings shall be cast gray iron, ASTM A48/A48M, Class 35B; cast ductile iron, ASTM A536, Grade 65-45-12; or cast aluminum, ASTM B26/B26M, Alloy 356.O-T6. Weight, shape, size, and waterway openings for grates and curb inlets shall be as indicated on the plans. The word "Storm Sewer" shall be stamped or cast into covers so that it is plainly visible.

2.3.3 Joints

2.3.3.1 Flexible Watertight Joints

a. Flexible watertight joints shall be made with plastic or rubber-type gaskets for concrete pipe and with factory-fabricated resilient materials for clay pipe. The design of joints and the physical requirements for preformed flexible joint sealants shall conform to ASTM C990, and rubber-type gaskets shall conform to ASTM C443. Factory-fabricated resilient joint materials shall conform to ASTM C425. Gaskets shall have not more than one factory-fabricated splice, except that two factory-fabricated splices of the rubber-type gasket are permitted if the nominal diameter of the pipe being gasketed exceeds 54 inches.

b. Rubber gaskets shall comply with the oil resistant gasket requirements of ASTM C443. Certified copies of test results shall be delivered to the Contracting Officer before gaskets or jointing materials are installed. Alternate types of watertight joint may be furnished, if specifically approved.

2.3.3.2 External Sealing Bands

Requirements for external sealing bands shall conform to ASTM C877.

2.3.3.3 Flexible Watertight, Gasketed Joints

a. Gaskets: When infiltration or exfiltration is a concern for pipe lines, the couplings may be required to have gaskets. The closed-cell expanded rubber gaskets shall be a continuous band approximately 7 inches wide and approximately 3/8 inch thick, meeting the requirements of ASTM D1056, Type 2, and shall have a quality retention rating of not less than 70 percent when tested for weather resistance by ozone chamber exposure, Method B of ASTM D1171. Rubber O-ring gaskets shall be 13/16 inch in diameter for pipe diameters of 36 inches or smaller and 7/8 inch in diameter for larger pipe having 1/2 inch deep end corrugation. Rubber O-ring gaskets shall be 1-3/8 inches in diameter for pipe having 1 inch deep end corrugations. O-rings shall meet the requirements of ASTM C990 or ASTM C443. Preformed flexible joint sealants shall conform to ASTM C990, Type B.

2.3.3.4 PVC Plastic Pipes

Joints shall be solvent cement or elastomeric gasket type in accordance with the specification for the pipe and as recommended by the pipe manufacturer.

2.3.3.5 Corrugated PE Plastic Pipe

Pipe joints shall be water tight and shall conform to the requirements in AASHTO M 294. Water tight joints shall be made using a PE coupling and rubber gaskets as recommended by the pipe manufacturer. Rubber gaskets shall conform to ASTM F477.

2.4 RESILIENT CONNECTORS

Flexible, watertight connectors used for connecting pipe to manholes and inlets shall conform to ASTM C923.

2.5 EROSION CONTROL RIP RAP

Provide non-erodible rock not exceeding 15 inches in its greatest dimension and choked with sufficient small rocks to provide a dense mass with a minimum thickness of 8 inches.

PART 3 EXECUTION

3.1 INSTALLATION OF PIPE CULVERTS, STORM DRAINS, AND DRAINAGE STRUCTURES

Excavation of trenches, and for appurtenances and backfilling for culverts and storm drains, shall be in accordance with the applicable portions of Section 31 00 00 EARTHWORK,.

3.1.1 Trenching

The width of trenches at any point below the top of the pipe shall be not greater than the outside diameter of the pipe plus 12 inches to permit satisfactory jointing and thorough tamping of the bedding material under and around the pipe. Sheeting and bracing, where required, shall be placed within the trench width as specified, without any overexcavation. Where trench widths are exceeded, redesign with a resultant increase in cost of stronger pipe or special installation procedures will be necessary. Cost of this redesign and increased cost of pipe or installation shall be borne by the Contractor without additional cost to the Government.

3.1.2 Removal of Rock

Rock in either ledge or boulder formation shall be replaced with suitable materials to provide a compacted earth cushion having a thickness between unremoved rock and the pipe of at least 8 inches or 1/2 inch for each foot of fill over the top of the pipe, whichever is greater, but not more than three-fourths the nominal diameter of the pipe. Where bell-and-spigot pipe is used, the cushion shall be maintained under the bell as well as under the straight portion of the pipe. Rock excavation shall be as specified and defined in Section 31 00 00 EARTHWORK.

3.1.3 Removal of Unstable Material

Where wet or otherwise unstable soil incapable of properly supporting the pipe, as determined by the Contracting Officer, is unexpectedly encountered in the bottom of a trench, such material shall be removed to the depth required and replaced to the proper grade with select granular material, compacted as provided in paragraph BACKFILLING. When removal of unstable material is due to the fault or neglect of the Contractor while performing shoring and sheeting, water removal, or other specified requirements, such removal and replacement shall be performed at no additional cost to the Government.

3.2 BEDDING

The bedding surface for the pipe shall provide a firm foundation of uniform density throughout the entire length of the pipe.

3.2.1 Concrete Pipe Requirements

When no bedding class is specified or detailed on the drawings, concrete pipe shall be bedded in granular material minimum 4 inch in depth in trenches with soil foundation. Depth of granular bedding in trenches with rock foundation shall be 1/2 inch in depth per foot of depth of fill, minimum depth of bedding shall be 8 inch up to maximum depth of 24 inches. The middle third of the granular bedding shall be loosely placed. Bell holes and depressions for joints shall be removed and formed so entire barrel of pipe is uniformly supported. The bell hole and depressions for the joints shall be not more than the length, depth, and width required for properly making the particular type of joint.

3.2.2 Plastic Pipe

Bedding for PVC and PEpipe shall meet the requirements of ASTM D2321. Use Class IB or II material for bedding, haunching, and initial backfill. Use Class I, II, or III material for PP pipe bedding, haunching and initial backfill.

3.3 PLACING PIPE

Each pipe shall be thoroughly examined before being laid; defective or damaged pipe shall not be used. Plastic pipe, excluding SRPE pipe shall be protected from exposure to direct sunlight prior to laying, if necessary to maintain adequate pipe stiffness and meet installation deflection requirements. Pipelines shall be laid to the grades and alignment indicated. Proper facilities shall be provided for lowering sections of pipe into trenches. Lifting lugs in vertically elongated pipe shall be placed in the same vertical plane as the major axis of the pipe. Pipe shall not be laid in water, and pipe shall not be laid when trench conditions or weather are unsuitable for such work. Diversion of drainage or dewatering of trenches during construction shall be provided as necessary. Deflection of installed flexible pipe shall not exceed the following limits:

TYPE OF PIPE	MAXIMUM ALLOWABLE DEFLECTION (percent)
Plastic PVC or PE	5

Note post installation requirements of paragraph DEFLECTION TESTING in PART 3 of this specification for all pipe products including deflection testing requirements for flexible pipe.

3.3.1 Concrete, PVC, Pipe

Laying shall proceed upgrade with spigot ends of bell-and-spigot pipe and tongue ends of tongue-and-groove pipe pointing in the direction of the flow.

3.4 JOINTING

3.4.1 Concrete Pipe

3.4.1.1 Flexible Watertight Joints

Gaskets and jointing materials shall be as recommended by the particular manufacturer in regard to use of lubricants, cements, adhesives, and other special installation requirements. Surfaces to receive lubricants, cements, or adhesives shall be clean and dry. Gaskets and jointing materials shall be affixed to the pipe not more than 24 hours prior to the installation of the pipe, and shall be protected from the sun, blowing dust, and other deleterious agents at all times. Gaskets and jointing materials shall be inspected before installing the pipe; any loose or improperly affixed gaskets and jointing materials shall be removed and replaced. The pipe shall be aligned with the previously installed pipe, and the joint pushed home. If, while the joint is being made the gasket becomes visibly dislocated the pipe shall be removed and the joint remade.

3.5 DRAINAGE STRUCTURES

3.5.1 Manholes and Inlets

Construction shall be of reinforced concrete, plain concrete, brick, precast reinforced concrete, precast concrete segmental blocks, prefabricated corrugated metal, or bituminous coated corrugated metal; complete with frames and covers or gratings; and with fixed galvanized steel ladders where indicated. Pipe studs and junction chambers of prefabricated corrugated metal manholes shall be fully bituminous-coated and paved when the connecting branch lines are so treated. Pipe connections to concrete manholes and inlets shall be made with flexible, watertight connectors.

3.5.2 Walls and Headwalls

Construction shall be as indicated.

3.6 BACKFILLING

3.6.1 Backfilling Pipe in Trenches

After the pipe has been properly bedded, selected material from excavation or borrow, at a moisture content that will facilitate compaction, shall be placed along both sides of pipe in layers not exceeding 6 inches in compacted depth. The backfill shall be brought up evenly on both sides of pipe for the full length of pipe. The fill shall be thoroughly compacted under the haunches of the pipe. Each layer shall be thoroughly compacted with mechanical tampers or rammers. This method of filling and compacting shall continue until the fill has reached an elevation equal to the midpoint (spring line) of concrete pipe or has reached an elevation of at least 12 inches above the top of the pipe for flexible pipe. The remainder of the trench shall be backfilled and compacted by spreading and rolling or compacted by mechanical rammers or tampers in layers not exceeding 12 inches. Tests for density shall be made as necessary to ensure conformance to the compaction requirements specified below. Where it is necessary, in the opinion of the Contracting Officer, that sheeting or portions of bracing used be left in place, the contract will be adjusted accordingly. Untreated sheeting shall not be left in place beneath structures or pavements.

3.6.2 Movement of Construction Machinery

When compacting by rolling or operating heavy equipment parallel with the pipe, displacement of or injury to the pipe shall be avoided. Movement of construction machinery over a culvert or storm drain at any stage of construction shall be at the Contractor's risk. Any damaged pipe shall be repaired or replaced.

3.6.3 Compaction

3.6.3.1 General Requirements

Cohesionless materials include gravels, gravel-sand mixtures, sands, and gravelly sands. Cohesive materials include clayey and silty gravels, gravel-silt mixtures, clayey and silty sands, sand-clay mixtures, clays, silts, and very fine sands. When results of compaction tests for moisture-density relations are recorded on graphs, cohesionless soils will show straight lines or reverse-shaped moisture-density curves, and cohesive soils will show normal moisture-density curves.

3.6.3.2 Minimum Density

Backfill over and around the pipe and backfill around and adjacent to drainage structures shall be compacted at the approved moisture content to the following applicable minimum density, which will be determined as specified below.

a. Under paved roads, streets, parking areas, and similar-use pavements including adjacent shoulder areas, the density shall be not less than 90 percent of maximum density for cohesive material and 95 percent of maximum density for cohesionless material, up to the elevation where requirements for pavement subgrade materials and compaction shall control.

b. Under unpaved or turfed traffic areas, density shall not be less than 90 percent of maximum density for cohesive material and 95 percent of maximum density for cohesionless material.

c. Under nontraffic areas, density shall be not less than that of the surrounding material.

3.7 FIELD QUALITY CONTROL

3.7.1 Tests

Testing is the responsibility of the Contractor. Perform all testing and retesting at no additional cost to the Government.

3.7.1.1 Determination of Density

Testing shall be performed by an approved commercial testing laboratory or by the Contractor subject to approval. Tests shall be performed in sufficient number to ensure that specified density is being obtained. Laboratory tests for moisture-density relations shall be made in accordance with ASTM D1557 except that mechanical tampers may be used provided the results are correlated with those obtained with the specified hand tamper. Field density tests shall be determined in accordance with ASTM D2167 or ASTM D6938. When ASTM D6938 is used, the calibration curves shall be checked and adjusted, if necessary, using the sand cone method as described in paragraph Calibration of the referenced publications. ASTM D6938 results in a wet unit weight of soil and ASTM D6938 shall be used to determine the moisture content of the soil. The calibration curves furnished with the moisture gauges shall be checked along with density calibration checks as described in ASTM D6938. Test results shall be furnished the Contracting Officer. The calibration checks of both the density and moisture gauges shall be made at the beginning of a job on each different type of material encountered and at intervals as directed.

3.7.2 Inspection

3.7.2.1 Post-Installation Inspection

Visually inspect each segment of concrete pipe for alignment, settlement, joint separations, soil migration through the joint, cracks, buckling, bulging and deflection.

3.7.2.1.1 Concrete

Cracks with a width greater than 0.01 inches. An engineer must evaluate all pipes with cracks with a width greater than 0.01 inches but less than 0.10 inches to determine if any remediation or repair is required.

3.7.2.1.2 Flexible Pipe

Check each flexible pipe (PE or PVC) for rips, tears, joint separations, soil migration through the joint, cracks, localized bucking, bulges, settlement and alignment.

-- End of Section --

SECTION 33 71 02

UNDERGROUND ELECTRICAL DISTRIBUTION
08/21

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO)

AASHTO HB-17	(2002; Errata 2003; Errata 2005, 17th Edition) Standard Specifications for Highway Bridges

AMERICAN CONCRETE INSTITUTE (ACI)

ACI 318M	(2014; ERTA 2015) Building Code Requirements for Structural Concrete & Commentary
ACI SP-66	(2004) ACI Detailing Manual

ASTM INTERNATIONAL (ASTM)

ASTM B1	(2013) Standard Specification for Hard-Drawn Copper Wire
ASTM B3	(2013) Standard Specification for Soft or Annealed Copper Wire
ASTM B8	(2011; R 2017) Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft
ASTM C32	(2023) Standard Specification for Sewer and Manhole Brick (Made from Clay or Shale)
ASTM C139	(2022) Standard Specification for Concrete Masonry Units for Construction of Catch Basins and Manholes
ASTM C309	(2019) Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete
ASTM C478	(2018) Standard Specification for Circular Precast Reinforced Concrete Manhole Sections
ASTM C478M	(2018) Standard Specification for Precast Reinforced Concrete Manhole Sections (Metric)

ASTM C857	(2016) Standard Practice for Minimum Structural Design Loading for Underground Precast Concrete Utility Structures
ASTM C990	(2009; R 2019) Standard Specification for Joints for Concrete Pipe, Manholes, and Precast Box Sections Using Preformed Flexible Joint Sealants
ASTM C990M	(2009; R 2019) Standard Specification for Joints for Concrete Pipe, Manholes, and Precast Box Sections Using Preformed Flexible Joint Sealants (Metric)
ASTM F2160	(2022a) Standard Specification for Solid Wall High Density Polyethylene (HDPE) Conduit Based on Controlled Outside Diameter (OD)

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 81	(2012) Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System
IEEE C2	(2023) National Electrical Safety Code
IEEE Stds Dictionary	(2009) IEEE Standards Dictionary: Glossary of Terms & Definitions

INTERNATIONAL ELECTRICAL TESTING ASSOCIATION (NETA)

NETA ATS	(2021) Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

ANSI C119.1	(2023) Electric Connectors - Sealed Insulated Underground Connector Systems Rated 600 Volts
NEMA RN 1	(2005; R 2013) Polyvinyl-Chloride (PVC) Externally Coated Galvanized Rigid Steel Conduit and Intermediate Metal Conduit
NEMA TC 2	(2020) Standard for Electrical Polyvinyl Chloride (PVC) Conduit
NEMA TC 3	(2021) Polyvinyl Chloride (PVC) Fittings for Use With Rigid PVC Conduit and Tubing
NEMA TC 7	(2021) Smooth-Wall Coilable and Straight Electrical Polyethylene Conduit
NEMA TC 9	(2020) Standard for Fittings for Polyvinyl Chloride (PVC) Plastic Utilities Duct for Underground Installation

NEMA WC 70	(2021) Power Cable Rated 2000 Volts or Less for the Distribution of Electrical Energy

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2023; ERTA 4 2023) National Electrical Code

SOCIETY OF CABLE TELECOMMUNICATIONS ENGINEERS (SCTE)

ANSI/SCTE 77	(2013) Specification for Underground Enclosure Integrity

TELECOMMUNICATIONS INDUSTRY ASSOCIATION (TIA)

TIA-758	(2012b) Customer-Owned Outside Plant Telecommunications Infrastructure Standard

U.S. DEPARTMENT OF AGRICULTURE (USDA)

RUS Bull 1751F-644	(2002) Underground Plant Construction

UNDERWRITERS LABORATORIES (UL)

UL 6	(2022) UL Standard for Safety Electrical Rigid Metal Conduit-Steel
UL 44	(2018; Reprint May 2021) UL Standard for Safety Thermoset-Insulated Wires and Cables
UL 83	(2017; Reprint Mar 2020) UL Standard for Safety Thermoplastic-Insulated Wires and Cables
UL 94	(2023; Reprint May 2023) UL Standard for Safety Tests for Flammability of Plastic Materials for Parts in Devices and Appliances
UL 467	(2022) UL Standard for Safety Grounding and Bonding Equipment
UL 486A-486B	(2018; Reprint Jul 2023) UL Standard for Safety Wire Connectors
UL 510	(2020; Dec 2022) UL Standard for Safety Polyvinyl Chloride, Polyethylene and Rubber Insulating Tape
UL 514B	(2012; Reprint May 2020) Conduit, Tubing and Cable Fittings
UL 651	(2011; Reprint May 2022) UL Standard for Safety Schedule 40, 80, Type EB and A Rigid PVC Conduit and Fittings
UL 854	(2020; Reprint Jan 2022) Standard for

	Service-Entrance Cables
UL 1242	(2006; Reprint Apr 2022) UL Standard for Safety Electrical Intermediate Metal Conduit -- Steel

1.2 SYSTEM DESCRIPTION

Items provided under this section must be specifically suitable for the following service conditions.

a. Altitude _500_feet.

b. Ambient Temperature 98 degrees.

c. Frequency 60

1.3 DEFINITIONS

a. Unless otherwise specified or indicated, electrical and electronics terms used in these specifications, and on the drawings, are as defined in IEEE Stds Dictionary.

b. In the text of this section, the words conduit and duct are used interchangeably and have the same meaning.

c. In the text of this section, "medium voltage cable splices," and "medium voltage cable joints" are used interchangeably and have the same meaning.

1.4 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. When used, a code following the "G" classification identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Precast Underground Structures; G

SD-03 Product Data

Precast Concrete Structures; G

Sealing Material

Pulling-In Irons

Manhole Frames and Covers; G

Cable Supports (racks, arms and insulators); G

SD-06 Test Reports

Directional Boring Certificate of Conformance; G

1.5 QUALITY ASSURANCE

1.5.1 Precast Underground Structures

Submittal required for each type used. Provide calculations and drawings for precast manholes and handholes bearing the seal of a registered professional engineer including:

a. Material description (i.e., f'c and Fy)

b. Manufacturer's printed assembly and installation instructions

c. Design calculations

d. Reinforcing shop drawings in accordance with ACI SP-66

e. Plans and elevations showing opening and pulling-in iron locations and details

1.5.2 Directional Boring Certificate of Conformance

Provide certification of compliance with the registered Professional Engineer's design requirements for each directional bore, including: HDPE conduit size and type, bend radius, elevation changes, vertical and horizontal path deviations, conductor size and type and any conductor derating due to depth of conduit. Record location and depth of all directional-bore installed HDPE conduits using Global Positioning System (GPS) recording means with "resource grade" accuracy.

1.5.3 Regulatory Requirements

In each of the publications referred to herein, consider the advisory provisions to be mandatory, as though the word, "must" had been substituted for "should" wherever it appears. Interpret references in these publications to the "authority having jurisdiction," or words of similar meaning, to mean the Contracting Officer. Equipment, materials, installation, and workmanship must be in accordance with the mandatory and advisory provisions of IEEE C2 and NFPA 70 unless more stringent requirements are specified or indicated.

1.5.4 Standard Products

Provide materials and equipment that are products of manufacturers regularly engaged in the production of such products which are of equal material, design and workmanship. Products must have been in satisfactory commercial or industrial use for 2 years prior to bid opening. The 2-year period must include applications of equipment and materials under similar circumstances and of similar size. The product must have been for sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 2-year period. Where two or more items of the same class of equipment are required, these items must be products of a single manufacturer; however, the component parts of the item need not be the products of the same manufacturer unless stated in this section.

1.5.4.1 Alternative Qualifications

Products having less than a 2-year field service record will be acceptable if a certified record of satisfactory field operation for not less than 6000 hours, exclusive of the manufacturers' factory or laboratory tests, is furnished.

1.5.4.2 Material and Equipment Manufacturing Date

Products manufactured more than 3 years prior to date of delivery to site are not acceptable, unless specified otherwise.

PART 2 PRODUCTS

2.1 CONDUIT, DUCTS, AND FITTINGS

2.1.1 Rigid Metal Conduit

UL 6.

2.1.1.1 Rigid Metallic Conduit, PVC Coated

NEMA RN 1, Type A40, except that hardness must be nominal 85 Shore A durometer, dielectric strength must be minimum 400 volts per mil at 60 Hz, and tensile strength must be minimum 3500 psi.

2.1.2 Intermediate Metal Conduit

UL 1242.

2.1.2.1 Intermediate Metal Conduit, PVC Coated

NEMA RN 1, Type A40, except that hardness must be nominal 85 Shore A durometer, dielectric strength must be minimum 400 volts per mil at 60 Hz, and tensile strength must be minimum 3500 psi.

2.1.3 Plastic Conduit for Direct Burial and Riser Applications

UL 651 and NEMA TC 2, EPC-40 or EPC-80. (See additional requirements in Specification section 33 82 00 Telecommunications Outside Plant.)

2.1.4 Plastic Duct for Concrete Encasement

Provide Type EPC-40 per UL 651 and NEMA TC 2.

2.1.5 High Density Polyethylene (HDPE) Electrical Conduit for Directional Boring

Smoothwall, approved/listed for directional boring, minimum Schedule 80, ASTM F2160, NEMA TC 7.

2.1.6 Duct Sealant

UL 94, Class HBF. Provide high-expansion urethane foam duct sealant that expands and hardens to form a closed, chemically and water resistant, rigid structure. Sealant must be compatible with common cable and wire jackets and capable of adhering to metals, plastics and concrete. Sealant must be capable of curing in temperature ranges of 35 degrees F to 95 degrees F. Cured sealant must withstand temperature ranges of -20 degrees F to 200 degrees F without loss of function.

2.1.7 Fittings

2.1.7.1 Metal Fittings

UL 514B.

2.1.7.2 PVC Conduit Fittings

UL 514B, UL 651NEMA TC 3.

2.1.7.3 PVC Duct Fittings

NEMA TC 9.

2.2 LOW VOLTAGE INSULATED CONDUCTORS AND CABLES

Insulated conductors must be rated 600 volts and conform to the requirements of NFPA 70, including listing requirements, or in accordance with NEMA WC 70. Wires and cables manufactured more than 24 months prior to date of delivery to the site are not acceptable. Service entrance conductors must conform to UL 854, type USE.

2.2.1 Conductor Types

Cable and duct sizes indicated are for copper conductors and THHN/THWN unless otherwise noted. Conductors No. 10 AWG and smaller must be solid. Conductors No. 8 AWG and larger must be stranded. All conductors must be copper.

2.2.2 Conductor Material

Unless specified or indicated otherwise or required by NFPA 70, wires in conduit, other than service entrance, must be 600-volt, Type THWN/THHN conforming to UL 83 or Type XHHW or RHW conforming to UL 44. Copper conductors must be annealed copper complying with ASTM B3 and ASTM B8.

2.2.3 In Duct

Cables must be single-conductor cable.

2.2.4 Cable Marking

Insulated conductors must have the date of manufacture and other identification imprinted on the outer surface of each cable at regular intervals throughout the cable length.

Identify each cable by means of a fiber, laminated plastic, or non-ferrous metal tags in each manhole, handhole, junction box, and each terminal. Each tag must contain the following information; cable type, conductor size, circuit number, circuit voltage, cable destination and phase identification.

Color code conductors. Provide conductor identification within each enclosure where a tap, splice, or termination is made. Conductor identification must be by color-coded insulated conductors, plastic-coated self-sticking printed markers, colored nylon cable ties and plates, heat shrink type sleeves,or colored electrical tape. Properly identify control circuit terminations. Color must be green for grounding conductors and white for neutrals; except where neutrals of more than one system are installed in same raceway or box, other neutrals may be white with a different colored (not green) stripe for each. Color of ungrounded conductors in different voltage systems are as follows:

a. 208/120 volt, three-phase

   (1) Phase A - black

   (2) Phase B - red

   (3) Phase C - blue

b. On three-phase, four-wire delta system, high leg must be orange, as required by NFPA 70.

2.3 LOW VOLTAGE WIRE CONNECTORS AND TERMINALS

Provide a uniform compression over the entire conductor contact surface. Use solderless terminal lugs on stranded conductors.

a. For use with copper conductors: UL 486A-486B.

2.4 LOW VOLTAGE SPLICES

Provide splices in conductors with a compression connector on the conductor and by insulating and waterproofing using one of the following methods which are suitable for continuous submersion in water and comply with ANSI C119.1.

2.4.1 Heat Shrinkable Splice

Provide heat shrinkable splice insulation by means of a thermoplastic adhesive sealant material applied in accordance with the manufacturer's written instructions.

2.4.2 Cold Shrink Rubber Splice

Provide a cold-shrink rubber splice which consists of EPDM rubber tube which has been factory stretched onto a spiraled core which is removed during splice installation. The installation must not require heat or flame, or any additional materials such as covering or adhesive. It must be designed for use with inline compression type connectors, or indoor, outdoor, direct-burial or submerged locations.

2.5 TELECOMMUNICATIONS CABLING

Provide telecommunications cabling in accordance with Section 33 82 00 TELECOMMUNICATIONS OUTSIDE PLANT (OSP).

2.6 TAPE

2.6.1 Insulating Tape

UL 510, plastic insulating tape, capable of performing in a continuous temperature environment of 80 degrees C.

2.6.2 Buried Warning and Identification Tape

Provide detectable tape in accordance with Section 31 00 00 EARTHWORK.

2.7 PULL ROPE

Plastic or flat pull line (bull line) having a minimum tensile strength of 200 pounds.

2.8 GROUNDING AND BONDING

2.8.1 Driven Ground Rods

Provide copper-clad steel ground rods conforming to UL 467 not less than 3/4 inch in diameter by 10 feet in length. Sectional type rods may be used for rods 20 feet or longer.

2.8.2 Grounding Conductors

Stranded-bare copper conductors must conform to ASTM B8, Class B, soft-drawn unless otherwise indicated. Solid-bare copper conductors must conform to ASTM B1 for sizes No. 8 and smaller. Insulated conductors must be of the same material as phase conductors and green color-coded, except that conductors must be rated no more than 600 volts. Aluminum is not acceptable.

2.9 CAST-IN-PLACE CONCRETE

Provide concrete in accordance with Section 03 30 00 CAST-IN-PLACE CONCRETE. In addition, provide concrete for encasement of underground ducts with 3000 psi minimum 28-day compressive strength. Concrete associated with electrical work for other than encasement of underground ducts must be 4000 psi minimum 28-day compressive strength unless specified otherwise.

2.10 UNDERGROUND STRUCTURES

Provide precast concrete underground structures or standard type cast-in-place manhole types as indicated, conforming to ASTM C857 and ASTM C478. Top, walls, and bottom must consist of reinforced concrete. Walls and bottom must be of monolithic concrete construction. Locate duct entrances and windows near the corners of structures to facilitate cable racking. Covers must fit the frames without undue play. Form steel and iron to shape and size with sharp lines and angles. Castings must be free from warp and blow holes that may impair strength or appearance. Exposed metal must have a smooth finish and sharp lines and arises. Provide necessary lugs, rabbets, and brackets. Set pulling-in irons and other built-in items in place before depositing concrete. Install a pulling-in iron in the wall opposite each duct line entrance. Cable racks, including rack arms and insulators, must be adequate to accommodate the cable.

2.10.1 Cast-In-Place Concrete Structures

Concrete must conform to Section 03 30 00 CAST-IN-PLACE CONCRETE. Construct walls on a footing of cast-in-place concrete except that precast concrete base sections may be used for precast concrete manhole risers. Concrete block must conform to ASTM C139 and Section 04 20 00, MASONRY.

2.10.2 Precast Concrete Structures, Risers and Tops

Precast concrete underground structures may be provided in lieu of cast-in-place subject to the requirements specified below. Precast units must be the product of a manufacturer regularly engaged in the manufacture of precast concrete products, including precast manholes.

2.10.2.1 General

Precast concrete structures must have the same accessories and facilities as required for cast-in-place structures. Likewise, precast structures must have plan area and clear heights not less than those of cast-in-place structures. Concrete materials and methods of construction must be the same as for cast-in-place concrete construction, as modified herein. Slope in floor may be omitted provided precast sections are poured in reinforced steel forms. Concrete for precast work must have a 28-day compressive strength of not less than 4000 psi. Structures may be precast to the design and details indicated for cast-in-place construction, precast monolithically and placed as a unit, or structures may be assembled sections, designed and produced by the manufacturer in accordance with the requirements specified. Structures must be identified with the manufacturer's name embedded in or otherwise permanently attached to an interior wall face.

2.10.2.2 Design for Precast Structures

ACI 318M. In the absence of detailed on-site soil information, design for the following soil parameters/site conditions:

a. Angle of Internal Friction (phi) = 30 degrees

b. Unit Weight of Soil (Dry) = 110 pcf, (Saturated) = 130 pcf

c. Coefficient of Lateral Earth Pressure (Ka) = 0.33

d. Ground Water Level = 3 feet below ground elevation

e. Vertical design loads must include full dead, superimposed dead, and live loads including a 30 percent magnification factor for impact. Live loads must consider all types and magnitudes of vehicular (automotive, industrial, or aircraft) traffic to be encountered. The minimum design vertical load must be for H20 highway loading per AASHTO HB-17.

f. Horizontal design loads must include full geostatic and hydrostatic pressures for the soil parameters, water table, and depth of installation to be encountered. Also, horizontal loads imposed by adjacent structure foundations, and horizontal load components of vertical design loads, including impact, must be considered, along with a pulling-in iron design load of 6000 pounds.

g. Each structural component must be designed for the load combination and positioning resulting in the maximum shear and moment for that particular component.

h. Design must also consider the live loads induced in the handling, installation, and backfilling of the manholes. Provide lifting devices to ensure structural integrity during handling and installation.

2.10.2.3 Construction

Provide a uniform thickness for structure top, bottom, and wall not less than 6 inches. Thin-walled knock-out panels for designed or future duct bank entrances are not permitted. Provide quantity, size, and location of duct bank entrance windows as directed, and cast completely open by the precaster. Size of windows must exceed the nominal duct bank envelope dimensions by at least 12 inches vertically and horizontally to preclude in-field window modifications made necessary by duct bank misalignment. However, the sides of precast windows must be a minimum of 6 inches from the inside surface of adjacent walls, floors, or ceilings. Form the perimeter of precast window openings to have a keyed or inward flared surface to provide a positive interlock with the mating duct bank envelope. Provide welded wire fabric reinforcing through window openings for in-field cutting and flaring into duct bank envelopes. Provide additional reinforcing steel comprised of at least two No. 4 bars around window openings. Provide drain sumps a minimum of 12 inches in diameter and 4 inches deep for precast structures.

2.10.2.4 Joints

Provide tongue-and-groove joints on mating edges of precast components. Shiplap joints are not allowed. Design joints to firmly interlock adjoining components and to provide waterproof junctions and adequate shear transfer. Seal joints watertight using preformed plastic strip conforming to ASTM C990. Install sealing material in strict accordance with the sealant manufacturer's printed instructions. Provide waterproofing at conduit/duct entrances into structures, and where access frame meets the top slab, provide continuous grout seal.

2.10.3 Man Mainenance Hole

See Specification section 33 82 00 Telecommunications Outside Plant.

2.10.4 Handhole Frames and Covers

Frames and covers of steel must be welded by qualified welders in accordance with standard commercial practice. Provide rolled-steel floor plate covers having an approved antislip surface. Hinges must be of stainless steel with bronze hinge pin 5 by 5 inches by approximately 3/16 inch thick, without screw holes, and must be for full surface application by fillet welding. Hinges must have nonremovable pins and five knuckles. The surfaces of plates under hinges must be true after the removal of raised antislip surface, by grinding or other approved method.

2.10.5 Brick for Manhole Collar

Provide sewer and manhole brick conforming to ASTM C32, Grade MS.

2.10.6 Composite/Fiberglass Handholes and Covers

ANSI/SCTE 77. Provide handholes and covers of polymer concrete, reinforced with heavy weave fiberglass with a design load (Tier rating) appropriate for or greater than the intended use. All covers are required to have the Tier level rating embossed on the surface which must not exceed the design load of the box.

2.11 CABLE SUPPORTS (RACKS, ARMS, AND INSULATORS)

Zinc coat the metal portion of racks and arms after fabrication.

2.11.1 Cable Rack Stanchions

The wall bracket or stanchion must be 4 inches by approximately 1-1/2 inch by 3/16 inch channel steel, or 4 inches by approximately 1 inch glass-reinforced nylon with recessed bolt mounting holes, 48 inches long (minimum) in manholes. Space slots for mounting cable rack arms at 8 inch intervals.

2.11.2 Rack Arms

Cable rack arms must be steel or malleable iron or glass reinforced nylon and must be of the removable type. Rack arm length must be a minimum of 8 inches and a maximum of 12 inches.

2.11.3 Insulators

Insulators for metal rack arms must be dry-process glazed porcelain. Insulators are not required for nylon arms.

PART 3 EXECUTION

3.1 INSTALLATION

Install equipment and devices in accordance with the manufacturer's published instructions and with the requirements and recommendations of NFPA 70. In addition to these requirements, install telecommunications in accordance with TIA-758 and RUS Bull 1751F-644.

3.2 CABLE INSPECTION

Inspect each cable reel for correct storage positions, signs of physical damage, and broken end seals prior to installation. If end seal is broken, remove moisture from cable prior to installation in accordance with the cable manufacturer's recommendations.

3.3 UNDERGROUND FEEDERS SUPPLYING BUILDINGS

Terminate underground feeders supplying building at a point 5 feet outside the building and projections thereof, except that conductors must be continuous to the terminating point indicated. Coordinate connections of the feeders to the service entrance equipment with Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Provide PVC, Type EPC-40 conduit from the supply equipment to a point 5 feet outside the building and projections thereof. Protect ends of underground conduit with plastic plugs until connections are made.

3.4 UNDERGROUND STRUCTURE CONSTRUCTION

Provide standard type cast-in-place construction as specified herein and as indicated, or precast construction as specified herein. Horizontal concrete surfaces of floors must have a smooth trowel finish. Cure concrete by applying two coats of white pigmented membrane forming-curing compound in strict accordance with the manufacturer's printed instructions, except that precast concrete may be steam cured. Curing compound must conform to ASTM C309. Locate duct entrances and windows in the center of end walls (shorter) and near the corners of sidewalls (longer) to facilitate cable racking and splicing. Covers for underground structures must fit the frames without undue play. Form steel and iron to shape and size with sharp lines and angles. Castings must be free from warp and blow holes that may impair strength or appearance. Exposed metal must have a smooth finish and sharp lines and arises. Provide necessary lugs, rabbets, and brackets. Set pulling-in irons and other built-in items in place before depositing concrete. Manhole locations, as indicated, are approximate. Coordinate exact manhole locations with other utilities and finished grading and paving.

3.4.1 Precast Concrete Construction

Set commercial precast structures on 6 inches of level, 90 percent compacted granular fill, 3/4 inch to 1 inch size, extending 12 inches beyond the structure on each side. Compact granular fill by a minimum of four passes with a plate type vibrator. Installation must additionally conform to the manufacturer's instructions.

3.4.2 Pulling-In Irons

Provide steel bars bent as indicated, and cast in the walls and floors. Alternatively, pipe sleeves may be precast into the walls and floors where required to accept U-bolts or other types of pulling-in devices possessing the strengths and clearances stated herein. The final installation of pulling-in devices must be made permanent. Cover and seal exterior projections of thru-wall type pulling-in devices with an appropriate protective coating. In the floor, locate the irons a minimum of 6 inches from the edge of the sump, and in the walls, locate the irons within 6 inches of the projected center of the duct bank pattern or precast window in the opposite wall. However, the pulling-in iron must not be located within 6 inches of an adjacent interior surface, or duct or precast window located within the same wall as the iron. If a pulling-in iron cannot be located directly opposite the corresponding duct bank or precast window due to this clearance limitation, locate the iron directly above or below the projected center of the duct bank pattern or precast window the minimum distance required to preserve the 6 inch clearance previously stated. In the case of directly opposing precast windows, pulling-in irons consisting of a 3 foot length of No. 5 reinforcing bar, formed into a hairpin, may be cast-in-place within the precast windows simultaneously with the end of the corresponding duct bank envelope. Irons installed in this manner must be positioned directly in line with, or when not possible, directly above or below the projected center of the duct bank pattern entering the opposite wall, while maintaining a minimum clear distance of 3 inches from any edge of the cast-in-place duct bank envelope or any individual duct. Pulling-in irons must have a clear projection into the structure of approximately 4 inches and must be designed to withstand a minimum pulling-in load of 6000 pounds. Hot-dip galvanize irons after fabrication.

3.4.3 Cable Racks, Arms and Insulators

Cable racks, arms and insulators must be sufficient to accommodate the cables. Space racks in power manholes not more than 3 feet apart, and provide each manhole wall with a minimum of two racks. Space racks in signal manholes not more than 16 1/2 inches apart with the end rack being no further than 12 inches from the adjacent wall. Methods of anchoring cable racks are as follows:

a. Provide a 5/8 inch diameter by 5 inch long anchor bolt with 3 inch foot cast in structure wall with 2 inch protrusion of threaded portion of bolt into structure. Provide 5/8 inch steel square head nut on each anchor bolt. Coat threads of anchor bolts with suitable coating immediately prior to installing nuts.

b. Provide concrete channel insert with a minimum load rating of 800 pounds per foot. Insert channel must be steel of the same length as "vertical rack channel;" and cast flush in structure wall. Provide 5/8 inch steel nuts in channel insert to receive 5/8 inch diameter by 3 inch long steel, square head anchor bolts.

c. Provide concrete "spot insert" at each anchor bolt location, cast flush in structure wall. Each insert must have minimum 800 pound load rating. Provide 5/8 inch diameter by 3 inch long steel, square head anchor bolt at each anchor point. Coat threads of anchor bolts with suitable coating immediately prior to installing bolts.

3.4.4 Field Painting

Clean cast-iron frames and covers not buried in concrete or masonry of mortar, rust, grease, dirt and other deleterious materials, and coat with bituminous paint.

3.5 UNDERGROUND CONDUIT AND DUCT SYSTEMS

3.5.1 Requirements

Run conduit in straight lines except where a change of direction is necessary. Provide numbers and sizes of ducts as indicated. Bond bare copper grounding conductor to ground rings (loops) in all manholes . Route grounding conductor into manholes with the duct bank (sleeving is not required). Ducts must have a continuous slope downward toward underground structures and away from buildings, laid with a minimum slope of 3 inches per 100 feet. Depending on the contour of the finished grade, the high-point may be at a terminal, a manhole, a handhole, or between manholes or handholes. Terminate all PVC conduit end points in utility holes, switching cabinets, transform handholes and buildings with end bells. The bell end of the conduits that enter manholes and handholes must be flush with the wall.

Perform changes in ductbank direction as follows:

a. Short-radius manufactured 90-degree duct bends may be used only for pole or equipment risers, unless specifically indicated as acceptable.

b. The minimum manufactured bend radius must be 18 inches for ducts of less than 3 inch diameter, and 36 inches for ducts 3 inches or greater in diameter.

c. As an exception to the bend radius required above, provide field manufactured longsweep bends having a minimum radius of 25 feet for a change of direction of more than 5 degrees, either horizontally or vertically, using a combination of curved and straight sections. Maximum manufactured curved sections allowed for use in field manufactured longsweep bend: 30 degrees.

3.5.2 Treatment

Keep ducts clean of concrete, dirt, or foreign substances during construction. Make field cuts requiring tapers with proper tools and match factory tapers. Use a coupling recommended by the duct manufacturer whenever an existing duct is connected to a duct of different material or shape. Store ducts to avoid warping and deterioration with ends sufficiently plugged to prevent entry of any water or solid substances. Thoroughly clean ducts before being laid. Store plastic ducts on a flat surface and protected from the direct rays of the sun.

3.5.3 Conduit Cleaning

As each conduit run is completed, for conduit sizes 3 inches and larger, draw a flexible testing mandrel approximately 12 inches long with a diameter less than the inside diameter of the conduit through the conduit. After which, draw a stiff bristle brush through until conduit is clear of particles of earth, sand and gravel; then immediately install conduit plugs. For conduit sizes less than 3 inches, draw a stiff bristle brush through until conduit is clear of particles of earth, sand and gravel; then immediately install conduit plugs.

3.5.4 Multiple Conduits

Separate multiple conduits by a minimum distance of 3 inches, except that light and power conduits must be separated from control, signal, and telephone conduits by a minimum distance of 12 inches. Stagger the joints of the conduits by rows (horizontally) and layers (vertically) to strengthen the conduit assembly. Provide plastic duct spacers that interlock vertically and horizontally. Spacer assembly must consist of base spacers, intermediate spacers, ties, and locking device on top to provide a completely enclosed and locked-in conduit assembly. Install spacers per manufacturer's instructions, but provide a minimum of two spacer assemblies per 10 feet of conduit assembly.

3.5.5 Conduit Plugs and Pull Rope

Provide new conduit indicated as being unused or empty with plugs on each end. Plugs must contain a weephole or screen to allow water drainage. Provide a plastic pull rope having 3 feet of slack at each end of unused or empty conduits.

3.5.6 Conduit and Duct Without Concrete Encasement

Depths to top of the conduit must be not less than 24 inches below finished grade. Provide not less than 3 inches clearance from the conduit to each side of the trench. Grade bottom of trench smooth; where rock, soft spots, or sharp-edged materials are encountered, excavate the bottom for an additional 3 inches, fill and tamp level with original bottom with sand or earth free from particles, that would be retained on a 1/4 inch sieve. The first 6 inch layer of backfill cover must be sand compacted as previously specified. The rest of the excavation must be backfilled and compacted in 3 to 6 inch layers. Provide color, type and depth of warning tape as specified in Section 31 00 00 EARTHWORK.

3.5.6.1 Encasement Under Roads and Structures

Under roads, paved areas, and railroad tracks, install conduits in concrete encasement of rectangular cross-section providing a minimum of 3 inch concrete cover around ducts. Extend concrete encasement at least 5 feet beyond the edges of paved areas and roads, and 12 feet beyond the rails on each side of railroad tracks. Depths to top of the concrete envelope must be not less than 24 inches below finished grade, and under railroad tracks not less than 50 inches below the top of the rails.

3.5.6.2 Directional Boring

HDPE conduits must be installed below the frostline and as specified herein.

For distribution voltages less than 1000 volts, depths to the top of the conduit must not be less than 48 inches in pavement- or non-pavement-covered areas. For branch circuit wiring less than 600 volts, depths to the top of the conduit must not be less than 24 inches in pavement- or non-pavement-covered areas.

3.6 CABLE PULLING

Test existing duct lines with a mandrel and thoroughly swab out to remove foreign material before pulling cables.

3.6.1 Cable Lubricants

Use lubricants that are specifically recommended by the cable manufacturer for assisting in pulling jacketed cables.

3.7 CABLES IN UNDERGROUND STRUCTURES

Do not install cables utilizing the shortest path between penetrations, but route along those walls providing the longest route and the maximum spare cable lengths. Form cables to closely parallel walls, not to interfere with duct entrances, and support on brackets and cable insulators. Support cable splices in underground structures by racks on each side of the splice. Locate splices to prevent cyclic bending in the spliced sheath. Install cables at middle and bottom of cable racks, leaving top space open for future cables, except as otherwise indicated for existing installations. Provide one spare three-insulator rack arm for each cable rack in each underground structure.

3.8 CONDUCTORS INSTALLED IN PARALLEL

Group conductors such that each conduit of a parallel run contains one Phase A conductor, one Phase B conductor, one Phase C conductor, and one neutral conductor.

3.9 LOW VOLTAGE CABLE SPLICING AND TERMINATING

Make terminations and splices with materials and methods as indicated or specified herein and as designated by the written instructions of the manufacturer. Do not allow the cables to be moved until after the splicing material has completely set. Make splices in underground distribution systems only in accessible locations such as manholes, handholes, or aboveground termination pedestals.

3.10 GROUNDING SYSTEMS

NFPA 70 and IEEE C2, except provide grounding systems with a resistance to solid earth ground not exceeding 25 ohms.

3.10.1 Grounding Electrodes

Provide cone pointed driven ground rods driven full depth plus 6 inches , installed to provide an earth ground of the appropriate value for the particular equipment being grounded.
If the specified ground resistance is not met, provide an additional ground rod in accordance with the requirements of NFPA 70 (placed not less than 6 feet from the first rod). Should the resultant (combined) resistance exceed the specified resistance, measured not less than 48 hours after rainfall, notify the Contracting Officer immediately.

3.10.2 Grounding Connections

Make grounding connections which are buried or otherwise normally inaccessible, by exothermic weld or compression connector.

a. Make exothermic welds strictly in accordance with the weld manufacturer's written recommendations. Welds which are "puffed up" or which show convex surfaces indicating improper cleaning are not acceptable. Mechanical connectors are not required at exothermic welds.

b. Make compression connections using a hydraulic compression tool to provide the correct circumferential pressure. Tools and dies must be as recommended by the manufacturer. An embossing die code or other standard method must provide visible indication that a connector has been adequately compressed on the ground wire.

3.10.3 Grounding Conductors

Provide bare grounding conductors, except where installed in conduit with associated phase conductors. Ground cable sheaths, cable shields, conduit, and equipment with No. 6 AWG. Ground other noncurrent-carrying metal parts and equipment frames of metal-enclosed equipment. Ground metallic frames and covers of maintenance holes with a braided, copper ground strap with equivalent ampacity of No. 6 AWG.

3.11 EXCAVATING, BACKFILLING, AND COMPACTING

Provide in accordance with NFPA 70 and Section 31 00 00 EARTHWORK.

3.11.1 Reconditioning of Surfaces

3.11.1.1 Unpaved Surfaces

Restore to their original elevation and condition unpaved surfaces disturbed during installation of duct . Preserve sod and topsoil removed during excavation and reinstall after backfilling is completed. Replace sod that is damaged by sod of quality equal to that removed. When the surface is disturbed in a newly seeded area, re-seed the restored surface with the same quantity and formula of seed as that used in the original seeding, and provide topsoiling, fertilizing, liming, seeding, sodding, sprigging, or mulching. Provide work in accordance with Section 32 92 19 SEEDING and Section 32 93 00 EXTERIOR PLANTS.

3.11.1.2 Paving Repairs

Where trenches, pits, or other excavations are made in existing roadways and other areas of pavement where surface treatment of any kind exists , restore such surface treatment or pavement the same thickness and in the same kind as previously existed, except as otherwise specified, and to match and tie into the adjacent and surrounding existing surfaces.

3.12 CAST-IN-PLACE CONCRETE

3.12.1 Sealing

When the installation is complete, seal all conduit and other entries into the equipment enclosure with an approved sealing compound. Seals must be of sufficient strength and durability to protect all energized live parts of the equipment from rodents, insects, or other foreign matter.

3.13 FIELD QUALITY CONTROL

3.13.1 Performance of Field Acceptance Checks and Tests

Perform in accordance with the manufacturer's recommendations, and include the following visual and mechanical inspections and electrical tests, performed in accordance with NETA ATS.

3.13.1.1 Low Voltage Cables, 600-Volt

Perform tests after installation of cable, splices and terminations and before terminating to equipment or splicing to existing circuits.

a. Visual and Mechanical Inspection

    (1) Inspect exposed cable sections for physical damage.

    (2) Verify that cable is supplied and connected in accordance with contract plans and specifications.

    (3) Verify tightness of accessible bolted electrical connections.

    (4) Inspect compression-applied connectors for correct cable match and indentation.

    (5) Visually inspect jacket and insulation condition.

    (6) Inspect for proper phase identification and arrangement.

b. Electrical Tests

    (1) Perform insulation resistance tests on wiring No. 6 AWG and larger diameter using instrument which applies voltage of approximately 1000 volts dc for one minute.

    (2) Perform continuity tests to insure correct cable connection.

3.13.1.2 Grounding System

a. Visual and mechanical inspection

    Inspect ground system for compliance with contract plans and specifications.

b. Electrical tests

Perform ground-impedance measurements utilizing the fall-of-potential method in accordance with IEEE 81. On systems consisting of interconnected ground rods, perform tests after interconnections are complete. On systems consisting of a single ground rod perform tests before any wire is connected. Take measurements in normally dry weather, not less than 48 hours after rainfall. Use a portable ground resistance tester in accordance with manufacturer's instructions to test each ground or group of grounds. The instrument must be equipped with a meter reading directly in ohms or fractions thereof to indicate the ground value of the ground rod or grounding systems under test. Provide site diagram indicating location of test probes with associated distances, and provide a plot of resistance vs. distance.

3.13.2 Follow-Up Verification

Upon completion of acceptance checks and tests, show by demonstration in service that circuits and devices are in good operating condition and properly performing the intended function. As an exception to requirements stated elsewhere in the contract, the Contracting Officer must be given 5 working days advance notice of the dates and times of checking and testing.

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SECTION 33 82 00

TELECOMMUNICATIONS OUTSIDE PLANT (OSP)
04/06

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM B1	(2013) Standard Specification for Hard-Drawn Copper Wire
ASTM B8	(2011; R 2017) Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft
ASTM D709	(2017) Standard Specification for Laminated Thermosetting Materials

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 100	(2000; Archived) The Authoritative Dictionary of IEEE Standards Terms
IEEE C2	(2023) National Electrical Safety Code

INSULATED CABLE ENGINEERS ASSOCIATION (ICEA)

ICEA S-87-640	(2023) Optical Fiber Outside Plant Communications Cable; 4th Edition
ICEA S-98-688	(2012) Broadband Twisted Pair Telecommunication Cable, Aircore, Polyolefin Insulated, Copper Conductors Technical Requirements
ICEA S-99-689	(2012) Broadband Twisted Pair Telecommunication Cable Filled, Polyolefin Insulated, Copper Conductors Technical Requirements

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2023; ERTA 4 2023) National Electrical Code

TELECOMMUNICATIONS INDUSTRY ASSOCIATION (TIA)

TIA-455-78-B	(2020c) FOTP-78 Optical Fibres - Part 1-40: Measurement Methods and Test Procedures - Attenuation

TIA-492CAAA	(1998; R 2002) Detail Specification for Class IVa Dispersion-Unshifted Single-Mode Optical Fibers
TIA-526-7	(2015a; R 2022) Measurement of Optical Power Loss of Installed Single-Mode Fiber Cable Plant, Adoption of IEC 61280-4-2 edition 2: Fibre-Optic Communications Subsystem Test Procedures - Part 4-2: Installed Cable Plant - Single-Mode Attenuation and Optical Return Loss Measurement
TIA-526-14	(2023d) OFSTP-14A Optical Power Loss Measurements of Installed Multimode Fiber Cable Plant
TIA-568.1	(2020e) Commercial Building Telecommunications Infrastructure Standard
TIA-568.2	(2018d) Balanced Twisted-Pair Telecommunications Cabling and Components Standards
TIA-568.3	(2022e) Optical Fiber Cabling Components Standard
TIA-569	(2019e; Add 1 2022) Telecommunications Pathways and Spaces
TIA-606	(2021d) Administration Standard for Telecommunications Infrastructure
TIA-607	(2019d) Generic Telecommunications Bonding and Grounding (Earthing) for Customer Premises
TIA-758	(2012b) Customer-Owned Outside Plant Telecommunications Infrastructure Standard
TIA/EIA-455	(1998b) Standard Test Procedure for Fiber Optic Fibers, Cables, Transducers, Sensors, Connecting and Terminating Devices, and Other Fiber Optic Components
TIA/EIA-598	(2014D; Add 2 2018) Optical Fiber Cable Color Coding

U.S. DEPARTMENT OF AGRICULTURE (USDA)

RUS 1755	Telecommunications Standards and Specifications for Materials, Equipment and Construction
RUS Bull 1751F-630	(1996) Design of Aerial Plant
RUS Bull 1751F-643	(2002) Underground Plant Design
RUS Bull 1753F-201	(1997) Acceptance Tests of

UNDERWRITERS LABORATORIES (UL)

UL 83	(2017; Reprint Mar 2020) UL Standard for Safety Thermoplastic-Insulated Wires and Cables

1.2 RELATED REQUIREMENTS

Section 27 10 00, BUILDING TELECOMMUNICATIONS CABLING SYSTEM, Section and Section 33 71 02, UNDERGROUND ELECTRICAL DISTRIBUTION apply to this section with additions and modifications specified herein.

1.3 DEFINITIONS

Unless otherwise specified or indicated, electrical and electronics terms used in this specification shall be as defined in TIA-568.1, TIA-568.2, TIA-568.3, TIA-569, TIA-606, and IEEE 100 and herein.

1.3.1 Campus Distributor (CD)

A distributor from which the campus backbone cabling emanates. (International expression for main cross-connect - (MC).)

1.3.2 Entrance Facility (EF) (Telecommunications)

An entrance to the building for both private and public network service cables (including antennae) including the entrance point at the building wall and continuing to the entrance room or space.

1.3.3 Entrance Room (ER) (Telecommunications)

A centralized space for telecommunications equipment that serves the occupants of a building. Equipment housed therein is considered distinct from a telecommunications room because of the nature of its complexity.

1.3.4 Building Distributor (BD)

A distributor in which the building backbone cables terminate and at which connections to the campus backbone cables may be made. (International expression for intermediate cross-connect - (IC).)

1.3.5 Pathway

A physical infrastructure utilized for the placement and routing of telecommunications cable.

1.4 SYSTEM DESCRIPTION

The telecommunications outside plant consists of cable, conduit, manholes, poles, etc. required to provide signal paths from the closest point of presence to the new facility, including free standing frames or backboards, interconnecting hardware, terminating cables, lightning and surge protection modules at the entrance facility. The work consists of providing, testing and making operational cabling, interconnecting hardware and lightning and surge protection necessary to form a complete outside plant telecommunications system for continuous use.

1.5 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval.for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Telecommunications Outside Plant; G

Telecommunications Entrance Facility Drawings; G

All shop drawings shall be designed and stamped by a BICSI registered communications designer (RCDD).

In addition to Section 01 33 00 SUBMITTAL PROCEDURES, provide shop drawings in accordance with paragraph SHOP DRAWINGS.

SD-03 Product Data

Wire and Cable; G

Cable Splices, and Connectors; G

Closures; G

SD-06 Test Reports

Pre-installation Tests; G

Acceptance Tests; G

Outside Plant Test Plan; G

SD-07 Certificates

Telecommunications Contractor Qualifications; G

Key Personnel Qualifications; G

Minimum Manufacturer's Qualifications; G

SD-08 Manufacturer's Instructions

Cable Tensions; G

Fiber Optic Splices; G

Submit instructions prior to installation.

SD-09 Manufacturer's Field Reports

Factory Reel Test Data; G

SD-10 Operation and Maintenance Data

Telecommunications Outside Plant (OSP), Data Package 5; G

Commercial off-the-shelf manuals shall be provided for operation, installation, configuration, and maintenance of products provided as a part of the telecommunications outside plant (OSP). Submit operations and maintenance data in accordance with Section 01 78 23, OPERATION AND MAINTENANCE DATA and as specified herein not later than 2 months prior to the date of beneficial occupancy. In addition to requirements of Data package 5, include the requirements of paragraphs TELECOMMUNICATIONS OUTSIDE PLANT SHOP DRAWINGS and TELECOMMUNICATIONS ENTRANCE FACILITY DRAWINGS.

SD-11 Closeout Submittals

Record Documentation; G

In addition to other requirements, provide in accordance with paragraph RECORD DOCUMENTATION.

1.6 QUALITY ASSURANCE

1.6.1 Shop Drawings

Include wiring diagrams and installation details of equipment indicating proposed location, layout and arrangement, control panels, accessories, piping, ductwork, and other items that must be shown to ensure a coordinated installation. Wiring diagrams shall identify circuit terminals and indicate the internal wiring for each item of equipment and the interconnection between each item of equipment. Drawings shall indicate adequate clearance for operation, maintenance, and replacement of operating equipment devices. Submittals shall include the nameplate data, size, and capacity. Submittals shall also include applicable federal, military, industry, and technical society publication references.

1.6.1.1 Telecommunications Outside Plant Shop Drawings

Provide Outside Plant Design in accordance with TIA-758, RUS Bull 1751F-630 for aerial system design, and RUS Bull 1751F-643 for underground system design. Provide T0 shop drawings that show the physical and logical connections from the perspective of an entire campus, such as actual building locations, exterior pathways and campus backbone cabling on plan view drawings, major system nodes, and related connections on the logical system drawings in accordance with TIA-606. Drawings shall include wiring and schematic diagrams for fiber optic and copper cabling and splices, copper conductor gauge and pair count, fiber pair count and type, pathway duct and innerduct arrangement, associated construction materials, and any details required to demonstrate that cable system has been coordinated and will properly support the switching and transmission system identified in specification and drawings. The telecommunications outside plant (OSP) shop drawings shall be included in the operation and maintenance manuals. See also 96CS requirements included in the appendix.

1.6.2 Telecommunications Qualifications

Work under this section shall be performed by and the equipment shall be provided by the approved telecommunications contractor and key personnel. Qualifications shall be provided for: the telecommunications system contractor, the telecommunications system installer, the supervisor (if different from the installer), and the cable splicing and terminating personnel. A minimum of 30 days prior to installation, submit documentation of the experience of the telecommunications contractor and of the key personnel.

1.6.2.1 Telecommunications Contractor Qualifications

The telecommunications contractor shall be a firm which is regularly and professionally engaged in the business of the applications, installation, and testing of the specified telecommunications systems and equipment. The telecommunications contractor shall demonstrate experience in providing successful telecommunications systems that include outside plant and broadband cabling within the past 3 years. Submit documentation for a minimum of three and a maximum of five successful telecommunication system installations for the telecommunications contractor. Each of the key personnel shall demonstrate experience in providing successful telecommunications systems in accordance with TIA-758 within the past 3 years.

1.6.2.2 Key Personnel Qualifications

Provide key personnel who are regularly and professionally engaged in the business of the application, installation and testing of the specified telecommunications systems and equipment. There may be one key person or more key persons proposed for this solicitation depending upon how many of the key roles each has successfully provided. Each of the key personnel shall demonstrate experience in providing successful telecommunications systems within the past 3 years.

Cable splicing and terminating personnel assigned to the installation of this system or any of its components shall have training in the proper techniques and have a minimum of 3 years experience in splicing and terminating the specified cables. Modular splices shall be performed by factory certified personnel or under direct supervision of factory trained personnel for products used.

Supervisors and installers assigned to the installation of this system or any of its components shall have factory or factory approved certification from each equipment manufacturer indicating that they are qualified to install and test the provided products.

Submit documentation for a minimum of three and a maximum of five successful telecommunication system installations for each of the key personnel. Documentation for each key person shall include at least two successful system installations provided that are equivalent in system size and in construction complexity to the telecommunications system proposed for this solicitation. Include specific experience in installing and testing telecommunications outside plant systems, including broadband cabling, and provide the names and locations of at least two project installations successfully completed using optical fiber and copper telecommunications cabling systems. All of the existing telecommunications system installations offered by the key persons as successful experience shall have been in successful full-time service for at least 18 months prior to the issuance date for this solicitation. Provide the name and role of the key person, the title, location, and completed installation date of the referenced project, the referenced project owner point of contact information including name, organization, title, and telephone number, and generally, the referenced project description including system size and construction complexity.

Indicate that all key persons are currently employed by the telecommunications contractor, or have a commitment to the telecommunications contractor to work on this project. All key persons shall be employed by the telecommunications contractor at the date of issuance of this solicitation, or if not, have a commitment to the telecommunications contractor to work on this project by the date that the bid was due to the Contracting Officer.

Note that only the key personnel approved by the Contracting Officer in the successful proposal shall do work on this solicitation's telecommunications system. Key personnel shall function in the same roles in this contract, as they functioned in the offered successful experience. Any substitutions for the telecommunications contractor's key personnel requires approval from The Contracting Officer.

1.6.2.3 Minimum Manufacturer's Qualifications

Cabling, equipment and hardware manufacturers shall have a minimum of 3 years experience in the manufacturing, assembly, and factory testing of components which comply with, TIA-568.1, TIA-568.2 and TIA-568.3. In addition, cabling manufacturers shall have a minimum of 3years experience in the manufacturing and factory testing of cabling which comply with ICEA S-87-640, ICEA S-98-688, and ICEA S-99-689.

1.6.3 Outside Plant Test Plan

Prepare and provide a complete and detailed test plan for field tests of the outside plant including a complete list of test equipment for the optical fiber cables, components, and accessories for approval by the Contracting Officer. Include a cut-over plan with procedures and schedules for relocation of facility station numbers without interrupting service to any active location. Submit the plan at least30 days prior to tests for Contracting Officer approval. Provide outside plant testing and performance measurement criteria in accordance with TIA-568.1 and RUS Bull 1753F-201. Include procedures for certification, validation, and testing that includes fiber optic link performance criteria.

1.6.4 Standard Products

Provide materials and equipment that are standard products of manufacturers regularly engaged in the production of such products which are of equal material, design and workmanship and shall be the manufacturer's latest standard design that has been in satisfactory commercial or industrial use for at least2 years prior to bid opening. The 2 -year period shall include applications of equipment and materials under similar circumstances and of similar size. The product shall have been on sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 2-year period. Products supplied shall be specifically designed and manufactured for use with outside plant telecommunications systems. Where two or more items of the same class of equipment are required, these items shall be products of a single manufacturer; however, the component parts of the item need not be the products of the same manufacturer unless stated in this section.

1.6.4.1 Alternative Qualifications

Products having less than a 2year field service record will be acceptable if a certified record of satisfactory field operation for not less than 6000 hours, exclusive of the manufacturers' factory or laboratory tests, is provided.

1.6.4.2 Material and Equipment Manufacturing Date

Products manufactured more than 3 years prior to date of delivery to site shall not be used, unless specified otherwise.

1.6.5 Regulatory Requirements

In each of the publications referred to herein, consider the advisory provisions to be mandatory, as though the word, "shall" had been substituted for "should" wherever it appears. Interpret references in these publications to the "authority having jurisdiction," or words of similar meaning, to mean the Contracting Officer. Equipment, materials, installation, and workmanship shall be in accordance with the mandatory and advisory provisions of NFPA 70 unless more stringent requirements are specified or indicated.

1.6.5.1 Independent Testing Organization Certificate

In lieu of the label or listing, submit a certificate from an independent testing organization, competent to perform testing, and approved by the Contracting Officer. The certificate shall state that the item has been tested in accordance with the specified organization's test methods and that the item complies with the specified organization's reference standard.

1.7 DELIVERY, STORAGE, AND HANDLING

Ship cable on reels. Radius of the reel drum shall not be smaller than the minimum bend radius of the cable. Wind cable on the reel so that unwinding can be done without kinking the cable. Two meters of cable at both ends of the cable shall be accessible for testing. Attach permanent label on each reel showing length, cable identification number, cable size, cable type, and date of manufacture. Provide water resistant label and the indelible writing on the labels. Apply end seals to each end of the cables to prevent moisture from entering the cable. Reels with cable shall be suitable for outside storage conditions when temperature ranges from minus 40 degrees C to plus 65 degrees C, with relative humidity from 0 to 100 percent. Equipment, other than cable, delivered and placed in storage shall be stored with protection from weather, humidity and temperature variation, dirt and dust, or other contaminants in accordance with manufacturer's requirements.

1.8 MAINTENANCE

1.8.1 Record Documentation

Provide the activity responsible for telecommunications system maintenance and administration a single complete and accurate set of record documentation for the entire telecommunications system with respect to this project.

a. Cables - A record of installed cable shall be provided in accordance with TIA-606. The cable records shall include only the required data fieldsinclude the required data fields for each cable and complete end-to-end circuit report for each complete circuit from the assigned outlet to the entry facility in accordance with TIA-606. Include manufacture date of cable with submittal.

b. Termination Hardware - Provide a record of installed patch panels, cross-connect points, campus distributor and terminating block arrangements and type in accordance with TIA-606. Documentation shall include only the required data fields as a minimum in accordance with TIA-606.

Provide record documentation as specified in Section 27 10 00 BUILDING TELECOMMUNICATIONS CABLING SYSTEM.

1.9 WARRANTY

The equipment items shall be supported by service organizations which are reasonably convenient to the equipment installation in order to render satisfactory service to the equipment on a regular and emergency basis during the warranty period of the contract.

PART 2 PRODUCTS

2.1 MATERIALS AND EQUIPMENT

Products supplied shall be specifically designed and manufactured for use with outside plant telecommunications systems. See also specific 96CS requirements included in the appendix.

2.2 TELECOMMUNICATIONS ENTRANCE FACILITY

2.2.1 Fiber Optic Terminations

Provide fiber optic cable terminations as specified in 27 10 00 BUILDING TELECOMMUNICATIONS CABLING SYSTEM AND IN THE APPENDIX.

2.3 CONDUIT

Provide conduit as specified in this and as indicated in Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION.

2.4 WIRE AND CABLE

2.4.1 Fiber Optic Cable

Provide single-mode, 8/125-um, 0.10 aperture 1310 nm fiber optic cable in accordance with TIA-492CAAAincluding any special requirements made necessary by a specialized design. Provide optical fiber counts as indicated on the drawings. Fiber optic cable shall be specifically designed for outside use with loose buffer construction. Provide fiber optic color code in accordance with TIA/EIA-598

2.4.1.1 Strength Members

Provide central, non-metallic strength members with sufficient tensile strength for installation and residual rated loads to meet the applicable performance requirements in accordance with ICEA S-87-640. The strength member is included to serve as a cable core foundation to reduce strain on the fibers, and shall not serve as a pulling strength member.

2.4.1.2 Performance Requirements

Provide fiber optic cable with optical and mechanical performance requirements in accordance with ICEA S-87-640.

2.4.2 Grounding and Bonding Conductors

Provide grounding and bonding conductors in accordance with RUS 1755.200, TIA-607, IEEE C2, and NFPA 70. Solid bare copper wire meeting the requirements of ASTM B1 for sizes No. 8 AWG and smaller and stranded bare copper wire meeting the requirements of ASTM B8, for sizes No. 6 AWG and larger. Insulated conductors shall have 600-volt, Type TW insulation meeting the requirements of UL 83.

2.5 CABLE TAGS IN MAINTENANCE HOLES

Provide tags for each telecommunications cable or wire located in manholes, handholes, and vaults. Cable tags shall be stainless steel or polyethylene and labeled in accordance with TIA-606. Handwritten labeling is unacceptable.

2.5.1 Stainless Steel

Provide stainless steel, cable tags 1 5/8 inches in diameter 1/16 inch thick minimum, and circular in shape. Tags shall be die stamped with numbers, letters, and symbols not less than 0.25 inch high and approximately 0.015 inch deep in normal block style.

2.5.2 Polyethylene Cable Tags

Provide tags of polyethylene that have an average tensile strength of 3250 pounds per square inch; and that are 0.08 inch thick (minimum), non-corrosive non-conductive; resistive to acids, alkalis, organic solvents, and salt water; and distortion resistant to 170 degrees F. Provide 0.05 inch (minimum) thick black polyethylene tag holder. Provide a one-piece nylon, self-locking tie at each end of the cable tag. Ties shall have a minimum loop tensile strength of 175 pounds. The cable tags shall have black block letters, numbers, and symbols one inch high on a yellow background. Letters, numbers, and symbols shall not fall off or change positions regardless of the cable tags' orientation.

2.6 MANUFACTURER'S NAMEPLATE

Each item of equipment shall have a nameplate bearing the manufacturer's name, address, model number, and serial number securely affixed in a conspicuous place; the nameplate of the distributing agent will not be acceptable.

2.7 FIELD FABRICATED NAMEPLATES

Provide laminated plastic nameplates in accordance with ASTM D709 for each patch panel, protector assembly, rack, cabinet and other equipment or as indicated on the drawings. Each nameplate inscription shall identify the function and, when applicable, the position. Nameplates shall be melamine plastic, 0.125 inch thick, white with blackcenter core. Surface shall be matte finish. Corners shall be square. Accurately align lettering and engrave into the core. Minimum size of nameplates shall be one by 2.5 inches. Lettering shall be a minimum of 0.25 inch high normal block style.

2.8 TESTS, INSPECTIONS, AND VERIFICATIONS

2.8.1 Factory Reel Test Data

Test 100 percent OTDR test of FO media at the factory in accordance with TIA-568.1 and TIA-568.3. Use TIA-526-7 for single mode fiber and TIA-526-14 Method B for multi mode fiber measurements. Calibrate OTDR to show anomalies of 0.2 dB minimum. Enhanced performance filled OSP copper cables, referred to as Broadband Outside Plant (BBOSP), shall meet the requirements of ICEA S-99-689. Enhanced performance air core OSP copper cables shall meet the requirements of ICEA S-98-688. Submit test reports, including manufacture date for each cable reel and receive approval before delivery of cable to the project site.

PART 3 EXECUTION

3.1 INSTALLATION

Install all system components and appurtenances in accordance with manufacturer's instructions IEEE C2, NFPA 70, and as indicated. Provide all necessary interconnections, services, and adjustments required for a complete and operable telecommunications system.

3.1.1 Cable Racks and Cable Rack Supports

Cable racks shall be installed in Maintenance Holes as required - this includes new and existing Maintenance Holes. Splices shall not be supported by the cables that enter each end of the splice case. The splices shall be supported by cable hooks under the splice case. Telecommunications industry standard cable hooks of the appropriate length shall be provided to support cables and splice cases. The cable hooks shall be secured using cable rack locking clips. All cables shall be supported using racking clips, cable racks, and cable hooks.

3.1.2 Labeling

The Contractor shall label all equipment and cables they install, and cables identified for re-use IAW TIA-606-B-2012, ANSI/TIA 606-C-2017 and as directed by the base communications organization. New ducts shall be permanently labeled on the wall of each building/Maintenance Hole indicating the connecting building/Maintenance Hole at the other end of the duct (for example, "To MH-200"). Tagging and labeling of new cables shall be IAW the following:

A48L8.3F
FO 1234-5678, 1-12

Line One: A = Armored Sheath (otherwise leave blank) 48 = Fiber Count. L = Loose Tube Buffer or T = Tight Tube Buffer. 8.3 = Single Mode. F = Filled core (otherwise leave blank).
Line Two: 1234-5678 = From-To Building numbers. 1-12 = Cable/strand Count.

3.1.3 Cable Tags

All tags shall be permanently labeled, easily visible and corrosion resistant. Install cable tags in all Maintenance Holes, cable vaults, pull boxes and building entrance terminal locations. When cables pass through a Maintenance Hole a tag will be placed on the cable approximately 2 feet from each duct entrance. Information on the cable tag shall identify cable by size, type, cable number and count. See Para 2.2.5

(above) for nomenclature for tagging.

3.1.4 Pulling Tape

All newly installed ducts left vacant shall be provided with a waterproof, corrosion resistant, pre-lubricated flat woven polyester pull tape with sequential footage markings (1250 lb. pulling strength) for future cable installations. The pull tape shall extend into the Maintenance Holes and be secured to a cable rack or pulling iron, etc.

3.1.5 Cable Terminations

Fiber optic cables shall be terminated via fusion splice to splice cassettes with LC connectors. The pigtails shall be sized the same as the OSP fiber they are spliced to, i.e., 125/8.3 micron to 125/8.3 micron. The pigtails shall be duplex (or simplex) unless otherwise agreed to by 96 CS/SCXP.

3.1.6 FOC Maintenance Loop(s)

The Contractor shall install a minimum of a 50-foot fiber optic cable maintenance loop at the first Maintenance Hole from the building, and at every 3rd Maintenance Hole in the route. At all other maintenance holes, do not install cable along the shortest route (route around the complete perimeter of the maintenance hole prior to exiting). The maintenance loop slack shall be properly labeled, securely supported to the cable ladder and off the Maintenance Hole floor.

3.1.7 New Mainenance Holes

Maintenance Holes (MHs) installed under this project shall have an American Association of State Highway and Transportation Officials (AASHTO) rating of H-20 or equivalent. As stated in this PWS, MHs shall have minimum interior dimensions of 3 feet W x 5 feet L x 4 feet H (Width, Length, and Height), unless identified in PWS. MHs shall be furnished with a lockable MH cover, ladder, cable racks hardware, pulling irons, a sump, water resistance gaskets, bonding ribbon and a grounding system. MH shall meet the requirements of TIA-758-B, paragraph 4.2.1. MH covers shall be labeled with 1/8 inch raised letters stating "COMMUNICATIONS". Maintenance Holes shall be pre-cast reinforced concrete, splayed, multi-directional type with cast-in multiple plastic terminators to accept the conduits. Thin concrete knockout sections may be provided for terminating multiple-bore conduits. Furnish with cable racks and sump with drain.
Maintenance holes shall be equipped with torsion assisted rectangular diamond plate covers and self-latching stainless steel slam locks. Polymer concrete (i.e., Quazite) construction is NOT authorized. Coordinate numbering/labeling of new MH with 96 CS/SCOW.

3.1.8 Grounding

Grounding hardware such as corrosion resistant wire, bonding ribbon, clamps, ground rod, etc. necessary to properly bond/ground the cable in MHs shall be provided by the Contractor. Reference ANSI/TIA 607-C-2017.

3.1.8.1 Underground Conduit System

The Contractor shall be responsible for any required trenching and/or boring necessary to lay the duct system. The Contractor is also responsible for backfilling ditch lines and compaction of fill materials with appropriate compaction tools. Directional drilling shall be used for major road crossings.

3.1.9 Composition.

3.1.10 Typical Situations

The ducts shall be 4-inch inside diameter (I.D.) round or metric equivalent. The ducts shall be made of EPC-40 Polyvinyl Chloride (PVC) (Schedule 40) IAW NEMA TC-2. The ducts shall be appropriately labeled indicating the composition material. Ducts shall have a sleeve or bell-end type coupling and shall be watertight when assembled. In addition, the Contractor shall adhere to any additional Host Base/site specific requirements.

3.1.11 Unique/Site Specific Situations

The ducts shall be 4-inch inside diameter (I.D.) round or metric equivalent. The ducts shall be made of EPC-80-PVC (Schedule 80) IAW NEMA TC-2; high density polyethylene (HDPE) SIDR 13.5, Galvanized Iron Pipe (GIP) or "Thick wall" stainless steel. High density polyethylene (HDPE) SIDR 11.5 shall be used when directional boring is used. The ducts shall be appropriately labeled indicating the composition material. Ducts shall have a sleeve or bell-end type coupling and shall be watertight when assembled. In addition, the Contractor shall adhere to any additional Host Base/site specific requirement.

3.1.12 Installation

Installation of underground conduits/ducts shall be IAW RUS Bulletin 1751F-643 and RUS Bulletin 1753F-151. Ducts installed beneath roads, sidewalks, parking areas, other paved surfaces or areas to be paved, etc. shall be installed a minimum of 36" below grade. In a MH with knockouts, ducts shall start at the bottom knockout, allowing for upward areas to expansion in the MH. All ducts not installed under roads, sidewalks, parking areas, etc., shall have a minimum of 36 inches ground cover, where possible. The Contractor shall provide other protective measures, concrete cap, etc., in those areas where the minimum ground cover cannot be achieved. Grading of ducts shall be accomplished IAW RUS Bulletin 1751F-643. All conduits shall be continuous between MH (i.e., no breaks or separations in the conduit runs between MH).

3.1.13 Bends and Sealing

All bends between MHs shall be a minimum of ten times (10X) the diameter of the duct size (i.e., 4-inch duct = 40 inches) with the sum of bends in all directions not exceeding a total of 90 degrees, where practical. Coordinate with 96 CS/SCXP if runs have bends that total more than 90 degrees is required. Ducts shall have bell-ends and enter a MH perpendicular to the surface of the wall through which it is entering. All ducts/inner ducts entering MH shall be sealed. Universal duct plugs or removable putty sealants may be used. Upon completion of conduit sections, a rigid 12" long test mandrel ¼" (6.4mm) smaller than the inside diameter of the conduit shall be pulled through two diagonally opposite ducts to ensure proper alignment. In addition, all ducts shall be cleared of loose materials such as concrete, mud, dirt, stones, etc.

3.1.14 Utility Separation

When communications ducts cross either power duct or buried power cable, maintain a minimum separation of 3 inches of concrete or 12 inches of well-tamped earth between the two or 12 inches of well tamped earth when parallel; for pipes (e.g., gas, water, oil) maintain 6 inches when crossing or 12 inches when parallel.

3.1.15 Spacers and Tracer Wire

Along the length of the duct run, if the ducts are installed by trenching, spacers shall be placed at five (5) foot intervals and cable warning tape shall be buried one (1) foot below the surface and shall follow the duct route. The tape shall be a minimum of three inches wide and orange in color with the appropriate warning message. Trace-Safe, water blocking tracer wire shall be installed as a means of providing traceability for each new duct bank. Install the 'Trace-Safe' 24" below finished grade directly over the duct banks and 12" below the 'marking/warning tape'. All new Trace-Safe systems installed for this project shall use a Trace-Safe approved splice, termination end, etc. connectors where needed and an approved label installed at all wire ends, and those wire ends secured to the maintenance hole walls within 6 inches of the top of the maintenance hole, accessible without having to enter the maintenance hole and not connected to grounds. The tracer will be secured to the maintenance whole wall, and tagged with a label indicating it as "Duct Tracer Wire to xxx - Do Not Remove (where xxx is the other end of the wire)." Tracer wire entering any facility shall be grounded IAW applicable standards. (Follow the 96 CS Cyber Infrastructure Standards and Installation Specifications)

3.1.16 Entrance Conduits into Existing Maintenance Holes

When new entrance conduits/ducts or sleeves are required, the Contractor shall bore and install the necessary holes and install the ducts or sleeves, if a knockout does not exist. Penetration shall not be in such a location through the wall as to block use of existing ducts in the Maintenance Hole. New ducts will be a minimum of 18 inches from either the Maintenance Hole floor or ceiling, if practical. The minimum bending radius for entry conduit/ducts shall be no less than 10 times the inside diameter of the conduit. Ducts and openings around ducts shall be sealed to prevent moisture from entering the Maintenance Holes.

3.1.17 Excavation/Building Penetrations

All wall penetrations, including inside buildings, shall be restored to meet the required base fire ratings.

3.1.18 Outside Plant Installation

The Contractor install Outside Plant Telecommunications Infrastructure in accordance with ANSI/TIA-758-B and 96 CS Cyber Infrastructure Standards and Installation Specifications. Each cable installation shall be coordinated with 96 CS/SCXP so that the impact on the building users is properly coordinated. The sequence of installation is at the Contractor's discretion.

3.1.19 Cable Pulling

Test duct lines with a mandrel and swab out to remove foreign material before the pulling of cables. Avoid damage to cables in setting up pulling apparatus or in placing tools or hardware. Do not step on cables when entering or leaving the manhole. Do not place cables in ducts other than those shown without prior written approval of the Contracting Officer. Roll cable reels in the direction indicated by the arrows painted on the reel flanges. Set up cable reels on the same side of the manhole as the conduit section in which the cable is to be placed. Level the reel and bring into proper alignment with the conduit section so that the cable pays off from the top of the reel in a long smooth bend into the duct without twisting. Under no circumstances shall the cable be paid off from the bottom of a reel. Check the equipment set up prior to beginning the cable pulling to avoid an interruption once pulling has started. Use a cable feeder guide of suitable dimensions between cable reel and face of duct to protect cable and guide cable into the duct as it is paid off the reel. As cable is paid off the reel, lubricate and inspect cable for sheath defects. When defects are noticed, stop pulling operations and notify the Contracting Officer to determine required corrective action. Cable pulling shall also be stopped when reel binds or does not pay off freely. Rectify cause of binding before resuming pulling operations. Provide cable lubricants recommended by the cable manufacturer. Avoid bends in cables of small radii and twists that might cause damage. Do not bend cable and wire in a radius less than 10 times the outside diameter of the cable or wire.

3.1.19.1 Cable Tensions

Obtain from the cable manufacturer and provide to the Contracting Officer, the maximum allowable pulling tension. This tension shall not be exceeded.

3.2 FIELD QUALITY CONTROL

Provide the Contracting Officer 10 working days notice prior to each test. Provide labor, equipment, and incidentals required for testing. Correct defective material and workmanship disclosed as the results of the tests. Furnish a signed copy of the test results to the Contracting Officer within 3 working days after the tests for each segment of construction are completed. Perform testing as construction progresses and do not wait until all construction is complete before starting field tests.

3.2.1 Pre-Installation Tests

Perform the following tests on cable at the job site before it is removed from the cable reel. For cables with factory installed pulling eyes, these tests shall be performed at the factory and certified test results shall accompany the cable.

3.2.1.1 Pre-Installation Test Results

Provide results of pre-installation tests to the Contracting Officer at least 5 working days before installation is to start. Results shall indicate reel number of the cable, manufacturer, size of cable, pairs tested, and recorded readings. When pre-installation tests indicate that cable does not meet specifications, remove cable from the job site.

3.2.2 Acceptance Tests

Perform acceptance testing in accordance with RUS Bull 1753F-201 and as further specified in this section. Provide personnel, equipment, instrumentation, and supplies necessary to perform required testing. Notification of any planned testing shall be given to the Contracting Officer at least 14 days prior to any test unless specified otherwise. Testing shall not proceed until after the Contractor has received written Contracting Officer's approval of the test plans as specified. Test plans shall define the tests required to ensure that the system meets technical, operational, and performance specifications. The test plans shall define milestones for the tests, equipment, personnel, facilities, and supplies required. The test plans shall identify the capabilities and functions to be tested. Provide test reports in booklet form showing all field tests performed, upon completion and testing of the installed system. Measurements shall be tabulated on a pair by pair or strand by strand basis.

3.2.2.1 Fiber Optic Cable

Test fiber optic cable in accordance with TIA/EIA-455 and as further specified in this section. Two optical tests shall be performed on all optical fibers: Optical Time Domain Reflectometry (OTDR) Test, and Attenuation Test. In addition, a Bandwidth Test shall be performed on all multimode optical fibers. These tests shall be performed on the completed end-to-end spans which include the near-end pre-connectorized single fiber cable assembly, outside plant as specified, and the far-end pre-connectorized single fiber cable assembly.

a. OTDR Test: The OTDR test shall be used to determine the adequacy of the cable installations by showing any irregularities, such as discontinuities, micro-bendings or improper splices for the cable span under test. Hard copy fiber signature records shall be obtained from the OTDR for each fiber in each span and shall be included in the test results. For singe-mode optical fiber, perform 100% (All Strands)optical fiber end-to-end attenuation tests in accordance with OFSTP-14, OFSTP-7, TIA-568-C.3 and TIA 526-7 using tier one, Optical Power Meter and Light Source or tier two, and OTDR for single-mode optical fiber in a bi-directional. Perform verification acceptance tests. Optical fibers found with damage or defective strands shall be replaced (from end to end)and will not be accepted by 96 CS/QAR. Review 96 CS Cyber Infrastructure Standards and Installation Specifications for testing requirements (CDRL A005).

b. Attenuation Test: End-to-end attenuation measurements shall be made on all fibers, in both directions, using a 1300 nanometer light source at one end and the optical power meter on the other end to verify that the cable system attenuation requirements are met in accordance with fiber optic cables. The measurement method shall be in accordance with TIA-455-78-B. Attenuation losses shall not exceed 0.5 db/km at 1310 nm and 1550 nm for single-mode fiber. Attenuation losses shall not exceed 5.0 db/km at 850 nm and 1.5 db/km at 1300 nm for multimode fiber.

-- End of Section --

APPENDIX A

STRUCTURAL INTERIOR DESIGN

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TABLE OF CONTENTS

STRUCTURAL INTERIOR DESIGN (SID) FINAL DESIGN SUBMITTAL

Chapter 6 – Structural Interior Design Requirements (SID)

A. Design Criteria

The following is a list of DoD and Eglin AFB specific criteria that shall be utilized for the design of this facility. Refer to other chapters for additional criteria specific to each design element.

1. Engineering Design Manual Eglin AFB, Florida, February 2019 with referenced:
    a. Eglin AFB Architectural Compatibility Plan – 2023
    b. 96th Communications Squadron Cyber Infrastructure Design Guide November 2022
    c. CHELCO Design and Construction Standards, December 1, 2008
    d. American States Utility Services, Inc. (ASUS) Standard Details Water and Sewer
2. UFC 1-200-01 General Building Design, September 1, 2022
3. UFC 3-600-01 Fire Protection Engineering for Facilities, 8 August 2016, Change 6, 6 May 2021
4. UFC 4-010-01 DoD Minimum Antiterrorism Standards for Buildings, 12 Dec. 2018, Change 2, 30 July 2022
5. UFC 4-021-01 Mass Notification System, 9 April 2008, Change 1, 1 Jan. 2010
6. International Building Code 2022
7. NFPA 101 2021
8. ABA Accessibility guidelines, 2015
9. FLHPSB - Federal Leadership in High Performance and Sustainable Buildings MOU (HPSB) (Issued 2006)

B. Design Statement

The design approach for this project is to convert the existing facade hangar into a Human Performance Center to support the physical requirements of the NSEOD HHP STRIKE Program. The design goal is to develop a physical fitness center that is comparable to those found in college athletic programs.

C. Structural Interior Design Statement

The finish materials used throughout are proposed based on specific performance requirements for each of the functional areas. Materials must respond to intense use and enhance the experience and safety of the users. The color palette is selected to provide a professional and polished athletic facility that will encourage and support the users in their goal to complete the training programs. Contributing to the acoustics within the building will be the use of acoustical panels in decorative formations to provide visual interest while improving the acoustics within the main area of the facility.

D. Individual Room Finish Requirements

This section provides specific functional finish requirements by room. Materials are listed to provide a basis of design for cost estimating purposes.

1. **Entrance** – This area serves as the primary entrance into the building. The flooring is a continuation of the seamless rubber strength and conditioning flooring that is designed to handle heavy weights and equipment. On the entry flooring will be an inkjet printed logo identifying the group. Outside the entry door is a recessed grid type walk-off mat designed to minimize the dirt, sand and grit brought into the facility from the exterior.

2. **Main Fitness Area** – The gym will receive both seamless rubber strength and conditioning flooring at the perimeter and under the rows of equipment and the center will be a turf area. The turf will be resilient and designed to perform with sleds and other equipment. The thickness of both the rubber flooring and the turf product will be coordinated to provide the technical requirements and to eliminate variances in floor height. In collaboration with the users at the review meeting, we reviewed flooring options for this

area as the technical requirements are the key to the selection. The rubber flooring will also be used as the wall base to provide impact resistance and durability. The primary colors in this area will be greys and black with a green accent color banding at the turf area. The design intent is to have the equipment racks provided in the selected accent color as well. The perimeter walls will have large textured acoustic panels and panels with digital graphics applied to the surface face.

3. **Unisex Restroom** – The unisex restroom will have solid body porcelain floor tile, 12" x 24" minimum tile size. Walls will have porcelain wall tiles in all areas except the north wall. The mix of neutral tone will be installed in vertical stripes. The ceiling will be painted gypsum board. The porcelain tiles are gray tones with accent color used on the toilet wall of each individual space. The sink/water cooler area will be accented with a mosaic horizontal tile pattern using polished and matte finishes.

4. **Shower** – the shower accessed from the outside will have solid surface wall panels for ease of cleaning and long-term durability. The flooring will be a ½" mosaic tile in a mix of gray, black, white, and ivory. The mosaic floor tile will be used with a linear drain. This product will provide a slip resistant floor and cover the surface wall to wall.

5. **Janitor** – The porcelain tile flooring of the restroom continues into the janitor's space. FRP panels will be on all walls for protection and durability.

6. **Corridors** – The porcelain floor tiles will continue through the corridors and into the laundry rooms and break room. This will provide easily maintained flooring and reduce changes of height at floor material changes. All walls will be painted, and ceilings will be high NRC value acoustical ceiling tile. The acoustical tile will also have a high recycled content to contribute to sustainability points.

7. **Training Rooms and Office –** Located adjacent to the main fitness area, these spaces will have high performance sheet vinyl bonded to vulcanized composition rubber base. This material will provide the performance demanded with 12.1% force reduction and 64.5% energy restitution in a working environment. The surface is easy to maintain and used with thermoplastic rubber cove base. Walls will be painted with an eggshell finish. The ceiling shall be 2' x 2' Acoustical Tiles with high recycled content and high NRC value. The flooring will be in a light wood appearance as a visual contrast to the darker gym flooring.

8. **Breakroom –** Located adjacent to the back corridor, the flooring will be the large-scale porcelain tiles used in the front corridor and laundry. Cabinets will be a stainless visual plastic laminate with the light color quartz countertop. Wall paint continues the neutral beige.

9. **Laundry/Corridor –** Selected for performance flooring is large scale porcelain tile with medium dark grout. The tile has a slip resistant finish for use in potentially wet areas. Counter tops are quartz with neutral wall paint.

10. **Mechanical/Electrical** – These spaces will have sealed concrete floors, painted walls, and open exposed ceilings. A Thermoplastic rubber cove base will be used on walls finished with gypsum board.

11. **COMM –** COMM spaces will have a static dissipative solid vinyl tile (SDVT) to respond to the requirements of the COMM Squadron. Walls will have paint with an eggshell finish.

Chapter 7 – Furniture, Fixtures & Equipment (FF&E)

A. Design Criteria

The following is a list of DoD and Eglin AFB specific criteria that shall be utilized for the design of this facility. Refer to other chapters for additional criteria specific to each design element.

1. Engineering Design Manual Eglin AFB, Florida, February 2019 with referenced:
   a. Eglin AFB Architectural Compatibility Plan – 2023
   b. 96th Communications Squadron Cyber Infrastructure Design Guide November 2022
   c. CHELCO Design and Construction Standards, December 1, 2008
   d. American States Utility Services, Inc. (ASUS) Standard Details Water and Sewer
2. UFC 1-200-01 General Building Design, September 1, 2022
3. UFC 3-600-01 Fire Protection Engineering for Facilities, 8 August 2016, Change 6, 6 May 2021
4. UFC 4-010-01 DoD Minimum Antiterrorism Standards for Buildings, 12 Dec. 2018, Change 2, 30 July 2022
5. UFC 4-021-01 Mass Notification System, 9 April 2008, Change 1, 1 Jan. 2010
6. International Building Code 2022
7. NFPA 101 2021
8. ABA Accessibility guidelines, 2015
9. FLHPSB - Federal Leadership in High Performance and Sustainable Buildings MOU (HPSB) (Issued 2006)

B. Furniture Fixtures & Equipment Design Statement

There is no FF&E component for this project. For coordination purposes, we have provided a furniture plan for each area that indicates the types, sizes and quantities of FF&E that can be accommodated in the facility. All FF&E will be government furnished/government installed.

C. Individual Room FF&E Requirements

This section provides a listing of the specific items shown for each space.

Main Exercise Area –We are showing rows of bench sets at the perimeter of the turf area. Currently we are showing 16 stations. In addition are five exercise bikes, five rowing machines, four sleds, five ski simulators, 3 hyperextension, medicine ball racks, and dumbbell racks. Power is located in the northeast corner for a future anti-gravity treadmill. Flat panels displays are located around the perimeter of the main space. The mezzanine has five treadmills and five rowing machines with flat panel displays and two shelving units.

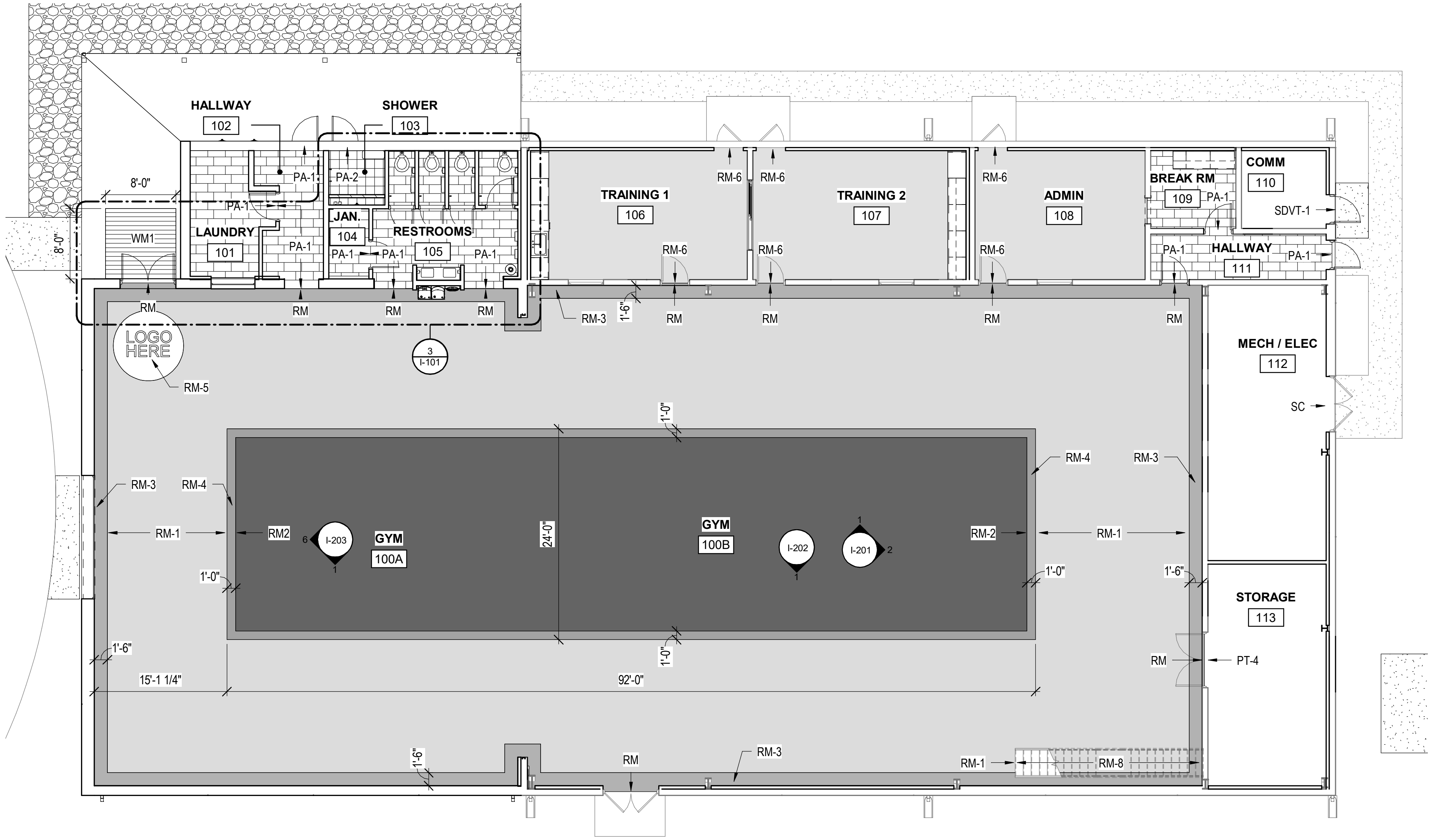
Training Rooms – The FF&E shall be flexible, easily rearranged. In each of the two training rooms we are showing two treatment tables, two stools on casters, one desk with task chair, one hydrocollator, one electrotherapy system, two waste receptacles, shared desk and task chair and built in counters and storage with room for ice maker.

Office – The office has space for four L-shape desks, four task chairs, one guest chair and waste receptacles.

Storage – The furniture plan shows 6 feet of 12-inch-deep shelving, 24 feet of 18-inch-deep shelving, and 27' of 24" deep shelving. All shelving would be 84" high with multiple shelves.

Equipment – The laundry rooms can accommodate two washers and two dryers, commercial grade stacking. The ice machine is located adjacent to the side door. The break room has space for one 1000-watt microwave, one coffee machine and one 18 cu.ft. refrigerator.

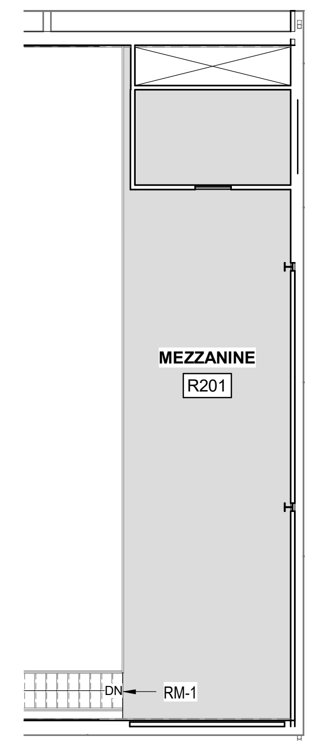
DRAWINGS



GROUND LEVEL - FINISH PLAN

NORTH 1 I-101

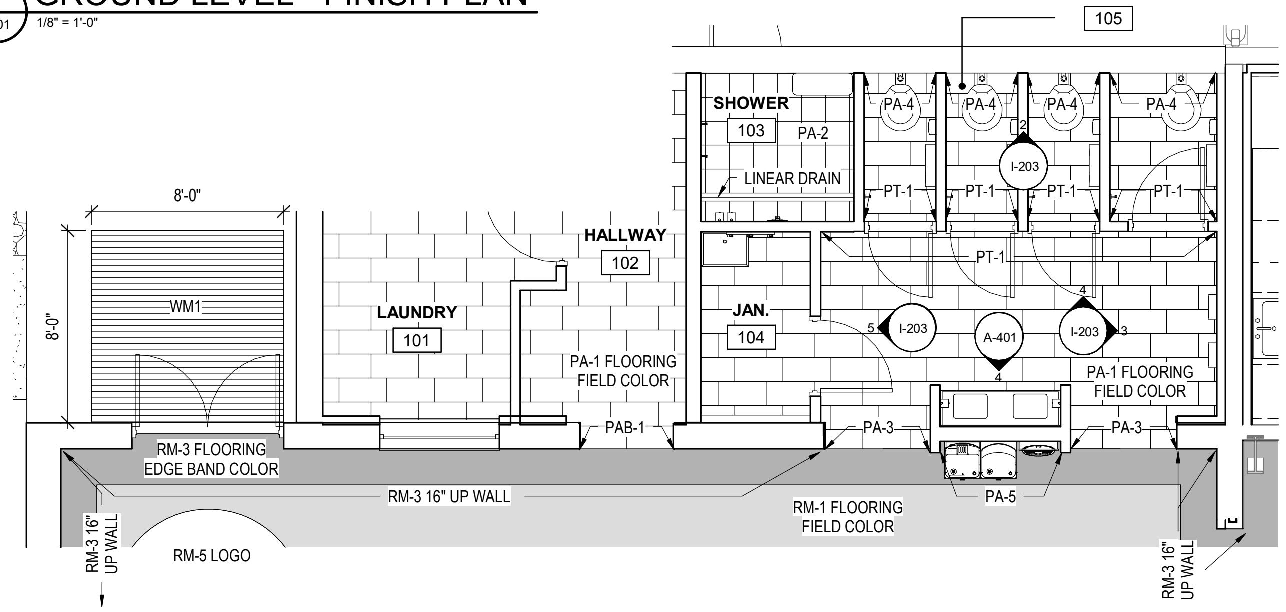
1/8" = 1'-0"



MEZZANINE - FINISH PLAN

NORTH 2 I-101

1/8" = 1'-0"



ENLARGED ENTRY AND RESTROOM FINISH PLAN

NORTH 3 I-101

1/4" = 1'-0"

FLOOR MATERIAL LEGEND

- RM1 - FIELD COLOR
- RM-2 - TURF
- RM-3 - ACCENT COLOR
- RM-4 - ACCENT COLOR
- RM-5 - LOGO
- RM-6 - TRAINING
- PA-1 - FLOOR TILE
- PA-2 - MOSAIC TILE
- WM1 - WALK-OFF MAT

GENERAL NOTES

1. REFER TO REFLECTED CEILING PLAN SHEET A-111 FOR CEILING HEIGHTS.
2. REFER TO SHEETS I-101 AND I-601 FOR EXTENT OF FLOOR FINISHES.
3. REFER TO SHEETS I-105 AND I-602 FOR SIGNAGE AND CORNER GUARD PLAN, SCHEDULE, AND DETAILS.
4. ALL INTERIOR HOLLOW METAL DOORS AND FRAMES SHALL BE PAINTED PT2 EXCEPT NORTH WALL ROOM 103.
5. ALL ELECTRICAL SWITCHES, RECEPTACLES, VOICE AND DATA PLATES SHALL BE STAINLESS STEEL.
6. ALL PLUMBING FIXTURES SHALL BE WHITE.
7. INSTALL FLOOR TRANSITION TRIM AT JUNCTURE OF DISSIMILAR MATERIALS; I.E. PORCELAIN PAVER AND RESILIENT FLOORING.
8. ALL EXPOSED STRUCTURE SHALL BE PAINTED PT3. IN EXISTING GYM AREA 100B, PAINT STRUCTURAL STEEL ONLY. IN NEW GYM AREA 100A, PAINT STRUCTURAL STEEL AND SPRAYED ON INSULATION.
9. CORNER GUARDS SHALL EXTEND FROM TOP OF WALL BASE TO CEILING. PROVIDE CORNER GUARDS AT ALL OUTSIDE CORNERS IN CORRIDORS.
10. AP (ACOUSTICAL PANELS) SHALL BE MOUNTED AT LOCATIONS SHOWN ON INTERIOR ELEVATION SHEETS, I-201, I-202, AND I-203.
11. PROVIDE FRP PANELS TO HEIGHT OF 48" ON ALL WALLS IN JANITOR ROOMS. INCLUDE ALL CORNER AND TRIM PIECES.
12. ALL CEILING MOUNTED DEVICES SHALL BE CENTERED ON THE ACOUSTICAL CEILING TILE.
13. PROVIDE VERTICAL (SQUARE PROFILE) METAL EDGE TRIM ON ALL OUTSIDE CORNERS OF WALL TILE. SEE DETAIL SHEET I-501.
14. PROVIDE PREFABRICATED COVE TILE TRIM TO RECEIVE FLOOR AND WALL TILE EDGES. SEE DETAIL SHEET I-501.
15. FOR CMU WALLS, PROVIDE 2 COATS BLOCK FILLER AND 2 COATS SEMI-GLOSS PAINT.
16. FLOOR DRAINS SHALL BE LINEAR IN SHOWER AND SQUARE IN ALL OTHER AREAS.
17. FINISH SCHEDULE IS BASED ON PLAN NORTH.
18. PATCH AND REPAIR ADJACENT WALLS DUE TO DEMOLITION.
19. SEE WALL TYPE LEGEND ON SHEET A-002 FOR WALL SUBSTRATE.
20. INTERIOR AND EXTERIOR FINISH MATERIALS AND COLORS SHALL BE AS REFERENCED IN THE SPECIFICATION SECTION 09 06 00 SCHEDULE FOR FINISHES WHICH PROVIDES DETAILS INFORMATION OF THE FINISH CODES SHOWN ON THE FINISH LEGEND.
21. REFERENCE FINISH SPECIFICATION SECTIONS FOR THE BASIS OF DESIGN EQUIVALENT MANUFACTURER TECHNICAL REQUIREMENTS.
22. INTERIOR CAULKING TO MATCH ADJACENT WALL FINISH COLOR.
23. CLEAN AND PREP ALL EXISTING SURFACES FOR NEW FINISH.

GRAPHIC LEGEND

- ROOM NAME 101 — ROOM NAME / NUMBER DESIGNATION
- FLOORING TRANSITION DESIGNATION

8' 0' 8' 16

SCALE: 1/8"=1'-0"

BASE CIVIL ENGINEER
EGLIN AIR FORCE BASE, FLORIDA

DATE
SIGNATURE

DRAWN BY K MCMURRAY
PROJ. ENGR. BTA
APPROVED FIRE PREVENTION
APPROVED SAFETY REPRESENTATIVE
APPROVED DIR. BASE MED. SERVICE
APPROVED SECURITY FORCES
APPROVED USING AGENCY
APPROVED ASUS
APPROVED COMMUNICATIONS
APPROVED CHELCO
APPROVED OPERATIONS ENGINEERING
APPROVED 96/CEG/CEN
APPROVED ENVIRONMENTAL
APPROVED DEPUTY BASE CIVIL ENGINEER

TITLE: D51 HANGAR CONVERSION, HUMAN PERFORMANCE CENTER

CONTENTS: FINISH PLAN

DATE: 23 MAY 2024

SCALE: AS SHOWN

INDEX NO. I-101

SPEC. NO.

PROJ. NO. FTFA 23-VH59

DRAWING NO.

FILE NO.

SHEET OF 91

FURNITURE NOTES

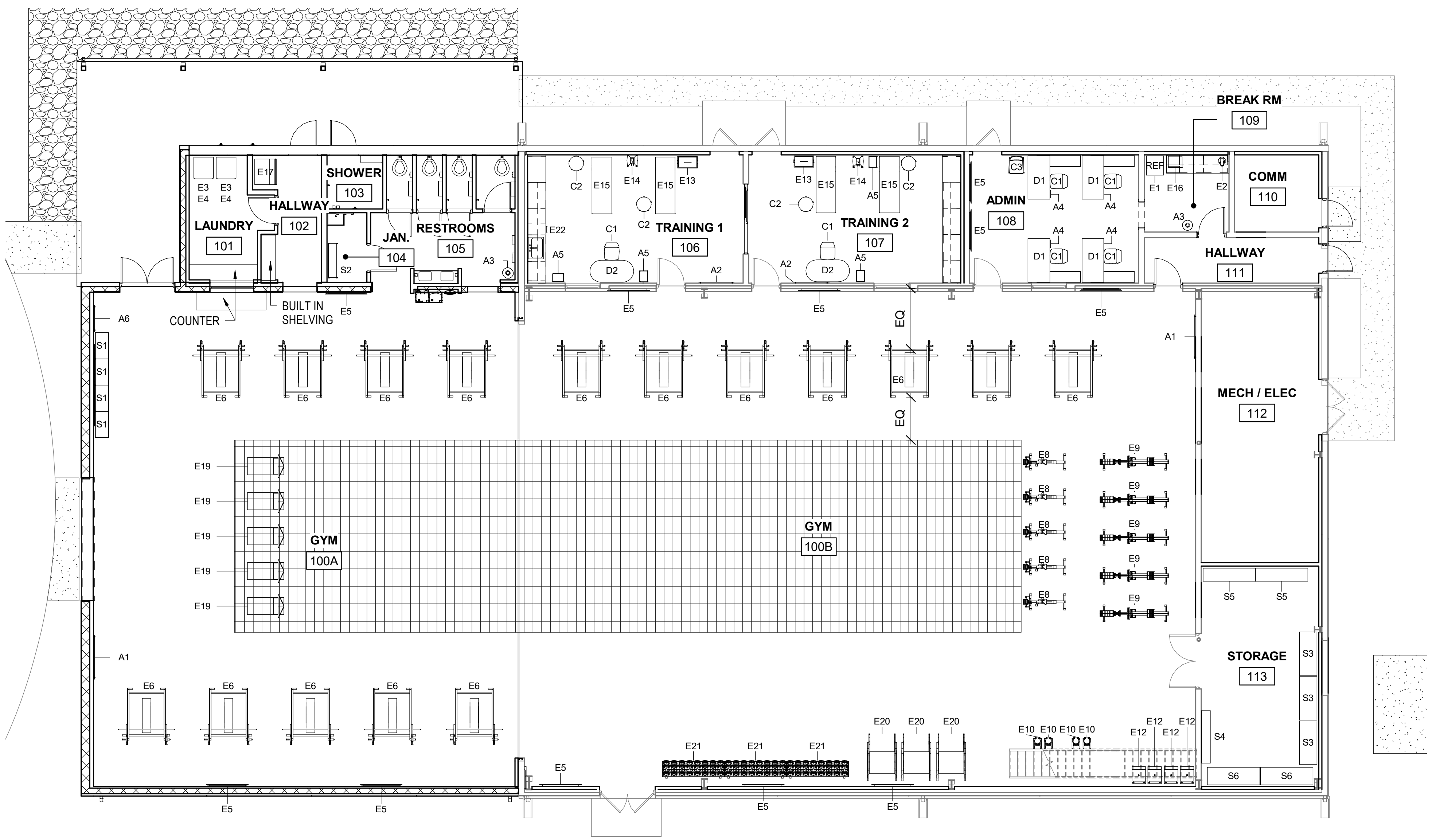
1. FURNITURE PLAN IS FOR COORDINATION ONLY.
2. ALL FURNITURE AND EQUIPMENT TAGGED AND LISTED IN THE SCHEDULE IS GFGI.

FURNITURE SCHEDULE - GFGI

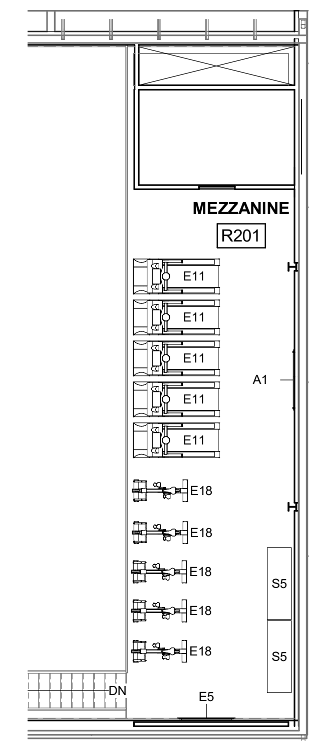
TYPE MARK	DESCRIPTION
A1	GLASS MAGNETIC MARKERBOARD - 60" x 42"
A2	GLASS MAGNETIC MARKERBOARD - 48" x 36"
A3	BULLET TOP HANDSFREE WASTEBASKET
A4	WASTEBASKET - 28 QT
A5	WASTEBASKET - 41 QT
A6	GLASS MAGNETIC MARKERBOARD - 36" x 36"
C	BULLET TOP HANDSFREE WASTEBASKET
C1	TASK CHAIR
C2	STOOL ON CASTERS
C3	GUEST CHAIR
D1	L-SHAPED DESK WITH HEIGHT ADJUSTABLE TABLE
D2	FLIP TOP TABLE ESK - 30" X 72"
E1	REFRIGERATOR WITH BOTTOM FREEZER
E2	COFFEE MAKER
E3	COMMERCIAL WASHER - STACKING FRONT LOAD
E4	COMMERCIAL DRYER - STACKING
E5	FLAT PANEL DISPLAY - 65"
E6	BENCH SET
E8	ASSAULT AIR BIKE
E9	ROWING MACHINE
E10	MEDICINE BALL RACK
E11	TREADMILL
E12	DRIVE SLED
E13	HYDROCOLLATOR
E14	ELECTROTHERAPY SYSTEM
E15	TREATMENT TABLE
E16	MICROWAVE
E17	ICE MACHINE - FREESTANDING
E18	STATIONARY PEDAL BIKE
E19	SKI SIMULATOR
E20	REVERSE HYPER
E21	DUMBBELL RACK
E22	UNDERCOUNTER ICEMAKER
S1	OPEN CUBBIES - 3HIGH
S2	UTILITY SHELVING - 48"W X 12"D x 85.25"H
S3	STORAGE SHELVING - 60" X 24" X 86"
S4	STORAGE SHELVING - 72" X 12" X 86"
S5	STORAGE SHELVING - 72" X 18" X 86"
S6	STORAGE SHELVING - 72" X 24" X 86"

FURNITURE LEGEND

MARK	DESCRIPTION
A	ACCESSORIES
C	SEATING
D	DESKING
E	EQUIPMENT
F	FILES
G	GOV'T FURNISHED / GOV'T INSTALLED (GFGI)
REF	REFRIGERATOR
S	STORAGE
T	TABLE



NORTH 1 I-103 GROUND LEVEL - FURNITURE PLAN
1/8" = 1'-0"



NORTH 2 I-103 MEZZANINE - FURNITURE PLAN
1/8" = 1'-0"

8' 0' 8' 16
SCALE: 1/8"=1'-0"

BASE CIVIL ENGINEER
EGLIN AIR FORCE BASE, FLORIDA

DRAWN BY K MCMURRAY
PROJ. ENGR. BTA

TITLE: D51 HANGAR CONVERSION, HUMAN PERFORMANCE CENTER

CONTENTS: FURNITURE PLAN

DATE: 23 MAY 2024

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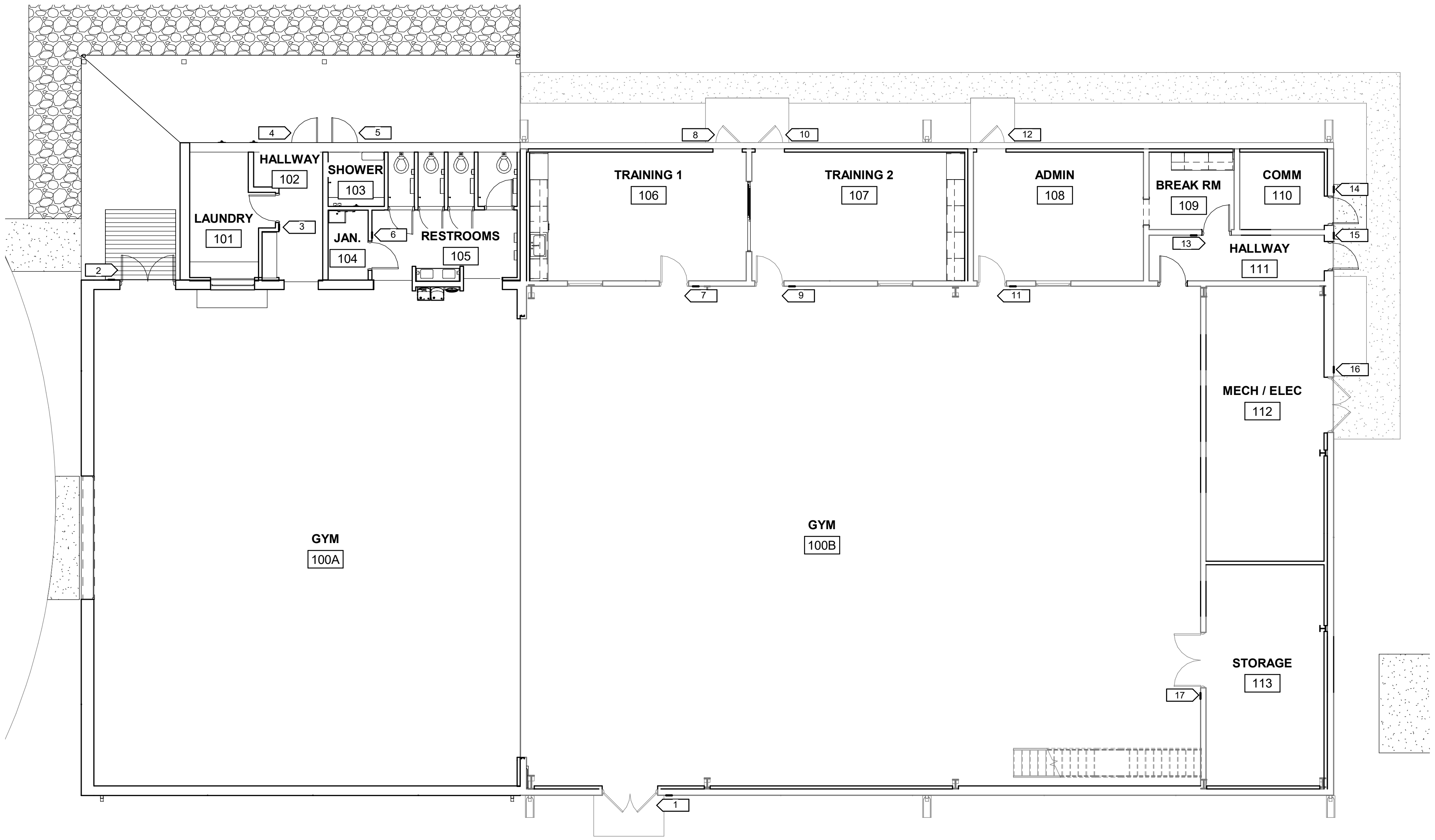
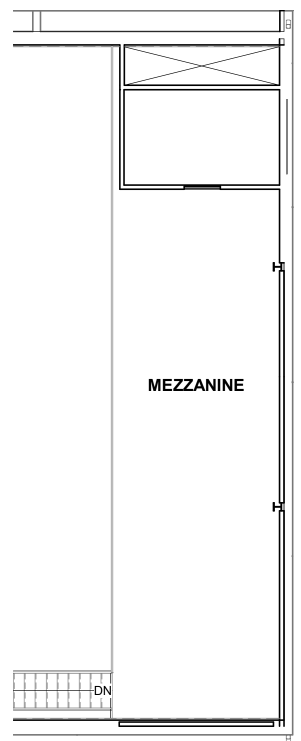
APPROVED: FIRE PREVENTION; SAFETY REPRESENTATIVE; DIR. BASE MED. SERVICE; USING AGENCY; COMMUNICATIONS; OPERATIONS ENGINEERING; ENVIRONMENTAL; SECURITY FORCES; ASUS; CHELCO; 96/CEG/CEN; DEPUTY BASE CIVIL ENGINEER



NORTH 1 I-105 GROUND LEVEL - SIGNAGE PLAN
1/8" = 1'-0"



NORTH 2 I-105 MEZZANINE - SIGNAGE PLAN
1/8" = 1'-0"

GENERAL NOTES

1. SIGNAGE SHALL BE FABRICATED AND INSTALLED IN ACCORDANCE WITH ADA / ABA GUIDELINES.
2. REFER TO THE INTERIOR FINISH LEGEND ON SHEET I-601 FOR SIGNAGE FINISHES.
3. REFER TO SHEET I-602 FOR SIGNAGE SCHEDULE AND DETAILS.
4. REFERENCE FINISH SPECIFICATION SECTIONS FOR THE BASIS OF DESIGN EQUIVALENT MANUFACTURERS TECHNICAL REQUIREMENTS.
5. CONFIRM / COORDINATE COPY TEXT WITH USER BEFORE PURCHASING SIGNAGE.

GRAPHIC LEGEND

ROOM NAME 101	ROOM NAME / NUMBER DESIGNATION
1	SIGNAGE TAG DESIGNATION

8' 0' 8' 16
SCALE: 1/8"=1'-0"

BASE CIVIL ENGINEER
EGLIN AIR FORCE BASE, FLORIDA

DATE	DRAWN BY K MCMURRAY	TITLE D51 HANGAR CONVERSION, HUMAN PERFORMANCE CENTER
SIGNATURE	PROJ. ENGR. BTA	
	APPROVED FIRE PREVENTION	
	APPROVED SAFETY REPRESENTATIVE	
	APPROVED DIR. BASE MED. SERVICE	
APPROVED SECURITY FORCES	APPROVED USING AGENCY	CONTENTS SIGNAGE AND CORNER GUARD PLAN
APPROVED ASUS	APPROVED COMMUNICATIONS	
APPROVED CHELCO	APPROVED OPERATIONS ENGINEERING	APPROVED 96/CEG/CEN — DATE 23 MAY 2024
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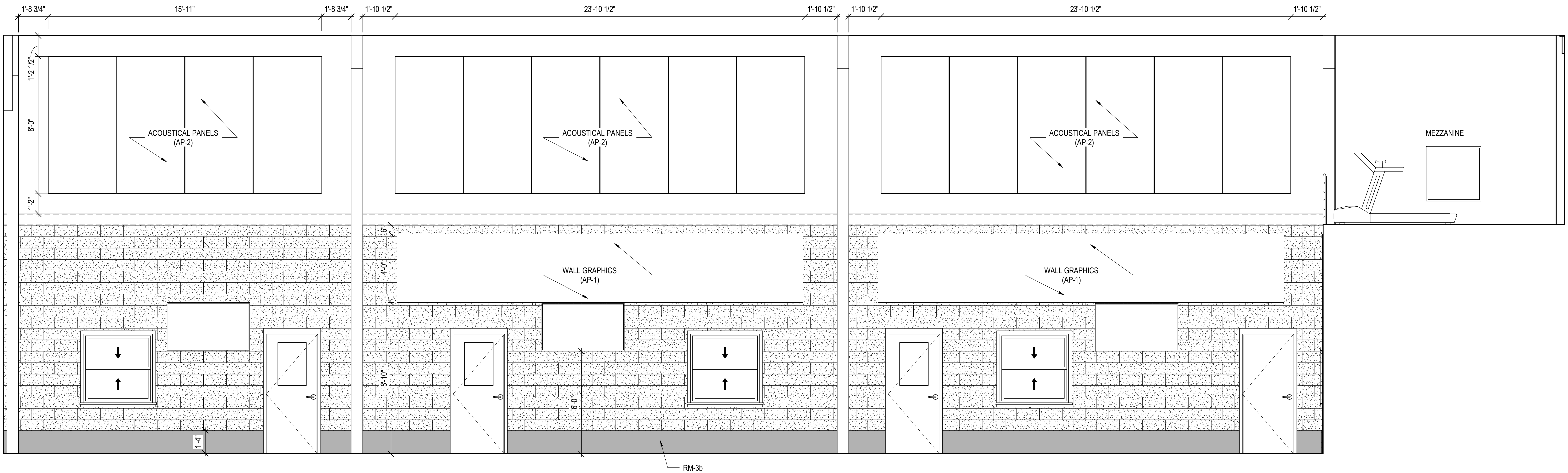
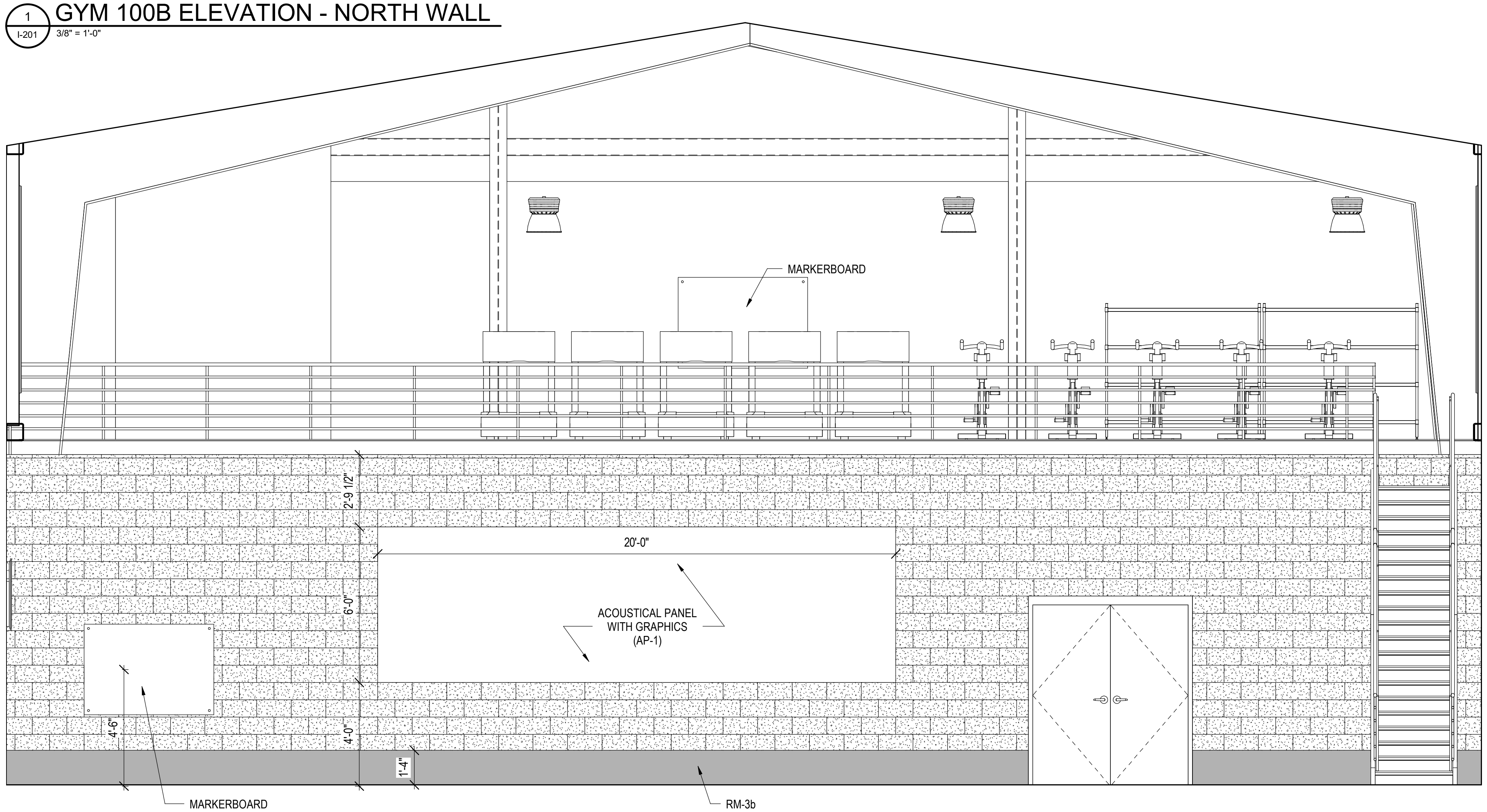


1 I-201 GYM 100B ELEVATION - NORTH WALL
3/8" = 1'-0"



2 I-201 GYM 100B ELEVATION - EAST WALL
3/8" = 1'-0"

2' 0' 2' 4' 6'
SCALE: 3/8"=1'-0"

BASE CIVIL ENGINEER
EGLIN AIR FORCE BASE, FLORIDA

DATE	DRAWN BY K MCMURRAY	TITLE D51 HANGAR CONVERSION, HUMAN PERFORMANCE CENTER
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	APPROVED SAFETY REPRESENTATIVE	
	APPROVED DIR. BASE MED. SERVICE	
APPROVED SECURITY FORCES	APPROVED USING AGENCY	CONTENTS INTERIOR ELEVATIONS
APPROVED ASUS	APPROVED COMMUNICATIONS	
APPROVED CHELCO	APPROVED OPERATIONS ENGINEERING	APPROVED 96/CEG/CEN — DATE 23 MAY 2024
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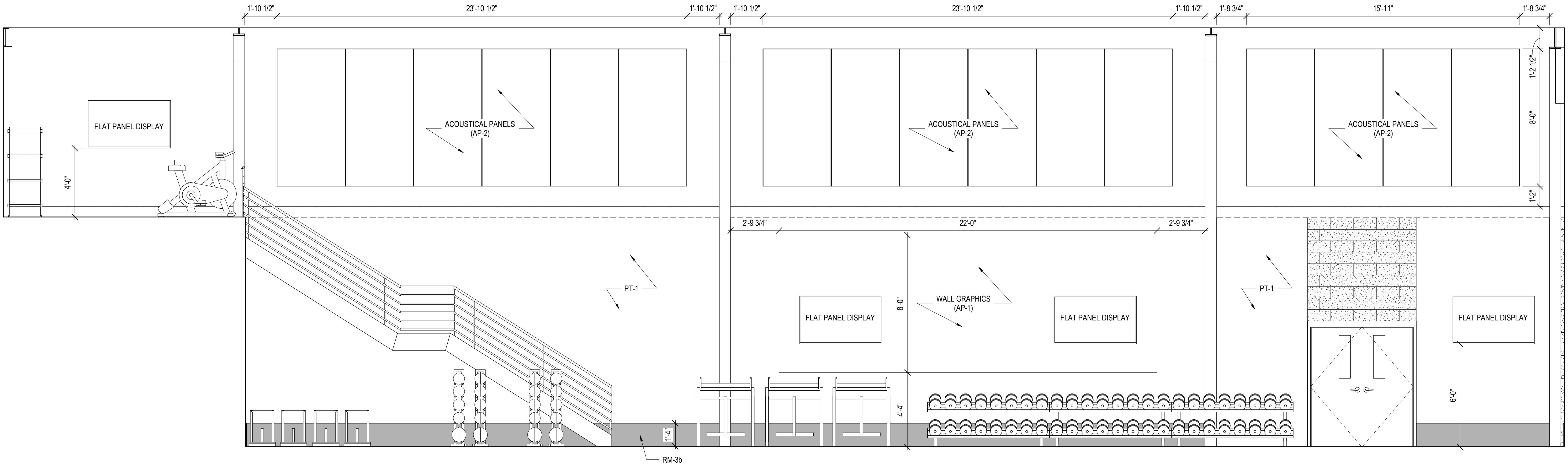
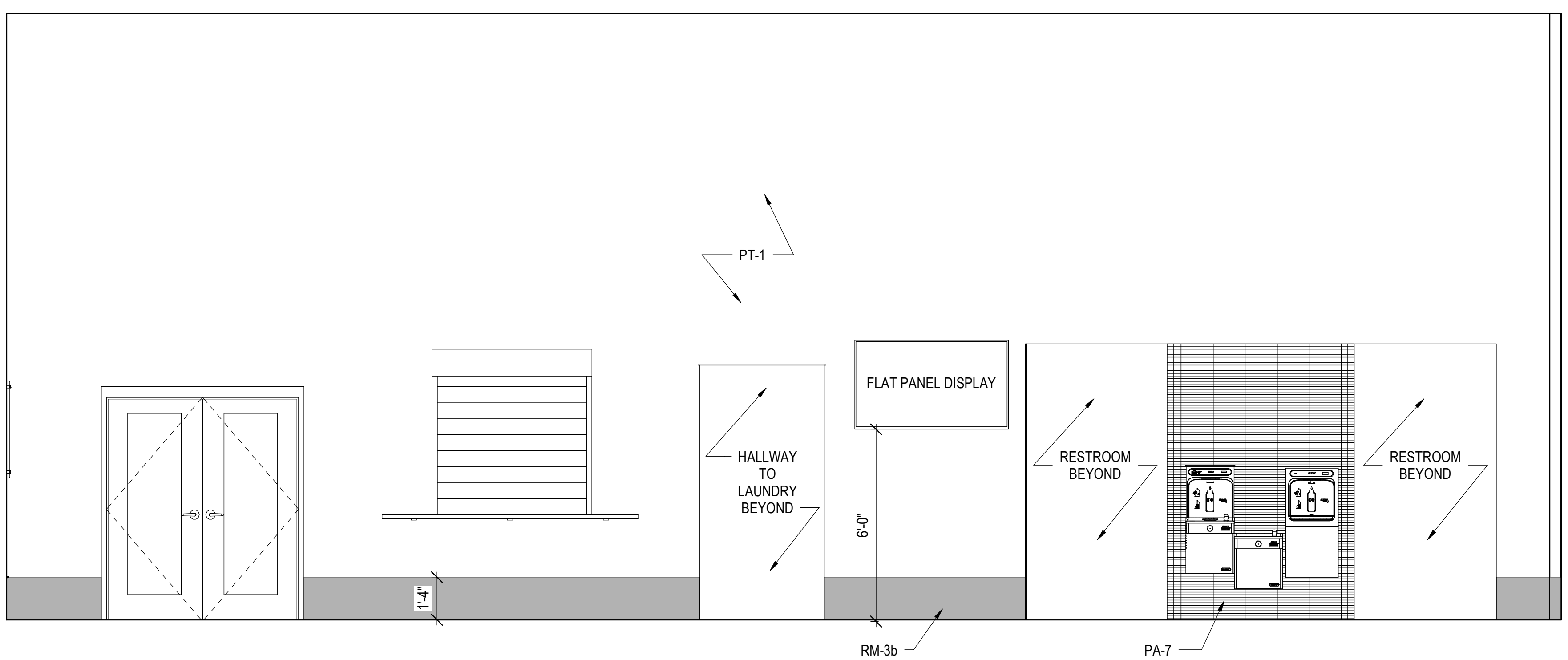
	SPEC. NO.	PROJ. NO. FTFA 23-VH59 — DRAWING NO. — FILE NO. — SHEET OF 91



1 I-202 **GYM 100B ELEVATION - SOUTH WALL**
3/8" = 1'-0"



2 I-202 **GYM 100A ELEVATION - NORTH WALL**
3/8" = 1'-0"

8' 0' 8' 16
SCALE: 1/8"=1'-0"

BASE CIVIL ENGINEER
EGLIN AIR FORCE BASE, FLORIDA

DRAWN BY K MCMURRAY
PROJ. ENGR. BTA
DATE
SIGNATURE
APPROVED
FIRE PREVENTION
APPROVED
SAFETY REPRESENTATIVE
APPROVED
DIR. BASE MED. SERVICE
APPROVED
SECURITY FORCES
APPROVED
USING AGENCY
APPROVED
ASUS
APPROVED
COMMUNICATIONS
APPROVED
CHELCO
APPROVED
OPERATIONS ENGINEERING
APPROVED
ENVIRONMENTAL

TITLE
D51 HANGAR CONVERSION, HUMAN PERFORMANCE CENTER

CONTENTS
INTERIOR ELEVATIONS

APPROVED
96/CEG/CEN
APPROVED
DEPUTY BASE CIVIL ENGINEER

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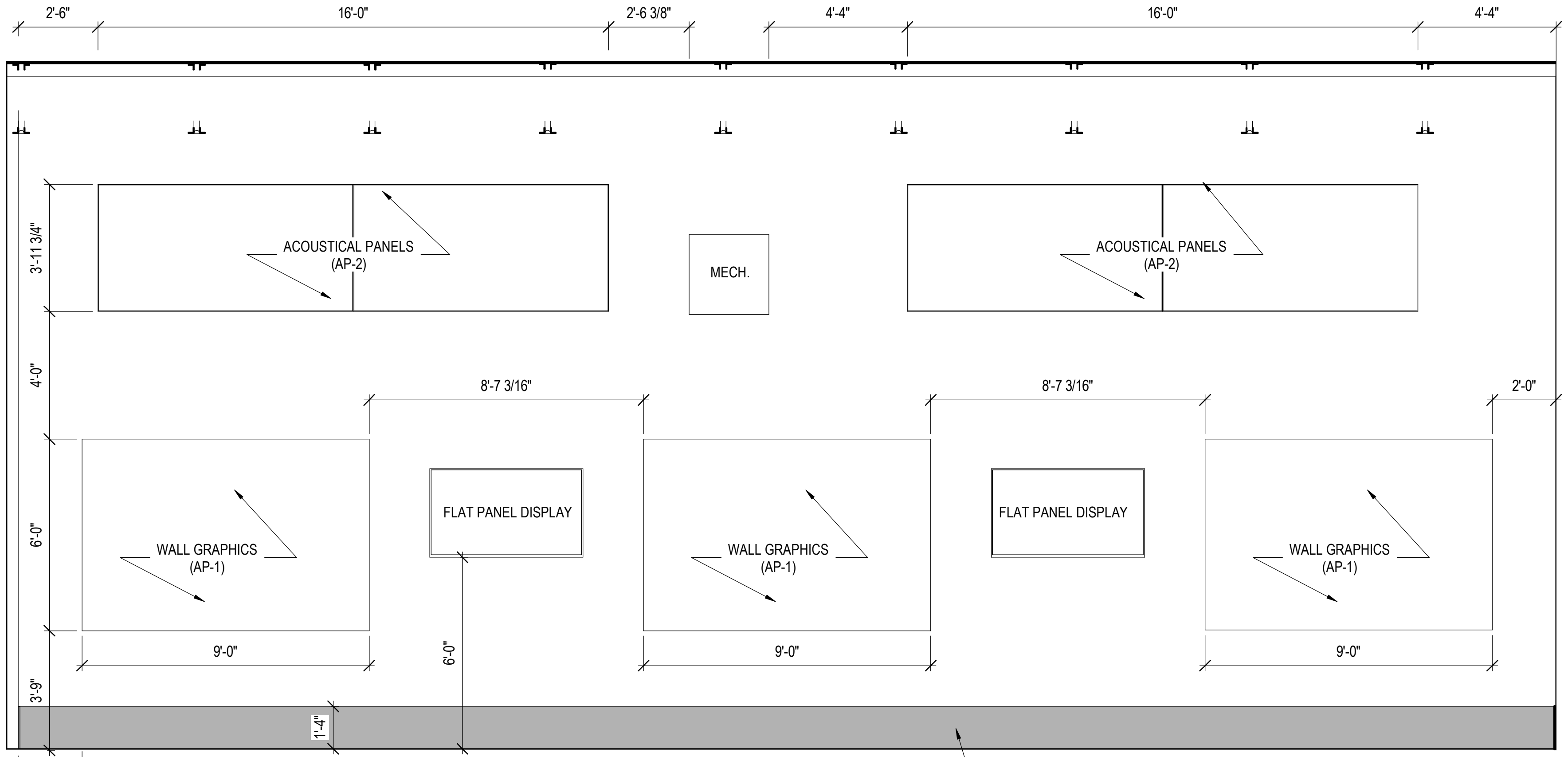
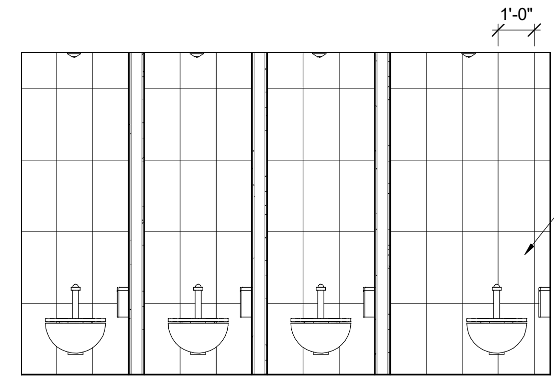
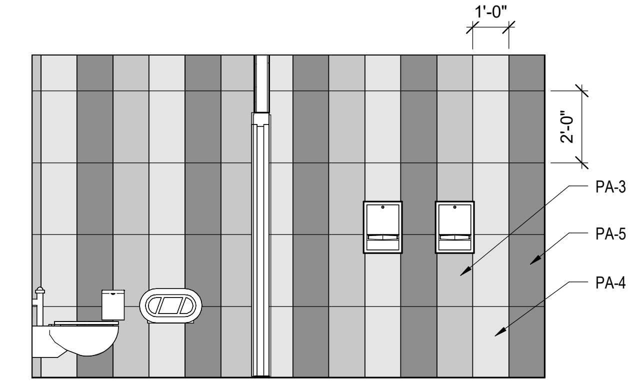


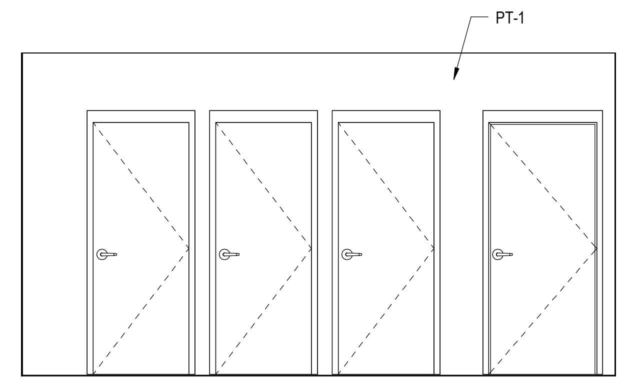
1 I-203 GYM 100A ELEVATION - SOUTH WALL
3/8" = 1'-0"



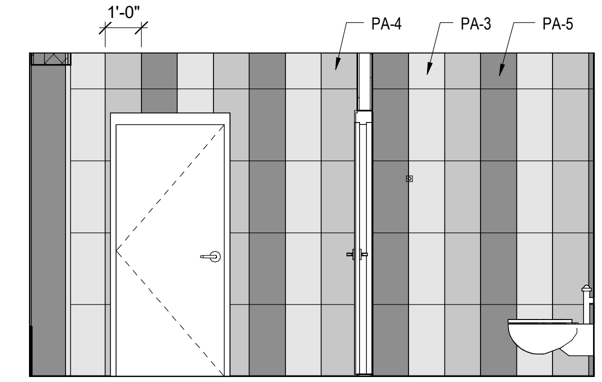
2 I-203 RESTROOM ELEVATION - NORTH WALL - A
3/8" = 1'-0"



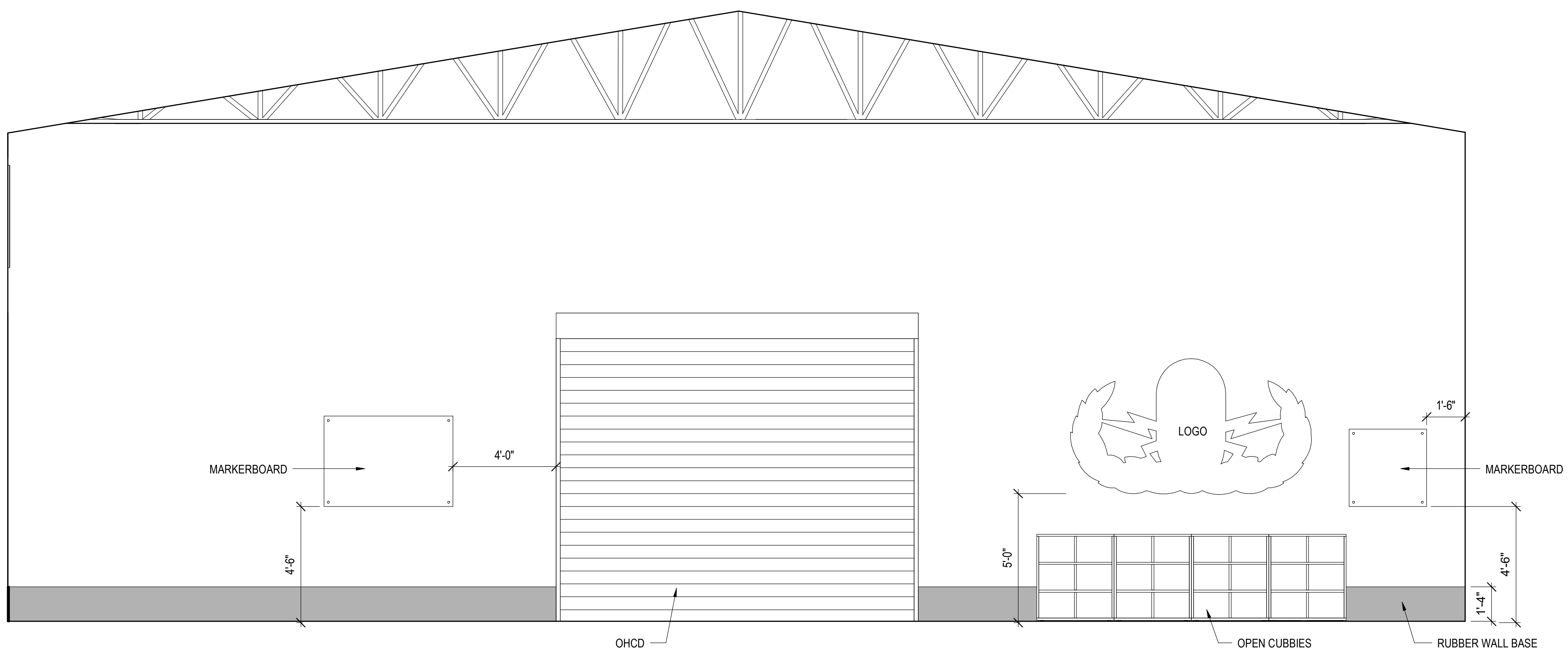
3 I-203 RESTROOM ELEVATION - EAST WALL
3/8" = 1'-0"



4 I-203 RESTROOM ELEVATION - NORTH WALL - B
3/8" = 1'-0"



5 I-203 RESTROOM ELEVATION - WEST WALL
3/8" = 1'-0"



6 I-203 GYM 100A ELEVATION - WEST WALL
3/8" = 1'-0"

8' 0' 8' 16
SCALE: 1/8"=1'-0"

BASE CIVIL ENGINEER
EGLIN AIR FORCE BASE, FLORIDA

DRAWN BY K MCMURRAY
PROJ. ENGR. BTA
TITLE
D51 HANGAR CONVERSION, HUMAN PERFORMANCE CENTER

DATE
SIGNATURE

APPROVED FIRE PREVENTION
APPROVED SAFETY REPRESENTATIVE
APPROVED DIR. BASE MED. SERVICE
APPROVED SECURITY FORCES
APPROVED USING AGENCY
APPROVED ASUS
APPROVED COMMUNICATIONS
APPROVED CHELCO
APPROVED OPERATIONS ENGINEERING
APPROVED ENVIRONMENTAL

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INTERIOR ELEVATIONS

APPROVED 96/CEG/CEN
APPROVED DEPUTY BASE CIVIL ENGINEER

DATE 23 MAY 2024
SCALE AS SHOWN

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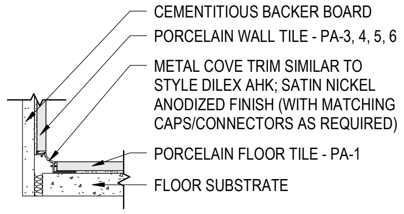
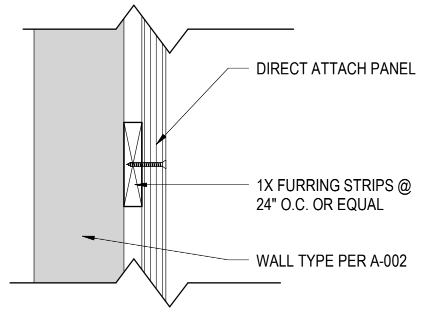
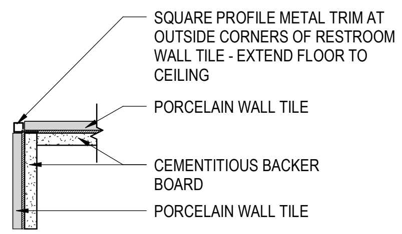
DRAWING NO.
FILE NO.
SHEET OF 91



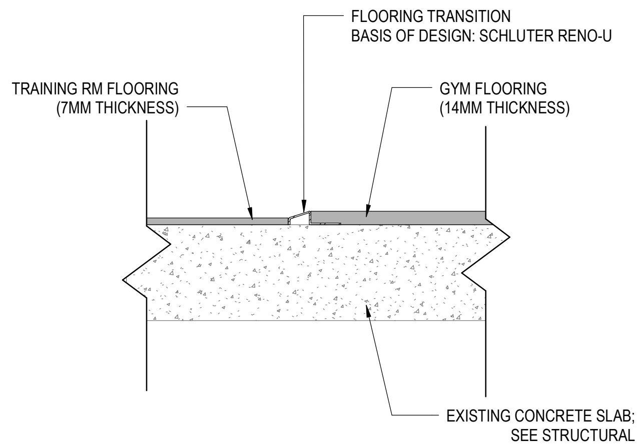
1 I-501 **COVE TRIM DETAIL**
3" = 1'-0"



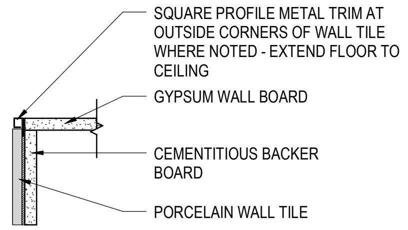
5 I-501 **ACOUSTICAL PANEL MOUNTING DETAIL**
3" = 1'-0"



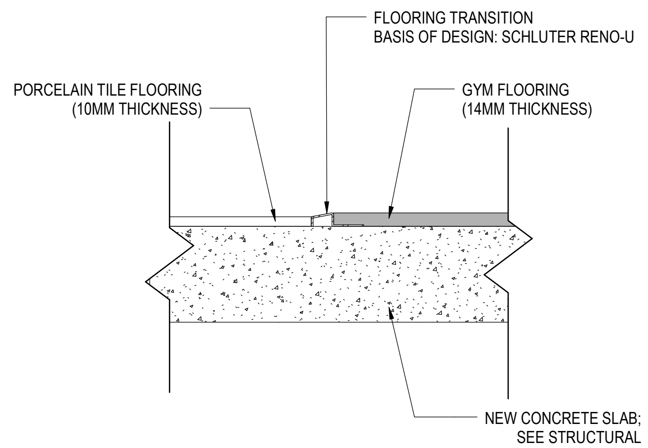
2 I-501 **CORNER DETAIL - TILE TO TILE**
3" = 1'-0"



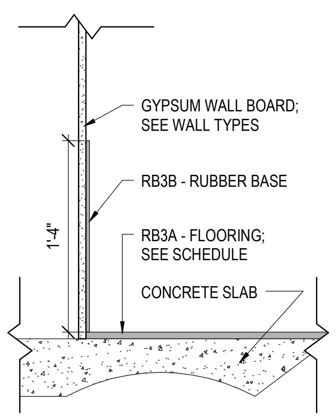
6 I-501 **RESILIENT MATERIAL FLOOR TRANSITION DETAIL**
3" = 1'-0"



3 I-501 **CORNER DETAIL - GWB TO TILE**
3" = 1'-0"



7 I-501 **RESILIENT MATERIAL FLOOR TO TILE TRANSITION DETAIL**
3" = 1'-0"



4 I-501 **RUBBER BASE DETAIL**
1 1/2" = 1'-0"

8" 0' 8" 16"
SCALE: 1 1/2"=1'-0"

6" 4" 2" 0' 6"
SCALE: 3"=1'-0"

BASE CIVIL ENGINEER
EGLIN AIR FORCE BASE, FLORIDA

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INTERIOR DETAILS

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INTERIOR FINISH LEGEND

UFGS SPEC NUMBER	MATERIAL CODE	DESCRIPTION	BASIS OF DESIGN MANUFACTURER	PRODUCT / STYLE NUMBER / SIZE	COLOR NAME / NUMBER	ADDITIONAL COMMENTS
1 - INTERIOR FLOOR FINISHES						
	G-1	GROUT - FLOORS	LATICRETE	TYPE: URETHANE	60 DUSTY GRAY	
	PA-1	PORCELAIN TILE - FLOOR	CASALGRANDE PADANA	COLLECTION: ARCHITECTURE; SIZE: 12" X 24"; FINISH: MATTE	DARK GREY	
	PA-2	PORCELAIN TILE - FLOOR	CASALGRANDE PADANA	COLLECTION: ARCHITECTURE; PATTERN: DECOR MOSAIC; SIZE: 12" X 12" MOSAIC SHEET WITH 3/8" X 3/8" TILES IN RANDOM 4 COLOR PATTERN.	ARCHITECTURAL B	
	PT-4	FLOOR COATING	H & C	SHIELD PLUS ULTRA ACRYLIC CONCRETE SEALER	GULL GRAY HC132	
	RM-1	RESILIENT MATERIAL - FLOOR	ECORE	COLLECTION: PERFORMANCE BEAST PLUS, 4' WIDE SHEETS. 14MM THICK, VULCANIZED COMPOSITION RUBBER GRANULES WITH AN EPDM SURFACE LAYER. 12MM BASE LAYER, 2.5MM SURFACE LAYER.	ES503 RAIDERS	FIELD COLOR
	RM-2	RESILIENT MATERIAL - FLOOR	ECORE	COLLECTION: RAGE TURF; PATTERN: MOTIVATE; SIZE: 35LF X 72" WIDE X 17MM THICK. POLYETHYLENE TURF WITH VULCANIZED COMPOSITION RUBBER BASE LAYER, FUSION BONDED.	BLACK	TURF FLOORING; CONFIRM STRIPING FOR TURF
	RM-3A	RESILIENT MATERIAL - FLOOR	ECORE	COLLECTION: PERFORMANCE BEAST PLUS, 4' WIDE SHEETS. 14MM THICK, VULCANIZED COMPOSITION RUBBER GRANULES WITH AN EPDM SURFACE LAYER. 12MM BASE LAYER, 2.5MM SURFACE LAYER.	ES15A STEEL APPEAL 2	RUBBER ACCENT BORDER COLOR AND WALL BASE
	RM-4	RESILIENT MATERIAL - FLOOR	ECORE	COLLECTION: PERFORMANCE BEAST PLUS, 4' WIDE SHEETS. 14MM THICK, VULCANIZED COMPOSITION RUBBER GRANULES WITH AN EPDM SURFACE LAYER. 12MM BASE LAYER, 2.5MM SURFACE LAYER.	ES509 GREEN	RUBBER ACCENT BORDER COLOR AROUND PERIMETER OF TURF
	RM-5	RESILIENT MATERIAL - FLOOR	ECORE	CUSTOM INK JET LOGO	MATCH LOGO COLORS	CONFIRM LOGO BEFORE ORDERING MATERIAL
	RM-6	RESILIENT MATERIAL - FLOOR	ECORE	COLLECTION: BALANCED MOTIVATE CLASS 1, VULCANIZED RUBBER, 7MM X 70"W SHEET	CATALINA	
	SC	SEALED CONCRETE	---	---	CLEAR	
	SDVT-1	STATIC DISSIPATIVE VINYL TILE	AMERICAN BILTRITE	COLLECTION: ELECTROTILE; SOLID VINYL TILE; SIZE: 12" X 12"	WHITE / BLACK SDT-111	
	WM-1	WALK OFF MAT	CS CONSTRUCTION SPECIALTIES, PEDIGRID	PEDIGRID, G1, RECESSED LEVEL FRAME, TREADS WITH EXTERIOR CARPET INSERTS, POLYPROPYLENE FIBERS AND ALUMINUM FRAME	FRAME: MILL FINISH, CARPET INSERTS: 7325 WROUGHT IRON EXTERIOR BRUSH TREAD.	
2 - INTERIOR BASE FINISHES						
	PAB-1	PORCELAIN TILE - BASE	CASALGRANDE PADANA	COLLECTION: ARCHITECTURE; BULLNOSE; SIZE: 9cmX60cm	DARK GREY	
	RM-3B	RESILIENT MATERIAL - WALL	ECORE	PERFORMANCE MOTIVATE, 16" H RUBBER WALL BASE; MATERIAL TO MATCH FLOOR BORDER TOP LAYER PATTERN AND COLOR OF MATERIAL RM-3A BUT BE 7.5 MM THICK	RM-3: PF-00	
	RM-7	RUBBER WALL BASE	MANNINGTON	4" RUBBER COVE WALL BASE	603 ASH	
3 - INTERIOR WALL FINISHES						
	AP-1	ACOUSTICAL WALL PANELS	ARMSTRONG ACOUSTICAL WALL PANELS	PRODUCT: TECTUM CREATE; DIRECT ATTACH, 1" THICK ACOUSTICAL WALL PANELS MOUNTED TO WALLS USING 1X FURRING STRIPS 24" O.C. LAID ON 3/4" FURRING STRIPS. PRINTED DIGITAL PHOTOGRAPHS TO BE PROVIDED BY USERS IN HIGH RESOLUTION FORMAT AS REQUIRED FOR PRINTING ON SURFACE OF TECTUM PANELS IN COLOR .SEE ELEVATIONS FOR OVERALL SIZE OF EACH PANEL. CONTRACTOR TO COORDINATE WITH USERS THE SELECTION OF GRAPHIC DIGITAL PHOTOS TO BE PRINTED ON EACH SHEET. USERS TO PROVIDE PICTURES IN REQUIRED FORMAT FOR USE BY CONTRACTOR FOR APPLICATION TO TECTUM ACOUSTIC PANELS. EACH PANEL WILL BE A DIFFERENT DIGITAL PHOTOGRAPH.	SEE ELEVATIONS FOR SIZES AND DETAILS.	
	AP-2	ACOUSTICAL WALL PANELS - HEXAGONAL	ARMSTRONG ACOUSTICAL WALL PANELS	PRODUCT: TECTUM CREATE DIRECT-ATTACH PANELS; PATTERN: TEXTURED HEX. SEE DRAWINGS FOR OVERALL SIZE AND LOCATION.	TEXTURED HEX (CXH)	INSTALL WITH FURRING STRIPS
	FRP-1	FIBERGLASS REINFORCED PANELS	CRANE COMPOSITES	VARIETEX LINEN TEXTURE	MORNING MIST GRAY, 363	INCLUDE ALL CORNER AND TRIM PIECES.
	G-2	GROUT - WALLS	LATICRETE	TYPE: URETHANE	SMOKE GRAY	
	PA-3	PORCELAIN TILE - WALL	CASALGRANDE PADANA	COLLECTION: ARCHITECTURE; SIZE: 12" X 24"; INSTALLATION METHOD: VERTICAL STRAIGHT STACK; FINISH: MATTE	MEDIUM GREY	
	PA-4	PORCELAIN TILE - WALL	CASALGRANDE PADANA	COLLECTION: ARCHITECTURE; SIZE: 12" X 24"; INSTALLATION METHOD: VERTICAL STRAIGHT STACK; FINISH: POLISHED	LIGHT GREY	
	PA-5	PORCELAIN TILE - WALL	CASALGRANDE PADANA	COLLECTION: ARCHITECTURE; SIZE: 12" X 24"; INSTALLATION METHOD: VERTICAL STRAIGHT STACK; FINISH: POLISHED	DARK GREY	
	PA-6	PORCELAIN TILE - WALL	CASALGRANDE PADANA	COLLECTION: R-EVOLUTION; SIZE: 12" X 24"; INSTALLATION: VERTICAL STRAIGHT STACK	BLUE	
	PA-7	PORCELAIN TILE - WALL	CASALGRANDE PADANA	COLLECTION: ARCHITECTURE; PATTERN: MIX LISTELLI; SIZE: 11-3/4" X 11-3/4" MOSAIC SHEET WITH ROWS OF 1/2" X 11-3/4" STRIPS. INSTALL WITH STRIPS HORIZONTAL.	ARCHITECTURE B	
	PT-1	PAINT - WALLS	PPG - PITTSBURGH PAINT	EGGSHELL FINISH; PPG0993-1	PEREGRINE	
	SS-2	SOLID SURFACE - SHOWER WALLS	CORIAN	THICKNESS: 1/2"; FULL HEIGHT PANELS	MODERN WHITE	
4 - INTERIOR CEILING FINISHES						
	ACT-1	ACOUSTICAL CEILING TILE	ARMSTRONG CEILING SOLUTIONS	PRODUCT: ULTIMA HIGH NRC; STYLE: BEVELED TEGULAR; SIZE: 24" X 24"; SUSPENSION SYSTEM: PRELUDE; SIZE: 15/16"; COLOR: WHITE	WHITE	
	EXP-1	EXPOSED STRUCTURE - PAINTED	PPG - PITTSBURGH PAINT	SEMI-GLOSS FINISH; PPG1002-1	SILVER FEATHER	
	PT-3	PAINT - CEILING	PPG - PITTSBURGH PAINT	EGGSHELL FINISH; PPG1002-1	SILVER FEATHER	
5 - INTERIOR TRIM						
	CG-1	CORNER GUARD	CS ACROVYN	TEXTURED ACRYLIC, 2" WINGS, FULL HEIGHT	927 FOLKSTONE	
	PT-2	PAINT - HOLLOW METAL DOORS AND TRIM	PPG - PITTSBURGH PAINT	SEMI GLOSS	PPG0996-4 CLOUDY SLATE	
6 - INTERIOR MISCELLANEOUS						
	PL-1	PLASTIC LAMINATE - BASE CABINET	WILSONART	HPL 18 LINEARITY FINISH WITH AEON	5058K-18 TITANIUM ALLOY	
	PL-2	PLASTIC LAMINATE - PIPESKIRT	WILSONART	HPL 18 LINEARITY FINISH WITH AEON	5058K-18 TITANIUM ALLOY	
	PT-4	PAINT - STAIR AND RAILING	PPG - PITTSBURGH PAINT	SEMI-GLOSS FINISH; PPG1133-6 PAINTED TURTLE	PAINTED TURTLE	
	RM-8	RUBBER STAIR TREADS AND RISERS	NORA	PRODUCT: NORAMENT ARAGO - STAIR TREAD / RISER COMBO, 100% RUBBER	5172 STAMINA WITH CORAL RED SMOOTH VISUAL STRIP	
	SS-1	SOLID SURFACE - COUNTERTOP	CORIAN	QUARTZ, THICKNESS: 1/2" WITH BUILT UP FRONT LIP AND EASED EDGES	STRATUS WHITE LEATHERED	
	WD-1	WOOD DOORS	VT INDUSTRIES	WHITE BIRCH, PLAIN SLICED, BOOK MATCHED	WHEAT WH18	
7 - INTERIOR SIGNAGE						
	IS	INTERIOR SIGNAGE - FACE MATERIAL	TAKEFORM	PRODUCT STYLE: FUSION 01	WILSONART 5058K-18 TITANIUM ALLOY	
	IS	INTERIOR SIGNAGE - RAISED COPY	TAKEFORM	---	BLACK	
	IS	INTERIOR SIGNAGE - INSERT TEXT	TAKEFORM	HELVETICA	PRINTED ON PAPER	
	IS	INTERIOR SIGNAGE - METAL ACCENT BAR	TAKEFORM	---	SILVER	
	IS	INTERIOR SIGNAGE - INSERT BACKGROUND	TAKEFORM	---	WHITE	
	IS	INTERIOR SIGNAGE - TEXT STYLE	TAKEFORM	HELVETICA	ADA/ABA COMPLIANT	

GENERAL NOTES

1. REFER TO REFLECTED CEILING PLAN SHEET A-111 FOR CEILING HEIGHTS.
2. REFER TO SHEETS I-101 AND I-601 FOR EXTENT OF FLOOR FINISHES.
3. REFER TO SHEETS I-105 AND I-602 FOR SIGNAGE AND CORNER GUARD PLAN, SCHEDULE, AND DETAILS.
4. ALL INTERIOR HOLLOW METAL DOORS AND FRAMES SHALL BE PAINTED PT2 EXCEPT NORTH WALL ROOM 103.
5. ALL ELECTRICAL SWITCHES, RECEPTACLES, VOICE AND DATA PLATES SHALL BE STAINLESS STEEL.
6. ALL PLUMBING FIXTURES SHALL BE WHITE.
7. INSTALL FLOOR TRANSITION TRIM AT JUNCTURE OF DISSIMILAR MATERIALS; I.E. PORCELAIN PAVER AND RESILIENT FLOORING.
8. EXPOSED STRUCTURE SHALL BE PAINTED PT3. IN EXISTING GYM AREA 100B, PAINT STRUCTURAL STEEL ONLY. IN NEW GYM AREA 100A, PAINT STRUCTURAL STEEL AND SPRAYED ON INSULATION.
9. CORNER GUARDS SHALL EXTEND FROM TOP OF WALL BASE TO CEILING. PROVIDE CORNER GUARDS AT ALL OUTSIDE CORNERS IN HALLWAYS
10. AP (ACOUSTICAL PANELS) SHALL BE MOUNTED AT LOCATIONS SHOWN ON INTERIOR ELEVATION SHEETS, I-201, I-202, AND I-203.
11. PROVIDE FRP PANELS TO HEIGHT OF 48" ON ALL WALLS IN JANITOR ROOMS. INCLUDE ALL CORNER AND TRIM PIECES.
12. ALL CEILING MOUNTED DEVICES SHALL BE CENTERED ON THE ACOUSTICAL CEILING TILE.
13. PROVIDE VERTICAL (SQUARE PROFILE) METAL EDGE TRIM ON ALL OUTSIDE CORNERS OF WALL TILE. SEE DETAIL SHEET I-501.
14. PROVIDE PREFABRICATED COVE TILE TRIM TO RECEIVE FLOOR AND WALL TILE EDGES. SEE DETAIL SHEET I-501.
15. FOR CMU WALLS, PROVIDE 2 COATS BLOCK FILLER AND 2 COATS SEMI-GLOSS PAINT.
16. FLOOR DRAINS SHALL BE LINEAR IN SHOWER AND SQUARE IN ALL OTHER AREAS.
17. FINISH SCHEDULE IS BASED ON PLAN NORTH.
18. PATCH AND REPAIR ADJACENT WALLS DUE TO DEMOLITION.
19. SEE WALL TYPE LEGEND ON SHEET A-002 FOR WALL SUBSTRATE.
20. INTERIOR AND EXTERIOR FINISH MATERIALS AND COLORS SHALL BE AS REFERENCED IN THE SPECIFICATION SECTION 09 06 00 SCHEDULE FOR FINISHES WHICH PROVIDES DETAILS INFORMATION OF THE FINISH CODES SHOWN ON THE FINISH LEGEND.
21. REFERENCE FINISH SPECIFICATION SECTIONS FOR THE BASIS OF DESIGN EQUIVALENT MANUFACTURER TECHNICAL REQUIREMENTS.
22. INTERIOR CAULKING TO MATCH ADJACENT WALL FINISH COLOR.
23. CLEAN AND PREP ALL EXISTING SURFACES FOR NEW FINISH.

FINISH SCHEDULE REMARKS

1. TREADS AND RISERS SHALL BE RM-8, ONE PIECE WITH STAIR NOSING, RISER AND TREAD TO FIT EXISTING STRAIGHT METAL STAIRS WITH CONCRETE AND AN ANGLED EDGE.
2. ALL COUNTERTOPS SHALL RECEIVE SS1. ALL UPPER AND BASE CABINETS SHALL RECEIVE PL1.
3. PROVIDE FULL HEIGHT SOLID SURFACE WALL PANELS AT SHOWER ALL WALLS.
4. RESTROOM WALL TILE SHALL HAVE PA-6 ON NORTH WALL OF EACH SEPARATE TOILET STALL. SEE ENLARGED RESTROOM FINISH PLAN.

ROOM FINISH SCHEDULE

		FLOOR	BASE	WALLS				MILLWORK	CEILING	
				NORTH	EAST	SOUTH	WEST			
ROOM NO.	ROOM NAME	FIN - COLOR	FIN - COLOR	FIN - COLOR	FIN - COLOR	FIN - COLOR	FIN - COLOR	FIN - COLOR	FIN - COLOR	REMARKS
100A	GYM	RM-1, RM-2, RM-3, RM-4, RM-5	RM-3, RM-7	PT-1, PA-5	---	PT-1	PT-1	SS-1	EXP - PT-3	
100B	GYM	RM-1, RM-2, RM-3, RM-4	RM-3	PT-1	PT-1	PT-1	---	---	EXP - PT-3	R2, R3
101	LAUNDRY	PA-1	PAB-1	PT-1	PT-1	PT-1	PT-1	SS-1	ACT-1	
102	HALLWAY	PA-1	PAB-1	PT-1	PT-1	PT-1	PT-1	PL-1	ACT-1	
103	SHOWER	PA-2	SS-3	SS-3	SS-3	SS-3	SS-3	---	GWB - PT-3	R5
104	JAN.	PA-1	PAB-1	PT-1 / FRP-1	PT-1 / FRP-1	PT-1 / FRP-1	PT-1 / FRP-1	---	GWB - PT-3	
105	RESTROOMS	PA-1	PA-3, PA-4, PA-5, PA-6	PA-6 / PT-1	PA-3, PA-4, PA-5	PA-3, PT-1	PA-3, PA-4, PA-5	SS-1 / PL-1	GWB - PT-3	R6
106	TRAINING 1	RM-6	RM-7	PT-1	PT-1	PT-1	PT-1	SS-1 / PL-1	ACT-1	R2, R4
107	TRAINING 2	RM-6	RM-7	PT-1	PT-1	PT-1	PT-1	SS-1 / PL-1	ACT-1	R2, R4
108	ADMIN	RM-6	RM-7	PT-1	PT-1	PT-1	PT-1	---	ACT-1	R2
109	BREAK RM	RM-3	PAB-1	PT-1	PT-1	PT-1	PT-1	SS-1 / PL-1	ACT-1	R2, R4
110	COMM	SDVT-1	RM-7	PT-1	PT-1	PT-1	PT-1	---	GWB - PT-3	R2
111	HALLWAY	RM-3	PAB-1	PT-1	PT-1	PT-1	PT-1	---	ACT-1	R2
112	MECH / ELEC	SC	RM-7	PT-1	PT-1	PT-1	PT-1	---	EXP - PT-3	R2
113	STORAGE	PT-4	RM-7	PT-1	PT-1	PT-1	PT-1	---	EXP - PT-3	R2
R201	MEZZANINE	RM-1	RM-7	PT-1	PT-1	PT-1	---	---	EXP - PT-3	R2

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APPROVED DEPUTY BASE CIVIL ENGINEER

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D51 HANGAR CONVERSION, HUMAN PERFORMANCE CENTER

CONTENTS
FINISH SCHEDULE, LEGEND, AND NOTES

DATE 23 MAY 2024
SCALE AS SHOWN

INDEX NO. I-601
SPEC. NO.
PROJ. NO. FTFA 23-VH59
DRAWING NO.
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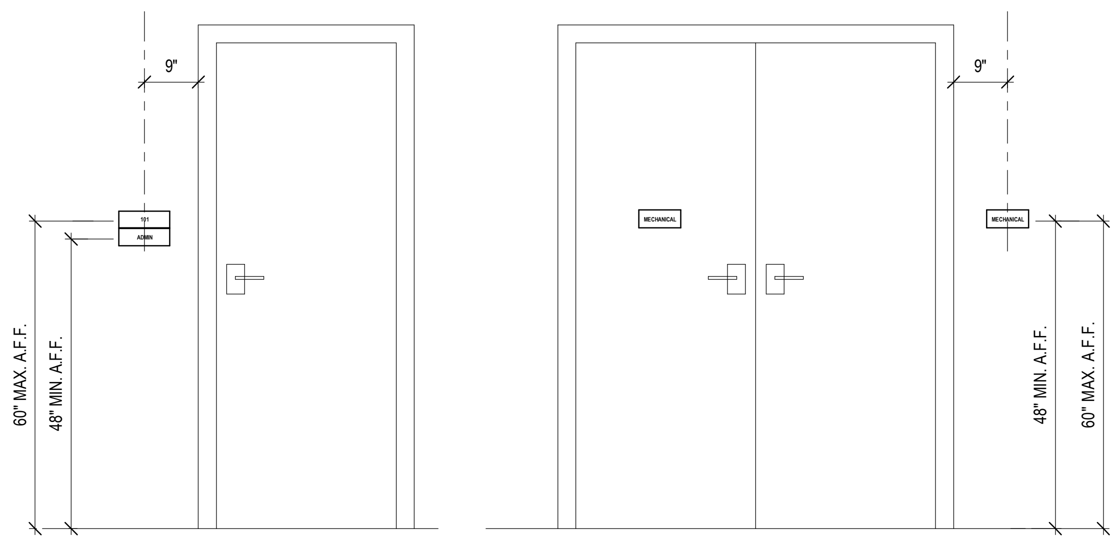
SIGNAGE SCHEDULE

MARK	ROOM NUMBER	ROOM NAME	PERMANENT COPY	CHANGEABLE COPY	TYPE	MOUNT LOCATION
1	100B	GYM	GYM	---	TYPE C	EXTERIOR WALL
2	100A	GYM	GYM	---	TYPE C	EXTERIOR WALL
3	101	LAUNDRY	LAUNDRY	---	TYPE A	INTERIOR WALL
4	102	HALLWAY	ICE / HALLWAY	---	TYPE C	EXTERIOR WALL
5	103	SHOWER	SHOWER	---	TYPE C	EXTERIOR WALL
6	104	JAN.	JANITOR	---	TYPE A	INTERIOR WALL
7	106	TRAINING 1	TRAINING	---	TYPE A	INTERIOR WALL
8	106	TRAINING 1	TRAINING	---	TYPE C	EXTERIOR WALL
9	107	TRAINING 2	TRAINING	---	TYPE A	INTERIOR WALL
10	107	TRAINING 2	TRAINING	---	TYPE C	EXTERIOR WALL
11	108	ADMIN	---	ADMIN NAMES	TYPE B	INTERIOR WALL
12	108	ADMIN	ADMIN	---	TYPE C	EXTERIOR WALL
13	109	BREAK RM	BREAK ROOM	---	TYPE A	INTERIOR WALL
14	110	COMM	COMM	---	TYPE C	EXTERIOR WALL
15	111	HALLWAY	HALLWAY	---	TYPE C	EXTERIOR WALL
16	112	MECH / ELEC	MECHANICAL / ELECTRICAL	---	TYPE C	EXTERIOR WALL
17	113	STORAGE	STORAGE	---	TYPE A	INTERIOR WALL

GENERAL NOTES

1. SIGNAGE SHALL BE FABRICATED AND INSTALLED IN ACCORDANCE WITH ADA / ABA GUIDELINES.
2. REFER TO THE INTERIOR FINISH LEGEND ON SHEET I-601 FOR SIGNAGE FINISHES.
3. REFER TO SHEET I-105 FOR SIGNAGE PLAN AND TAG LOCATIONS.
4. REFERENCE FINISH SPECIFICATION SECTIONS FOR THE BASIS OF DESIGN EQUIVALENT MANUFACTURERS TECHNICAL REQUIREMENTS.
5. CONFIRM / COORDINATE COPY TEXT WITH USER BEFORE PURCHASING SIGNAGE.

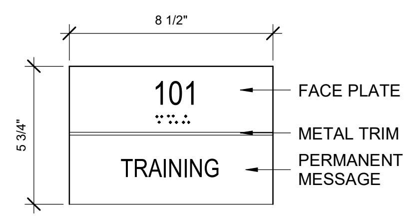
SIGN TYPE MOUNTING TYPICAL



ADA / ABA SIGN INSTALLATION HEIGHT AND LOCATION

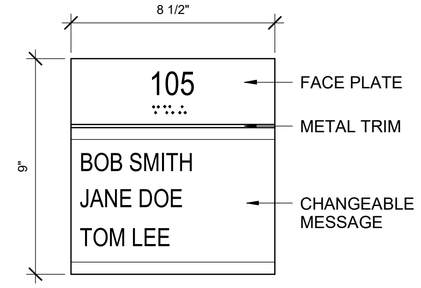
ADA / ABA SIGN INSTALLATION HEIGHT AND LOCATION. IF ONE DOOR IS INACTIVE SIGN MAY BE CENTERED ON INACTIVE DOOR. IF BOTH DOORS ARE ACTIVE, SIGN SHALL HANG TO THE RIGHT OF THE DOORS.

SIGN TYPES - TAKEFORM FUSION 01



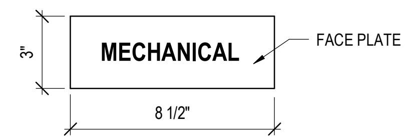
SIGN TYPE "A"

USE FOR ALL OFFICES AND ROOMS NOT SPECIFICALLY LISTED AS TYPES B OR C. SIGNS WILL HAVE ROOM NUMBERS, BRAILLE, AND ONE PERMANENT MESSAGE. SEE MOUNTING TYPICAL FOR SIGN MOUNTING.



SIGN TYPE "B"

USE FOR ALL OFFICES AND ROOMS NOT SPECIFICALLY LISTED AS TYPES A OR C. SIGNS WILL HAVE ROOM NUMBERS, BRAILLE, AND ONE CHANGEABLE MESSAGE SLOT. SEE MOUNTING TYPICAL FOR SIGN MOUNTING.



SIGN TYPE "C"

PROVIDE EXTERIOR GRADE SIGN. SEE MOUTNING TYPICAL FOR SIGN MOUNTING.

BASE CIVIL ENGINEER
EGLIN AIR FORCE BASE, FLORIDA

DATE
SIGNATURE

DRAWN BY K MCMURRAY
PROJ. ENGR. BTA
APPROVED FIRE PREVENTION
APPROVED SAFETY REPRESENTATIVE
APPROVED DIR. BASE MED. SERVICE
APPROVED SECURITY FORCES
APPROVED ASUS
APPROVED CHELCO
APPROVED USING AGENCY
APPROVED COMMUNICATIONS
APPROVED OPERATIONS ENGINEERING
APPROVED ENVIRONMENTAL
APPROVED 96/CEG/CEN
APPROVED DEPUTY BASE CIVIL ENGINEER

TITLE
D51 HANGAR CONVERSION, HUMAN PERFORMANCE CENTER

CONTENTS
SIGNAGE SCHEDULE, NOTES, AND DETAILS

DATE 23 MAY 2024
SCALE AS SHOWN

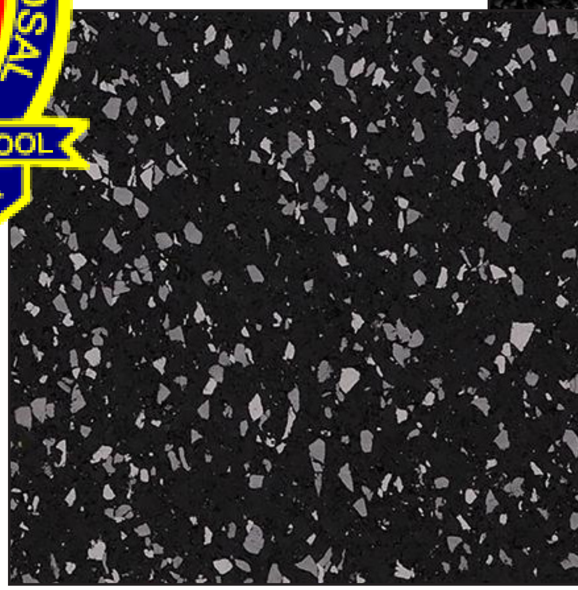
INDEX NO. I-602
SPEC. NO.
PROJ. NO. FTFA 23-VH59
DRAWING NO.
FILE NO.
SHEET OF 91

FINISH BOARDS

D51 HANGAR CONVERSION
HUMAN PERFORMANCE CENTER
STRUCTURAL INTERIOR DESIGN FINISH BOARD

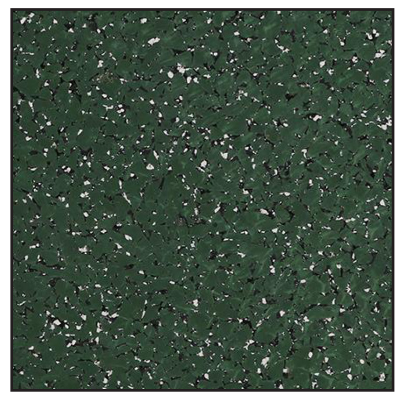
RM-5 - RESILIENT FLOORING
CUSTON LASER JET LOGO

RM-2 - RESILIENT FLOORING
TURF

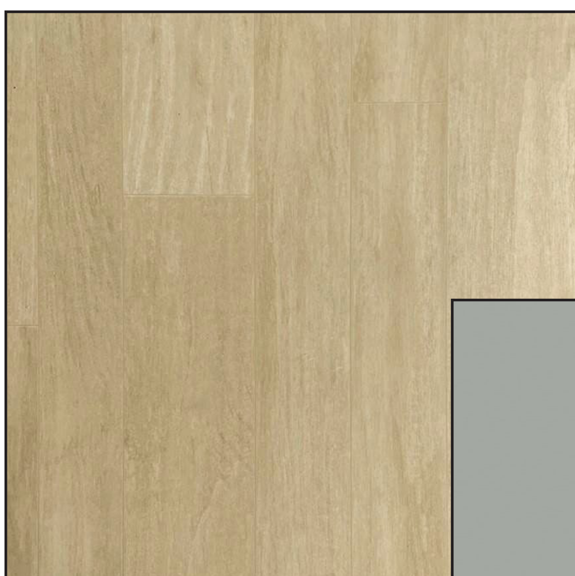


RM-1 - RESILIENT FLOORING
MAIN FLOORING COLOR

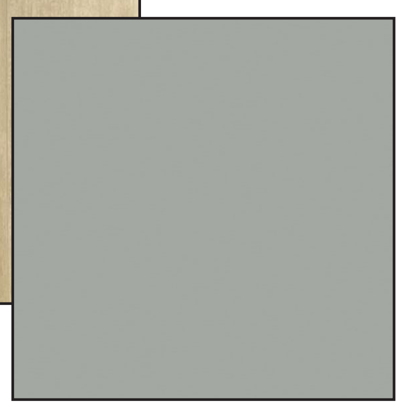
RM-3 - RESILIENT FLOORING
ACCENT BAND



RM-4 - RESILIENT FLOORING
ACCENT BAND



RM-6 - RESILIENT FLOORING
TRAINING AND ADMIN AREAS



RM-7 - RUBBER
WALL BASE

BTA
A GHC COMPANY

D51 HANGAR CONVERSION

HUMAN PERFORMANCE CENTER

STRUCTURAL INTERIOR DESIGN FINISH BOARD

PORCELAIN
WALL TILE

PA-3

PA-4

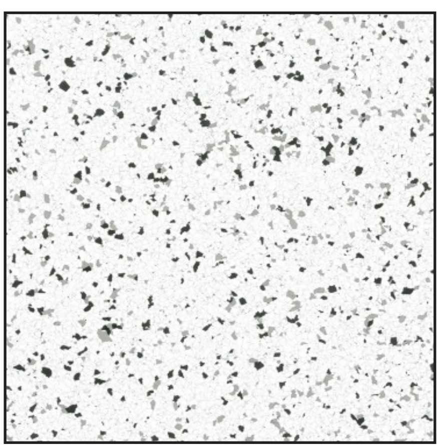
PA-5

PA-7- PORCELAIN WALL TILE
ACCENT TILE

PA-1 - PORCELAIN FLOOR TILE
PAB-1 - PORCELAIN TILE BASE

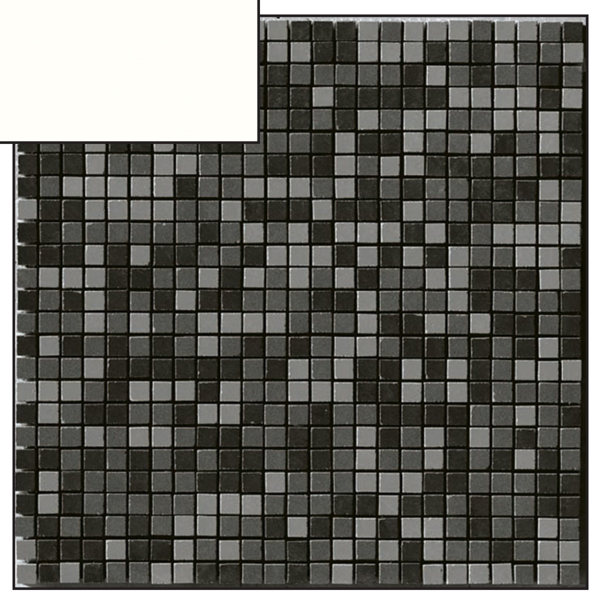
PA-6 - PORCELAIN WALL TILE
ACCENT WALL

SS-2 - SOLID SURFACE
WALL PANELS



SDVT-1 - STATIC DISSIPATIVE
VINYL TILE

RM-8 - STAIR TREAD AND
RISER

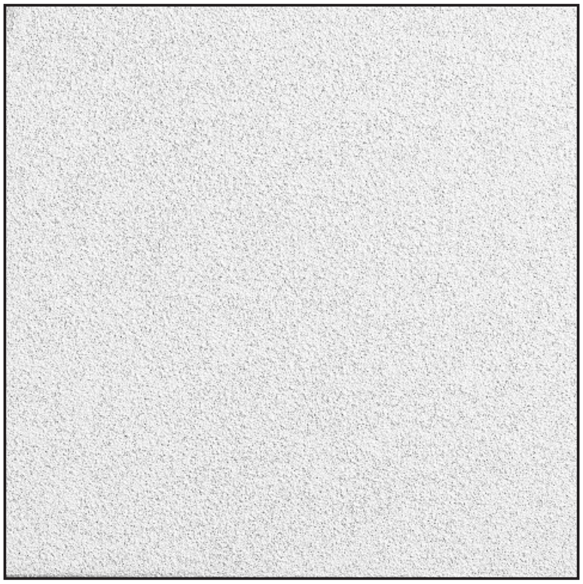


PA-2 - PORCELAIN FLOOR TILE
MOSAIC TILE

D51 HANGAR CONVERSION

HUMAN PERFORMANCE CENTER

STRUCTURAL INTERIOR DESIGN FINISH BOARD



ACT-1 - ACOUSTICAL CEILING TILE

PT-1 - WALLS

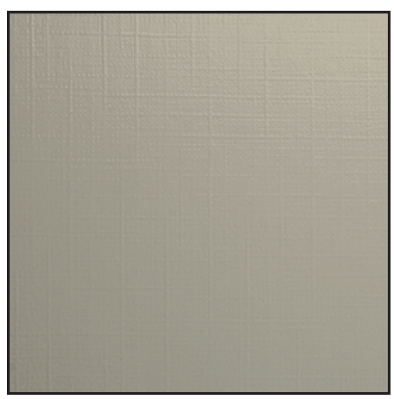
PT-2 - TRIM

CG-1 - CORNER GUARD

PT-3 - CEILING

PT-4 - STAIR AND RAILING

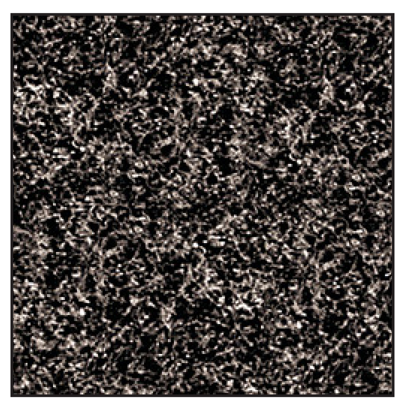
SS-1 - QUARTZ COUNTERTOP



FRP-1 - FIBERGLASS REINFORCED PANELS

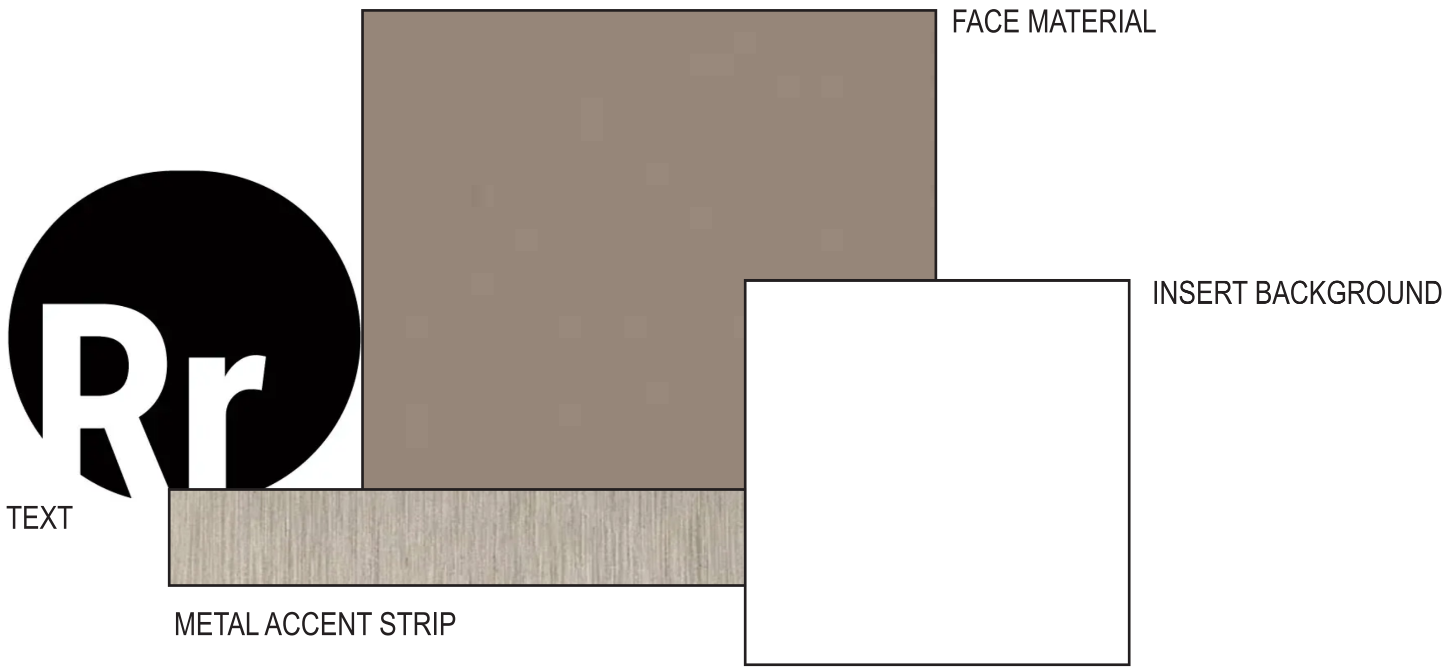
PL-1, PL-2 - PLASTIC LAMINATE

WM-1 - WALK-OFF MAT EXTERIOR CARPET INSERT



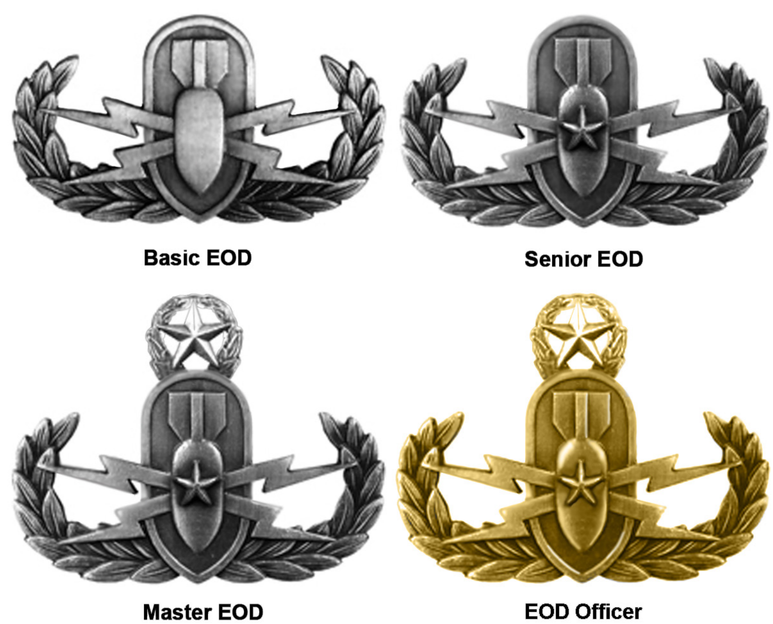
D51 HANGAR CONVERSION
HUMAN PERFORMANCE CENTER
STRUCTURAL INTERIOR DESIGN FINISH BOARD

INTERIOR SIGNAGE



ENTRY LOGO STYLE - 3FORM

WALL LOGO - 3FORM MATERIAL
CONTRACTOR TO PROVIDE SELECTIONS & DRAWINGS FOR USER APPROVAL.



D51 HANGAR CONVERSION
HUMAN PERFORMANCE CENTER
STRUCTURAL INTERIOR DESIGN FINISH BOARD

ACOUSTICAL PANELS

AP-1 - ACOUSTICAL WALL PANELS
PRINTED IMAGE
TECTUM IMAGE SHOWN IS FOR EXAMPLE ONLY. USERS TO PROVIDE DIGITAL PHOTOS FOR CONTRACTOR USE.

AP-2 - ACOUSTICAL WALL PANELS
HEXAGON SHAPES

TECHNICAL INFORMATION

ULTIMA®
ULTIMA® High NRC

Tegular
fine texture

TOTAL ACOUSTICS®
Sound Absorption (NRC)
+ Sound Blocking (CAC)

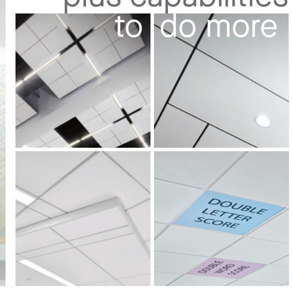
SUSTAIN®
High Performance
Sustainable
Ceiling Systems

Ultima® Beveled Tegular panels with Silhouette® 1/4" reveal 9/16" suspension system

CAD/Revit® drawings at:
armstrongceilings.com/cadrevit

DESIGNFlex®
A New World of Choice
for Ceiling Systems

plus capabilities to do more



armstrongceilings.com/capabilities
See more photos at:
armstrongceilings.com/photogallery

Smooth-texture panels that are washable, impact- and scratch-resistant with a non-directional visual.
Offer both Sustain® and Total Acoustics® panel performance for flexible spaces.

KEY SELECTION ATTRIBUTES

- DesignFlex® options include shapes and made-to-order sizes available to ship in 3 weeks
- Get total noise control and floor plan versatility with Total Acoustics® ceiling panels: NRC + CAC = Total Acoustics performance
- Ultima® panels are part of the Sustain® portfolio, and meet the most stringent industry sustainability compliance standards today
- new High sound absorption options available up to 0.85 NRC
- CleanAssure™ family of products – includes disinfectable panels, suspension systems, and trim
- Mold- and mildew-resistant surface
- Smooth, clean, durable finish –
  Washable, Impact-resistant,
  Scratch-resistant, Soil-resistant
- Ceiling-2-Ceiling™ Post-consumer Recycled Content options: items 1911HRC, 1912HRC, 1914HRC, 1915HRC. 71% Pre-consumer; 15% Post-consumer
- USDA-Certified Biobased Product – 95%
- Available with AirGuard™ coating
- Item 1912 available with Create!™ printed images and patterns
- Non-directional visual reduces scrap and installation time
- Compatible with the TechZone® Ceiling Systems
- 30-Year Limited System Warranty against visible sag (excludes items 1905 and 1929), mold, and mildew
- 10-Year replacement panel available for items 1911, 1912, 1914, 1915

  10-YEAR REPLACEMENT PANEL AVAILABILITY
- Available with factory-cut holes for USAI® trimless downlight fixture integration.

TYPICAL APPLICATIONS

- Offices – closed spaces for privacy and confidentiality; open spaces for focus, collaboration, and teaming
- Healthcare – assists in addressing HIPAA, HCAHPS, and FGI acoustical requirements
- Classrooms
- Corridors
- Lobbies/reception areas
- Department stores/retail

COLOR

White
(WH)

DETAILS (Other Suspension Systems compatible. Refer to listing on next page.)

1. Ultima® Beveled Tegular
2. Ultima® with Suprafine® 9/16" suspension system
3. Ultima® with Silhouette® XL® 9/16" suspension system with 1/4" reveal

TechLine 877 276-7876
armstrongceilings.com/ultima

Armstrong®
World Industries

ULTIMA®
ULTIMA® High NRC
Tegular
fine texture

CLOSED LOOP RECYCLED CONTENT
CEILING-2-CEILING™

USDA CERTIFIED BIOBASED PRODUCT
PRODUCT 95%

Declare.

SUSTAIN®
High Performance
Sustainable Ceiling Systems

GREENGUARD
Gold Certified
(details below)

LEED® WELL™ LBC

UP TO 87% RECYCLED CONTENT

Calculate sustainability with Green Genie™
armstrongceilings.com/greengenie

energy management ✓ | construction waste mgmt ✓ | regional materials ✓ | design for flexibility ✓ | EPD ✓ | recyclable/extended producer resp. ✓ | biobased materials ✓ | recycled content ✓ | sourcing of raw materials ✓ | material ingredient reporting ✓ | low emitting/materials ✓ | lighting quality ✓ | acoustics ✓

▲ LOCATION DEPENDENT

VISUAL SELECTION

PERFORMANCE SELECTION
Dots represent high level of performance.

$$$$

armstrongceilings.com/suspdwgs	Susp. Dwg.		Item No.	Dimensions (Inches)	UL Classified Acoustics NRC	CAC	Total Acoustics[1] (NRC + CAC)	Articulation Class	Fire Performance	Light Reflect	Bio-Block Anti-Mold/Mildew	Humi-Guard+ Sag Resistant	Certified Low VOC Emissions	CleanAssure™ Disinfectable Panels Fog	Durability Wash	Durability Impact	Durability Scratch	Durability Soil	Recycle Program	30-Yr Warranty
ULTIMA® High NRC 15/16" Beveled Tegular	15	new	2081	24 × 24 × 1"	0.85 •	35 •	BEST	170 •	Class A	0.85 •	•	•	•	•	•	•	•	•	•	•
		new	2084	24 × 48 × 1"	0.85 •	35 •	BEST	170 •	Class A	0.85 •	•	•	•	•	•	•	•	•	•	•
HRC items not included in made-to-order panels.			1941	24 × 24 × 7/8"	0.80 •	35 •	BEST	170 •	Class A	0.87 •	•	•	•	•	•	•	•	•	•	•
			1944	24 × 48 × 7/8"	0.80 •	35 •	BEST	170 •	Class A	0.87 •	•	•	•	•	•	•	•	•	•	•
			1433	24 × 60 × 7/8"	0.80 •	35 •	BEST	170 •	Class A	0.87 •	•	•	•	•	•	•	•	•	•	•
			1436	24 × 72 × 7/8"	0.80 •	35 •	BEST	170 •	Class A	0.87 •	•	•	•	•	•	•	•	•	•	•
ULTIMA® High NRC 9/16" Beveled Tegular	29, 44, 48, 52, 56	new	2082	24 × 24 × 1"	0.85 •	35 •	BEST	170 •	Class A	0.85 •	•	•	•	•	•	•	•	•	•	•
		new	2085	24 × 48 × 1"	0.85 •	35 •	BEST	170 •	Class A	0.85 •	•	•	•	•	•	•	•	•	•	•
HRC items not included in made-to-order panels.			1942	24 × 24 × 7/8"	0.80 •	35 •	BEST	170 •	Class A	0.87 •	•	•	•	•	•	•	•	•	•	•
			1942HRC	24 × 24 × 3/4"	0.75 •	35 •	BEST	170 •	Class A	0.87 •	•	•	•	•	•	•	•	•	•	•
			1945	24 × 48 × 7/8"	0.80 •	35 •	BEST	170 •	Class A	0.87 •	•	•	•	•	•	•	•	•	•	•
			1431	30 × 30 × 7/8"	0.80 •	35 •	BEST	170 •	Class A	0.87 •	•	•	•	•	•	•	•	•	•	•
			1434	24 × 60 × 7/8"	0.80 •	35 •	BEST	170 •	Class A	0.87 •	•	•	•	•	•	•	•	•	•	•
			1437	24 × 72 × 7/8"	0.80 •	35 •	BEST	170 •	Class A	0.87 •	•	•	•	•	•	•	•	•	•	•

7/8" & 1" Thick – 15/16" & 9/16" Beveled Tegular

Made-to-Order Sizes	Width (short side)	Length (long side)	NRC	CAC	Total Acoustics	Articulation Class	Fire Performance	Light Reflect	Anti-Mold/Mildew	Sag Resistant	Certified Low VOC Emissions	Fog	Wash	Impact	Scratch	Soil	Recycle Program	30-Yr Warranty
1 Ctn Min FASTSIZE 3 WEEKS order to ship	4" – 30"	12" – 72"	N/A	N/A	N/A	N/A	Class A	0.87 •	•	•	•	•	•	•	•	•	•	•

Visit the product page online and see "Configure an Item" to verify capabilities. Questions? email Techline@armstrongceilings.com

MORE ITEMS ▶

[1] Total Acoustics® ceiling panels have an ideal combination of sound absorption and sound blocking in one product.
GOOD (NRC 0.60-0.65; CAC 35+) **BETTER** (NRC 0.70-0.75; CAC 35+) **BEST** (NRC 0.80+; CAC 35+)

ULTIMA®
ULTIMA® High NRC
Tegular
fine texture

CLOSED LOOP RECYCLED CONTENT
CEILING-2-CEILING™

USDA CERTIFIED BIOBASED PRODUCT
PRODUCT 95%

Declare.

SUSTAIN®
High Performance Sustainable Ceiling Systems

GREENGUARD
Gold Certified

LEED® | WELL™ | LBC

UP TO 87% RECYCLED CONTENT

Calculate sustainability with Green Genie™
armstrongceilings.com/greengenie

energy management	construction waste mgmt	regional materials	design for flexibility	EPD	recyclable/ extended producer resp.	biobased materials	recycled content	sourcing of raw materials	material ingredient reporting	low emitting/ materials	lighting quality	acoustics
✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

LOCATION DEPENDENT

VISUAL SELECTION

PERFORMANCE SELECTION
Dots represent high level of performance.

$$$$

	armstrongceilings. com/suspdwgs Susp. Dwg.	Item No.	Dimensions (Inches)	UL Classified Acoustics NRC	CAC	Total Acoustics[1] NRC + CAC	Fire Performance	Light Reflect	Bio-Block Anti-Mold/ Mildew	Humi-Guard+ Sag Resistant	Certified Low VOC Emissions	CleanAssure™ Disinfectable Panels Fog	DURABILITY Wash	Impact	Scratch	Soil	Recycle Program	30-Yr Warranty
ULTIMA® 15/16" Beveled Tegular	15	1422	6 × 48 × 3/4"	N/A	N/A	N/A	Class A	0.88 •	•	•	•	•	•	•	•	•	•	•
		1917	12 × 24 × 3/4"	N/A	N/A	N/A	Class A	0.88 •	•	•	•	•	•	•	•	•	•	•
HRC items not included in made-to-order panels.		1993	12 × 48 × 3/4"	0.65*	N/A	N/A	Class A	0.88 •	•	•	•	•	•	•	•	•	•	•
		1994	12 × 60 × 3/4"	0.65*	N/A	N/A	Class A	0.88 •	•	•	•	•	•	•	•	•	•	•
		1995	12 × 72 × 3/4"	0.65*	N/A	N/A	Class A	0.88 •	•	•	•	•	•	•	•	•	•	•
		1911 1911HRC	24 × 24 × 3/4" 24 × 24 × 3/4"	0.75 •	35 •	BETTER	Class A	0.88 •	•	•	•	•	•	•	•	•	•	•
		1951	24 × 24 × 3/4"	0.60	40 •	GOOD	Class A	0.88 •	•	•	•	•	•	•	•	•	•	•
		1894	24 × 24 × 3/4"	0.60	40 •	GOOD	Fire Guard™	0.88 •	•	•	•	•	•	•	•	•	•	•
		1914 1914HRC	24 × 48 × 3/4" 24 × 48 × 3/4"	0.75 •	35 •	BETTER	Class A	0.88 •	•	•	•	•	•	•	•	•	•	•
		1985	24 × 60 × 3/4"	0.75 •	35 •	BETTER	Class A	0.88 •	•	•	•	•	•	•	•	•	•	•
		1981	24 × 72 × 3/4"	0.75 •	35 •	BETTER	Class A	0.88 •	•	•	•	•	•	•	•	•	•	•
9/16" Beveled Tegular	29, 44, 48, 52, 56	1423	6 × 48 × 3/4"	N/A	N/A	N/A	Class A	0.88 •	•	•	•	•	•	•	•	•	•	•
		1427	6 × 60 × 3/4"	N/A	N/A	N/A	Class A	0.88 •	•	•	•	•	•	•	•	•	•	•
HRC items not included in made-to-order panels.		1916	12 × 24 × 3/4"	N/A	N/A	N/A	Class A	0.88 •	•	•	•	•	•	•	•	•	•	•
		1996	12 × 48 × 3/4"	0.65*	N/A	N/A	Class A	0.88 •	•	•	•	•	•	•	•	•	•	•
		1997	12 × 60 × 3/4"	0.65*	N/A	N/A	Class A	0.88 •	•	•	•	•	•	•	•	•	•	•
		1998	12 × 72 × 3/4"	0.65*	N/A	N/A	Class A	0.88 •	•	•	•	•	•	•	•	•	•	•
		1912 1912HRC	24 × 24 × 3/4" 24 × 24 × 3/4"	0.75 •	35 •	BETTER	Class A	0.88 •	•	•	•	•	•	•	•	•	•	•
		1952	24 × 24 × 3/4"	0.60	40 •	GOOD	Class A	0.88 •	•	•	•	•	•	•	•	•	•	•
		1895	24 × 24 × 3/4"	0.60	40 •	GOOD	Fire Guard	0.88 •	•	•	•	•	•	•	•	•	•	•
		1915 1915HRC	24 × 48 × 3/4" 24 × 48 × 3/4"	0.75 •	35 •	BETTER	Class A	0.88 •	•	•	•	•	•	•	•	•	•	•
		1986	24 × 60 × 3/4"	0.75 •	35 •	BETTER	Class A	0.88 •	•	•	•	•	•	•	•	•	•	•
		1982	24 × 72 × 3/4"	0.75 •	35 •	BETTER	Class A	0.88 •	•	•	•	•	•	•	•	•	•	•

Red Numbers are Fire Guard items.

[1] Total Acoustics® ceiling panels have an ideal combination of sound absorption and sound blocking in one product.
GOOD (NRC 0.60-0.65; CAC 35+) **BETTER** (NRC 0.70-0.75; CAC 35+) **BEST** (NRC 0.80+; CAC 35+)

* Item not UL tested

MINERAL FIBER – Standard

ULTIMA®
ULTIMA® High NRC
Tegular
fine texture

CLOSED LOOP RECYCLED CONTENT CEILING-2-CEILING™

USDA CERTIFIED BIOBASED PRODUCT
PRODUCT 95%

Declare.

SUSTAIN® High Performance Sustainable Ceiling Systems

GREENGUARD Gold Certified (details below)

LEED® | WELL™ | LBC

UP TO 87% RECYCLED CONTENT

Calculate sustainability with Green Genie™ armstrongceilings.com/greengenie

energy management · construction waste mgmt · regional materials · design for flexibility · EPD · recyclable/extended producer resp. · biobased materials · recycled content · sourcing of raw materials · material ingredient reporting · low emitting/materials · lighting quality · acoustics

▲ LOCATION DEPENDENT

VISUAL SELECTION

PERFORMANCE SELECTION
Dots represent high level of performance.

$$$$

Description	armstrongceilings.com/suspdwgs Susp. Dwg.	Item No.	Dimensions (Inches)	UL Classified Acoustics NRC	CAC	Total Acoustics[1]	Fire Performance	Light Reflect	Bio-Block Anti-Mold/Mildew	Humi-Guard+ Sag Resistant	Certified Low VOC Emissions	CleanAssure™ Disinfectable Panels Fog	Wash	DURABILITY Impact	Scratch	Soil	Recycle Program	30-Yr Warranty
9/16" Beveled Tegular	29, 44, 48, 52, 56	1905 1905HRC	30 × 30 × 3/4" 30 × 30 × 3/4"	0.75 •	35 •	BETTER	Class A	0.88 •	•	Std	•	•	•	•	•	•	•	1-Yr
HRC items not included in made-to-order panels.		1929 1929HRC	30 × 54 × 3/4" 30 × 54 × 3/4"	0.75 •	35 •	BETTER	Class A	0.88 •	•	Std	•	•	•	•	•	•	•	1-Yr
3/4" Thick – 15/16" & 9/16" Beveled Tegular																		
Made-to-Order Sizes (1 Ctn Min FASTSIZE 3 WEEKS order to ship) Visit the product page online and see "Configure an Item" to verify capabilities. Questions? email Techline@armstrongceilings.com		Width (short side) 4" – 30"	Length (long side) 12" – 72"	N/A	N/A	N/A	Class A	0.88 •	•	•	•	•	•	•	•	•	•	•
ULTIMA® with AirGuard™ Coating 15/16" Beveled Tegular	15	1901	24 × 24 × 3/4"	0.75 •	35 •	BETTER	Class A	0.88 •	•	•	•	•	•	•	•	•	•	•
		1904	24 × 48 × 3/4"	0.75 •	35 •	BETTER	Class A	0.88 •	•	•	•	•	•	•	•	•	•	•
9/16" Beveled Tegular	29, 44, 48, 52, 56	1902	24 × 24 × 3/4"	0.75 •	35 •	BETTER	Class A	0.88 •	•	•	•	•	•	•	•	•	•	•
AirGuard™ Coating actively removes formaldehyde from indoor air.		1906	24 × 48 × 3/4"	0.75 •	35 •	BETTER	Class A	0.88 •	•	•	•	•	•	•	•	•	•	•

[1] Total Acoustics® ceiling panels have an ideal combination of sound absorption and sound blocking in one product.
GOOD (NRC 0.60-0.65; CAC 35+) **BETTER** (NRC 0.70-0.75; CAC 35+) **BEST** (NRC 0.80+; CAC 35+)

SUSPENSION SYSTEMS

15/16" Prelude®

9/16" Silhouette® 1/4" Reveal · Silhouette 1/8" Reveal · Suprafine® · Interlude® XL® HRC

Blizzard White – Suspension System Finish
A color and texture coordinated suspension system to complement Ultima® ceiling panels for a monolithic look and feel.

PHYSICAL DATA

Material
Wet-formed mineral fiber with DuraBrite® acoustically transparent membrane

Surface Finish
DuraBrite with factory-applied latex paint

Fire Performance
Class A: ASTM E84 and CAN/ULC S102 surface burning characteristics. Flame Spread Index of 25 or less. Smoke Developed Index of 50 or less (UL labeled).

Fire Guard™: A fire-resistive ceiling when used in applicable UL assemblies

ASTM E1264 Classification
Type IV, Form 2, Pattern E; Fire Class A

Humidity/Sag Resistance
HumiGuard® Plus ceiling panels are recommended for areas subject to high humidity, up to, but not including, standing water and outdoor applications. (Excludes items 1905 and 1929).

Anti-Mold/Mildew
Ceiling panels with BioBlock® performance resist the growth of mold and mildew on the tile surface.

VOC Emissions
GREENGUARD Gold Certified
Third-party certified compliant with California Department of Public Health CDPH/EHLB/Standard Method Version 1.2, 2017. This standard is the guideline for low emissions in LEED®, WELL Building Standard™, Living Building Challenge® (LBC), CalGreen Title 24, ANSI/ASHRAE/USGBC/IES Standard 189; ANSI/GBI Green Building Assessment Protocol.

PRODUCT CERTIFIED FOR LOW CHEMICAL EMISSIONS UL.COM/GG UL 2818
GREENGUARD GOLD

Acoustical Performance
CAC testing conducted using Prelude® XL® suspension system for 15/16" edge detail and Silhouette® suspension system for 9/16" edge detail.

Primary (Embodied) Energy
See all LCA information on our EPDs.

High Recycled Content
Contains greater than 50% total recycled content. Total recycled content based on product composition of post-consumer and pre-consumer (post-industrial) recycled content per FTC guidelines. HRC items contain 15% or greater post-consumer recycled ceilings.

Insulation Value
R Factor – 2.2 (BTU units); R Factor – 0.39 (Watts units)
2081, 2081, 2084, 2085 – R Factor – 2.9 (BTU units); 0.445 (Watts units)

Cleaning and Disinfecting
Cleaning and CDC recommended disinfecting options available on armstrongceilings.com/cleaning

30-Year Performance Guarantee & Warranty
When installed with Armstrong® Suspension System. Details at armstrongceilings.com/warranty

Weight; Square Feet/Carton
1945 – 1.14 LBS/SF; 48 SF/CTN
1941, 1942 – 1.125 LBS/SF; 40 SF/CTN
1944, 1942HRC – 1.125 LBS/SF; 48 SF/CTN
1433, 1434 – 1.05 LBS/SF; 60 SF/CTN
1436, 1437 – 1.04 LBS/SF; 72 SF/CTN
2081, 2082 - 1.0 LBS/SF; 40 SF/CTN
2084, 2085 - 1.0 LBS/SF; 48 SF/CTN
1431 – 1.06 LBS/SF; 62.5 SF/CTN
1917, 1993 – 1.05 LBS/SF; 24 SF/CTN
1422, 1423 – 1.08 LBS/SF; 24 SF/CTN
1905, 1905HRC – 1.05 LBS/SF; 62.5 SF/CTN
1911, 1911HRC, 1912, 1912HRC, 1914, 1914HRC, 1915 – 1.05 LBS/SF; 48 SF/CTN
1916, 1996 – 1.05 LBS/SF; 24 SF/CTN
1427 – 1.07 LBS/SF; 24 SF/CTN
1929, 1929HRC – 1.02 LBS/SF; 68 SF/CTN
1895, 1952, 1951 – 1.31 LBS/SF; 48 SF/CTN
1901, 1902, 1904, 1906,
1894 – 1.08 LBS/SF; 48 SF/CTN
1997, 1994 – 1.05 LBS/SF; 30 SF/CTN
1998, 1995 – 1.05 LBS/SF; 36 SF/CTN
1981, 1982 - 1.08 LBS/SF; 72 SF/CTN
1985, 1986 – 1.08 LBS/SF; 80 SF/CTN

Minimum Order Quantity
1 carton

Metric Items Available
1941M, 1944M, 1945M, 1905M, 1912M, 1912MHRC, 1914M, 1915M, 1916M – Metric items are subject to extended lead times and minimum quantities. Contact your representative for more details.

MINERAL FIBER – Standard

TechLine / 1 877 276-7876
armstrongceilings.com/ultima

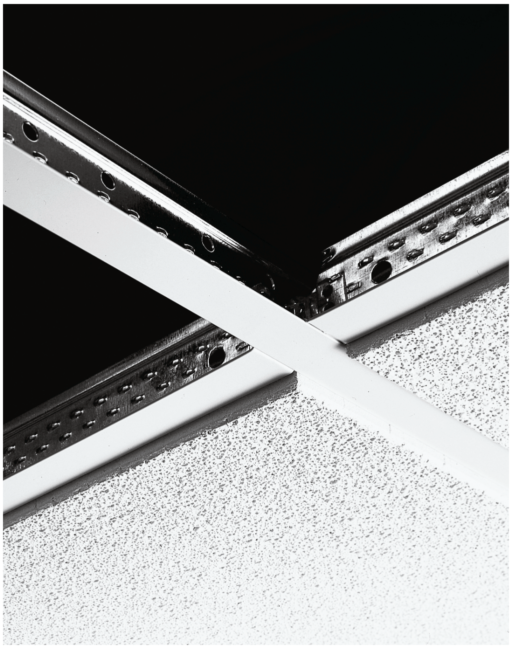
BPCS-3039-1023

Armstrong® World Industries

PRELUDE® ML

15/16" Exposed Tee Suspension System

SUSTAIN™
High Performance
Sustainable
Ceiling Systems



Prelude® ML suspension system

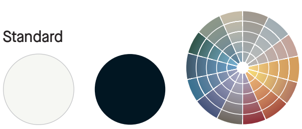
A 15/16" suspension system with hook-end details.

KEY SELECTION ATTRIBUTES

- **PeakForm**® profile increases strength and stability for improved performance during installation
- Prelude® ML is part of the Sustain™ portfolio and meets the most stringent industry sustainability compliance standards today – White only
- CleanAssure™ family of products – includes disinfectable panels, suspension systems, and trim (Cleaning and CDC approved disinfecting options available on armstrongceilings.com/cleaning)
- **SuperLock**™ main beam clip is engineered for a strong, secure connection and fast, accurate alignment confirmed with an audible click; easy to remove/relocate
- Hot-dipped galvanized coating inhibits red rust better than electrogalvanized or painted systems
- Rotary-stitched during manufacture for additional torsional strength and extra stability during installation
- Hook staked-on end detail provides secure locked connection; easy to remove, reuse, and relocate
- 10-Year Limited Warranty; 30-Year Limited Warranty with **HumiGuard**® **Plus** products
- **Made-to-Order** main beams and cross tees can be ordered with special sizing and rout spacing for your project needs in one carton minimums with two-week lead times

COLORS

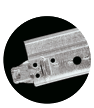
Standard



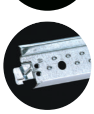
White (WH)	Black (BL)	Custom Colors Available*

* Colors that are pre-qualified to meet Sustain™ portfolio requirements are available upon request. Other made-to-order colors must be evaluated if sustainability criteria is required. Lead time will increase.

DETAILS

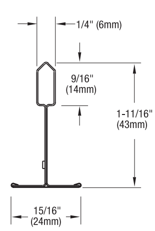


PRELUDE ML Main Beam

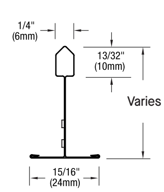


PRELUDE ML Cross Tee

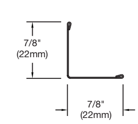
PRELUDE ML Main Beam



PRELUDE ML Cross Tee



7/8" Hemmed Angle Molding



PRELUDE® ML

15/16" Exposed Tee Suspension System

SUSTAIN™
High Performance
Sustainable Ceiling Systems
Declare.

LEED® WELL™ LBC

UP TO 30% RECYCLED CONTENT

Calculate sustainability with Green Genie™
armstrongceilings.com/greengenie

energy management | construction waste mgmt | regional materials | design for flexibility | EPD | recyclable/ extended producer resp. | biobased materials | recycled content | sourcing of raw materials | material ingredient reporting | low emitting/ materials | lighting quality | acoustics

LOCATION DEPENDENT

VISUAL SELECTION

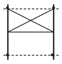
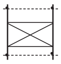
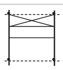
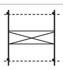
	Item No.◆	Description	Rout Spacing	Dimensions (Inches)	HANGER SPACING** LBS./LFT 4 Ft.	5 Ft.		PERFORMANCE Fire Guard™	Seismic Category	PACKAGING Pieces/ Carton	LFT/ Carton
PRELUDE® ML 15/16"	7301 _ _	12' HD Main Beam	6" O.C.	144 x 15/16 x 1-11/16"	16.73	8.73		N/A	•	20	240
	7300	12' ID Main Beam	6" O.C.	144 x 15/16 x 1-11/16"	13.50	6.35		N/A	N/A	20	240
	7302	10' ID Main Beam	6" O.C.	120 x 15/16 x 1-11/16"	13.50	6.35		N/A	N/A	20	200
	ML7357	5' Cross Tee	10", 30", 50", 56", 76", 96", 116", 122"	60 × 15/16 × 1-11/16"	N/A	7.61		N/A	N/A	60	300
	ML7343 _ _	4' Cross Tee	10", 30", 50", 70", 90", 110", 116"	48 x 15/16 x 1-1/2"	7.80	N/A		N/A	N/A	60	240
	ML7323 _ _	2' Cross Tee	6" O.C	24 x 15/16 x 1-1/2"	38.63	N/A		N/A	N/A	60	120
		15/16" Prelude® ML									
Size Capabilities NOTE: Up to 6 weeks for color and size combinations.	1 Ctn Min FASTSIZE 2 WEEKS order to ship	Main Beams Length 36" – 144" Rout spacing 3" from ends, 4" thereafter	Cross Tees Length 3" – 144"	N/A	N/A	N/A	N/A	N/A	N/A	Varies	Varies
Suggested Moldings (Additional molding options available. Visit armstrongceilings.com/moldings)	7800 _ _ 7800HRC	12' Hemmed Angle Molding (7/8")		144 x 7/8 x 7/8"	N/A	N/A		N/A	N/A	30	360
	7808 _ _**	10' Hemmed Angle Molding (9/16")		120 x 2 x 2"	N/A	N/A		N/A	N/A	10	100
	780812 _ _**	12' Hemmed Channel Molding (9/16")		120 x 2 x 2"	N/A	N/A		N/A	N/A	10	100

** Simple Span
◆ When specifying or ordering, add 2-letter color suffix to item number (ex. 7301 B L)

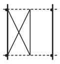
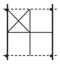
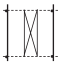
Dots represent high level of performance.

ASTM Class
HD - Heavy-duty
ID - Intermediate-duty
LD - Light-duty

MAXIMUM FIXTURE WEIGHT Drawing Key: Main beam (↑) Cross tee (---) Hanger wire (+)

	Configuration A	Configuration B	Item No.	Fixture A	Fixture B	Planning Module A	Planning Module B	Hanger Spacing A	Hanger Spacing B	Maximum Weight A	Maximum Weight B
Main Beam to Main Beam			7300/7302 7301	24" x 48" 24" x 48"	24" x 48" 24" x 48"	48" x 48" 48" x 48"	48" x 48" 48" x 48"	48" 48"	48" 48"	72.0 lbs. 76.0 lbs.	72.0 lbs. 76.0 lbs.
			7300/7302 7301	12" x 48" 12" x 48"	12" x 48" 12" x 48"	48" x 48" 48" x 48"	48" x 48" 48" x 48"	48" 48"	– –	72.0 lbs. 76.0 lbs.	54.0 lbs. 76.0 lbs.

Main beams tested as follows: 7300 tested at 13.0 lbs./LF to 1/360 of 4' span; 7301 tested at 16.5 lbs./LF to 1/360 of 4' span;

	Configuration A	Configuration B	Item No.	Fixture A	Fixture B	Planning Module A	Planning Module B	Hanger Spacing A	Hanger Spacing B	Maximum Weight A	Maximum Weight B
Cross Tee to Cross Tee			ML7343	24" x 48"	24" x 24"	48" x 48"	48" x 48"	48"	48"	51.0 lbs.	36.0 lbs.
			ML7343	24" x 48"	12" x 48"	48" x 48"	48" x 48"	48"	48"	51.0 lbs.	47.0 lbs.

Fixtures weighing more than 56 lbs. should be independently supported. Fixture weight is based on single fixture only. For end-to-end fixtures or other configurations not shown, consult your Armstrong Ceilings representative.
NOTE: The above data is based on 48" hanger wire spacing, board weight of 1 lb./SF, maximum deflection of tees not to exceed 1/360 of the span, and suspension system installed in accordance with ASTM C636.

SEISMIC PERFORMANCE

Main Beams
7300, 7302, 7301

Minimum Lbs. To Pull Out Compression/Tension
334.0
330.0

Cross Tees
All ML cross tees exceed 130 lbs. in both compression and tension.

ICC Reports
For areas under ICC jurisdiction, see ICC evaluation report number ESR-1308 for allowable values and/or conditions of use concerning the suspension system components listed on this page. The report is subject to re-examination, revisions, and possible cancellation.

PHYSICAL DATA

Material
Hot-dipped galvanized steel

Surface Finish
Baked polyester paint, anodized, or powder coated
Manufactured and tested in accordance with ASTM C635

Face Dimension
15/16"

Profile
Exposed tee

Cross Tee/Main Beam Interface
Flush fit

Design Considerations
Physical product samples for standard and custom colors are available upon request. Please refer to the physical product sample prior to making a final selection. While we strive to ensure exact color matches, various factors such as differences in materials, texture, substrate porosity, painting processes, lighting, and observer subjectivity can all affect how paint colors appear on ceiling and wall panels, suspension systems, and trim products. Due to these and other differences, ceiling and wall panels, trim products, and suspension systems with the same color name will coordinate but may not be an exact color match. Product is dye-lotted. Order sufficient initial quantities and attic stock to minimize possible color variation.

End Detail
Main Beam: Staked-on clip
Cross Tee: Staked-on hook clip

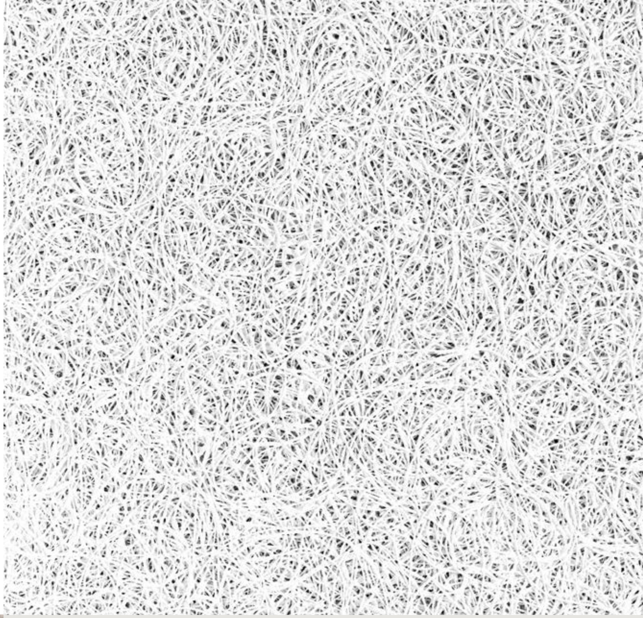
Duty Classification
Intermediate or Heavy-duty

Cleaning & Disinfecting
Cleaning and CDC-approved disinfecting options available on armstrongceilings.com/cleaning

Armstrong® World Industries

Tectum®

Ceiling & Wall Panels



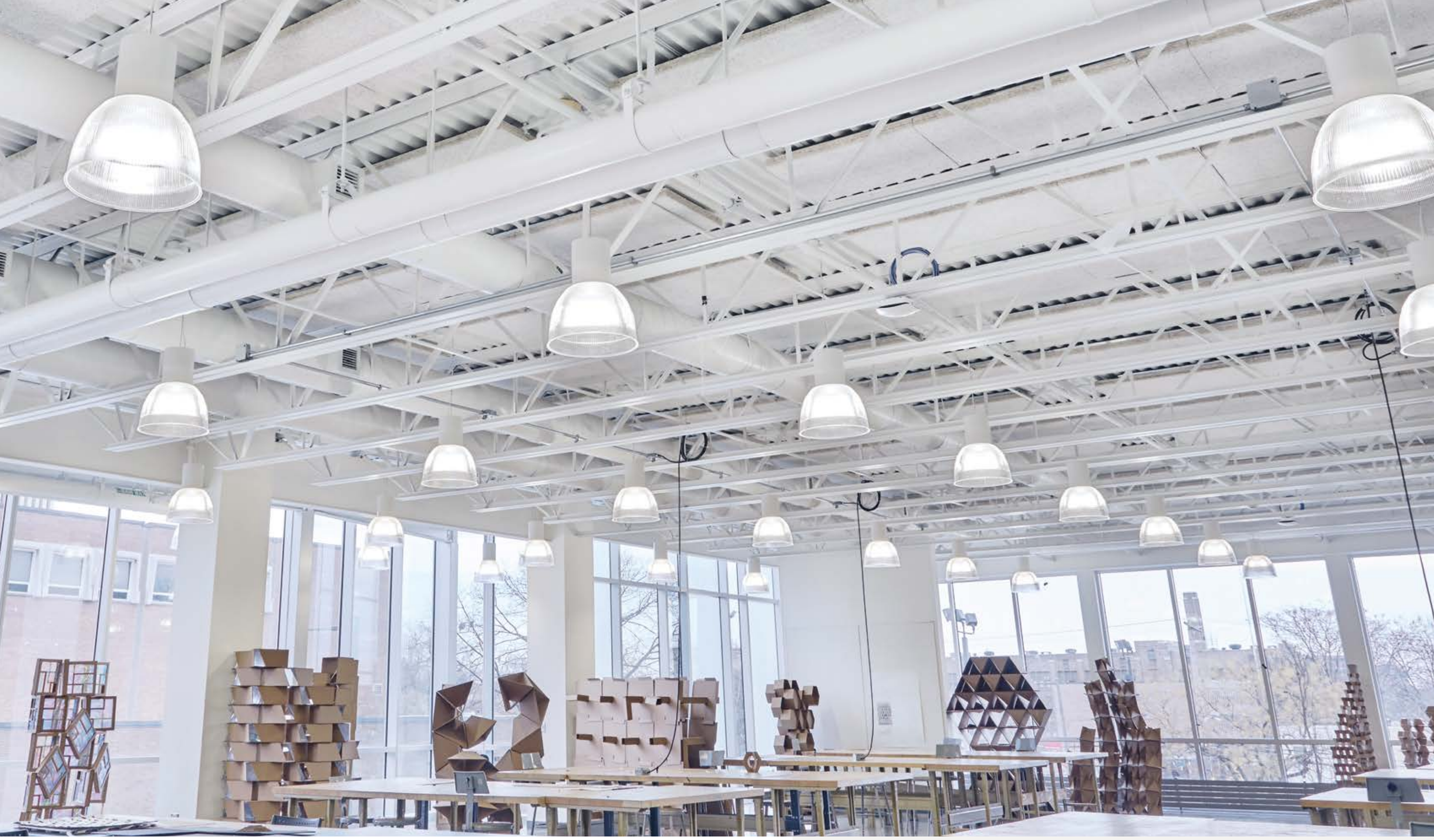
Armstrong®
World Industries

Tectum®

Ceiling & Wall Panels

Tectum® ceiling and wall panels provide durable, sustainable, acoustical solutions with unlimited design options. Tectum 1" thick panels are part of the Sustain® portfolio and meet the most stringent sustainability standards today. Tectum panels also have UL® Certified acoustics with acoustical testing and reporting that align with industry-wide best practices.

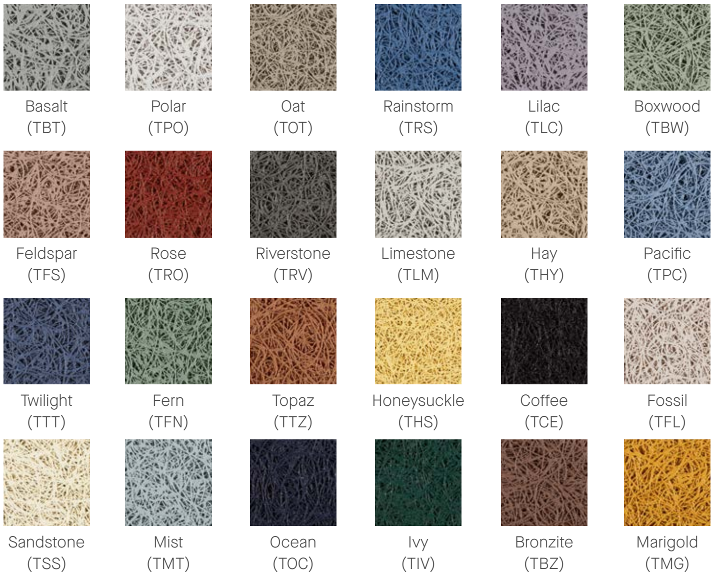
Direct-Attach in custom colors; Kalamazoo Public Library, Kalamazoo, MI; David Milling Architects, Ann Arbor, MI



Tectum Direct-Attach Ceiling Panels; Temple School of Architecture, Philadelphia, PA; NELSON, Philadelphia, PA

The Sustain® Portfolio Contributes to Better Spaces

1" Thick Tectum® Panels in Standard Colors



Available as standard colors for Tectum® DesignArt™ – Shapes and Tectum DesignArt – Lines only

Here's how:

- Contribute to LEED® v4 (including new Materials and Resources credits)
- Have Health Product Declarations (HPDs) which tell you what's in the products
- Are free of Red List chemicals per Living Building Challenge® 3.0 (including no added formaldehyde)
- Have Declare® labels – easy reference "nutrition labels"
- Meet California Department of Public Health (CDPH) low- emissions standards
- Have Environmental Product Declarations (EPDs) which tell you the impact of the products
- Contribute to WELL Building Standard™

SUSTAIN®
High Performance Sustainable Ceiling Systems

* Colors that are pre-qualified to meet Sustain portfolio requirements are available upon request. Other made-to-order colors must be evaluated if sustainability criteria is required. Lead time will increase.

Made from Nature

Tectum® products are made of fibers from one of the most sustainably harvested trees of its kind - the Wisconsin Aspen. The part of the Aspen that grows above ground can live between 40-150 years. The root system of the Aspen can survive thousands of years. Aspens quickly regenerate from their root system after the trunks have been harvested. Tectum panels are certified by the Forest Stewardship Council® (FSC), ensuring wood comes from responsibly managed forests.

FSC
www.fsc.org
FSC® C007626
The mark of responsible forestry

Tectum products are made of natural fibers and binders that are turned into unique, sound-absorbing, textured ceiling and wall panels that bring nature inside. Ideal for spaces where sustainability, durability, and noise control are needed.

Wisconsin Aspen Trees

Tectum High NRC 47-3/4" x 96" Direct-Attach wall panels in White

Direct-Attach & Direct-Attach High NRC Fit the Bill

Install panels directly to ceilings and walls to add durability and noise reduction to a wide variety of spaces using a sustainable solution.

- new Tectum® Direct-Attach panels now have UL® Certified acoustics with acoustical testing and reporting that align with industry-wide best practices
- new Tectum High NRC panels have a proprietary, factory-applied acoustical backing, adding sound absorption that is UL-certified
- 1" thick panels are part of the Sustain® and CleanAssure™ portfolios
- Excellent sound absorption – NRC up to 1.0 (mounting and thickness dependent)
- Retrofit solution for noise reduction
- Can be mechanically fastened to a wide variety of surfaces
- Install 1" thick Tectum on Trusses and I-Beams for added acoustics while maintaining an exposed structure visual on the deck
- Durable for heavy-use interiors, pools, and exterior-covered spaces

CLASSIFIED UL®

SUSTAIN® High Performance Sustainable Ceiling Systems

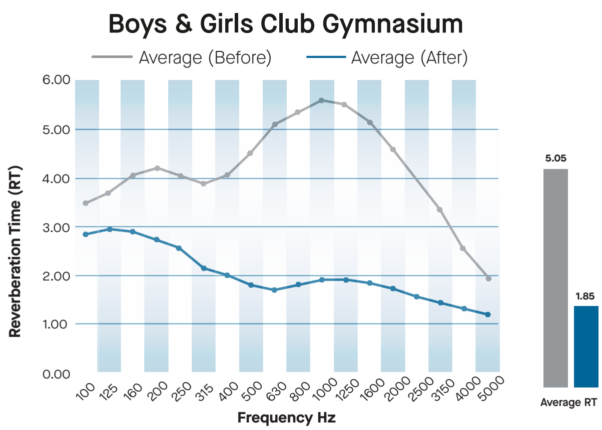
Boys & Girls Club of Lancaster

Case Study

Location: Lancaster, PA

Product: Tectum Direct-Attach Wall Panels, Tectum Panel Art Shapes and Soundsoak Baffles

Architect: You Inspire™ Solutions Center



The Challenge

The gymnasium at the Boys & Girls Club of Lancaster is in use every day, not only for sports activities but for a variety of other functions as well. Its acoustic environment, however, was not always ideal. Acoustical testing showed that reverberation time in the gym was 5.05 seconds, far above the 2.00 seconds or less recommended for this type of space. As Karen Schloer, the Club's chief executive officer, notes, "The noise level was putting a real strain on the staff because they had to shout so often when trying to communicate with the kids."

The Solution

To solve the problem, Armstrong Ceiling and Wall Solutions installed more than 3,500 square feet of Tectum® Direct-Attach wall panels to the gym's masonry walls. The panels were chosen because of their ability to absorb both sound and the impact of basketballs, volleyballs, and other objects that hit the walls.

Aesthetically, the two-inch-thick, 2' x 4' panels are installed in ribbons of white and a custom blue that match the Club's colors. They start nearly 10 feet off the floor and continue up the wall another 18 feet.

In addition, a re-creation of the Boys & Girls Club logo is installed at each end of the gym. The 15-foot wide and 13-foot high visual of two interlocking hands was created using eight-inch triangular custom Tectum panels. The white triangles are one-inch thick, while the blue triangles are two-inches thick so that they stand out from the wall. Two rows of 12 Soundsoak® Baffles were installed in the center of the ceiling for added noise absorption.

Acoustically, the 2" Direct-Attach Tectum wall panels have a Noise Reduction Coefficient (NRC) of 0.70. Acoustical testing conducted after the installation of the combination acoustical treatment showed that reverberation time dropped to 1.85 seconds, a 63% reduction. According to Chief Operations Officer, Scott McLellan, "The difference is like night and day. The biggest takeaway is how much easier it is now for the staff to gain control of the space because the kids can hear directions much more clearly."

Looking back at the difference in the gym's acoustic comfort, McLellan adds, "The staff simply didn't realize how bad it was because they didn't realize how good it could be."

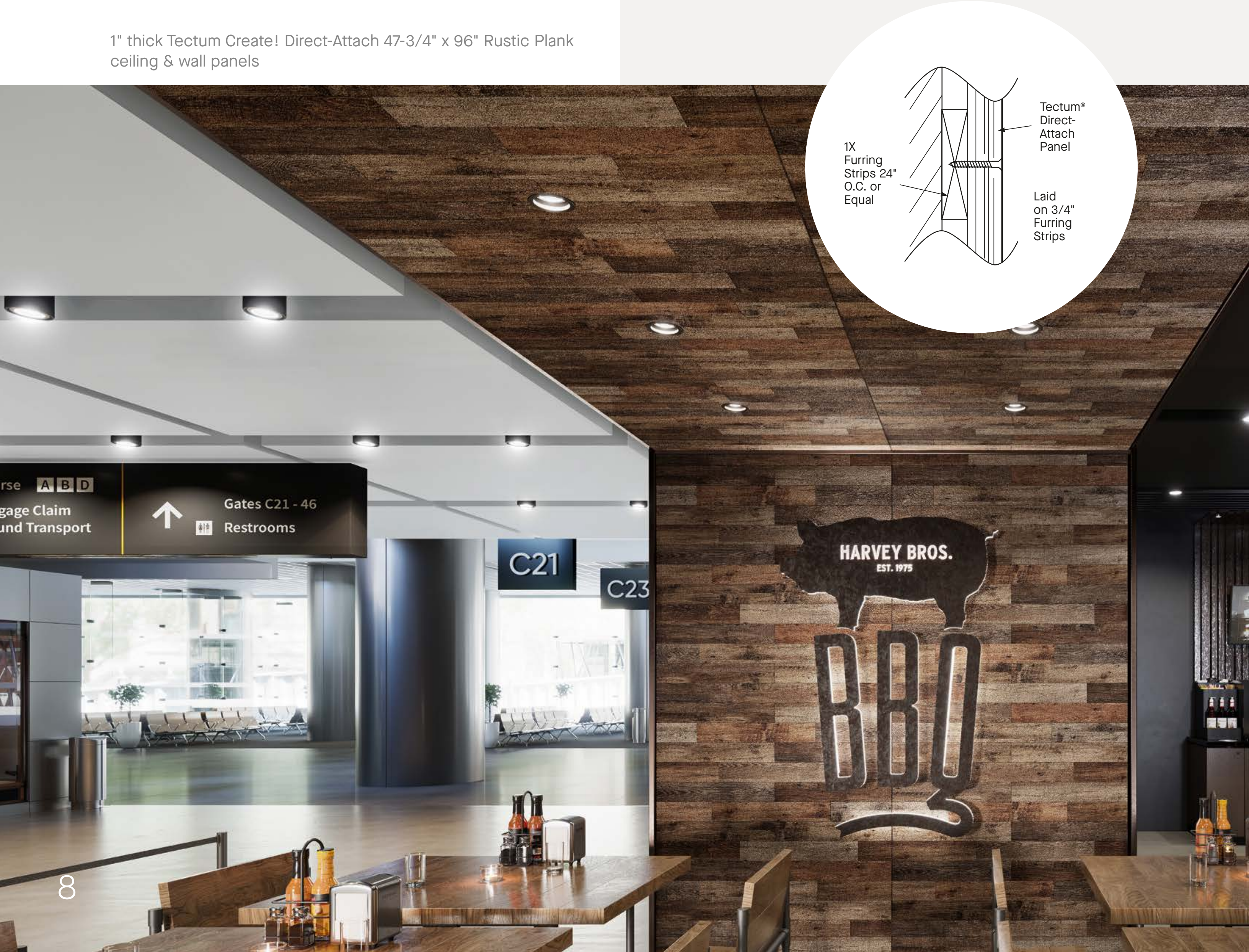
Tectum® Create!™ Direct-Attach
Fit the Aesthetic

Transform interior spaces with distinctive image depth and personality with texture-rich custom panels.

- 1" thick Tectum® Create!™ Direct-Attach panels are now available in four standard designs, or you can submit your own custom artwork
- Repeat panel patterns that can span wall surfaces in both vertical and horizontal directions
- Marry art with excellent sound absorption – NRC up to 0.85 (mounting method dependent)
- Panel sizes include 23-3/4" x 48" and 47-3/4" x 96" with long and short beveled edges (no additional custom sizes available)
- Panels can be directly attached to a wide variety of interior wall surfaces
- Tectum Create! panels are part of the Sustain® and CleanAssure™ portfolios

SUSTAIN®
High Performance Sustainable Ceiling Systems

1" thick Tectum Create! Direct-Attach 47-3/4" x 96" Rustic Plank ceiling & wall panels



1" thick Tectum® Create!™ Direct-Attach 47-3/4" x 96" custom wall panels

DesignArt™
Fit to Transform

Combining texture, shapes, linear designs, patterns, and colors with sustainable, acoustical Tectum® DesignArt™ Ceiling and Wall panels.

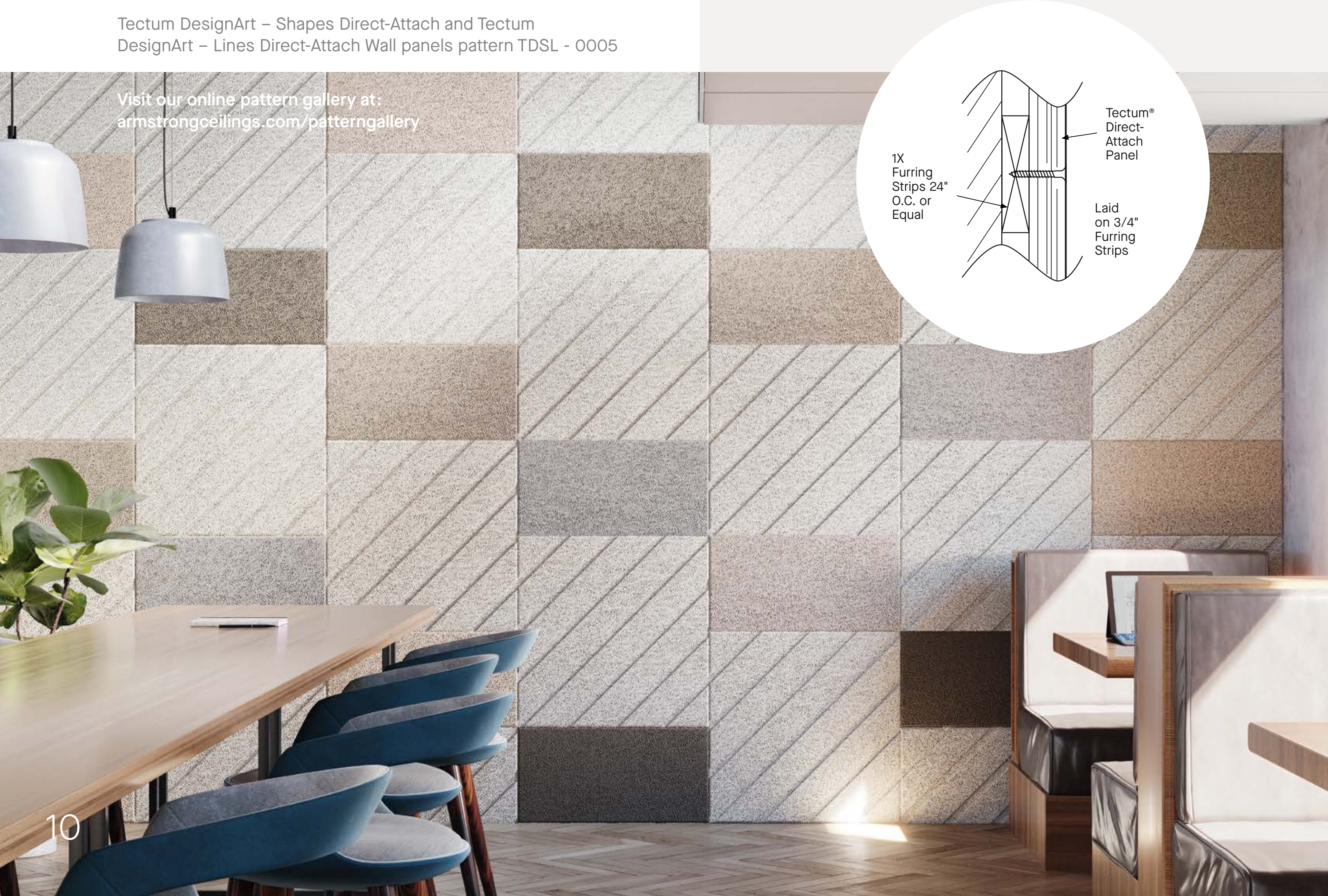
- Mix and match standard Shapes and Lines to create your own unique visual
  - 30 standard Shapes direct-attach ceiling and wall panels
  - 29 standard Lines direct-attach ceiling and wall panels
  - 29 standard Lines tegular ceiling panels
  - 24 new standard colors inspired by nature
- Over 100 variations of pre-designed patterns ready to add energy and beauty to your interiors
- Tectum DesignArt – Lines High NRC panels have a proprietary, factory-applied acoustical backing, adding sound absorption that is UL-certified
- 1" thick panels are part of the Sustain® and CleanAssure™ portfolios
- Tectum® DesignArt™ panels have UL® Certified acoustics with testing and reporting that align with industry-wide best practices
- Color-coordinated suspension systems available

CLASSIFIED UL

SUSTAIN® High Performance Sustainable Ceiling Systems

Tectum DesignArt – Shapes Direct-Attach and Tectum DesignArt – Lines Direct-Attach Wall panels pattern TDSL - 0005

Visit our online pattern gallery at:
armstrongceilings.com/patterngallery



Our Town Brewery

The Challenge

Our Town Brewery, a 6,000-square-foot pub housed in a former auto showroom, opened in September 2020. According to owner Rob Tarves, a common complaint soon after opening was acoustics. “Patrons said they couldn’t hear themselves think,” he says. “In addition, we weren’t able to conduct trivia contests as we had hoped and had to limit our live music choices.” Improving acoustics while maintaining the brewery’s aesthetic thus became the challenge.

Case Study

Location: Lancaster, PA

Product: Tectum DesignArt – Shapes

The Solution

To help remedy the situation, Tarves contacted Armstrong Ceiling & Wall Solutions. “The space was full of flat surfaces including picture windows on three sides,” Armstrong designer Marie DePaul explains. “Plus, the owner wanted to preserve the brewery’s 91-year-old tin ceiling, which meant there were not a lot of surfaces to treat acoustics. The challenge was to install enough acoustic treatment to make a difference and also contribute to the design of the space.”

Selected for use were Armstrong Tectum® DesignArt™ - Shapes, which are direct-attach wall panels. The durable panels feature a unique textured wood fiber visual and are ideally suited for high-traffic interiors. Tectum DesignArt panels transform interior spaces by combining texture, shapes, patterns, and colors with sustainability and acoustics. As part of the Armstrong Sustain® portfolio, standard Tectum DesignArt panels meet the most stringent industry sustainability compliance standards today.

The focal point of the space is now a 33-foot-long by 7-foot-high mosaic-type wall pattern above the bar. It was created using Tectum DesignArt - Shapes and consists of 48 full hexagons and 37 partial hexagons in Polar, the standard color, and three custom colors: light gray, medium gray, and dark gray. Hexagonal panels in a blue/green color were installed on the side and front walls.

All together, 167 two-foot-wide Tectum DesignArt hexagons were installed. The colors were chosen to match the pub’s brand design and to complement the existing aesthetics. “The ability to work with a brand’s standards to coordinate custom colors was key,” DePaul adds.

According to Tarves, installation went quickly and smoothly. One reason was that each panel was labeled as to where it went in the pattern. The panels were installed on 1" thick furring strips which results in a Noise Reduction Coefficient (NRC) of 0.85, meaning they absorb 85% of the sound that strikes them.

Once complete, Tarves notes both the patrons and the staff noticed the improvement. Acoustical tests confirmed it. Reverberation time fell from 4.94 seconds to 2.88 seconds, a 42% reduction. As Tarves says, “The efficacy of the panels was quickly evident. You could hear the difference as each panel was installed.

“We wanted the space to look great and control sound at the same time,” Tarves adds. “The Tectum DesignArt panels accomplished that by combining aesthetics and acoustics.”

Lay-in & Tegular and Lay-in & Tegular High NRC
Fit For Purpose

Durable, sustainable, noise control for spaces requiring acoustics and design flexibility.

- new Tectum® Lay-in and Tegular panels now have UL® Certified acoustics with acoustical testing and reporting that align with industry-wide best practices
- new Tectum High NRC panels have a proprietary, factory-applied acoustical backer, adding sound absorption that is UL-certified
- 1" thick panels are part of the Sustain® and CleanAssure™ portfolios
- Tegular panels have Total Acoustics® Performance (NRC 0.90 CAC 35) with 1713 infill panel
- Durable for heavy-use interiors
- Lay-In and Tegular panels are part of the automated ceiling solutions in ProjectWorks®

CLASSIFIED UL

SUSTAIN® High Performance Sustainable Ceiling Systems

ProjectWorks®

TOTAL ACOUSTICS® Sound Absorption (NRC) + Sound Blocking (CAC)

Tectum Tegular 24" x 48" panels in White with Prelude® XL® 15/16" suspension system

Tectum Finale PB ceiling and wall panels in White

Finale™ & Finale PB
A Sound Fit

Tectum® Finale™ and Finale PB ceiling and wall panels have built-in furring pieces with factory-filled panels that provide maximum sound control and install 2.5x faster than C-20 mount Direct-Attach panels for reduced installation costs. A perfect way to add acoustics to exposed structure spaces.

- new • Tectum Finale and Finale PB now have UL® Certified acoustics with acoustical testing and reporting that align with industry-wide best practices
- new • Finale PB panels are manufactured with a plant-based binder infill
- new • Finale PB panels are part of the Sustain® portfolio
- All panels are part of the CleanAssure™ portfolio
- new • Select products are included in the FAST134 program – ready to ship in 4 weeks or less
- Excellent sound absorption – NRC up to 0.90 (mounting method dependent)
- Available in White, Natural, and custom colors

CLASSIFIED UL

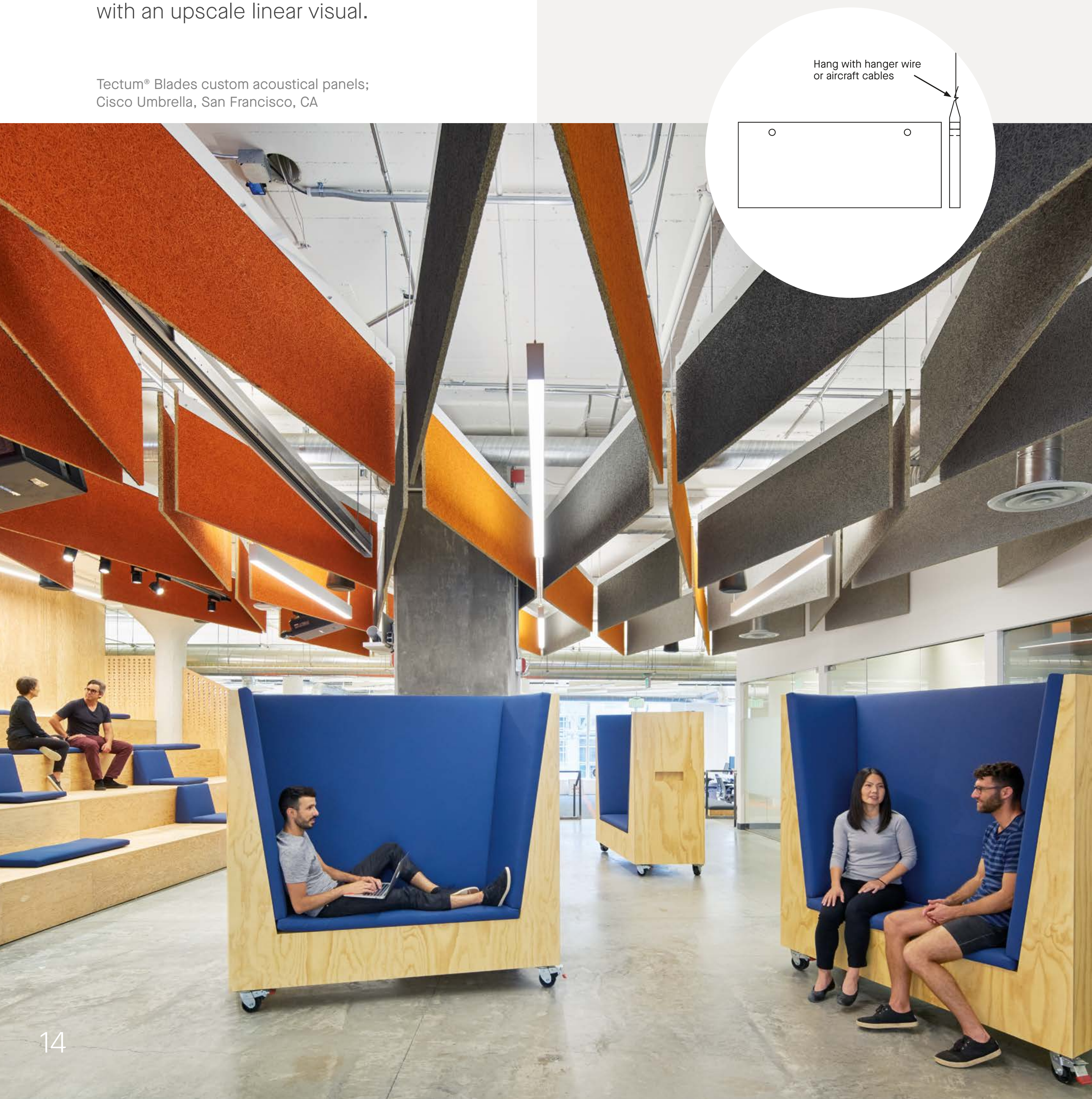
SUSTAIN®
High Performance Sustainable Ceiling Systems

Blades & Baffles
Fit to the Max

Vertical elements control acoustics with an upscale linear visual.

Tectum® Blades custom acoustical panels; Cisco Umbrella, San Francisco, CA

- Upscale linear visual adds acoustics and aesthetics to any space
- Noise absorption up to 0.60 Sabins/SF
- Custom shapes and sizes available to meet your project needs
- Mounting channels available to extend panel length beyond four feet



Tectum® Clouds; Retail Me Not, Austin, TX; STG Design, Austin, TX

Shapes & Clouds
Flexible Fit

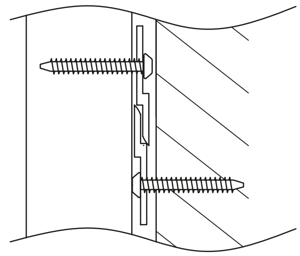
Shapes and Clouds offer design flexibility in a floating system.

- Noise absorption up to 0.50 Sabins/SF
- Wide variety of color options available
- Installs with Prelude® XL® 15/16" heavy-duty main beams
- Square or radius edges
- Made in sizes up to 4' and can be suspended or direct-attached to drywall grid system

Fabric Walls
Twice the Fit

Tectum® fabric walls do double duty, providing both acoustics and a tackable surface for displays and bulletin boards.

- Abuse-resistant, fabric-wrapped panels attach directly to walls
- Excellent Noise Absorption – NRC up to 0.90
- Mounting is quick and easy using internal spline system
- Durable fabric options available



Fabric Wall – Decor Clip

Tectum Fabric wall panels; Southland Christian Church, Lexington, KY

1" thick Tectum® Create!™ Direct-Attach 47-3/4" x 96" custom wall panels

TECTUM®
Made to Fit

Tectum® ceiling and wall panels are available in a variety of sizes, shapes, forms, and colors. Select from a natural factory finish, white, or made-to-order colors. Panels can be field painted up to six times without impacting acoustic or fire performance. Tectum panels are made to fit your design needs.

Tectum® DesignArt™ - Lines Direct-Attach Wall Panels

Sizes
Colors
Acoustics

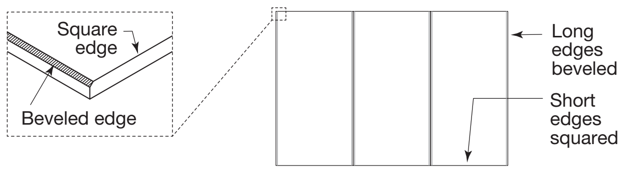
TECTUM® Panels

	Width	Length	Thickness
Blades & Baffles	23-3/4" – 47-3/4"	11-3/4" – 23-3/4"*	1", 1-1/2", 2"
Shapes & Clouds	23-3/4" – 47-3/4"	Up to 96"	1-1/2", 2"
Direct-Attach	23-3/4" – 47-3/4"	48" – 144"	1", 1-1/2", 2"
DesignArt™ – Shapes	6" – 48"	6-15/16" – 48"	1"
DesignArt – Lines	24"	24"	1"
Finale™ and Finale PB	23-3/4" – 47-3/4"	48" – 144"	1", 1-1/2", 2"
Lay-in & Tegular	23-3/4" – 47-3/4"	23-3/4" – 47-3/4"	1", 1-1/2", 2"
Fabric Walls	23-3/4" – 47-3/4"	48" – 120"	1", 1-1/2", 2"

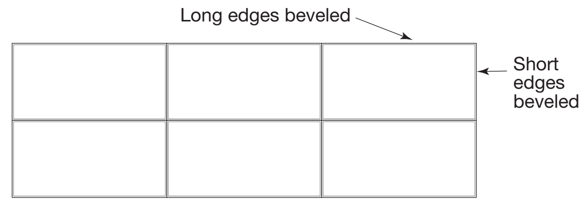
* Available height for Blades & Baffles. Length can extend beyond 48" with mounting channels.

			Mounting				
			NRC Rating				
Product	Panel Thickeness	Weight (SF)	Suspended	A Mounting	D-20 Mounting	C-20 Mounting	C-40 Mounting
Tectum® Blades & Baffles	1"	1.63 LBS/SF	0.40 (Sabins/SF)	–	–	–	–
	1-1/2"	2.53 LBS/SF	0.50 (Sabins/SF)	–	–	–	–
Tectum® Create!™ Direct-Attach Ceiling & Wall Panels	1"	1.63 LBS/SF	–	0.40	0.45	0.80	0.85
Tectum Direct-Attach Ceiling & Wall Panels	1"	1.63 LBS/SF	I-Beam: 3.8 (Sabins/24 × 48 × 1" Tectum panel) Truss: 2.9 (Sabins/24 × 48 × 1" Tectum panel)	0.40	0.45	0.80	0.85
Tectum® DesignArt™ – Shapes & Tectum DesignArt – Lines Direct-Attach Ceiling & Wall Panels	1"	1.63 LBS/SF	–	0.40	0.45	0.80	0.85
Tectum DesignArt – Lines High NRC Direct-Attach Ceiling & Wall Panels	1"	1.63 LBS/SF	–	–	0.60	–	–
Tectum DesignArt – Lines Tegular Ceiling Panels	1"	1.63 LBS/SF	0.40	–	–	–	–
Tectum DesignArt – Lines High NRC Tegular Ceiling Panels	1"	1.63 LBS/SF	0.85	–	–	–	–
Tectum® Finale™ Ceiling & Wall Panels	1" Panel with Integral Minwool Insert & 1" Furring	3.00 LBS/SF	–	0.85	0.90	–	–
Tectum Fabric Walls	1"	1.63 LBS/SF	–	0.50	0.60	–	0.90
Tectum Finale PB Ceiling & Wall Panels	1" Panel with Plant-based Binder Infill & 1" Furring	3.00 LBS/SF	–	0.80	0.85	–	–
Tectum High NRC Direct-Attach Ceiling & Wall Panels	1"	1.63 LBS/SF	–	–	0.60	–	–
Tectum High NRC Lay-in & Tegular Ceiling Panels	1"	1.63 LBS/SF	0.85	–	–	–	–
Tectum Lay-in & Tegular Ceiling Panels	1"	1.63 LBS/SF	0.40	–	–	–	–
	1" w/ 1713 Infill	2.94 LBS/SF	0.90/CAC 33	–	–	–	–
	1-1/2"	2.53 LBS/SF	0.50	–	–	–	–
Tectum Shapes & Clouds	1-1/2"	2.55 LBS/SF	0.50 (Sabins/SF)	–	–	–	–

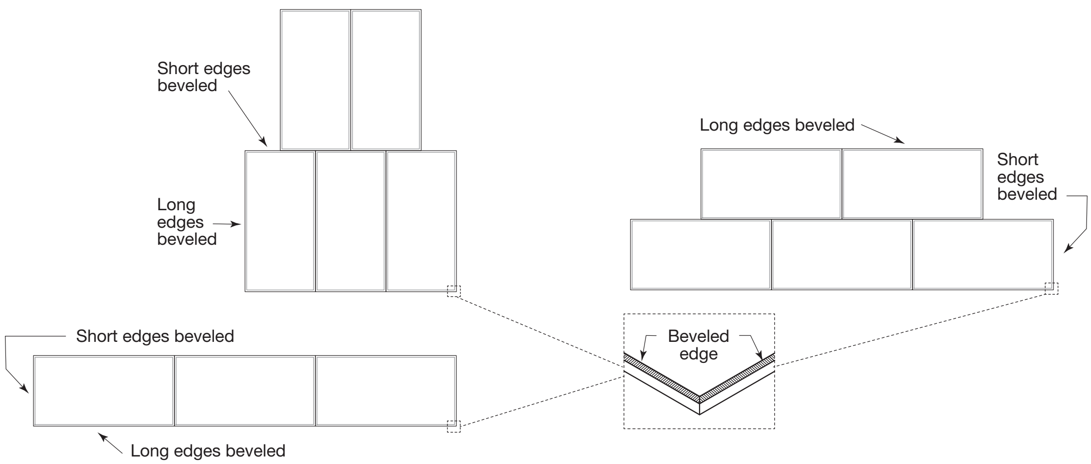
Edge Detail Recommendations



NOTE: Use Beveled Edge/Square End for the above panel layout.



NOTE: Stacked bond patterns are possible, but not recommended. Field trimming panels may be required to achieve desired fit and alignment.



NOTE: All exposed edges of the panel are factory painted.

NOTE: Use Beveled Edge/Beveled End panels for all adjoining panel installations.

Take the Next Step

1 877 276-7876

Customer Service Representatives
7:45 a.m. to 5:00 p.m. EST
Monday through Friday

TechLine – Technical information, detail drawings, CAD design assistance, installation information, other technical services – 8:00 a.m. to 5:30 p.m. EST, Monday through Friday. FAX 1 800 572 8324 or email: techline@armstrongceilings.com

armstrongceilings.com/commercial

Latest product news

Standard and custom product information

Online catalog

CAD, Revit®, SketchUp® files

A Ceiling for Every Space® Visual Selection Tool

Product literature and samples – express service or regular delivery

Contacts – reps, where to buy, who will install

ProjectWorks®

armstrongceilings.com/projectworks

The power of ProjectWorks® Design and Pre-Construction Service

Mix and match different sizes, shapes, colors, and materials to reinvent your standard, specialty, or custom ceiling.

Visit our pattern gallery online to see ideas for your next project at armstrongceilings.com/patterngallery

Contact your local representative to get a design started! Not sure who your local rep is? Visit armstrongceilings.com/findarep

armstrongceilings.com/tectum

Armstrong® World Industries

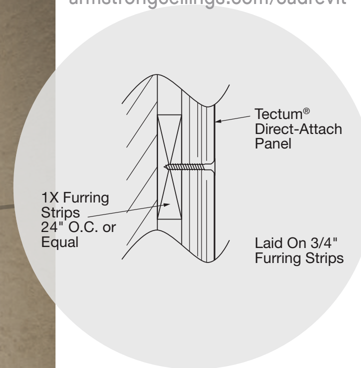
BPCS-5496-623

TECTUM® Create!™ Direct-Attach

Standard & Custom Wall Panels coarse texture

SUSTAIN®
High Performance
Sustainable
Ceiling Systems

CAD/Revit® drawings at:
armstrongceilings.com/cadrevit



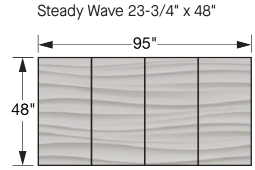
1" thick Tectum Create! Direct-Attach 47-3/4" X 96" vertical wall panels in standard Textured Hex design

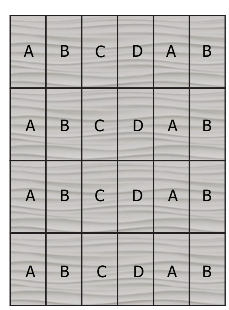
Transform interior spaces with distinctive image depth and personality on texture-rich Tectum® Create!™ Direct-Attach wall panels.

KEY SELECTION ATTRIBUTES

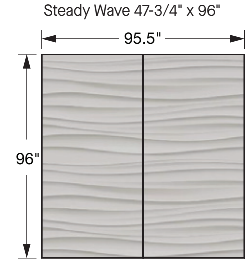
- new Now, 1" thick Tectum® Create!™ Direct-Attach panels are available in four standard designs or submit your own custom artwork
- Repeat panel patterns can span wall surfaces in both vertical and horizontal directions
- Excellent sound absorption – NRC up to 0.85 (mounting method dependent)
- Panel sizes include 23-3/4" x 48" and 47-3/4" x 96" with long and short beveled edges (No additional custom sizes available)
- Panels can be directly attached to a wide variety of interior wall surfaces
- Great retrofit solution for noise reduction
- CleanAssure™ family of products – includes disinfectable panels, suspension systems, and trim
- new Sustainable Beyond Standard: Custom sizes in 1" thickness and all standard panels are part of the Sustain® portfolio and meet the most stringent industry sustainability compliance standards today
- Create your one-of-a kind acoustic artwork! To get started, contact ASQuote@armstrongceilings.com

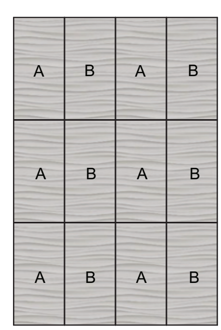
Steady Wave 23-3/4" x 48"





Steady Wave 47-3/4" x 96"





STANDARD DESIGNS

Multiple panels are used to create full patterns.

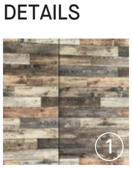
Textured Hex (CXH)

Exposed Brick (CXB)

Rustic Plank (CXP)

Steady Wave (CXW)

DETAILS



1. Rustic Plank design on multiple Tectum Create! Direct-Attach panels viewed from greater than 5'
2. Close-up of Rustic Plank Tectum Create! image from Detail 1

NOTE: For optimal visual, product is best viewed at a distance with direct lighting. Panel face and bevel are printed, while vertical edges are painted white. Custom solid color edge painting is available upon request.

TECTUM® Create!™ Direct-Attach

Standard & Custom Wall Panels coarse texture

SUSTAIN® High Performance Sustainable Ceiling Systems

Declare.

LEED® WELL™ LBC

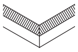
For LEED contribution contact TechLine

energy management | construction waste mgmt | regional materials ✓ | design for flexibility | EPD ✓ | recyclable/ extended producer resp. | biobased materials | FSC® (for wood) | recycled content | sourcing of raw materials ✓ | material ingredient reporting ✓ | low emitting/ materials ✓ | lighting quality | acoustics ✓

▲ LOCATION DEPENDENT

VISUAL SELECTION

	Item No. ◆	Dimensions W x L x H (Inches)
TECTUM® Create!™ Direct-Attach Standard Wall Panels	new 5334W2L04T10_ _ _ _	23-3/4 × 48 × 1"
Long Edges Beveled/Short Edges Beveled*	new 5334W4L08T10_ _ _ _	47-3/4 × 96 × 1"



PERFORMANCE

Dots represent high level of performance.

Fire Rating	Bio-Block: Anti-Mold/ Mildew	Humi-Guard+: Sag Resist	CleanAssure™ Disinfectable Panels: Fog	DURABILITY: Impact
Class A	•	•	•	•
Class A	•	•	•	•

ACOUSTICAL INFORMATION

Panel Thickness	NRC	Mounting Methods
1"	0.40	A
	0.45	D-20
	0.80	C-20
	0.85	C-40

* Printed image will continue on beveled edge. Vertical edge of panel will be painted Tectum White (TWH) unless specified otherwise.

◆ When specifying or ordering, include the appropriate 3-digit design suffix (CXH = Textured Hex, CXB = Exposed Brick, CXP = Rustic Plank, CXW = Steady Wave) and panel identifier = A-D (e.g. 5334W2L04T10 C X B C)

Tailor Designs with Custom Tectum Create! Wall Panels

Create beautiful, unique spaces with printed imagery on Direct-Attach wall panels




Higher resolution files will have best results. The rich texture of the panels enhances images with high contrast, and appears almost three-dimensional when viewed from greater than 5'.

Raster Images: Digital photographs should be created in a raster based program such as Adobe® Photoshop®.

- Image must be 150 dpi at full print size
- Acceptable file types:
  - Joint Photographic Experts Group – .jpg
  - Tagged Image File Format – .tiff
- Acceptable color mode: RGB

Vector Graphics: Logos and illustrations should be created in a vector-based program such as Adobe® Illustrator®.

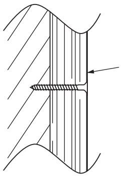
- Acceptable file types:
  - Encapsulated PostScript – .eps
  - Scalable Vector Graphics – .svg
- Acceptable color mode: CMYK

* Armstrong will not be held liable for artwork color variances from computer screen to completed project, or between runs of similar material.

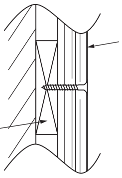
ACOUSTICAL MOUNTING METHODS

Based on desired final aesthetic, installer may want to field-color screw heads using permanent markers (by others) to coordinate with image colors.

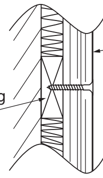
Mounting A



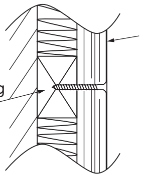
Mounting D-20



Mounting C-20



Mounting C-40



PHYSICAL DATA

Material
Cementitious Wood Fiber

Surface Finish
Factory-applied latex paint with powerful LED curing technology.

Fire Performance
Class A. Flame Spread Index 25 or less and Smoke Developed Index 50 or less when tested in accordance with ASTM E84.

Humidity/Sag Resistance
HumiGuard® Plus performance panels are recommended for areas subject to high humidity, up to, but not including, standing water and outdoor applications.

Anti-Mold/Mildew
Ceiling panels with BioBlock® performance resist the growth of mold and mildew on the panel surface.

Installation Considerations
The face and bevels of the panel are printed. Vertical edges of the panel are painted Tectum White (TWH). Custom solid colors may be available upon specification.

Viewing angles and direct light will impact the viewing surface. The surface has a great deal of texture and results may vary.

Primary (Embodied) Energy
See all LCA information on our EPDs.

Application Considerations
Color variation among panels is common due to the natural characteristics of the wood.

Tectum Create! is not for use in exterior spaces.

The rich texture of the panels enhances images with high contrast, and appear almost three-dimensional when viewed from greater than 5'.

Design Considerations
For touch-up solutions, use colored permanent markers to touch-up any defects on the board or to blend white or unfinished screw faces.

For each design, the standard order quantity is 128 square feet: four 2 × 4' panels or two 4 × 8' panels. Panels may be ordered as a single piece, however a minimum order quantity fee applies to any order under 128 square feet.

Imagery with linear patterns may not align perfectly, panel to panel.

For optimal visual, product is best viewed at a distance.

Cleaning and Disinfecting
Cleaning and CDC recommended disinfecting options available on armstrongceilings.com/cleaning

Seismic Restraint
Tectum Direct-Attach panels are approved for application in all seismic areas when installed per the seismic guidelines in the Armstrong Ceilings & Walls Installation Instructions.

Weight, Pcs and SF/Pallet
1" – 1.65 lbs/SF

PARTITIONS & WALLS

TechLine / 1 877 276-7876
armstrongceilings.com/tectumcreate

BPCS-6550-322

Armstrong® World Industries

CRANE®
Composites

STYLED + DURABLE
surface systems

VARIETEX® Innovative Textured + Colored Wall Panels

12 STANDARD COLORS + 3 TEXTURE OPTIONS

VARIETEX® Innovative Textured + Colored Wall Panels

ALMOND BREEZE SANDSTONE (866)

MAUNA RED SANDSTONE (1296) + MORNING MIST GRAY SANDSTONE (636)

SUGARLOAF SAND (1294)

Take your surfaces beyond the traditional frp white bumpy board. Our VARIETEX resilient wall coverings offer you a wide range of stylish finishes and colors, while still meeting the sanitary requirements of even the toughest commercial environments.

Add depth and dimension to walls, with our unique textures including sandstone, linen, tile and beaded finishes. Beyond the beauty, VARIETEX offers all the same benefits of traditional fiberglass reinforced plastic (FRP) wallcoverings, including stain, abrasion and moisture resistance. Plus it's easy to install and even easier to keep clean. VARIETEX provides stability and a simple, stylish solution for your walls that's designed to last.

style + hygiene

When you need grace under pressure, fiberglass reinforced plastic (FRP) panels are the perfect choice for your walls. From moisture and germs to daily dirt and grime, our FRP panels are able to stand up to even the toughest environments - without sacrificing style and beauty.

As the first and largest global manufacturer of FRP wall paneling, Crane Composites offers the industry's most innovative and resilient FRP panels, backed by our expert technical and installation support staff.

VARIETEX (STCS + STDSC) panels are the first FRP panels that are HACCP certified. Hazard Analysis Control Point (HACCP) certifies that VARIETEX panels are suitable for use in food and beverage facilities that operate in accordance with a HACCP based Food Safety Program. Orientation of embossed panels must be installed/ run vertically for any areas that require a sanitary finish under HACCP certification.

APPLICATIONS:

- School Hallways
- Cafeterias
- Restrooms
- Dining Rooms
- Reception Areas
- Health Clubs
- Hospitals

FEATURES:

- Mold + Mildew Free
- Meets USDA/FSIS Requirements
- Easy to Install
- Cleanable
- Durable

HACCP INTERNATIONAL FOOD SAFETY PROGRAMME CERTIFICATION

order samples at **frpsamples.com**

Color + Finish Options

SANDSTONE TEXTURE

Sugarloaf Sand | 1294* Clear Water | 1277* Shelter Cove Gray | 1281* Morning Mist Gray | 636

Graphite Vik | 1276* South Beach Ivory | 1282* Almond Breeze | 866 Pepper Dust | 8044

Cotton White | 1130 Sand Dune | 8043* Mauna Red | 1295*

LINEN TEXTURE

Sugarloaf Sand | 1294* Clear Water | 1277* Shelter Cove Gray | 1281* Morning Mist Gray | 636

Graphite Vik | 1276* South Beach Ivory | 1282* Almond Breeze | 866 Pepper Dust | 8044

Cotton White | 1130 Sand Dune | 8043* Mauna Red | 1295*

BEADED TEXTURE

Cotton White | 1130 *

* AVAILABLE IN CLASS C PER ASTM E-84 AND CAN/ULC-S102 ONLY

MINIMUM ORDER QUANTITIES AND OTHER TERMS MAY APPLY.

DUE TO LIMITATIONS OF THE PRINTING PROCESS, PATTERNS AND COLORS MAY VARY. THEY ARE A REPRESENTATION OF THE PRODUCT. PLEASE OBTAIN A SAMPLE BEFORE MAKING A FINAL SELECTION AT FRPSAMPLES.COM

product specs

AVAILABLE SIZES:
4' x 8' | 4' x 10'

FIRE RATINGS:**
Class A + C per ASTM E-84 | CAN/ULC-S102

*** see technical data sheets for fire rating information by color options*

THICKNESSES:
0.09" (sandstone + linen) | 0.075" (beaded)

ACCESSORIES:
Color Rite™ Color-Matched Silicone Caulk

Silhouette Trims Moldings | Aluminum Moldings

Beaded Panel Moldings

Finishing Touches Seam Treatment Accessories

SILHOUETTE TRIMS®

Silhouette Trims offer a narrow profile to minimize the seam. Crane Composites Silhouette Trims feature patterned expansion control guides to assist with proper FRP installation. Available in 10' lengths in Classic collection.

COLOR SIL COLOR-MATCHED CAULK

Use Color Rite's Color Sil caulk for professional looking panel installations without the use of moldings. Crane has teamed up with Color Rite to provide materials that compliment Crane wall panels in over 40 colors. Use with Color Rite's Pre-Tooling Mist to install with ease.

BEADED PANEL MOLDINGS

Specially designed beaded division bar to compliment our beaded panels. Available in 10' lengths in cotton white (1130) color.

ALUMINUM TRIMS

Designed for a contrasting and upscale look. Available in 10' lengths in silver color.

ecocolore

architecture

GRANITOGRES

CASALGRANDE PADANA
THE GREEN WAY TO PAVE

architecture white

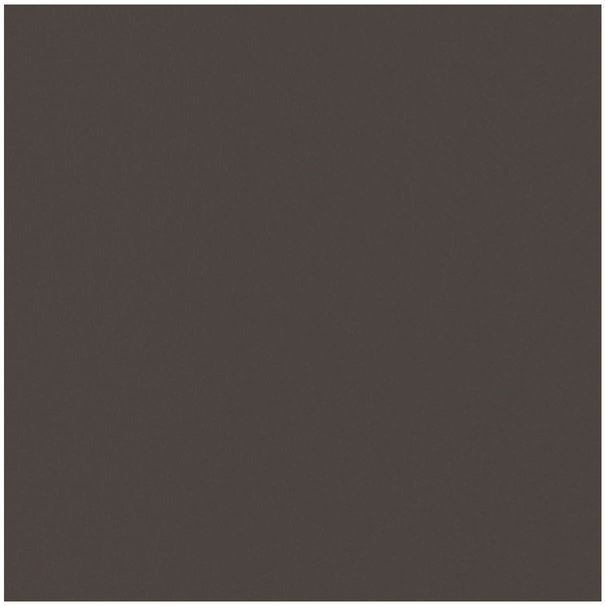
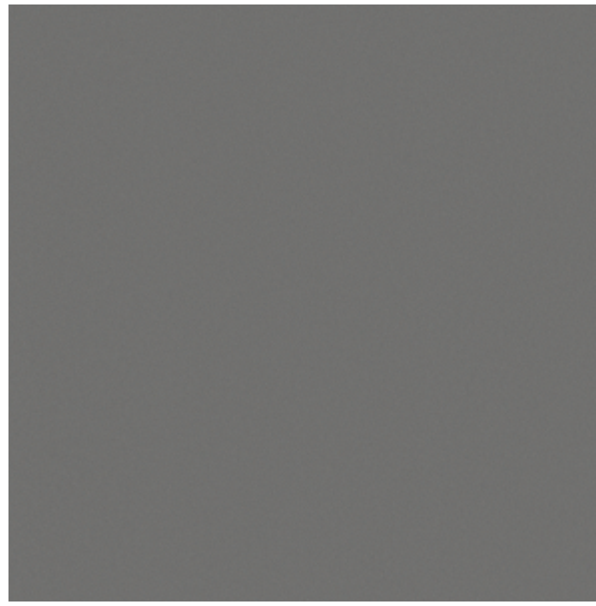
architecture

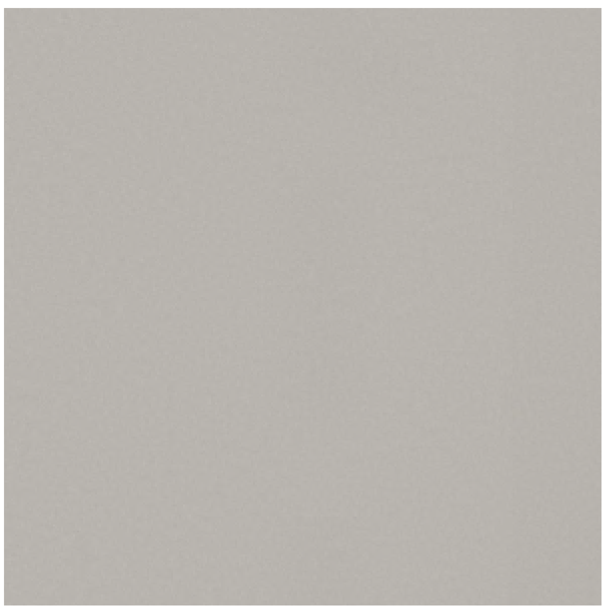
GRANITOGRES

FLOOR: architecture white cm 60x60 - $23^{5/8}$"x$23^{5/8}$"

COLORI COLOURS COULEURS FARBEN

architecture black | **architecture dark grey** | **architecture medium grey**



architecture light grey | **architecture cool grey** | **architecture warm grey**

Caratteristiche tecniche ed estetiche a pagina: Technical and aesthetics features on page:
Caractéristiques techniques et esthétiques à la page : Technische und ästhetische Eigenschaften auf Seite: 471

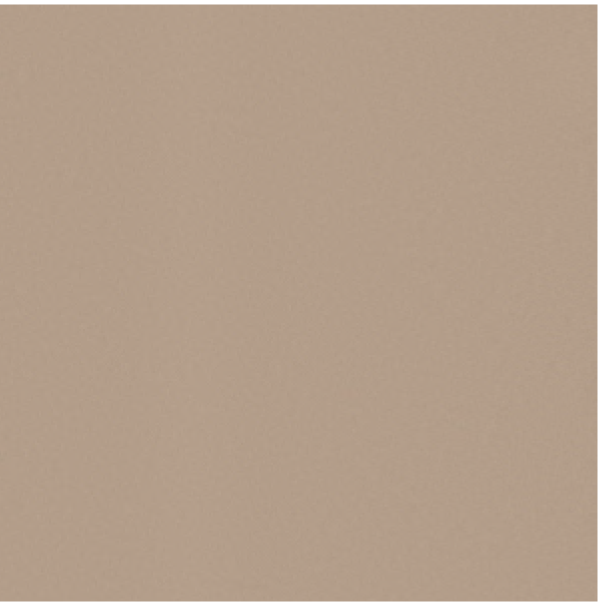
architecture

GRANITOGRES

architecture light brown

architecture dark ivory

architecture light ivory

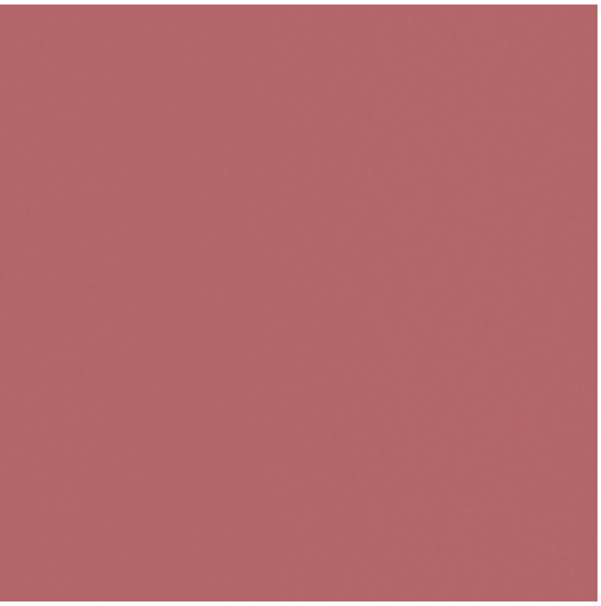


architecture beige

architecture white

COLORI COLOURS COULEURS FARBEN

architecture purple*



architecture acid green*

* Su richiesta On request Sur demande Auf Anfrage können

Caratteristiche tecniche ed estetiche a pagina: Technical and aesthetics features on page:
Caractéristiques techniques et esthétiques à la page : Technische und ästhetische Eigenschaften auf Seite: 471

architecture

GRANITOGRES

FLOOR: architecture white, architecture black cm 30x60 - 11 3/4"x23 5/8"

FORMATI SIZES FORMATS FORMATE

Formati Sizes Formats Formate	**cm 30x30** 11 3/4"x11 3/4"	**cm 30x60** 11 3/4"x23 5/8"	**cm 60x60** 23 5/8"x23 5/8"	**cm 45x90**** 17 3/4"x35 3/8"	**cm 90x90**** 35 3/8"x35 3/8"	**cm 60x120** 23 5/8"x47 1/4"
Spessori Thicknesses* Epaisseurs Stärken	mm 9,4	mm 9,4	mm 9,4	mm 10	mm 10	mm 9,4
Superfici Surfaces Surfaces Oberflächen	●	●	● ●	●	●	●

Uniforme
Uniform
Uniforme
Einheitliche

Vedi pagina: See page: Voir page : Siehe Seite: 482

● Naturale Matt Naturelle Matt **R9**
(A richiesta On request Sur demand Auf Anfrage **R10**)
● Levigata Polished Polie Poliert

Rettificate in un unico calibro Rectified version in a single caliber Rectifiés en un unique calibre Boden Sie in einem einzigen Kaliber

* Spessore su superficie naturale Thickness on matt surface Épaisseur sur surface naturelle Stärke der Fliesen mit Mattoberfläche

** Ad eccezione di: Except for: À l'exception de: Mit Ausnahme von: **Architecture Acid Green, Architecture Purple**

Nel caso di combinazioni di formati di spessori diversi, specificarlo espressamente nell'ordine
Please specify in your order if you wish to purchase formats including more than one thickness
Prière de spécifier dans votre commande si vous souhaitez acheter des formats avec différentes épaisseurs
Bitte weisen Sie im Bestellungsformular ausdrücklich darauf hin, wenn Sie Formatkombinationen mit verschiedenen Stärken wünschen

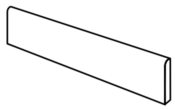
Caratteristiche tecniche ed estetiche a pagina: Technical and aesthetics features on page:
Caractéristiques techniques et esthétiques à la page : Technische und ästhetische Eigenschaften auf Seite: 471

SUPERFICI SURFACES SURFACES OBERFLÄCHEN

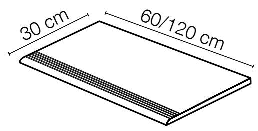
architecture

GRANITOGRES

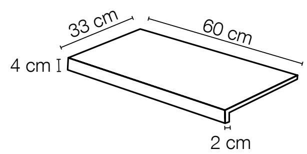
PEZZI SPECIALI TRIMS ACCESSOIRES FORMSTÜCKE



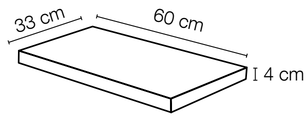
Battiscopa
Bullnose
Plinthe à bord arrondi
Stehsockel



Gradino
Step tread
Nez de marche
Stufenplatte



Gradone (assemblato)



Angolare (assemblato)

	Battiscopa	Gradino	Gradone (assemblato)	Angolare (assemblato)
Formati Sizes Formats Formate	**cm 9x60** 3$^{1/2}$”x23$^{5/8}$”	**cm 30x60** 11$^{3/4}$”x23$^{5/8}$”	**cm 60x33** 23$^{5/8}$”x13”	**cm 60x33** 23$^{5/8}$”x13”
	cm 9x90 3$^{1/2}$”x35$^{3/8}$”	**cm 30x120** 11$^{3/4}$”x47$^{1/4}$”		

DECORI DECORS DÉCORS DEKORE

mix listelli architecture A

cm 30x30 - 11$^{3/4}$”x11$^{3/4}$”
tessera **cm 1,4x30** - 1/2”x11$^{3/4}$”
su rete on net sur trame auf Netz

architecture beige, architecture dark ivory, architecture light ivory, architecture white

Naturale Matt Naturelle Matte

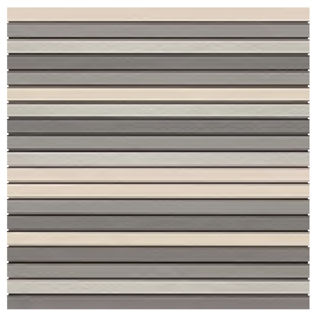
mix listelli architecture B

cm 30x30 - 11$^{3/4}$”x11$^{3/4}$”
tessera **cm 1,4x30** - 1/2”x11$^{3/4}$”
su rete on net sur trame auf Netz

architecture medium grey, architecture dark grey, architecture black

Naturale Matt Naturelle Matte

mix listelli architecture C



cm 30x30 - 11$^{3/4}$”x11$^{3/4}$”
tessera **cm 1,4x30** - 1/2”x11$^{3/4}$”
su rete on net sur trame auf Netz

architecture warm grey, architecture cool grey, architecture light grey, architecture medium grey

Naturale Matt Naturelle Matte

mix listelli ■

cm 30x30 - 11$^{3/4}$”x11$^{3/4}$”
tessera **cm 1,4x30** - 1/2”x11$^{3/4}$”
su rete on net sur trame auf Netz

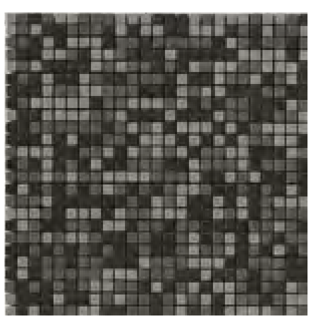
■ Disponibile in tutti i colori della serie. Listelli in superfice gloss e naturale. Available in all the colours of the series. Listellos in gloss and matt surface. Disponible dans toutes les couleurs de la série. Listelli en surface naturelle et gloss. Verfügbar in allen Farben. Listelli Gloss und Natur Oberfläche.

mosaico architecture A

cm 30x30 - 11$^{3/4}$”x11$^{3/4}$”
tessera **cm 1x1** - 3/8”x3/8”
su rete on net sur trame auf Netz

architecture beige, architecture dark ivory, architecture light ivory, architecture white

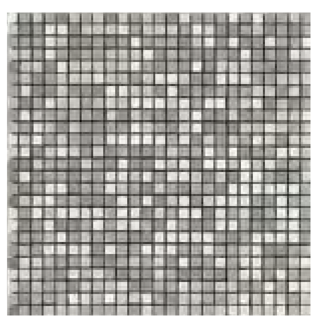
mosaico architecture B



cm 30x30 - 11$^{3/4}$”x11$^{3/4}$”
tessera **cm 1x1** - 3/8”x3/8”
su rete on net sur trame auf Netz

architecture medium grey, architecture dark grey, architecture black

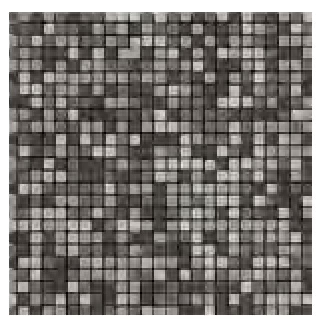
mosaico architecture C



cm 30x30 - 11$^{3/4}$”x11$^{3/4}$”
tessera **cm 1,4x30** - 1/2x11$^{3/4}$”
su rete on net sur trame auf Netz

architecture warm grey, architecture cool grey, architecture light grey, architecture white

mosaico architecture E



cm 30x30 - 11$^{3/4}$”x11$^{3/4}$”
tessera **cm 1,4x30** - 1/2x11$^{3/4}$”
su rete on net sur trame auf Netz

architecture dark grey, architecture medium grey, architecture light grey, architecture cool grey

ARCHITECTURE
GRANITOGRES

Gres porcellanato Fully vitrified porcelain
Grès cerame vitrifié **Feinsteinzeug**

CASALGRANDE PADANA
THE GREEN WAY TO PAVE

CARATTERISTICHE TECNICHE TECHNICAL FEATURES
CARACTÉRISTIQUES TECHNIQUES TECHNISCHE EIGENSCHAFTEN

UPEC**

PT0050

	norma standards norme Norm	risultato prova* test results* resultats des essais* Ergebnisse*
classificazione prodotto product classification classement Klassifizierung	UNI EN 14411-G ISO 13006	gruppo Bla UGL completamente greificato group Bla UGL fully vitrified group Bla UGL grès cérame fin Gruppe Bla UGL Feinsteinzeug
caratteristiche dimensionali e d'aspetto dimensional and surface quality caractéristiques de la surface Oberflächenqualität	UNI EN ISO 10545-2	tolleranze minime nella 1ª scelta very low tolerance des tolérances minimes en 1er choix Entspricht Normen
assorbimento di acqua water absorption absorption d'eau Wasseraufnahme	UNI EN ISO 10545-3	< 0,1%
resistenza alla flessione flexural strength résistance à la flexion Biegezug-Festigkeit	UNI EN ISO 10545-4	45 N/mm^2
resistenza al gelo frost resistance résistance au gel Frostwiderstandsfähigkeit	qualsiasi norma all standards toute norme alle normen	garantita guaranteed garantie Garantiert
resistenza attacco chimico (esclusione acido fluoridrico) resistance to acids and alkalis (with the exception of hydrofluoric acid) résistance à l'attaque chimique (exclusion de l'acide fluorhydrique) Saüre und Laugen Beständigkeit (mit Ausnahme von Fluorwasserstoff)	UNI EN ISO 10545-13	A
resistenza usura e abrasione wear and abrasion resistance résistance à l'usure et abrasion Abriebhärte	UNI EN ISO 10545-6	≤ 150 mm^3
dilatazione termica lineare linear thermal expansion coefficient linéaire de dilatation thermique Lineare Wärmeausdehnung	UNI EN ISO 10545-8	6 x 10^{-6}
resistenza alle macchie stain resistance résistance aux taches Fleckenfestigkeit	UNI EN ISO 10545-14	4 - 5 garantita guaranteed garantie Garantiert
resistenza alla scivolosità (Superficie Naturale) slip resistance (Matt surface) résistance au glissement (Surface naturelle) Trittsicherheit (Natur Oberflächen)	DIN 51130	Naturale Matt Naturelle Matt **R9** (A richiesta On request Sur demande Auf Anfrage **R10**)
	D.M. N° 236 DEL 14.06.89 METODO B.C.R.	valore μ > 0,40***
	BS7976-2:2002 BSEN13036-4:201	PTV > 36***
resistenza dei colori alla luce colour resistance to sunlight exposure résistance de la couleur à la lumière Unveränderlichkeit der Farben wenn Strahlung zugesetzt wird	DIN 51094	nessuna variazione no change of colours couleurs inchangées Keinerlei Farbänderung

* valore indicativo approx value donnée approximative Ungefähre Werte
** si rimanda all'elenco prodotti UPEC ufficiale, consultabile sul sito: please see the official UPEC product list: veuillez consulter la liste officielle produits UPEC: sihe die offizielle UPEC-Produktliste auf der Website: **http://webapp.cstb.fr/upec-ceramique/**
*** prova su superficie asciutta test on a dry surface essai sur surface sèche Test auf trockener Oberfläche

Al pari dei materiali naturali di riferimento, l'aspetto estetico, la differenza di tono e le venature possono essere diverse da piastrella a piastrella. Per una corretta comprensione della variabilità del prodotto è consigliabile prendere visione delle immagini a tutto ambiente sul catalogo di collezione, sul nostro sito all'indirizzo www.casalgrandepadana.it o chiedere maggiori informazioni ai nostri concessionari.

Just like the natural materials they are inspired by, the aesthetics, colouration and veining of the tiles can differ. To properly gauge the suitability of a product, we advise that you view the full-space photos that you can find in our collection catalogue and on our website at www.casalgrandepadana.com. Alternatively, please ask a reseller for more information.

Tout comme pour les matières naturelles de référence, la différence de tonalité, les veines ainsi que l'aspect esthétique peuvent varier d'une dalle à l'autre. Pour bien comprendre la variabilité du produit, il est conseillé de consulter les images d'ambiance présentes sur le catalogue de la collection, sur notre site à l'adresse www. casalgrandepadana.fr ou de demander plus d'informations à nos concessionnaires.

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CASALGRANDE PADANA

THE GREEN WAY TO PAVE

via Statale 467, n. 73 - 42013 Casalgrande (Re) Italy
tel + 39 0522 9901 - fax + 39 0522 996121
info@casalgrandepadana.it - www.casalgrandepadana.com

ARCHITECTURE
GRANITOGRES

Gres porcellanato Fully vitrified porcelain
Grès cerame vitrifié **Feinsteinzeug**

CASALGRANDE PADANA
THE GREEN WAY TO PAVE

CARATTERISTICHE TECNICHE TECHNICAL FEATURES
CARACTÉRISTIQUES TECHNIQUES TECHNISCHE EIGENSCHAFTEN

UNI EN ISO 14001:2015 CERTIQUALITY SISTEMA DI GESTIONE AMBIENTALE CERTIFICATO

EMAS GESTIONE AMBIENTALE VERIFICATA

QB UPEC**

PT0050

	norma standards **norme** Norm	**risultato prova*** test results* **resultats des essais*** Ergebnisse*
classificazione prodotto product classification classement Klassifizierung	UNI EN 14411-G ISO 13006	gruppo Bla UGL completamente greificato group Bla UGL fully vitrified group Bla UGL grès cérame fin Gruppe Bla UGL Feinsteinzeug
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* valore indicativo approx value donnée approximative Ungefähre Werte
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*** prova su superficie asciutta test on a dry surface essai sur surface sèche Test auf trockener Oberfläche

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ecocemento

r-evolution

GRANITOKER

CASALGRANDE PADANA

THE GREEN WAY TO PAVE

r-evolution light pink

PLAY VIDEO

r-evolution

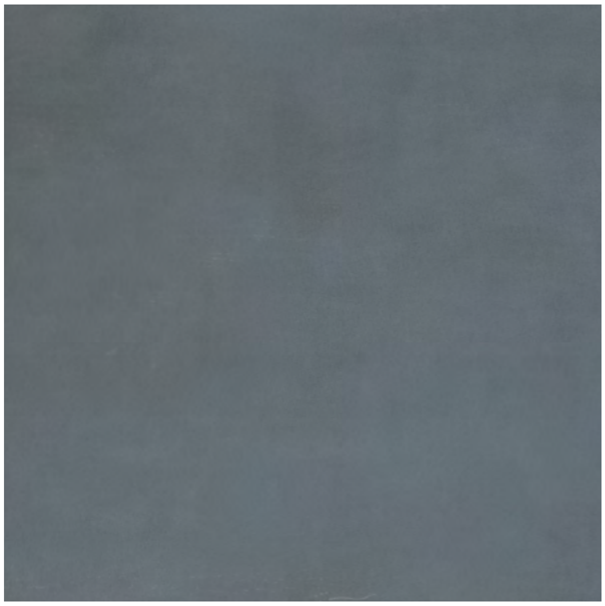
GRANITOKER

WALL / FLOOR: light pink cm 90x90 - 35$^{3/8}$”x35$^{3/8}$”_cm 90x180 - 35$^{3/8}$”x70$^{7/8}$”

COLORI COLOURS COULEURS FARBEN

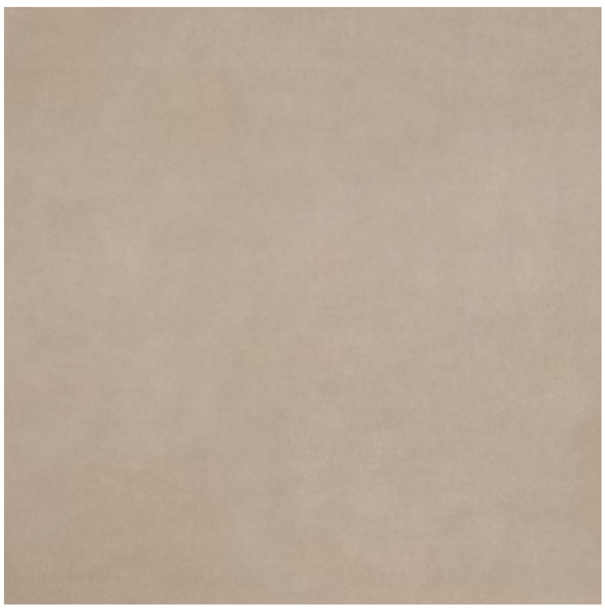
r-evolution black

r-evolution dark grey

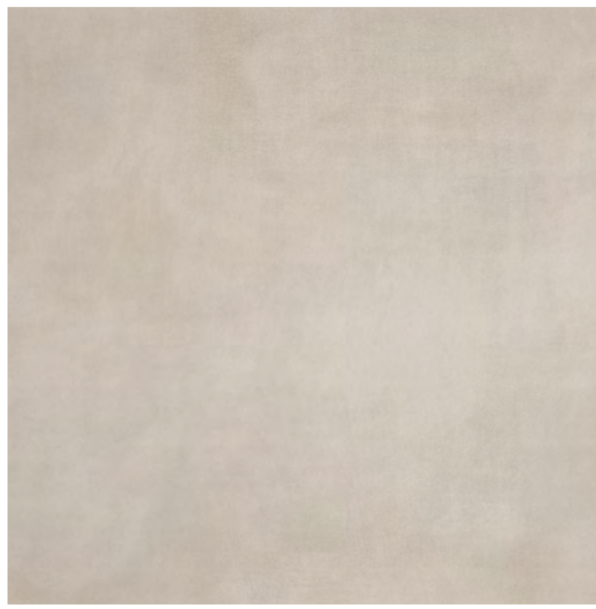


r-evolution blue

r-evolution terra



r-evolution tortora



r-evolution sand

Caratteristiche tecniche ed estetiche a pagina: Technical and aesthetics features on page:
Caractéristiques techniques et esthétiques à la page : Technische und ästhetische Eigenschaften auf Seite: 481

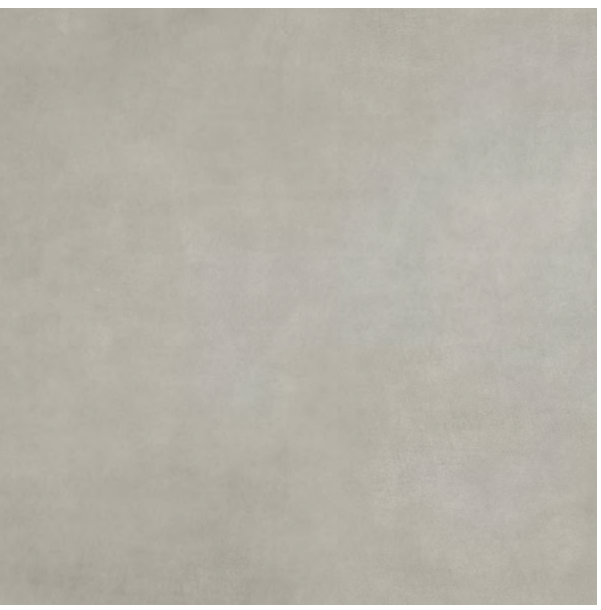
r-evolution

GRANITOKER

r-evolution azure

r-evolution green

r-evolution light pink

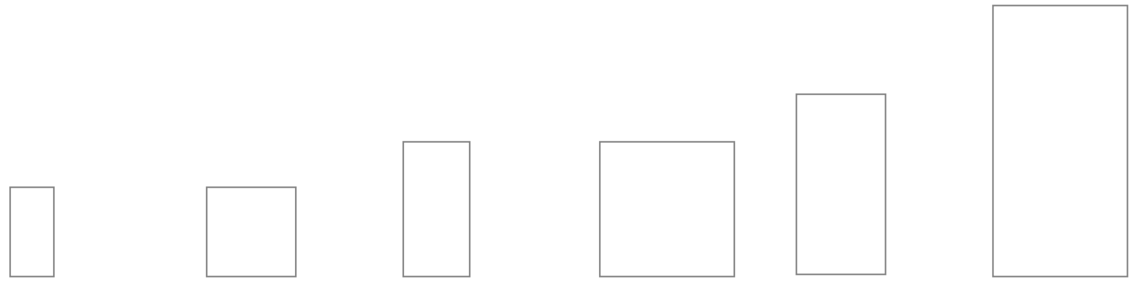


r-evolution grey

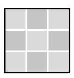
r-evolution white

r-evolution total white

FORMATI SIZES FORMATS FORMATE



Formati Sizes Formats Formate	**cm 30x60** $11^{3/4}$"x$23^{5/8}$"	**cm 60x60** $23^{5/8}$"x$23^{5/8}$"	**cm 45x90** $17^{3/4}$"x$35^{3/8}$"	**cm 90x90** $35^{3/8}$"x$35^{3/8}$"	**cm 60x120** $23^{5/8}$"x$47^{1/4}$"	**cm 90x180** $35^{3/8}$"x$70^{7/8}$"
Spessori Thicknesses Epaisseurs Stärken	mm 9	mm 9	mm 9	mm 9	mm 9	mm 9
Superfici Surfaces Surfaces Oberflächen	● ●	● ●	●	●	● ●	●



Leggera
Minimal
Légère
Leichte

● Naturale Matt Naturelle Matt
● Naturale Matt Naturelle Matt **R10 A+B PTV>36**

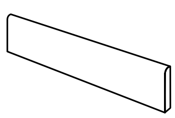
Vedi pagina: See page: Voir page : Siehe Seite: 490

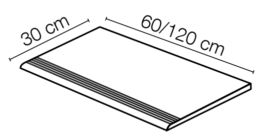
Rettificate in un unico calibro Rectified version in a single caliber Rectifiés en un unique calibre Boden Sie in einem einzigen Kaliber

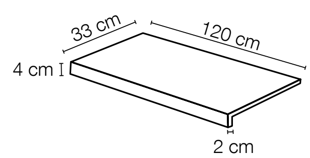
Consigliata per residenziale e commerciale leggero Suitable for residential or light commercial
Conseillé pour résidentielle et commerciale à circulation légère Geeignet für wohn oder leichte kommerzielle

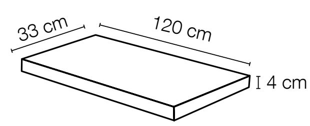
Caratteristiche tecniche ed estetiche a pagina: Technical and aesthetics features on page:
Caractéristiques techniques et esthétiques à la page : Technische und ästhetische Eigenschaften auf Seite: 481

PEZZI SPECIALI TRIMS ACCESSOIRES FORMSTÜCKE









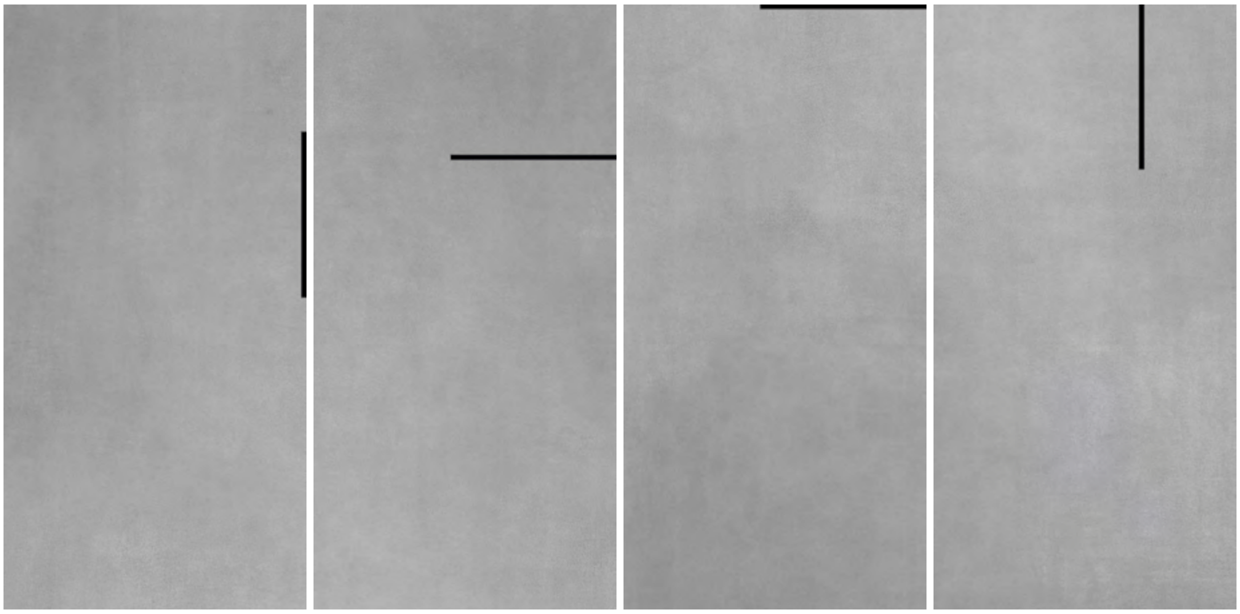
	Battiscopa Bullnose Plinthe à bord arrondi Stehsockel	**Gradino** Step tread Nez de marche Stufenplatte	**Gradone (assemblato)**	**Angolare (assemblato)**
Formati Sizes Formats Formate	**cm 7x60** $2^{3/4}$"x$23^{5/8}$"	**cm 30x60** $11^{3/4}$"x$23^{5/8}$"	**cm 120x33** $47^{1/4}$"x13"	**cm 120x33** $47^{1/4}$"x13"
	cm 7x90 $2^{3/4}$"x$35^{3/8}$"	**cm 30x120** $11^{3/4}$"x$47^{1/4}$"		

r-evolution

GRANITOKER

DECORI DECORS DÉCORS DEKORE

r-evo row ■



cm 30x60 - $11^{3/4}$"x$23^{5/8}$"

Abbinabile a Combined with Combiné avec Kombiniert mit

inserto r-evo**

cm 16,5x0,5 - $6^{1/2}$"x1/4"

bacchetta r-evo**

cm 60x0,5 - $23^{5/8}$"x1/4"

mosaico 6x6 ■

cm 30x30 - $11^{3/4}$"x$11^{3/4}$"
tessera **cm 6x6** - $2^{3/8}$"x$2^{3/8}$"
su rete on net sur trame auf Netz

stripes***

cm 60x120 - $23^{5/8}$"x$47^{1/4}$"

■ Disponibile in tutti i colori della serie Available in all the colours of the series Disponible dans toutes les couleurs de la série Verfügbar in allen Farben

** Disponibile nei colori: Available in the colours: Disponible dans les couleurs : Verfügbar in den folgenden Farben:
R-evolution Black, R-evolution Blue, R-evolution Dark Grey, R-evolution Green, R-evolution Light Pink, R-evolution Terra

*** Solo per posa affiancata Only for side-by-side installation Uniquement pour une installation côte à côte Nur fuer die Installierung nebeneinander geignet
Disponibile nei colori: Available in the colours: Disponible dans les couleurs : Verfügbar in den folgenden Farben:
A (Total White/Black), **B** (White/Grey), **C** (Sand/Tortora), **D** (Total White/Blue)

R-EVOLUTION

GRANITOKER

Gres porcellanato Fully vitrified porcelain
Grès cerame vitrifié **Feinsteinzeug**

CASALGRANDE PADANA
THE GREEN WAY TO PAVE

CARATTERISTICHE TECNICHE TECHNICAL FEATURES
CARACTÉRISTIQUES TECHNIQUES TECHNISCHE EIGENSCHAFTEN

UNI EN ISO 14001:2015 CERTIQUALITY SISTEMA DI GESTIONE AMBIENTALE CERTIFICATO — EMAS GESTIONE AMBIENTALE VERIFICATA — QB UPEC**

PT0078

	norma / standards / **norme** / Norm	**risultato prova*** / test results* / **resultats des essais*** / Ergebnisse*
classificazione prodotto / product classification / classement / Klassifizierung	UNI EN 14411-G / ISO 13006	gruppo Bla completamente greificato / group Bla fully vitrified / group Bla grès cérame fin / Gruppe Bla Feinsteinzeug
caratteristiche dimensionali e d'aspetto / dimensional and surface quality / caractéristiques de la surface / Oberflächenqualität	UNI EN ISO 10545-2	tolleranze minime nella 1ª scelta / very low tolerance / des tolérances minimes en 1er choix / Entspricht Normen
assorbimento di acqua / water absorption / absorption d'eau / Wasseraufnahme	UNI EN ISO 10545-3	< 0,1%
resistenza alla flessione / flexural strength / résistance à la flexion / Biegezug-Festigkeit	UNI EN ISO 10545-4	45 N/mm²
resistenza al gelo / frost resistance / résistance au gel / Frostwiderstandsfähigkeit	qualsiasi norma / all standards / toute norme / alle normen	garantita / guaranteed / garantie / Garantiert
resistenza attacco chimico (esclusione acido fluoridrico) / resistance to acids and alkalis (with the exception of hydrofluoric acid) / résistance à l'attaque chimique (exclusion de l'acide fluorhydrique) / Saüre und Laugen Beständigkeit (mit Ausnahme von Fluorwasserstoff)	UNI EN ISO 10545-13	A
resistenza usura e abrasione / wear and abrasion resistance / résistance à l'usure et abrasion / Abriebhärte	UNI EN ISO 10545-6	≤ 150 mm³
dilatazione termica lineare / linear thermal expansion / coefficient linéaire de dilatation thermique / Lineare Wärmeausdehnung	UNI EN ISO 10545-8	6 x 10^{-6}
resistenza alle macchie / stain resistance / résistance aux taches / Fleckenfestigkeit	UNI EN ISO 10545-14	4 - 5 / garantita guaranteed / garantie Garantiert
resistenza alla scivolosità (Superficie Naturale) / slip resistance (Matt surface) / résistance au glissement (Surface naturelle) / Trittsicherheit (Natur Oberflächen)	DIN 51130	Naturale **R10 A+B PTV>36**
	D.M. N° 236 DEL 14.06.89 METODO B.C.R.	valore μ > 0,40***
	BS7976-2:2002 BSEN13036-4:201	PTV > 36***
resistenza dei colori alla luce / colour resistance to sunlight exposure / résistance de la couleur à la lumière / Unveränderlichkeit der Farben wenn Strahlung zugesetzt wird	DIN 51094	nessuna variazione / no change of colours / couleurs inchangées / Keinerlei Farbänderung

* valore indicativo approx value donnée approximative Ungefähre Werte
** si rimanda all'elenco prodotti UPEC ufficiale, consultabile sul sito: please see the official UPEC product list: veuillez consulter la liste officielle produits UPEC: sihe die offizielle UPEC-Produktliste auf der Website: **http://webapp.cstb.fr/upec-ceramique/**
*** prova su superficie asciutta test on a dry surface essai sur surface sèche Test auf trockener Oberfläche

Al pari dei materiali naturali di riferimento, l'aspetto estetico, la differenza di tono e le venature possono essere diverse da piastrella a piastrella. Per una corretta comprensione della variabilità del prodotto è consigliabile prendere visione delle immagini a tutto ambiente sul catalogo di collezione, sul nostro sito all'indirizzo www.casalgrandepadana.it o chiedere maggiori informazioni ai nostri concessionari.

Just like the natural materials they are inspired by, the aesthetics, colouration and veining of the tiles can differ. To properly gauge the suitability of a product, we advise that you view the full-space photos that you can find in our collection catalogue and on our website at www.casalgrandepadana.com. Alternatively, please ask a reseller for more information.

Tout comme pour les matières naturelles de référence, la différence de tonalité, les veines ainsi que l'aspect esthétique peuvent varier d'une dalle à l'autre. Pour bien comprendre la variabilité du produit, il est conseillé de consulter les images d'ambiance présentes sur le catalogue de la collection, sur notre site à l'adresse www. casalgrandepadana.fr ou de demander plus d'informations à nos concessionnaires.

Wie bei den als Vorbild dienenden Naturmaterialien können sich auch hier das ästhetische Erscheinungsbild, der Farbtonunterschied und die Maserung von Fliese zu Fliese unterscheiden. Um die Variabilität des Produkts besser zu verstehen, raten wir Ihnen, die Bilder mit ausgestatteten Räumen im Kollektionskatalog auf unserer Website www.casalgrandepadana.de zu konsultieren. Weitere Informationen können Sie auch bei unseren Vertragshändlern erhalten.

CASALGRANDE PADANA
THE GREEN WAY TO PAVE

via Statale 467, n. 73 - 42013 Casalgrande (Re) Italy
tel + 39 0522 9901 - fax + 39 0522 996121
info@casalgrandepadana.it - www.casalgrandepadana.com

R-EVOLUTION
GRANITOKER

Gres porcellanato Fully vitrified porcelain
Grès cerame vitrifié **Feinsteinzeug**

CARATTERISTICHE TECNICHE TECHNICAL FEATURES
CARACTÉRISTIQUES TECHNIQUES TECHNISCHE EIGENSCHAFTEN

CASALGRANDE PADANA
THE GREEN WAY TO PAVE

UNI EN ISO 14001:2015 CERTIQUALITY SISTEMA DI GESTIONE AMBIENTALE CERTIFICATO
EMAS GESTIONE AMBIENTALE VERIFICATA
UPEC**

PT0078

	norma / standards / norme / Norm	risultato prova* / test results* / resultats des essais* / Ergebnisse*
classificazione prodotto product classification classement Klassifizierung	UNI EN 14411-G ISO 13006	gruppo Bla completamente greificato group Bla fully vitrified group Bla grès cérame fin Gruppe Bla Feinsteinzeug
caratteristiche dimensionali e d'aspetto dimensional and surface quality caractéristiques de la surface Oberflächenqualität	UNI EN ISO 10545-2	tolleranze minime nella 1ª scelta very low tolerance des tolérances minimes en 1er choix Entspricht Normen
assorbimento di acqua water absorption absorption d'eau Wasseraufnahme	UNI EN ISO 10545-3	< 0,1%
resistenza alla flessione flexural strength résistance à la flexion Biegezug-Festigkeit	UNI EN ISO 10545-4	45 N/mm²
resistenza al gelo frost resistance résistance au gel Frostwiderstandsfähigkeit	qualsiasi norma all standards toute norme alle normen	garantita guaranteed garantie Garantiert
resistenza attacco chimico (esclusione acido fluoridrico) resistance to acids and alkalis (with the exception of hydrofluoric acid) résistance à l'attaque chimique (exclusion de l'acide fluorhydrique) Saüre und Laugen Beständigkeit (mit Ausnahme von Fluorwasserstoff)	UNI EN ISO 10545-13	A
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dilatazione termica lineare linear thermal expansion coefficient linéaire de dilatation thermique Lineare Wärmeausdehnung	UNI EN ISO 10545-8	6 x 10⁻⁶
resistenza alle macchie stain resistance résistance aux taches Fleckenfestigkeit	UNI EN ISO 10545-14	4 - 5 garantita guaranteed garantie Garantiert
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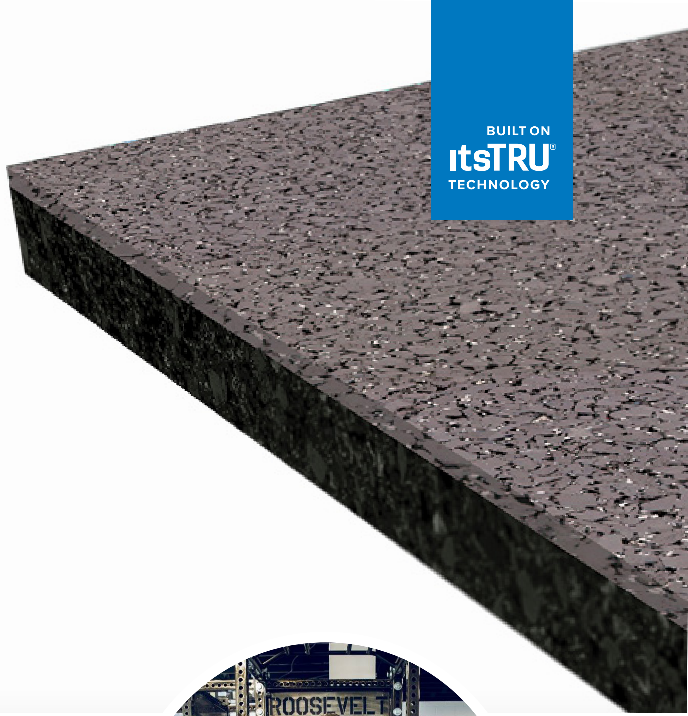
Performance Beast Plus

Durable Strength & Conditioning Surfacing



BUILT ON
itsTRU®
TECHNOLOGY

PRODUCT ATTRIBUTES

- **2.5mm Vulcanized Composition Rubber (VCR) Surface Layer**
  Provides excellent durability and slip resistance
- **12mm Factory Fusion-Bonded VCR Beast Plus Base Layer**
  Beast, PLUS an additional 4mm of toughness. This extremely dense, upcycled VCR base layer minimizes bar bounce and provides ultimate durability

*Transition-free to Performance Rally, allowing you to tailor the performance characteristics throughout your facility.

Designed to withstand extreme weight impacts while minimizing bar bounce, Performance Beast Plus is the ideal floor for power, strength, and functional training applications.

APPLICATIONS

- Selectorized Strength
- Free Weights
- Functional Training
- Olympic Style Lifting

BENEFITS

- Extrreme durability
- Sustainable
- Slip-resistant
- Provides substrate protection

NOMINAL DIMENSIONS

Available as a standard in rolls. Talk to your local sales rep to determine availability, pricing, minimums, and lead times.

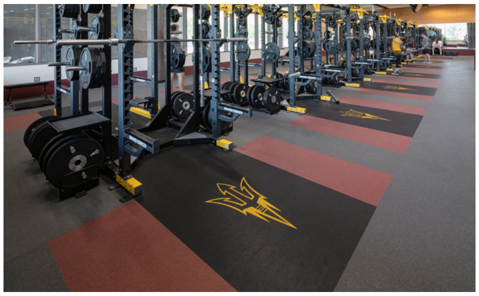
14.5mm (2.5mm + 12mm) x 48" (1.22m)

NRG =

Force Reduction: 17.4%
Absorption of impact energy

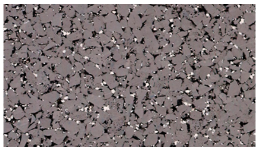
Energy Restitution: 66.3%
Useful return of impact energy

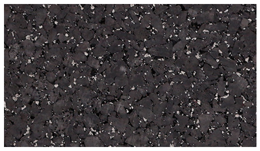
Typical Deltec Field Tester Results

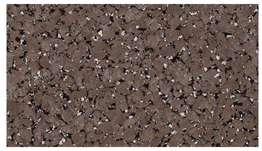


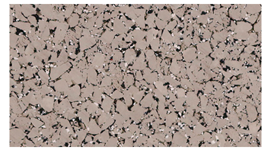
Performance Beast Plus

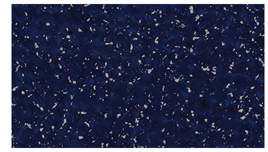
COLOR SWATCHES

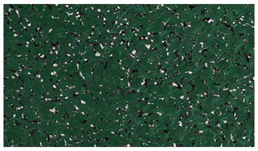

Medium Gray ES504

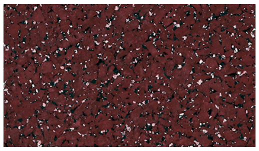

Charcoal ES505

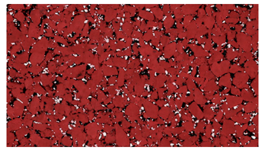

Dark Taupe ES506


Warm Gray ES507


Navy ES508

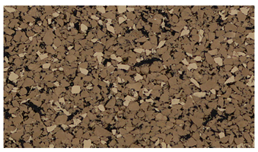

Green ES509

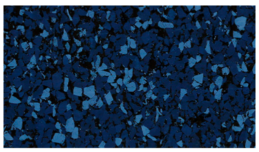

Maroon ES510

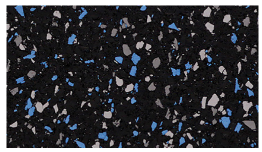

Red ES511

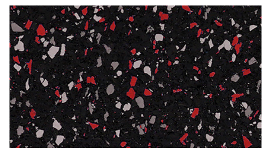

Steel Appeal 2 ES15A

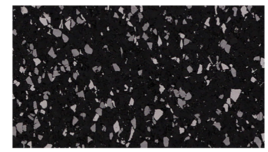

Dark Gray ES502

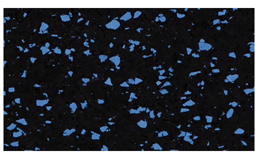

Mocha Latte 2 ES43A

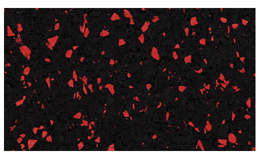

Blue ES500

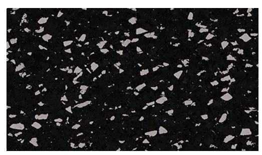

Blue Jays ES103


Cardinals ES104


Raiders ES503


Buff Blue 20 ES45


Rippin Red 20 ES47


Grippin Gray 20 ES46


Whey Protein 2 ES97A


Basic Black ES00

TECHNICAL DETAILS

Performance Criteria	Test Standard	Typical Results
Recovery after Static Load	ASTM F970	0.008"
Coefficient of Friction	ASTM D2047	>0.8
Abrasion Resistance	ASTM D3389	Pass
Flammability - Pill Test	ASTM D2859	Pass
Force Reduction	Deltec Field Tester	17.4%
Energy Restitution	Deltec Field Tester	66.3%
Impact Insulation Class (IIC)*	ASTM E492	55
Delta IIC*	ASTM E2179	25

**Tested on a 6" concrete slab with no ceiling.*

Custom Colors & Logos

Custom Colors

Ecore offers more than 35 standard EPDM colors (see page 2)! These colors are created through Ecore's ColorMill®. Ecore is unique, because it is one of a few flooring manufacturers to develop its own EPDM products at its facility in Lancaster, PA. The exclusive ColorMill® process ensures your design will feature the most vivid colors and exhibit a smooth, even finish. There are no limits to the imagination! Create a new shade with various formulations from the color palette.

Custom Logos

Whether you want to boost your school's spirit with an inlaid mascot logo or add sophisticated design to your facility with freeform shapes, Ecore can make it happen with our custom logos program! Your design ambitions don't have to come second to production capabilities — our custom color options and superior pattern abilities can make achieving your design a reality.

ecore™

*Note: 1904 Orange is for indoor use only.

ecore

Product Safety Data Sheet

Turf & Carpet Products

1. IDENTIFICATION OF THE PRODUCT & MANUFACTURER	Product Name: **RageTurf Motivate, RageTurf Rally, RageTurf UltraTile, RageTurf dBTile, FlexTurf Motivate, FlexTurf Monster, FierceTurf Monster** **1.1** Company Details: Ecore International Inc., 715 Fountain Avenue, Lancaster, PA 17601 Phone: 717.295.3400 Fax: 717.295.3414
2. HAZARD(S) IDENTIFICATION	These products are non-hazardous
3. COMPOSITION / INFORMATION ON INGREDIENTS	There are no substances in this product presenting a health or environmental hazard within the meaning of the Chemicals (Hazard Information & Packaging for Supply) Regulations
4. FIRST AID MEASURES	Inhalation: no specific measures required Eye contact: no specific measures required Skin contact: no specific measures required Ingestion: no specific measures required
5. FIRE FIGHTING MEASURES	**5.1** Suitable extinguishing media: Water spray jet, foam, dry powder, carbon dioxide **5.2** Extinguishing media that MUST NOT be used: Not applicable **5.3** Special exposure hazard arising from combustion products, resulting gases: carbon monoxide, carbon dioxide, hydrogen chloride, sulfur oxides, nitrogen oxides, aromatic hydrocarbons, PAH's, traces of hydrogen cyanide, particulate matter, ozone, heavy metals. **5.4** Special protective equipment for firefighting: Use respiratory protection independent of recirculated air.
6. ACCIDENTAL RELEASE MEASURES	**6.1** Personal precautions: No special measures required **6.2** Environmental precautions: No special measures required **6.3** Methods for cleaning up: Dispose of according to regulations
7. HANDLING & STORAGE	**7.1** General information: No special protective measures required **7.2** Handling: Normal safe handling practices must be applied **7.3** Storage: Rolls should be stored horizontally
8. EXPOSURE CONTROLS/ P.P.E.	Personal protection equipment: None required
9. PHYSICAL & CHEMICAL PROPERTIES	Appearance: Polyethylene, polypropylene or Nylon fibers with polyurethane or rubber backing.
10. STABILITY & REACTIVITY	**10.1** General information: If stored and handled in accordance with standard industry practices, no hazardous reactions are known **10.2** Hazardous decomposition information: Thermal decomposition in the presence of air may yield hydrogen chloride gas, carbon dioxide and carbon monoxide
11. TOXICOLOGICAL INFORMATION	**11.1** General information: No harmful effects have been reported to date Inhalation: not applicable Eye contact: not applicable Skin contact: no known hazard Ingestion: not applicable
12. ECOLOGICAL INFORMATION	**12.1** Environmental fate and distribution: The products have no mobility in soil; are insoluble in water; are not expected to bioaccumulate **12.2** Persistence and degradability: The products will not biodegrade
13. DISPOSAL CONSIDERATIONS	Dispose of in accordance with local and national legislation
14. TRANSPORT INFORMATION	The products are not classified as dangerous for transportation
15. REGULATORY INFORMATION	The products are defined as "not hazardous" in the Chemicals Hazard Information and Packaging regulations (CHIP3)
16. OTHER INFORMATION **Doc. Number:** CRP01.RD.PSL.PS.0065 **Rev.:** 009 **Original Issue:** 22-Aug-2014 **Reviewed:** 8-Dec-2021 **Reviewed by:** W. Welch	Ecore International provides a Product Safety Data Sheet (PSDS) for finished floor covering products based on the "article exemption" found in 29 CFR 1910.1200 (b) (6) (v). An article is defined as: "a manufactured item other than a fluid or particle: (i) which is formed to a specific shape or design during manufacture; (ii) which has an end use function dependent in whole or in part upon its shape or design during end use; and (iii) which under normal conditions of use, does not release more than very small quantities, e.g. minute or trace amounts of a hazardous chemical and does not pose a physical hazard or health risk to employees." Disclaimer: Although the above information is presented in good faith and believed to be correct as of the current date, Ecore International gives no guarantee and disclaims responsibility for individual items being incomplete or incorrect. Furthermore, Ecore gives no guarantee that all possible measures are contained within the safety data sheet (including exceptional circumstances)

LEED v4 Sheet

Turf

Building Design & Construction (BD+C), Interior Design & Construction (ID+C)

Category	Credit Title	How Product Contributes
Materials & Resources	Building Product Disclosure and Optimization- Sourcing of Raw Materials	Recycled content varies by product; please consult the recycled content chart at the end of this guide for specific recycled content by product
Indoor Environmental Quality	Low Emitting Materials	FlexTurf Motivate, RageTurf Motivate and RageTurf Rally: CDPH Standard Method v1.2 compliant

Building Operations & Maintenance (O+M)

Category	Credit Title	How Product Contributes
Materials & Resources	Purchasing-Facility Maintenance and Renovation	Recycled content: Recycled content varies by product; please consult the recycled content chart at the end of this guide for specific recycled content by product Low emissions of VOCs: FlexTurf Motivate, RageTurf Motivate and RageTurf Rally: CDPH Standard Method v1.2 compliant

Certifications, documentation, and more information can be found at
https://www.ecoreintl.com/circularity/environmental-responsibility/transparency-certifications

Recycled Content

Product	Total Recycled Content	Pre-Consumer	Post-Consumer
RageTurf Motivate	59%	0%	59%
RageTurf Rally	73%	0%	73%
RageTurf UltraTile	90%	0%	90%
RageTurf dBTile	91%	0%	91%
FlexTurf Motivate	55%	0%	55%
FlexTurf Monster with 8mm ShockPad	63%	0%	63%
FlexTurf Monster with 10mm ShockPad	67%	0%	67%
FlexTurf Monster with 12mm ShockPad	71%	0%	71%
FlexTurf Monster with 15mm ShockPad	74%	0%	74%
FierceTurf Monster with 10mm ShockPad	62%	0%	62%
FierceTurf Monster with 12mm ShockPad	67%	0%	67%

Mannington
COMMERCIAL

BurkeBase®

Style	BurkeBase (PVC-Free) Premium TS Molded Wall Base 1/8″ *	BurkeBase Type TP 1/8″ ** (Non-Ortho Phthalate)
Construction	Thermoset Rubber	Thermoplastic Rubber
Finish	Satin	Matte
Classification	ASTM F1861 Type TS, Group 1	ASTM F1861 Type TP, Group 1
Total Thickness	1/8″ (3.2 mm)	1/8″ (3.2 mm)
Profile	Coved 4″ (102 mm) 6″ (152 mm)	Coved or Toeless 2.5″ (64 mm) 4″ (102 mm) 4.5″ (114 mm) 6″ (152 mm)
Colors	25	100 (36 are Accord)
Packaging	25-4′ pieces = 100′ per carton	1-100′ continuous roll or 25-4′ pieces
Weight Per Carton – 2.5″ / 4″ / 4.5 ″ / 6″	Coved = 39/53 lbs.	Coved = 25/38/41/53 lbs. Toeless = 24/36/40/52 lbs.
Weight Per Carton – Corners	Coved = 4/7 lbs.	Coved = 3/4/4/9 lbs. Coved = 3/4/4/9 lbs.
Corners (must be ordered at time of wall base order to ensure color match)	Factory molded corners available	Factory pre-formed corners available
Adhesive	MR-101	MR-101

Testing	
Static Load (ASTM E970)	500 psi
Flooring Radiant Panel (ASTM E648)	Passes - Class I; ≥ 0.45 watts/cm^2
Smoke Density (ASTM E662)	Passes - < 450

Environmental Data	
Indoor Air Quality	FloorScore Certified
Product Declarations	Third party verified EPD, HPD
Carbon Offset	105% Cradle to Gate (A1-A3); see website for additional information
LEED Scoreboard	May contribute to LEED and Green Globes credits LEED 2009: MRc5 Regional Material; IEQ4.1 Low Emitting Adhesives; IEQ4.3 Low Emitting Materials - Flooring LEEDv4: IEQc2 - Low Emitting Materials
mindful MATERIALS	For more information on environmental and material health data, visit mindfulmaterials at https://portal.mindfulmaterials.com/?query=mannington
Manufacturing	Calhoun, GA and Eustis, FL (USA); Buy American Act compliant

Warranty	
	Limited 5-Year Commercial Warranty

- Maintain a minimum temperature in the spaces to receive the wall base and accessories of 65°F (18°C) and a maximum temperature of 85°F (29°C) for at least 48 hours before, during and for not less than 48 hours after installation. Thereafter, maintain a minimum temperature of 55°F (13°C) in areas where work is completed. Dirt, wetness and improper maintenance may cause significant variation in actual performance. Such variations do not affect product performance.
- Specifications are based on averages from normal manufacturing tolerances.
- This product is intended solely for use indoors and is not recommended or sold for any other purpose.

* Type TS Coved 4′ lengths available in 4″ and 6″.
** Type TP & TV Coved and Toeless 4′ lengths & 100′ rolls available in 2.5″, 4″, 4.5″, and 6″ heights.

BurkeBase®

Style	BurkeBase Type TV 1/8″ ** (Non-Ortho Phthalate)	BurkeBase Type TV .080″ ** (Non-Ortho Phthalate)
Construction	Vinyl	Vinyl
Finish	Matte	Matte
Classification	ASTM F1861 Type TV, Group 1	ASTM F1861 Type TV, Group 1
Total Thickness	1/8″ (3.2 mm)	.080″ (2.0 mm) & 1/8″ (3.2 mm)
Profile	Coved or Toeless	Coved or Toeless
Sizes	2.5″ (64 mm) 4″ (102 mm) 4.5″ (114 mm) 6″ (152 mm)	2.5″ (64 mm) 4″ (102 mm) 6″ (152 mm)
Colors	100	100
Packaging	1-100′ continuous roll or 25-4′ pieces	1-100′ continuous roll or 25-4′ pieces
Weight Per Carton – 2.5″ / 4″ / 4.5 ″ / 6″	Coved (1/8″) = 24/37/41/53 lbs. Toeless (1/8″) = 23/36/39/52 lbs.	Coved (.080″) = 19/27/42 lbs. Toeless (.080″) = 17/25/39 lbs.
Weight Per Carton – Corners	Coved = 3/4/4/9 lbs. Toeless = 3/4/4/9 lbs.	Coved (.080″) = 2/3/8 lbs. Toeless (.080″) = 2/3/8 lbs
Corners (must be ordered at time of wall base order to ensure color match)	Factory pre-formed corners available	Factory pre-formed corners available
Adhesive	MR-101	MR-101

Testing	
Static Load (ASTM E970)	500 psi
Flooring Radiant Panel (ASTM E648)	Passes - Class I; ≥ 0.45 watts/cm^2
Smoke Density (ASTM E662)	Passes - < 450

Environmental Data	
Indoor Air Quality	FloorScore Certified
Product Declarations	Third party verified EPD, HPD
Carbon Offset	105% Cradle to Gate (A1-A3); see website for additional information
LEED Scoreboard	May contribute to LEED and Green Globes credits LEED 2009: MRc5 Regional Material; IEQ4.1 Low Emitting Adhesives; IEQ4.3 Low Emitting Materials - Flooring LEEDv4: IEQc2 - Low Emitting Materials
mindful MATERIALS	For more information on environmental and material health data, visit mindfulmaterials at https://portal.mindfulmaterials.com/?query=mannington
Manufacturing	Calhoun, GA and Eustis, FL (USA); Buy American Act compliant

Warranty	
	Limited 5-Year Commercial Warranty

- Maintain a minimum temperature in the spaces to receive the wall base and accessories of 65°F (18°C) and a maximum temperature of 85°F (29°C) for at least 48 hours before, during and for not less than 48 hours after installation. Thereafter, maintain a minimum temperature of 55°F (13°C) in areas where work is completed. Dirt, wetness and improper maintenance may cause significant variation in actual performance. Such variations do not affect product performance.
- Specifications are based on averages from normal manufacturing tolerances.
- This product is intended solely for use indoors and is not recommended or sold for any other purpose.

* Type TS Coved 4′ lengths available in 4″ and 6″.
** Type TP & TV Coved and Toeless 4′ lengths & 100′ rolls available in 2.5″, 4″, 4.5″, and 6″ heights.

Corian.
SOLID SURFACE

DUPONT™ CORIAN® INTERIOR VERTICAL CLADDING

TABLE OF CONTENTS

INTRODUCTION

This bulletin is offered to facilitate specification and installation of DuPont™ Corian® solid surface interior wall surfacing for dry applications. The information needed to make design decisions on the primary features for a vertical surface application is summarized in Table 1.

TABLE 1: DESIGN DECISIONS; INTERIOR WALL VERTICAL SURFACING

Feature	Comments
Color	DuPont™ Corian® solid surface is offered in over one hundred colors. Colors can be viewed at www.corian.com. Local distributors can provide color brochures and samples. Call 1 800 436 6072 for the location of the distributor nearest you.
Cladding Sheet Thickness	All bulletin sketches show 6 mm (¼") sheet material, but 12 mm (½") material could also be used. Although 6 mm material is very durable in most applications, 12 mm material will provide additional protection against impact damage in areas where high levels of abuse can be anticipated.
Cladding Adhesive	A 100% silicone with 50% movement capability is suggested for bonding sheets to walls. Reference Section A for silicone thickness and placement. Silicone thickness needs to be increased if inside corners are hard seamed (Reference Figure E-1).
Cladding Wall Seams (Hard versus Silicone)	Long expanses of inconspicuous hard seamed cladding provide desirable seamless appearance and can ease cleaning and maintenance. However, hard seamed wall lengths need to be limited per Table 3, page 3 to accommodate thermal expansion and contraction. Soft silicone seams may be inserted as needed to allow for expansion.
Outside Corner Details	Outside corners can be made with either inconspicuous hard seams or silicone soft seams, reference Section C. The wall length limits in Table 3 also apply to walls with outside corners.
Inside Corner Details	Inside corners can also be made with either inconspicuous hard seams or silicone soft seams. The hard-seam wall length limits in Table 4 apply to walls with inside corners. The decision process for room inside corners is summarized in Figure D-2. Options for hard seamed inside corners appear in Section E. Options for silicone soft seamed inside corners appear in Sections F, G, H, and I.
Wall to Floor Details	Options for the connection between walls and floors appear in Figure J-1 through Figure J-4.
Wall to Ceiling Details	Options for the connection between walls and ceilings appear in Figure K-1 through Figure K-3.
Other Topics	Mounting devices or equipment, e.g., handrails, and wet walls are covered in Sections N and O, respectively.

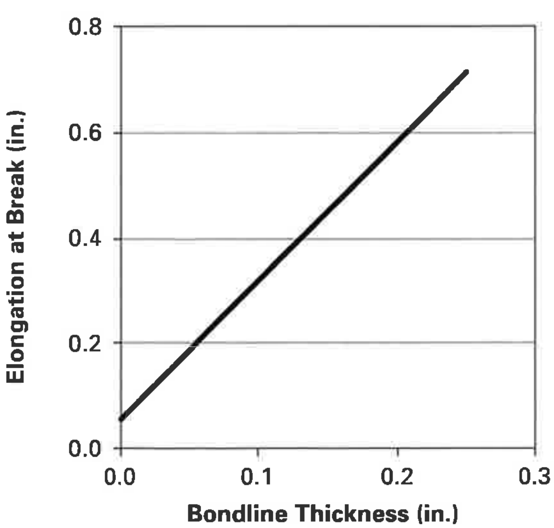
Additional introductory comments most applicable to the fabricator/installer include:

- DuPont™ Corian® sheet can be mounted with either horizontal or vertical seams in vertical cladding applications. Sheets can be seamed together using butt, tongue and groove edge, or wavy edge seams. Reference Section P, Hard Seaming, for more information on tongue and groove joints.
- To ease alignment between sheets it is preferable to only have vertical or horizontal seams, not both. Therefore, for long, full height walls, vertical seams are preferable. Develop an overall installation plan based on the application. Care must be taken to mount sheets with plumb and level vertical and horizontal edges, respectively, especially for the initial sheet mounted on a wall. Both vertical edges of corner panels should be plumb. It is easier to align a larger sheet than a narrow vertical or horizontal strip. To ease alignment for hard seamed panels it is suggested that narrow strip pieces, e.g., corner pieces or baseboards, be seamed to larger pieces prior to installation on the wall.
- Reference Section M for requirements for cutouts. A general rule of thumb for interior applications where temperature is not well controlled or variable sun loads exist on the walls is to provide an allowance (gap from potential hard restraints) for 1/64" movement (panel dimension expansion or contraction) for every foot of panel dimension (1.5 mm per meter).
- Although the guidelines documented in this bulletin are generally applicable to walls in both dry and wet environments, some special consideration are needed for walls in wet environments.

A. SILICONE ADHESIVE

A 100% silicone sealant with minimum 50% movement capability[1] is suggested for bonding sheets to walls. The use of an elastic silicone and the final thickness of the silicone bond are important to create an elastic connection between the Corian® sheet and the wall substrate to allow for differential expansion and contraction (Reference Figure A-1). A minimum silicone adhesive thickness of 1/16" (1.5 mm) is suggested to apply sheet panels to the wall. Greater silicone thickness can accommodate even longer hard seamed wall lengths for a given variable temperature environment. Be sure to clean both the substrate surface and the surface of the sheet you are adhering to the substrate to ensure a quality silicone bond.

FIGURE A-1: SILICONE MOUNTING BOND LINE THICKNESS VS. ELONGATION AT BREAK: LAP SHEAR DATA BETWEEN DUPONT™ CORIAN® SOLID SURFACE AND COMMON SUBSTRATES

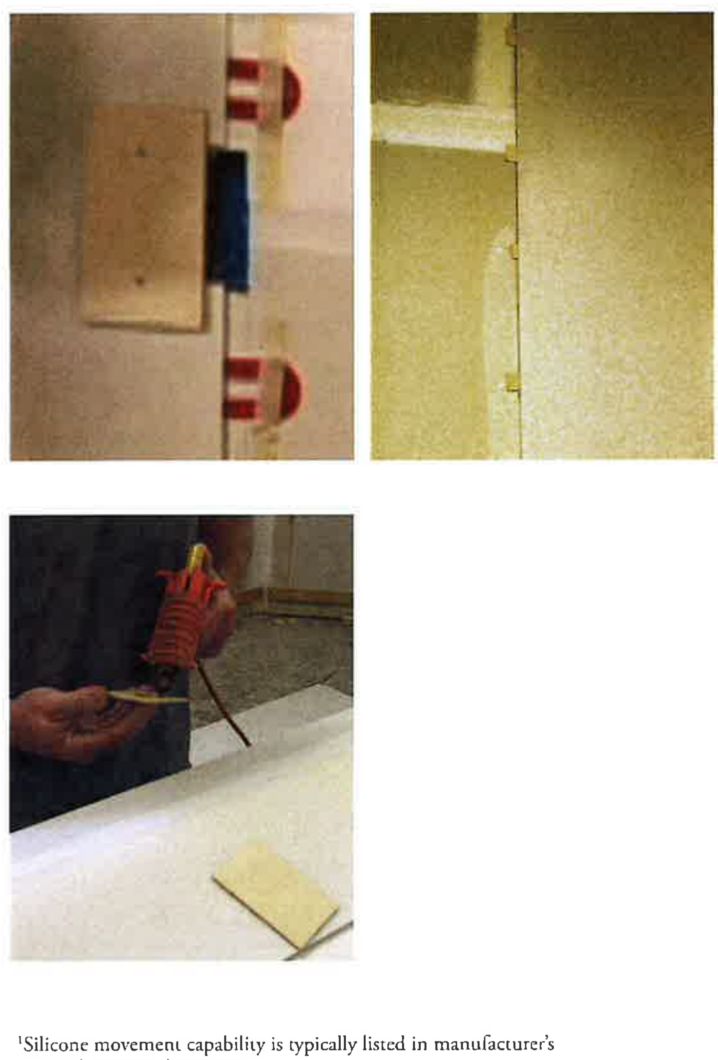


The data in Figure A-1 is adequate for design purposes as minimum performance with gypsum board, cement board, wood, MDF, metals, and ceramic tiles. Higher elongation capabilities are applicable for some of these materials. If there is any question regarding bond strength, quality testing should be performed using a peel-in-adhesion or other quality test, reference ASTM C794, *Standard Test Method for Adhesion-in-Peel of Elastomeric Joint Sealants*, for a procedure to test and record adhesion strength.

Examples: 1/16" (1.5 mm) 100% silicone will allow approximately 0.15" (3.8 mm) movement before failure. 1/8" (3 mm) and 1/5" (5 mm) 100% silicone will allow approximately 0.4" (10 mm) and 0.6" (15 mm) movement before failure, respectively. Applying a safety factor of 2 to these values is suggested.

Typical silicone manufacturer guidance includes use of 3:1 silicone width to thickness bond lines and limit of static loads to one pound per square inch (1 psi) or 7 kPa. The applied silicone bead diameter should be 2 to 2.5X your desired finished silicone thickness. This will result in a bite width to thickness ratio of approximately three. Fabrication methods should be used to insure the thickness is achieved, e.g., the use of shims as shown in Figure A-2. Table 2 is a tabulation of silicone bead diameters and bead lengths suggested to achieve manufacturer's recommendations for silicone bonds.

FIGURE A-2: SHIMS MAINTAIN MINIMUM SILICONE BOND LINE THICKNESS (SHIMS CAN BE SECURED WITH HOT MELT GLUE AND LEFT IN PLACE)



[1]Silicone movement capability is typically listed in manufacturer's material property literature.

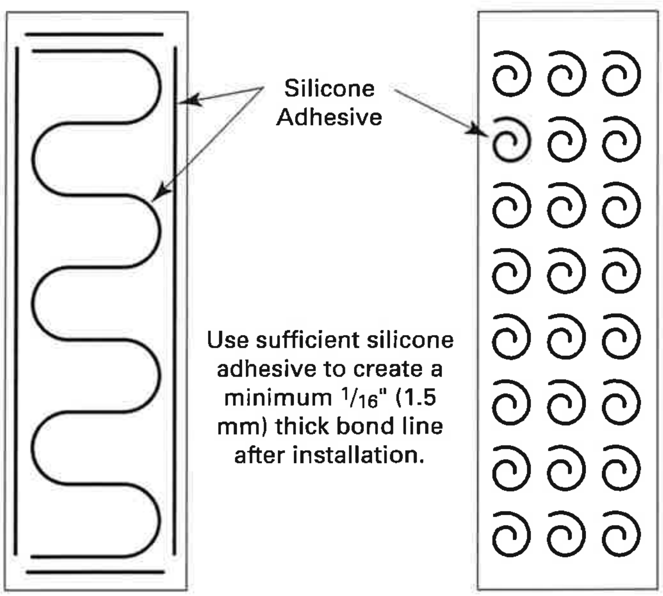
TABLE 2: SILICONE ADHESIVE BONDING GUIDELINES

Suggested Silicone Bead Diameters to Achieve Different Bond Line Thicknesses and Suggested Silicone Bead Lengths Per Area of Different Sheet Thicknesses.

Sheet Thickness		Bead Diameter		Compressed Thickness		Bead Length Required / Unit Sheet Length		Bead Length Required / Unit Sheet Area	
(in.)	(mm)	(in.)	(mm)	(in.)	(mm)	(in./ft.)	(cm/m)	(in./ft.²)	(cm/m²)
¼	6	⅛	3.2	1/16	1.6	40	310	15	405
¼	6	¼	6.4	⅛	3.2	20	620	8	205
½	12	⅛	3.2	1/16	1.6	75	155	30	810
½	12	¼	6.4	⅛	3.2	40	310	15	410

Use a distributed silicone placement pattern to provide panel bonding near all panel edges and across spans to provide consistent dimensional gap support from the substrate (Reference Figure A-3). It is important not to create closed loops of silicone adhesive as silicone uses atmospheric moisture to cure. Closed loops create a barrier to moisture and will retard cure.

FIGURE A-3: SILICONE ADHESIVE PLACEMENT



B. HARD SEAMED WALL LENGTH LIMITATIONS

Long expanses of inconspicuous hard seamed cladding can be fabricated using Corian® solid surface sheets when 100% silicone is used for mounting. For 1/16" (1.5 mm) silicone bond lines the maximum suggested wall lengths versus the expected temperature change appear in Table 3. If desired wall dimensions exceed those suggested, thicker silicone bond lines can be used or an expansion joint is suggested (Reference Table 3).

TABLE 3: HARD-SEAMED WALL LENGTH LIMITS AS FUNCTION OF EXPECTED TEMPERATURE CHANGE FOR 100% SILICONE WITH 50% MOVEMENT CAPABILITY[2,3]

1/16" (1.6 mm) Silicone Thickness

ΔT (°F)	length limit (ft.)	ΔT (°C)	length limit (m)
±10	49	±5	16.7
±15	33	±10	8.3
±20	25	±15	5.6
±25	20	±20	4.2
±30	16	±25	3.3
±35	14		
±40	12		

1/8" (3.2 mm) Silicone Thickness

ΔT (°F)	length limit (ft.)	ΔT (°C)	length limit (m)
±10	115	±5	38.9
±15	77	±10	19.4
±20	57	±15	13.0
±25	46	±20	9.7
±30	38	±25	7.8
±35	33		
±40	29		

The temperature range used for design should be based on the expected deviation from the installation temperature and should include consideration for the construction phase as well as occupation. Plan the installation to minimize ambient temperature changes on site. If possible, the building should be heated prior to installation. Acclimate the materials and building to the design temperature for at least 48 hours with air circulation around the materials. The temperature needs to be controlled once installation is complete.

[2]Suggested limits are based on silicone capability plotted in Figure A-1, installation on gypsum board and a safety factor of 2. Reference Appendix A: Example Application Calculations for example application calculations.

[3]Silicone movement capability is typically listed in manufacturer's material property literature.

C. OUTSIDE CORNERS

Outside corners may be either hard seamed or silicone seamed as shown in Figure C-1.

FIGURE C-1: ALTERNATIVE OUTSIDE CORNERS – HARD SEAM

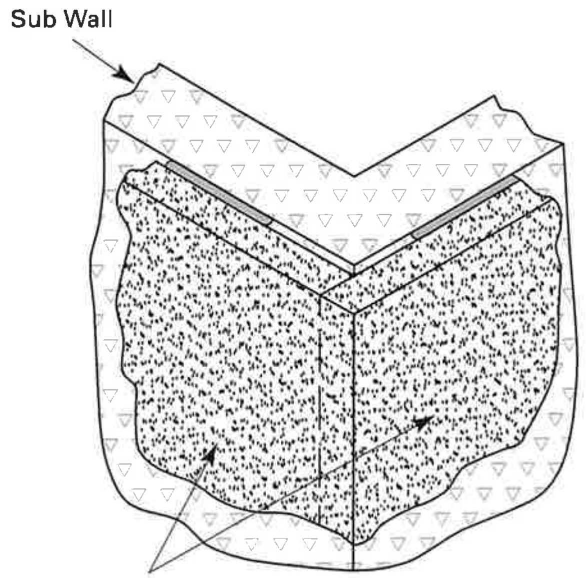
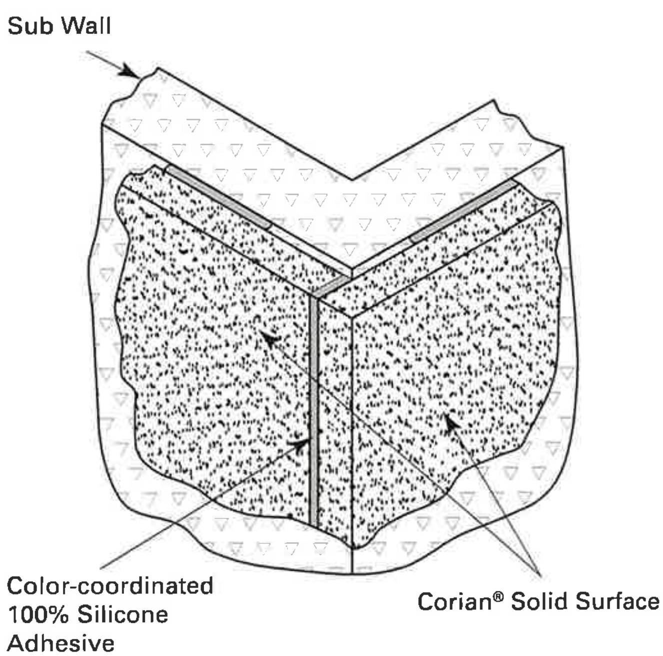


FIGURE C-2: ALTERNATIVE OUTSIDE CORNERS – SILICONE SEAM



D. INSIDE CORNERS

Any inside corners at the end of walls should be designed to allow for expansion. Corian® wall-panel expansions as a function of wall length for three different temperatures are shown in Figure D-1. Corian® wall-panel expansion can be calculated using the following formula:

$$\Delta Length = \alpha \times Length \times \Delta Temperature$$

α is the Coefficient of Thermal Expansion (CTE) and it is important to select the correct value for the selected temperature scale.

$$\alpha = \frac{2.2 \times 10^{-5}}{°F} \text{ or } \alpha = \frac{0.000022}{°F}$$

$$\alpha = \frac{3.9 \times 10^{-5}}{°C} \text{ or } \alpha = \frac{0.000039}{°C}$$

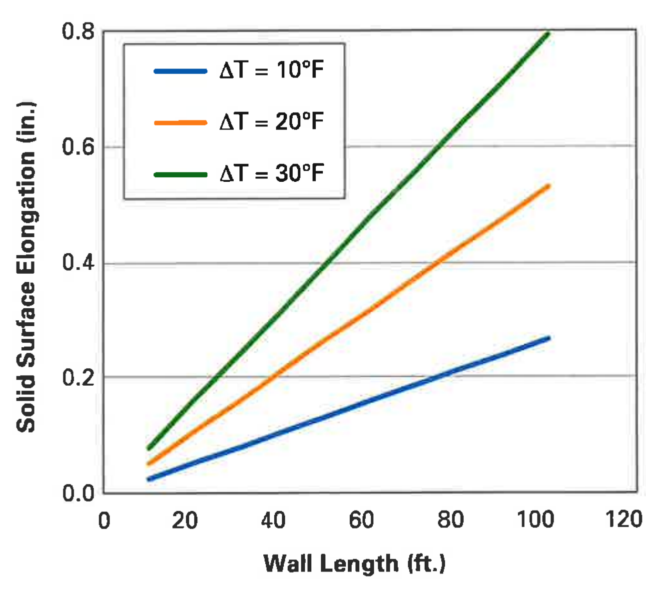
The units used for length are arbitrary, but must be the same for both initial length and change in length. These equations are often written with length units included for clarity.

$$\Delta Length\ (inch) = \alpha \left(\frac{inch}{inch\ °F}\right) \times Length(inch) \times \Delta Temperature\ (°F)$$

$$\Delta Length\ (meter) = \alpha \left(\frac{meter}{meter\ °C}\right) \times Length(meter) \times \Delta Temperature\ (°C)$$

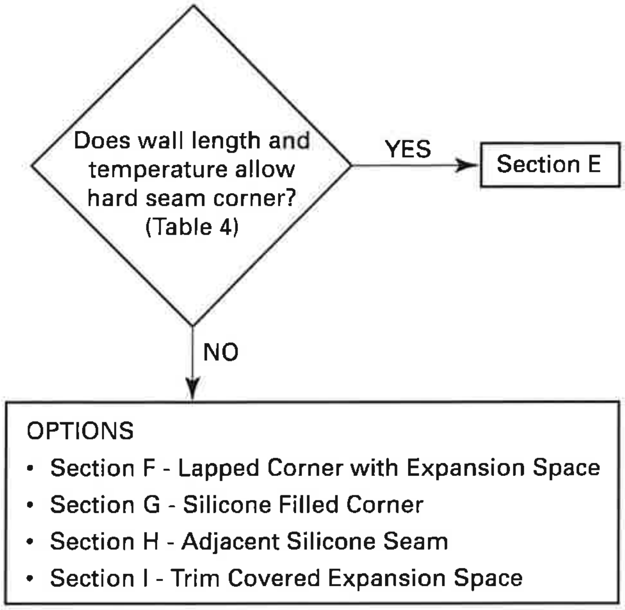
Use of this formula is suggested neglecting the expansion of the wall substrate material. Neglecting the differential expansion or contraction of the wall substrate simply adds a factor of safety. An example calculation appears in Appendix A: Example Application Calculations.

FIGURE D-1: WALL EXPANSION AND CONTRACTION



Alternatives for inside corners at the end of walls are outlined below. Figure D-2 presents a decision tree outlining inside corner options.

FIGURE D-2: INSIDE CORNER OPTIONS



E. INSIDE CORNER ALTERNATIVE: HARD SEAMED WALL CORNERS

Perpendicular walls can be completely hard seamed including the corners as shown in Figures E-1 and E-2, subject to the wall length limits suggested in Table 4. A minimum ⅛" (3 mm) thick 100% silicone bond line to control the gap behind each panel is suggested when hard seamed inside corners are used. Be sure to radius the inside corner of butting panels.

FIGURE E-1: HARD SEAMED CORNERS – V-GROOVED COVE

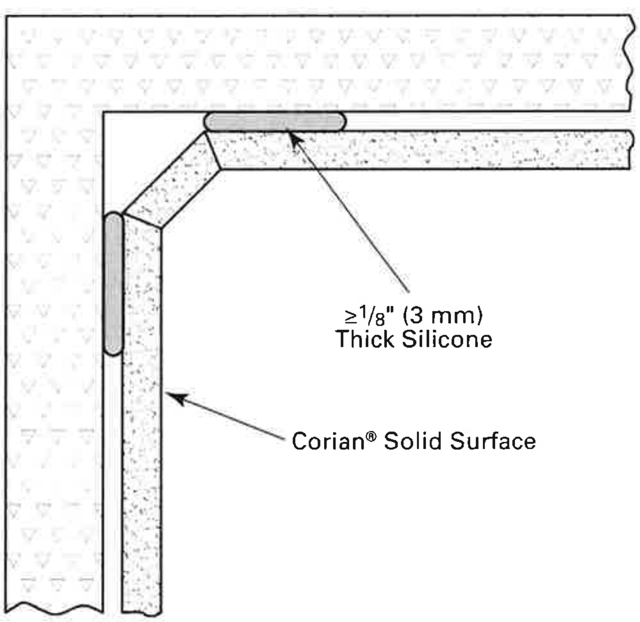


FIGURE E-2: HARD SEAMED CORNERS – THERMOFORMED COVE

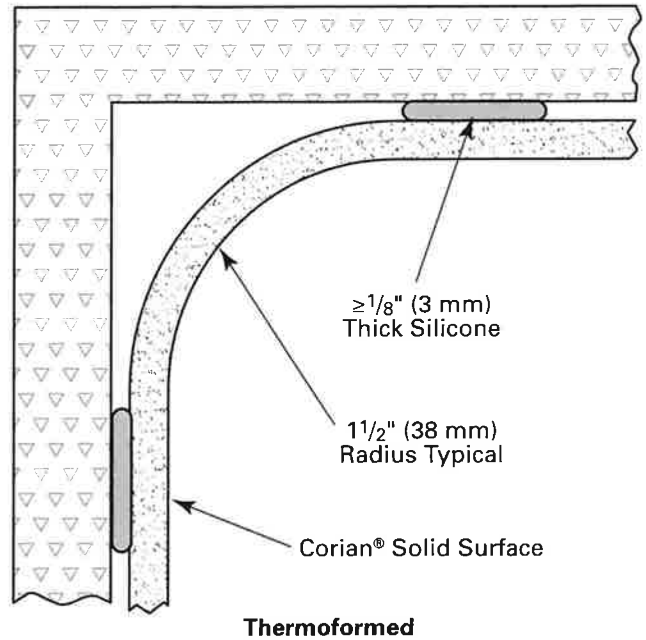


TABLE 4: SUGGESTED WALL LENGTH LIMITS FOR WALLS WITH INSIDE HARD-SEAMED CORNERS AS FUNCTION OF EXPECTED TEMPERATURE CHANGE (REFERENCE FIGURE D-2)

ΔT (°F)	Suitable Wall Length Limit (ft.)	ΔT (°C)	Suitable Wall Length Limit (m)
±10	30.9	±5	10.5
±15	20.6	±10	5.2
±20	15.4	±15	3.5
±25	12.3	±20	2.6
±30	10.3	±25	2.1
±35	8.8		
±40	7.7		

F. INSIDE CORNER ALTERNATIVE: LAPPED CORNER WITH EXPANSION SPACE

Perpendicular walls can lap adjacent walls as shown in Figure F-1, allowing expansion space for one wall length in each corner of the room. Corner void spaces equal to 1.5 times the estimated wall expansion for the free expanding wall are suggested. Typical values are tabulated in Table 5. The free expanding wall should project behind the lapping wall by at least one half the thickness of the wall sheet. The space between the lapping wall is suggested to be at least 1⁄16" (1.5 mm) in dimension and filled with color-coordinated silicone.

CAUTION: do not remove wall material from a fire-rated wall to create a corner void space.

FIGURE F-1: LAPPED CORNER WITH EXPANSION SPACE

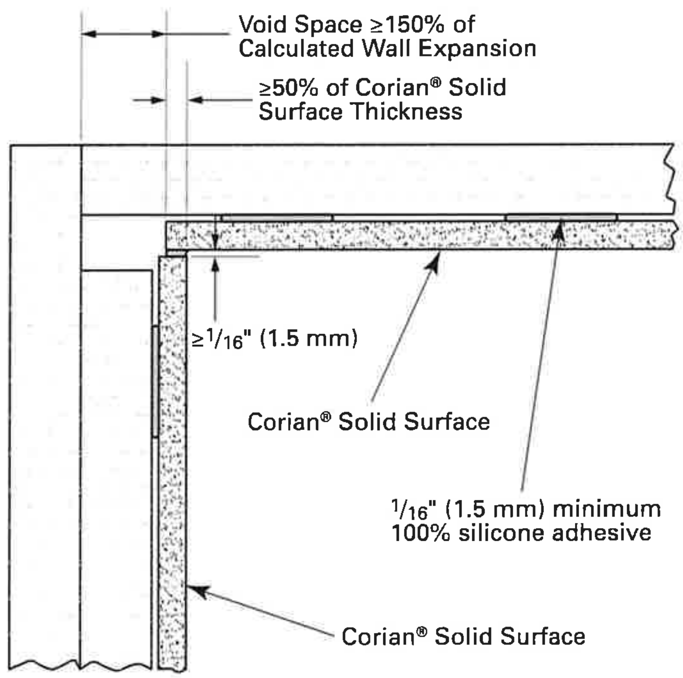


TABLE 5: SUGGESTED VOID SPACE AS FUNCTION OF EXPECTED TEMPERATURE CHANGE FOR LAPPED CORNER WITH EXPANSION SPACE (REFERENCE FIGURE F-1)

1/16" Silicone Thickness

Length (ft.)	ΔT = ±10°F Void (in.)	ΔT = ±20°F Void (in.)	ΔT = ±30°F Void (in.)
10	0.04	0.08	0.12
15	0.06	0.12	0.18
20	0.08	0.16	0.24
25	0.10	0.20	
30	0.12		
40	0.16		
50	0.20		

1/8" Silicone Thickness

Length (ft.)	ΔT = ±10°F Void (in.)	ΔT = ±20°F Void (in.)	ΔT = ±30°F Void (in.)
30	0.12	0.24	0.36
40	0.16	0.32	0.48
45	0.18	0.36	
60	0.24	0.48	
75	0.30		
100	0.40		
115	0.46		

1.6 mm Silicone Thickness

Length (m)	ΔT = ±5°C Void (mm)	ΔT = ±10°C Void (mm)	ΔT = ±15°C Void (mm)
3	0.9	1.8	2.7
6	1.8	3.6	5.3
8	2.4	4.8	
11	3.3		
13	3.9		
15	4.5		
17	5.0		

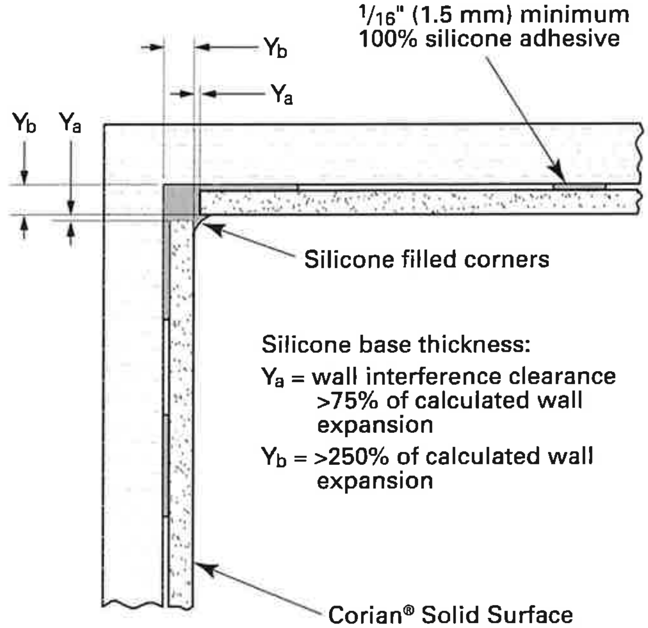
3.2 mm Silicone Thickness

Length (m)	ΔT = ±5°C Void (mm)	ΔT = ±10°C Void (mm)	ΔT = ±15°C Void (mm)
8	2.4	3.6	7.1
13	3.9	5.8	11.6
18	5.3	8.0	
20	5.9	8.9	
25	7.4		
30	8.9		
40	11.9		

G. INSIDE CORNER ALTERNATIVE: SILICONE FILLED CORNERS

Corners may be silicone filled as shown in Figure G-1. Suggested minimum dimensions are shown.

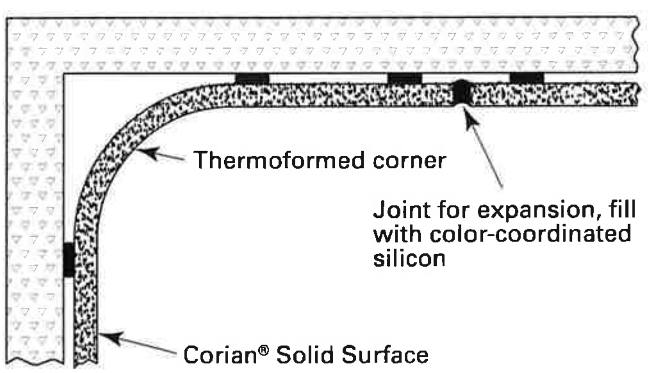
FIGURE G-1: SILICONE FILLED CORNERS



H. INSIDE CORNER ALTERNATIVE: ADJACENT SILICONE SOFT SEAMS

It may be desirable to locate exposed silicone away from inside corners to ease janitorial maintenance. An example of a seamless corner with an adjacent soft seam appears in Figure H-1. Soft seams can also be used at other locations in extensive wall lengths as expansion joints. A minimum gap of 3⁄16" (4.5 mm) filled with color-coordinated silicone is suggested. Reference Section Q of this bulletin for more information on silicone soft seams.

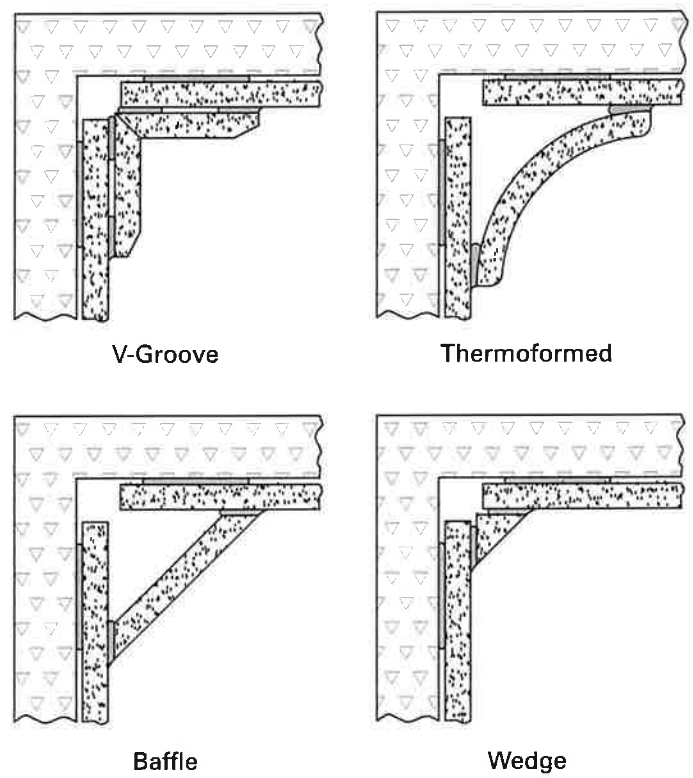
FIGURE H-1: ADJACENT SILICONE SOFT SEAMS



I. INSIDE CORNER ALTERNATIVE: TRIM COVERED EXPANSION SPACE

Corners may be made using trim pieces as shown in Figure I-1. Expansion clearance greater than 0.75 times the greatest wall expansion is suggested relative to the projection of any perpendicular wall into the corner to prevent interference between adjacent walls. Reference detailed drawings for these options are available from DuPont. Values for the wall panel clearance dimension in these figures can be determined by dividing the values in Table 5 by a factor of two.

FIGURE I-1: SILICONE SOFT SEAMED INSIDE CORNERS



J. WALL TO FLOOR DETAILS

Wall to floor details are shown in Figure J-1through Figure J-3.

FIGURE J-1: WALL BASE DETAIL

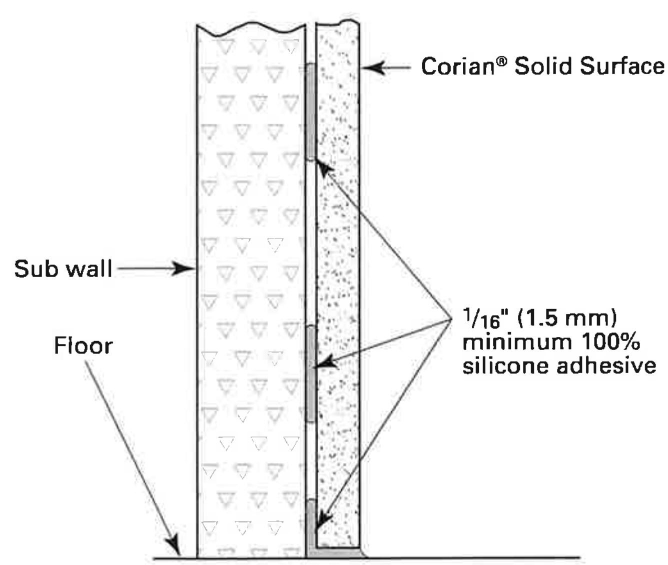


FIGURE J-2: WALL BASE DETAIL WITH TRIM

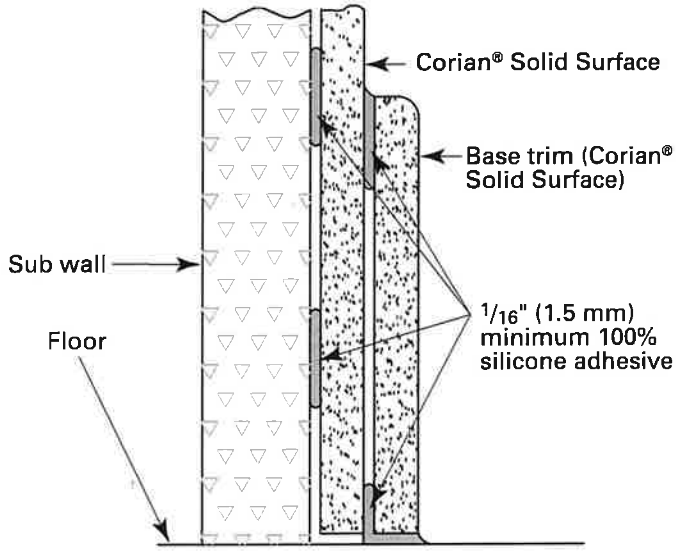


FIGURE J-3: WALL BASE DETAIL WITH FLASH COVE

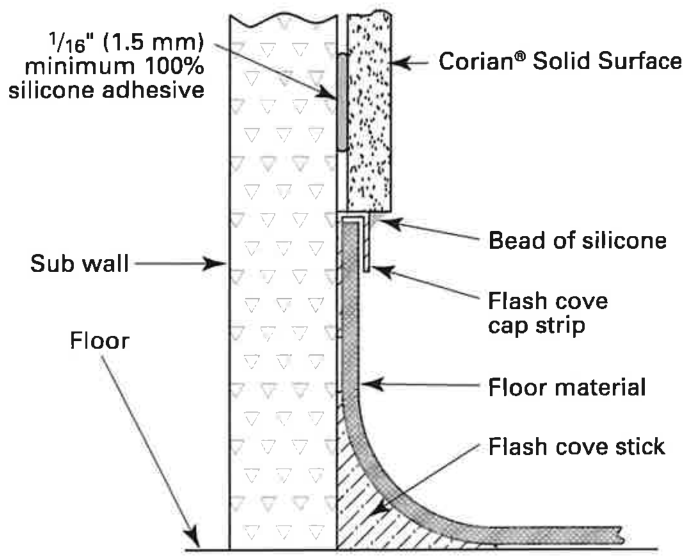
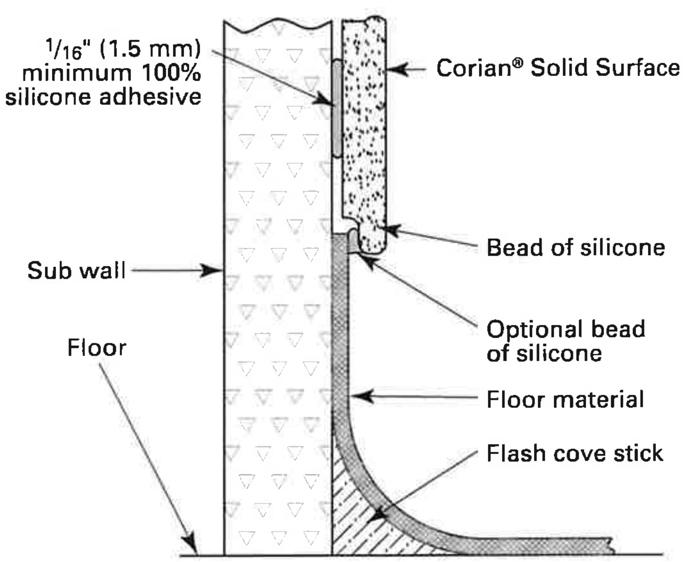


FIGURE J-4: WALL BASE DETAIL WITH DADO AND FLASH COVE



K. WALL TO CEILING DETAILS

Wall to ceiling details are shown in Figure K-1through Figure K-3.

FIGURE K-1: WALL CEILING DETAIL

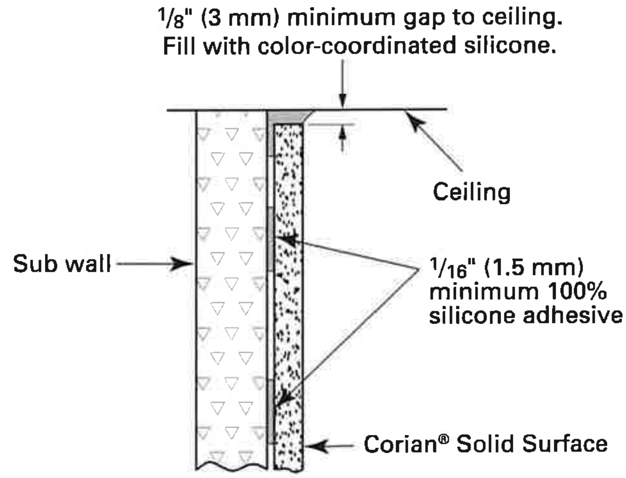


FIGURE K-2: WALL CEILING DETAIL WITH TRIM

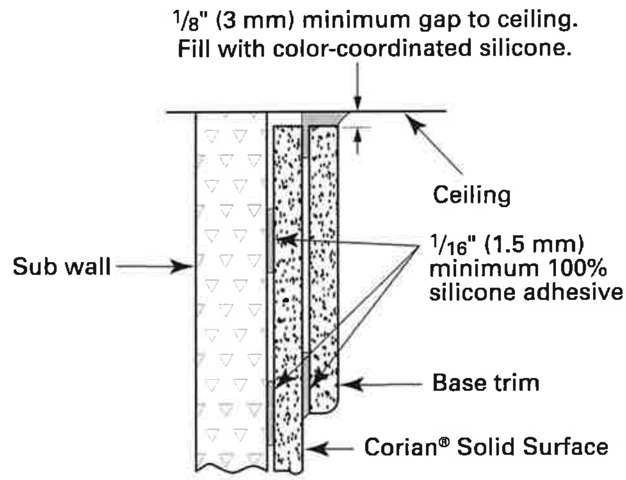
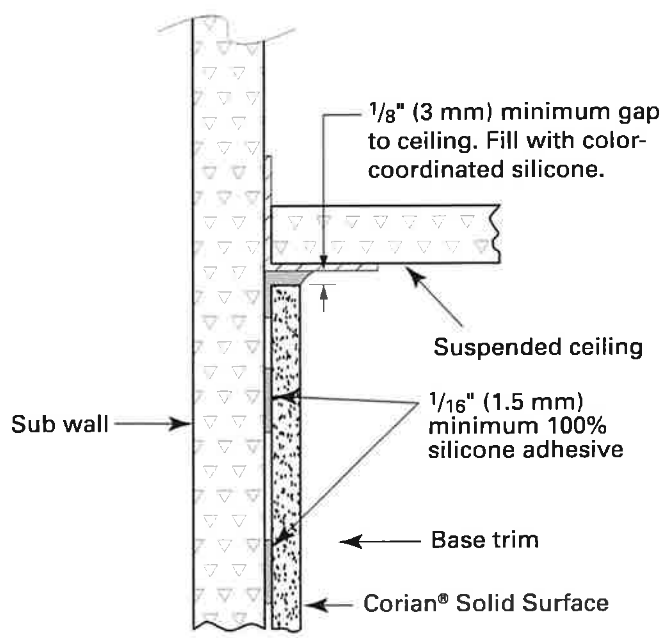


FIGURE K-3: WALL CEILING DETAIL FOR SUSPENDED CEILING

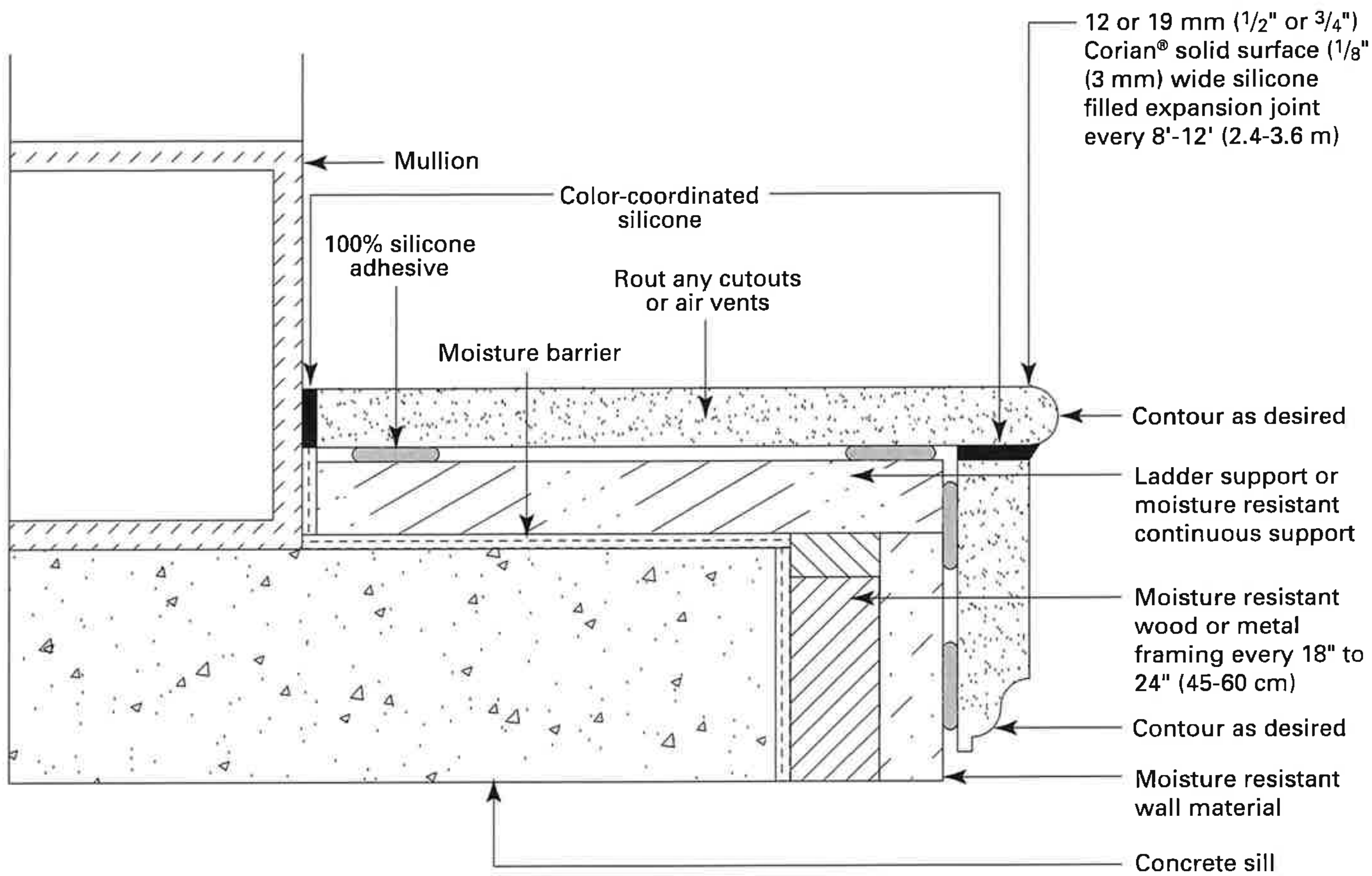


L. WINDOW SILLS

Figure L-1 illustrates specific design details for a "typical" window sill application. Window sills often experience wider temperature extremes due to solar heating and lower insulation provided by the window. Allow for expansion and contraction at either end of sills. As a conservative rule of thumb for window sills, allowance of 1/64" of movement per foot (1.3 mm per meter) of sill length is suggested. The allowance (gap) can be divided between the two ends of a sill section. If filled with 50% movement capable silicone (typical), gaps need to be doubled. Reference Section Q on silicone soft seams guidance.

The silicone thickness bonding the window sill to substrate may have to be increased to accommodate sill movement under greater window exposure, e.g., 1/8" (3 mm) bond line thickness.

FIGURE L-1: TYPICAL WINDOW SILL APPLICATION



M. CUTOUTS

Cutouts in Corian® applications are suggested to be made oversized to allow for expansion and contraction. Table 6 documents suggested oversize dimensions around any equipment or accessory protruding from a cutout or other potential restraint. Examples of potential restraints include electrical outlets and window or door frames. Radius cutout corners with 3/16" (4.5 mm) radii and sand edges smooth to prevent possible cracking.

Table 6 is divided into two sections, for cases with and without silicone fill in the gap. If the gap is covered by a flange and not filled with silicone the needed clearance dimensions are smaller. Table 6 is used by selecting a column for the appropriate maximum temperature variation from the installation temperature. The maximum length dimension in the wall under consideration between any two potential restraints or between a potential restraint and the end of the wall should be used to select the appropriate row in Table 6. The width value listed in the table at the intersection of the critical length row and temperature column is the appropriate clearance gap. Reference Section Q, Silicone Soft Seams, for further discussion on sizing and fabrication.

TABLE 6: SUGGESTED GAP WIDTHS AROUND WALL RESTRAINTS[4]

With silicone in gap

Temperature change (°F)	ΔT = ±10°F	ΔT = ±20°F	ΔT = ±40°F	ΔT = ±60°F
Length (ft.)	Width (in.)	Width (in.)	Width (in.)	Width (in.)
10	0.092	0.123	0.184	0.245
20	0.123	0.184	0.306	0.428
30	0.153	0.245	0.428	0.611
40	0.184	0.306	0.550	0.794

With nothing in gap

Temperature change (°F)	ΔT = ±10°F	ΔT = ±20°F	ΔT = ±40°F	ΔT = ±60°F
Length (ft.)	Width (in.)	Width (in.)	Width (in.)	Width (in.)
10	0.077	0.092	0.123	0.153
20	0.092	0.123	0.184	0.245
30	0.108	0.153	0.245	0.336
40	0.123	0.184	0.306	0.428

[4]Table 6 is based on the seam sizing equation in Section Q. No live load movement is included. Table 6 values do include a 1/16" (1.5 mm) fabrication tolerance.

With silicone in gap

Temperature change (°C)	ΔT = ±5°C	ΔT = ±10°C	ΔT = ±20°C	ΔT = ±30°C
Length (m)	Width (mm)	Width mm)	Width (mm)	Width (mm)
3	2.3	2.9	4.3	5.7
6	2.9	4.3	7.1	9.8
9	3.6	5.7	9.8	13.9
12	4.3	7.1	12.5	18.0

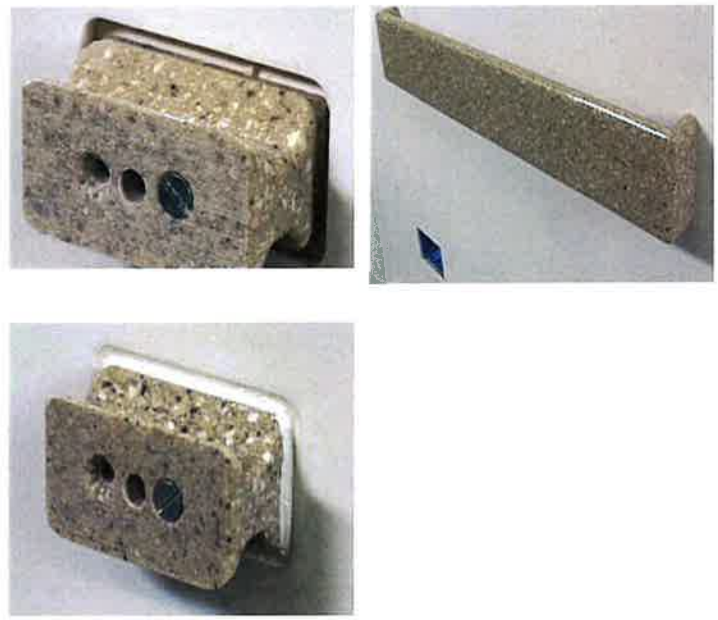
With nothing in gap

Temperature change (°C)	ΔT = ±5°C	ΔT = ±10°C	ΔT = ±20°C	ΔT = ±30°C
Length (m)	Width (mm)	Width mm)	Width (mm)	Width (mm)
3	1.9	2.3	2.9	3.6
6	2.3	2.9	4.3	5.7
9	2.6	3.6	5.7	7.7
12	2.9	4.3	7.1	9.8

N. MOUNTING HANDRAILS OR OTHER DEVICES

Handrail mounting brackets or other accessories should be mounted by creating an oversized cutout in the Corian® material and directly fastening the accessory to the wall or substrate structure. Reference Section M, Cutouts above and Section Q, Silicone Soft Seams, for cutout sizing. Figure N-1 shows an installation sequence for a handrail bracket.

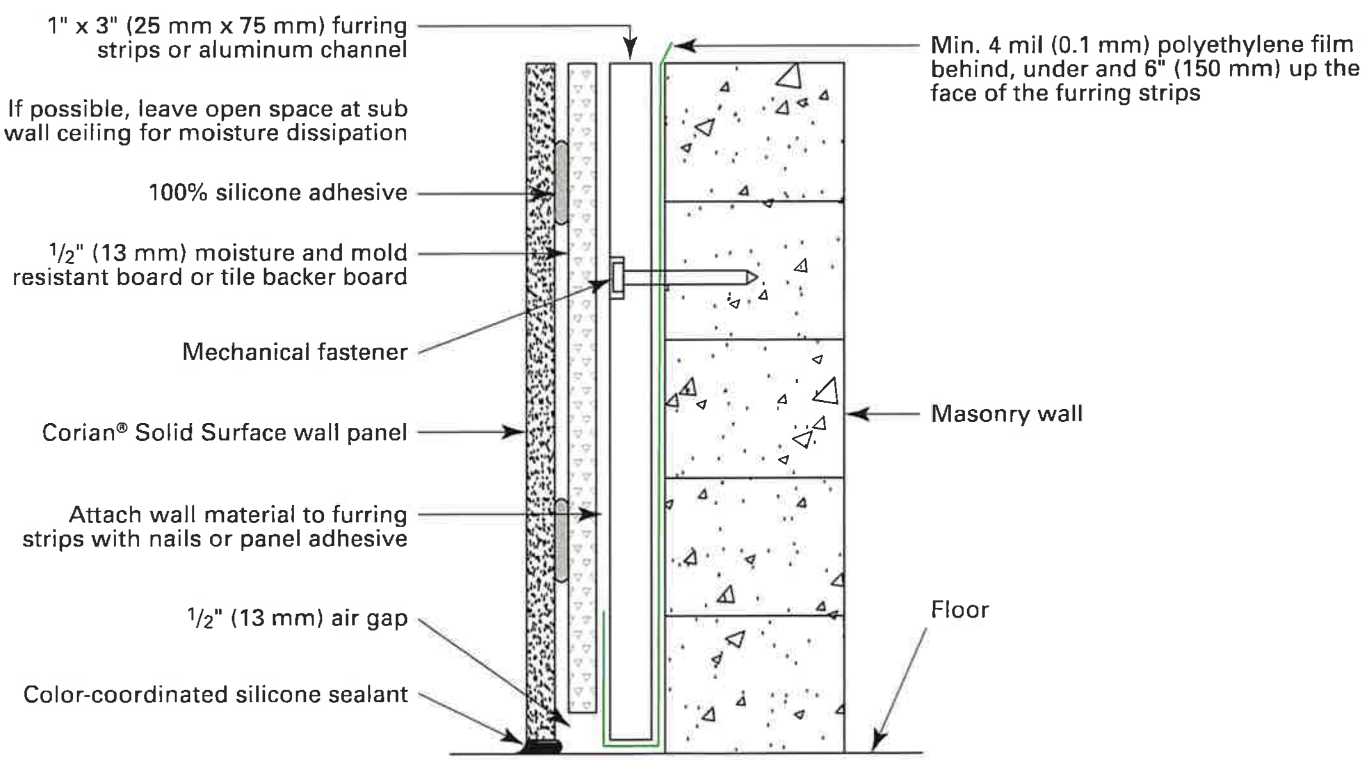
FIGURE N-1: ACCESSORIES OR EQUIPMENT SHOULD BE MOUNTED USING CUTOUTS TO AVOID CREATION OF RESTRAINTS



O. COVERING MASONRY

Figure O-1 shows recommendations for mounting Corian® solid surface over masonry. Masonry products are known to hold and release moisture. Although Corian® solid surface is nonporous and will absorb little moisture, it, like other materials, will change dimension due to moisture pickup. Trapped moisture behind a wall can lead to wall panel warpage due to differential dimensional changes. The vertical channels or furring strips depicted in Figure O-1 create a drying air space and gap promoting drainage away for the Corian® material.

FIGURE O-1: COVERING MASONRY



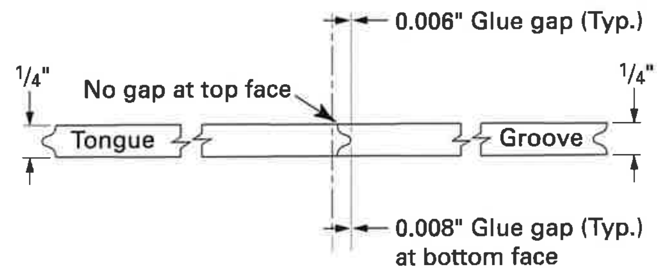
P. HARD SEAMING

DuPont™ Corian® sheets can be hard seamed together using DuPont™ Joint Adhesive or DuPont™ Joint Adhesive 2.0 using either butt, tongue and groove edge, or wavy edge joints. The choice between a butt or alternative edge should be based on ease of installation and fabrication cost. The potential advantage of a tongue and groove or wavy edge relative to a butt edge is easier sheet alignment. This can translate into labor savings by reducing the time to install and/or finish sand the seam. Depending on the installer's capability to align butt joints using clamps or other methods, the added cost of cutting the tongue and groove detail may not be justified. Figure P-1 shows field butt seams aligned with adjustment screw blocks mounted adjacent to the seam using hot melt glue. Vacuum clamps and braces are shown in use to hold hard seams together.

FIGURE P-1: CLAMPING SEAMS

Use vacuum clamps and/or bracing to pull or push and hold seams together. Adjustment blocks can be mounted with hot melt glue to help align adjacent surfaces to achieve inconspicuous seams. Use of a wooden shim is shown in top right view to maintain silicone adherent thickness. Figure P-2 shows the assembly of a tongue and groove seam for 6 mm (¼") solid surface sheet.

FIGURE P-2: ASSEMBLED TONGUE AND GROOVE JOINT



CAUTION: Demonstrate tongue and groove or wavy edge seaming is acceptable for the Corian® solid surface color chosen. Several Corian® colors are quite translucent, e.g., Cameo White, and unacceptable seam shadows can be apparent when these alternative edge geometries, e.g., tongue and groove, are used. Also be sure to clean all seaming edge surfaces before applying joint adhesive to keep visible dirt lines out of the seams.

Figure P-3 shows 6 mm cutter detail dimensions. Cutters are also available for 12 mm sheet. Potential sources for tongue and groove cutters or router bits include those listed in Table 7.

FIGURE P-3: TONGUE AND GROOVE PROFILE, 6 MM (¼") FIGURE DIMENSIONS IN METRIC UNITS (MM)

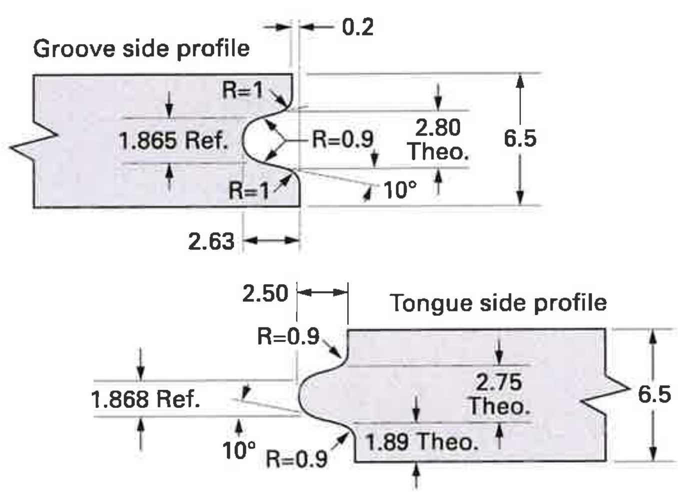


TABLE 7: POTENTIAL TONGUE AND GROOVE CUTTER SOURCES

Sources	Part Numbers 6 mm (¼")	12 mm (½")
Diversified Equipment (704) 533-1891	H9662, H9663	H6664, H9665
Titman USA (800) 722-6486	0.506.190.21 and 0.511.190.21	
F. M. Velepec Co. (800) 365-6636	60-250	

It is important to center tongue and groove features in the material thickness and remove the same amount of material on both sides of the tongue. CNC equipment can be used with proper sheet hold down. It is critical to hold the sheet flat, especially the edge which is being routed. Alternatively, hand held routers can be used either in the field or shop. Setting up two routers with base plates for both cutters is suggested.

Complete as much of the fabrication as possible before wall installation. Fabrication tasks are typically easier with the sheet flat in a horizontal plane either in the shop or at the job site. Handle panels carefully to prevent breakage until panels are mounted to the wall. Dry fit sheet panels before adhesive application. A good dry fit is needed to produce inconspicuous seams. Clean both edge surfaces before applying adhesive. Completely fill seams with adhesive. Application of adhesive to both sides on the tongue and into the groove of tongue and groove features is suggested to eliminate air pockets.

Q. SILICONE SOFT SEAMS

Soft seams are sometimes needed to divide walls into manageable sections and are typically needed around hard restraints. Restraints typically exist at the ends of walls and at columns, but are also common around electrical cutouts or cutouts for other wall mounted equipment or accessories. Wall mounted hand rails are another example of potential restraint points, see Section N.

A 100% silicone sealant with minimum 50% movement capability is suggested for construction of soft seams. The minimum joint width can be calculated as:

$$\textit{Minimum Joint Width} = W_{joint} = (100/C_S)\,(M_{temp} + M_{load}) + \textit{tolerance}$$

Where C_S = silicone movement capability. If capability is 50%, $(100/50) = 2$

M_{temp} = *Movement due to thermal expansion*

M_{load} = *Movement due to live load*

tolerance = an added dimension for construction to assure minimum is maintained

The movement due to thermal expansion can be determined by either calculation or use of rules of thumb.

Corian® wall-panel expansion can be calculated using the following formula:

$$\Delta Length = \alpha \times Length \times \Delta Temperature$$

$$\alpha = \frac{2.2 \times 10^{-5}}{°F} \text{ or } \alpha = \frac{0.000022}{°F}$$

$$\alpha = \frac{3.9 \times 10^{-5}}{°C} \text{ or } \alpha = \frac{0.000039}{°C}$$

An example calculation appears in Appendix A: Example Application Calculations. Alternatively, a conservative rule of thumb for interior applications where temperature is not well controlled or variable sun loads exist on the walls is to provide a movement allowance (joint width from potential hard restraints) of 1/64" for every foot of panel dimension (1.5 mm per meter).

A minimum ¼" (6 mm) joint width is typically recommended by silicone manufacturers with joint geometry ratio of 2:1, width to depth. Always clean the edges of the solid surface using denatured alcohol or acetone and clean white rags before applying the silicone to the joint.

R. SAFETY

DuPont™ Corian® solid surface can be cut and worked with like wood. It is best to minimize all dust and shavings by containing them with a vacuum. Use proper safety equipment when working with Corian® solid surface and DuPont™ Joint Adhesive, including safety glasses, appropriate gloves, steel-toe shoes, and ear plugs. Lifting devices or carts may be used to improve safe handling for larger pieces. Reference product Safety Data Sheets (SDS) available from DuPont.

APPENDIX A: EXAMPLE APPLICATION CALCULATIONS

Example input:

- Expected installation temperature change, over time, relative to installation temperature = 20°F
- Designed length of hard seamed installation = 37 feet = 37 (12) = 444 inches

Corian® wall-panel expansion can be calculated using the following formula:

$$\Delta Length\ (inch) = \alpha \left(\frac{inch}{inch\ °F}\right) \times Length(inch) \times \Delta Temperature\ (°F)$$

where:

$$\alpha = \frac{2.2 \times 10^{-5}\ in}{in\ °F}$$

$$0.195\ in = \frac{2.2 \times 10^{-5}\ in}{in\ °F} \times 444\ in \times 20°F$$

Potential change in length is 0.195" (≈3/16")

For straight walls or walls with only outside corners:

This is longer than limit tabulated in Table 3 for 1/16" (1.5 mm) silicone mounting. It can still be hard seamed if thicker silicone elastic foundation is used. Doubling the silicone mounting thickness to ⅛" (3 mm) and using the ⅛" table in Table 3 yields a limit of 57 feet (17.4 m). This is greater than 37 feet or 444 inches (11 m), and therefore meets guideline criteria. Another check: Using factor a safety of two, 2(0.195) = 0.39" (9.9 mm). Figure A-1 shows elongation limit for ⅛" (3 mm) is approximately 0.4" (10.0 mm). Since 0.39" < 0.4", ⅛" adherent thickness will provide a factor of safety of approximately two for the example application.

For walls with inside corners:

This is longer than limit tabulated in Table 4, so a soft seam will need to be added to the wall, see Section Q, Silicone Soft Seams, for seam sizing and construction recommendations.

TABLE OF FIGURES

Please visit www.surfaces.dupont.com or contact your DuPont representative for more information about DuPont™ Corian® solid surfaces.

K-20025 5/17

AmericanBiltrite
Flooring

NO WAX

GLOSS OPTIONS

ELECTROTILE

SOLID VINYL TILE

Electrotile

ELECTROTILE SOLID VINYL TILE

ELECTROTILE CONDUCTIVE (CVT) AND STATIC DISSIPATIVE (SDT) TILES PLAY AN ESSENTIAL ROLE IN SAFEGUARDING CRITICAL ELECTRONIC EQUIPMENT.

With more and more sensitive medical and electronic machinery in need of protection from static charge, the call for Electrotile flooring products has never been greater. Engineered specifically to meet the strict electrical resistance performance requirements that healthcare and high tech applications demand, Electrotile is the ESD flooring solution companies turn to time and time again. For decades now, American Biltrite has provided industry with millions of square feet of flooring to address ESD concerns worldwide. American Biltrite was the first to bring electrostatic flooring and carbon filament matrix technology to the market in 1965. As pioneers in the field of electrostatic flooring, American Biltrite's goal isn't simply to sell flooring that meets your ESD requirements. Our goal is to become an integrated part of your ESD protocol team and assist in the development of your ESD program. From specifying the flooring itself to the subfloor to the adhesive to ongoing ESD evaluations, we're there. Once the floor is evaluated a warranty is issued based on all these factors. No one else does it, WE DO.

FEATURES & BENEFITS

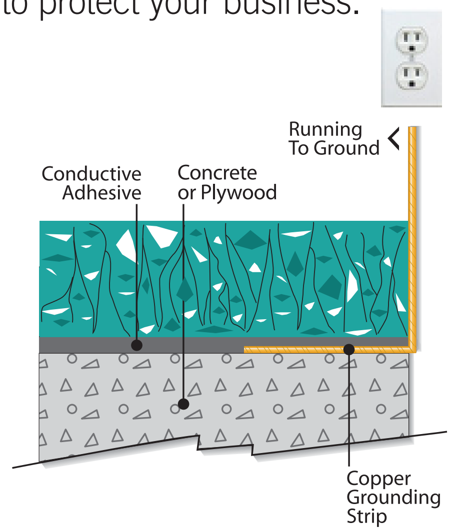
- Meets static dissipative and conductive requirements
- Easy maintenance with only dry buffing means **no waxing** is required
- Excellent wear resistance
- Lifetime warranty of conductivity
- A dynamic chip pattern

Homogeneous Conductive and Static Dissipative tile

Protecting your business from ESD damage is critical. From electronics and clean rooms, to healthcare, pharmaceutical and telecommunications environments, Electrotile gives wafer or fiber optics manufacturers, hospitals, radiological facilities, or even munitions facilities, the reliability and durability they demand without forsaking aesthetics.

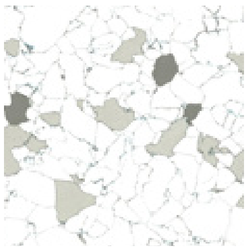
All the while meeting strict electrical resistance performance requirements. Engineered to be durable and easy to maintain, Electrotile provides a specific electrical resistance range to protect your business.

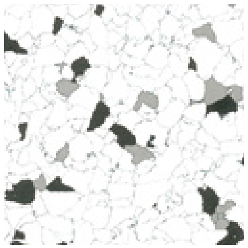
With its dynamic pattern and range of colors, Electrotile is as beautiful as it is functional. Available in three sizes, Electrotile's flexibility makes it an indispensable design tool regardless of the application.

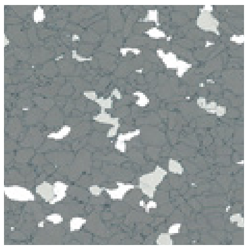


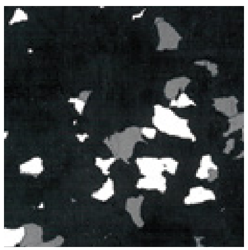
The Electrotile color palette consists of earth, neutral and chromatic tones that allow for mix and match harmony throughout the line.

NEUTRALS

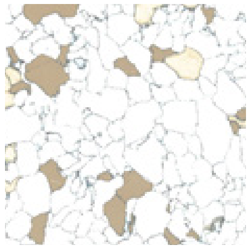

CVT/SDT-130 White I Gray

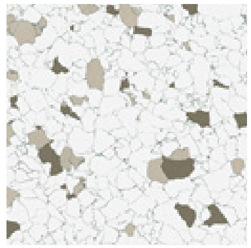

CVT/SDT-111 White I Black

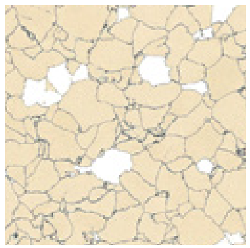

CVT/SDT-135 Gray

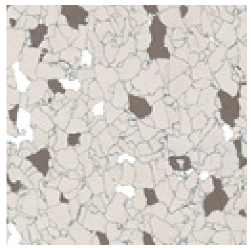

CVT/SDT-122 Black

EARTH TONES

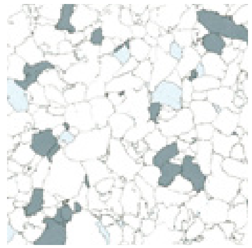

CVT/SDT-147 Mission White

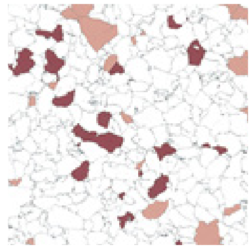

CVT/SDT-143 White I Taupe

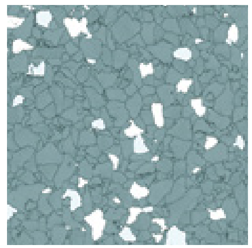

CVT/SDT-146 Almond Shell

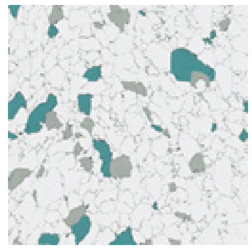

CVT/SDT-145 Taupe

CHROMATIC


CVT/SDT-190 White I Blue


CVT/SDT-153 White I Rose


CVT/SDT-195 Blue


CVT/SDT-183 White I Green

Electrotile is backed by **proven performance over decades of use** in heavy commercial environments.

Perfect for all healthcare, institutional and commercial environments where sensitive electronic equipment is in use.

12" x 12" (305 mm x 305 mm) 24" x 24" (610 mm x 610 mm) 36" x 36" (915 mm x 915 mm) Gauge: 0.125" (3.17 mm)

Gloss Options

Electrotile can be buffed to achieve different shine levels. From a high gloss to a low gloss, you've got options!*

High Gloss

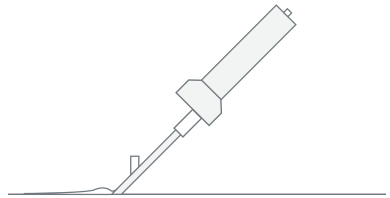
Medium Gloss

Low Gloss

*Shine levels are achieved from buffing during maintenance. Factory tiles available in standard gloss finish only (slightly less shiny than high gloss example shown).

Flash Cove Base

Electrotile can be flash coved and heat welded for increased hygiene.



Heat welding rods are available in 9 coordinating colors.

- **VHW-15** WHITE
- **VHW-17** LIGHT GREY
- **VHW-35** DARK GREY
- **VHW-19** BEIGE
- **VHW-46** ALMOND
- **VHW-45** TAUPE
- **VHW-77** AMBER
- **VHW-95** BLUE
- **VHW-22** BLACK

AmericanBiltrite Flooring

ELECTROTILE®

TECHNICAL SPECIFICATIONS

Gauge	**3.17 mm**	**0.125"**
Sizes	**305 mm x 305 mm Micro-Ground™** **610 mm x 610 mm Micro-Ground™** **915 mm x 915 mm**	**12" X 12" Micro-Ground™*** **24" X 24" Micro-Ground™*** **36" X 36"**
ASTM F 150	Electrical Resistance : Conductive Tile	Greater than 25 kilo-ohms (> 25 x 10^3 Ohms) & Less than 1 megohms (<1 x 10^6 Ohms)
ASTM F 150	Electrical Resistance : Dissipative Tile	Equal to or greater than 1 megohms (≥10^6 Ohms) & Equal to or less than 1,000 megohms (≤10^9 Ohms)
Federal Standard Test Method 101 B, Method 4048 (Static Decay 5,000 Volts to 0 Volts)		Complies

ASTM D 3389	Abrasion Resistance (H-22 500 g @ 1,000 cycles)	Pass
ASTM E 648	Critical Radiant Flux CRF (W/cm^2)	> 0.45
ASTM E 662	Smoke Density	≤ 450
ASTM F 137	Flexibility	Pass
ASTM F 925	Chemical Resistance	Meets requirements (details upon request)
ASTM F 970	Static Load (modified at 2,500 psi)	≤ 0.005"
ASTM F 1700	Solid Vinyl Floor Tile	Class I, Type A
Static Propensity		Complies
Indoor Air Quality (IAQ) **Volatile Organic Compounds (VOC's)**		FloorScore Certified by SCS Certification Registration Number SCS-FS-01495
Adhesive	AD-555SF (two-part epoxy)	Regular traffic & heavy rolling traffic
Grounding		Required – use 1/2" wide copper foil tape
Maintenance		No waxing
Limited Wear Warranty		10 years - product Lifetime - conductivity

Please note that technical website documents prevail.

***Micro-Ground:** Tiles are factory sanded on all 4 sides to form perfect squares resulting in a seamless looking floor.

INSTALLATION

Optimal results can only be achieved by following manufacturer's instructions closely. Only adhesives approved by American Biltrite specifically for Electrotile should be used for gluing. Detailed installation instructions can be found at american-biltrite.com and should be carefully followed.

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Pedigrid®

Model Pedigrid G1

Stop dirt at the door with durable Pedigrid flooring systems. Ideal for high-traffic areas, these aluminum recessed grids with scraping capabilities enhance traction and trap large amounts of dirt, mud, slush and snow. WIth many aesthetic choices, Pedigrid looks as good as it performs.

Advantages

- Capable of trapping large amounts of snow and debris
- Easy to clean
- Multiple insert options
- Available with or without drain pans
- Aluminum tread rails and key lock bar
- Completely customizable

Building Segments

- Aviation & Transportation
- Education
- Healthcare
- Office & Mixed Use
- Retail & Hospitality
- Senior Living
- Sports & Entertainment

Applications

- Vestibules
- Interior & exterior entries
- New construction or renovation

Pedigrid®

Product Details

MODEL	GRID DEPTH	PRODUCT WEIGHT	ROLLING LOAD	TREAD SPACING	MULTIPLE INSERT OPTIONS
G1	$1\frac{11}{16}$" (42.9mm)	3.14 lbs/ sq ft	400 lbs/ wheel	1½" (38.1mm) on center	Yes
SA G8	$1\frac{11}{16}$" (42.9mm)	3.14 lbs/ sq ft	400 lbs/ wheel	1½" (38.1mm) on center	Aluminum Serrated Tread Only

**Rolling load for deep pit frame applications is 300 lbs./wheel*

Certifications/Testing

- Static Coefficient of Friction Test
- Pedigrid ASTM E-648 Test
- CDPH Standard Method v1.1 VOC Emission Testing

Mounting & Frame Options

FRAME TYPE	G1	SA G8
Recessed Level Base	●	●
Recessed Deep Pit w/ Optional Drain Pan	●	●
Recessed Level Base w/ Optional Drain Pan	●	●
Recessed Deep Pit Frame w/ Optional Slope to Drain	●	●

Model Options

Pedigrid G1

Pedigrid SA G8

Rail/Frame Finish Options*

Mill

Anodized

Powder Coat

**SA G8 is available ONLY in Clear Anodized*

Insert Options

Heavy-duty Carpet

Exterior Carpet

Rubber

Logo

Abrasive

Recycled Rubber

Poured Abrasive

See all frame & finish options online at c-sgroup.com.

Warranty

- Two-Year Limited Warranty

Learn More

APPENDIX B

96_CS CYBER INFRASTRUCTURE STANDARDS AND INSTALLATION SPECIFICATIONS_JAN 2024

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96th Communications Squadron Cyber Infrastructure Standards and Installation Specifications

January 2024

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Chapter 1

INTRODUCTION

1.1. Purpose: The 96th Communications Squadron Cyber Infrastructure Standards and Installation Specifications provides the compliance requirements for Eglin Air Force Base Command, Control, Communications and Computer (C4) requirements. This Cyber Infrastructure typically includes telecommunications spaces, pathways, inside and outside plant cabling and interconnecting Base Area Network (BAN) equipment and Air Force Network (AFNET) components. Therefore, the design of interior and exterior telecommunications infrastructure shall be designed by a Registered Communications Distribution Designer (RCDD) using current Department of Defense, Air Force, and industry standards. Moreover, the 96th Communications Squadron Cyber Infrastructure Standards and Installation Specifications provides compliance specifications to those employed or tasked with implementing existing and emerging interior and exterior BAN telecommunications Cyber infrastructure task orders, work orders, contracts, customer information technology and Simplified Acquisition of Base Engineering Requirements (SABER). Furthermore, these specifications shall be used and included as a whole when implementing, engineering, and designing communications requirements in order to meet mission operating and maintenance standards for protecting 96 TW Cyber Space domain.

1.2. Scope: These mandatory specification and technical requirements, parts, materials register, and referenced applicable publications contained within this document, shall be adhered to, and incorporated within all project designs, contracts and SABER renovations for implementation on the Cyber Infrastructure. Deviation from this guide requires Communications Squadron (CS) approval. The telecommunications contractor(s) herein must coordinate with the 96th Communications Squadron concerning layout and configuration of the BAN. Outside Plant (OSP) is defined as network transportation (copper and fiber) outside a building (e.g., underground or buried) and Inside Plant (ISP) is defined as network transport (copper and fiber) within a building supporting the cyber infrastructure.

1.3. Communications and Information Systems Officer: The 96th Communications Squadron, Commander is designated by Technical Order (TO) 00-33A-1001 as the Communications and Information Systems Officer (CSO) for the base. The 96 CS Commander is the operational and maintaining authority for Cyber Infrastructure that supports the base and tenant units and has final approval over all Cyber Infrastructure C4 processes, procedures, requirements, and installations.

> **NOTE:** The term approved is defined in this document and other standards as acceptable to the authority having jurisdiction.

Chapter 2

TECHNICAL REQUIREMENTS

2. The following standards and installation specification criteria provides additional installation specification requirements for 96th Test Wing, Eglin AFB. These compliance specific requirements shall be executed IAW Department of Defense, Air Force, industry standards, applicable publications and documents referenced within attachment G of this document. In the case of conflicting guidance, defer to the most stringent communications applicable standard.

Contractor and subcontractor(s) are recommended to read and understand the Cyber Infrastructure Standards and Installation Specifications prior to working on or changing the BAN Cyber Infrastructure and should pose any questions to the 96 CS/SCXP, in a formal Request for Interpretation or Information (RFI), for Telecommunications design, product submittals, test results and other communications related issues that may need clarification for a complete understanding.

All coordination shall exist in writing, preferably electronic format using industry standard compatible documentation software available to all parties. i.e., Word or Outlook.

2.1. Land Mobile Radio (LMR) Equipment

2.1.1. Construction and Renovation: For new construction and renovation of existing buildings, coordinate with 96 CS/SCXP, Projects and Requirements work center regarding the installation, relocation or removal of any land mobile radio equipment and air-to-ground radio equipment. A Project Manager will provide guidance on the purchase and installation of new equipment, removal and disposition of installed equipment and removal and re-installation of equipment being moved.

2.1.2. Planning: For planning purposes, the Eglin LMR infrastructure is currently version 2022HS. All Eglin LMR equipment is tied to the United States Space Force's LMR zone core at Peterson AFB, CO. All changes to the LMR infrastructure will require coordination with AF Installation and Mission Support Center (AFIMSC).

2.1.3. Subscriber Equipment: All subscriber equipment intended to operate on the Eglin LMR infrastructure will be compatible and interoperable with the Motorola system. Subscriber equipment will have the required feature set and capabilities required to operate on the Eglin system. Subscriber programming will be completed by the 96 CS.

2.1.4. Antenna Systems and Cabling: All radio frequency antenna systems and cabling shall be installed, terminated, protected, and tested based on industry standards, manufacturer instructions and design technical specifications.

2.2. Telecommunication Spaces

2.2.1. Floor Mount Equipment Cabinet: All 72-inch or taller cabinet enclosures shall be 4-Post and blend seamlessly into existing or new fixed ladder rack assemblies. In order to support, internal to the cabinet, copper and fiber cable installation; all 4-Post cabinet enclosures shall be outfitted with all necessary cable management accessories IAW Attachment E. All 4-Post cabinet enclosures shall be Great Lakes model GL790ES-2442MS or equal with two sidecars and end panels (P/N

SC67942 and P/N SCP7942) cable managers or equal, however customer requirements may dictate the size. All 4-Post cabinet enclosures shall follow the rack elevation layout in Attachment D. All 4-Post cabinet enclosures shall be lockable with unique lock cylinders and corresponding keys turned over to 96 CS that are compliant and only accessible by 96 CS technicians in accordance with Attachment F. Dedicated circuits with electrical receptacles depicted in the rack elevations shall be supplied by onsite contractor and shall be placed in accordance with Attachment D. Exact electrical receptacles shall be identified in all iterations of the design drawings based on customer requirements and any future changes.

Any cabinet requiring fiber patch cables in excess of 6-foot fiber patch cords to access switches shall require horizontal cable management accessories. All Surge Arrestors shall always be 1U higher than the top mounted UPS. In narrow or crowded telecommunication rooms, equipment cabinets shall be floor-mounted adjacent to a wall but shall provide a minimum 36-inches of space both in front of and behind the cabinet and behind any installed equipment. A minimum side clearance of 24-inches shall be provided on end cabinets. Provide 100 percent spare cabinet capacity based on the amount of cabinet capacity utilized by the patch panels provided. Spare cabinets shall be provided for the mounting of Government-purchased/installed LAN equipment, if required. Only 96 CS network equipment shall reside within the confines of 96 CS lockable enclosures in accordance with Attachment F. Wall-mounted cabinets may be utilized in small buildings or smaller areas not conducive for floor mount cabinet enclosures.

2.2.2. Wall Mount Equipment Cabinet: All wall mount lockable enclosures shall be Great Lakes, Model: GL48WDXM-B-SH-AF, GL36WDXM-B-SH-AF, or GL24WMCMS-B-SH-AF or equal based on customer requirements mounted to fire rated backboard and grounded IAW para 2.2.11. All wall-mount lockable enclosures shall follow elevation layout IAW Attachment D. Dedicated circuits with electrical receptacles depicted in the rack elevation shall be supplied by onsite contractor and shall be placed IAW rack elevation drawings in Attachment D. Exact electrical receptacles shall be identified in all iterations of the design drawings based on customer requirements and any future changes.

2.2.3. Information Processing System (IPS) Container: A SIPR switch not located in an approved classified storage safe, vault, approved open storage area (AKA: secure room), or in a SCIF shall be secured in an IPS container. All IPS containers shall follow elevation layout IAW Attachment D. All IPS containers shall be Hamilton Class 5 Single Door Model 23-36-19 or equal based on customer requirements. Dedicated circuits with electrical receptacles depicted in the rack elevation shall be supplied by onsite contractor and shall be placed in the nearest wall next to the IPS container. Exact electrical receptacles shall be identified in all iterations of the design drawings based on customer requirements and any future changes. End user encryption equipment shall reside outsider the IPS container IAW DISA STIG V-245788 under Traditional Security or most current applicable STIG.

2.2.4. Network Switches: All network switches and or network design solutions providing LAN connectivity for NIPR and SIPR shall be specified by 96 CS and funded by the occupying customer.

2.2.5. Temporary Network Switches: Temporary switches shall meet all aspects of this Cyber Infrastructure Standards and Installation Specification. Temporary switches shall only remain active for a period of 120 days at which a permanent solution shall be implemented and funded by the occupying customer.

2.2.6. Voice Networking Services: All voice networking services will be provided utilizing Voice over Internet Protocol (VoIP). All VoIP devices and equipment to provide voice service shall be specified by 96 CS and funded by the occupying customer.

2.2.7. Intrusion Detection System (IDS) Services: All IDS services will be coordinated through the 96 SFS prior to request for installation. SF's IDS provider will engineer a solution based on customer's requirements. Any variation to a fiber solution shall be approved through 96 CS/Authority Having Jurisdiction (AHJ). Customer may be required to purchase IDS Network Switches. Telecommunications design engineer or supporting contractor shall be responsible for incorporating an appropriately sized conduit from IDS provider security panel to the nearest supporting 96 CS communications room. Appropriate CAT-6 plenum-rated cable or fiber optic cable shall be installed inside the IDS supporting conduit to ensure the IDS controller and the supporting IDS switch are interconnected to complete the IDS path. 96 CS personnel will interconnect the cable/fiber in the 96 CS communications room to establish the remainder of the IDS path to the Base Defense Operations Center (BDOC).

2.2.8. Copper Patch Panels: Modular patch panels shall consist of a metal panel that accepts all Panduit Mini-Com® Modules to mix and match media types in the same panel. Patch panels shall accept all modules for UTP and ScTP applications and shall mount to standard 19" racks. A 1RU cable management panel shall be installed between all equipment and patch panels as necessary. For existing patch panels, see Note 4.11

> **NOTE:** Users must provide and install factory-produced patch cords for work area outlet locations. Patch cables must be CAT-6 and cable jacket must match the horizontal cabling 1-GBASE-T connections.
> **Cable jacket colors:** GREEN - NIPR/VOIP, RED - SIPR, BLUE - Wireless, YELLOW – SCI, VIOLET – DDC.
> **NOTE:** 7 SFG (A) jacket colors: BLUE – Air Force NIPR/VOIP, GREEN – Army NIPR/VOIP, RED – SIPR, VIOLET - DDC

2.2.9. Fiber Optic Distribution Panels: Shall be populated for maximum density utilizing LC type connectors. Optical fiber termination shall use fusion splices with factory produced pigtails for all backbone and premise cabling with a 3-foot slack loop, strain relieve cables at panel and other termination points included with each panel in the Communications Equipment Room (CER).

2.2.10. Distribution Pathway: All pathways shall be installed IAW all applicable industry standards. Cable tray shall consist of a welded wire cable tray with flat solid bottom or plenum rated tray insert in the telecommunication spaces to provide distribution between the plywood backboard, equipment racks, backbone conduits, and the pathway cable tray to alleviate micro/macro bends on cabling. When multiple distributor rooms are located on the same floor, they should be interconnected by a minimum of (2-each 4-inch) conduit or equivalent pathway. The CER distributors shall be dedicated to the telecommunications function and related communications support facilities. These CERs shall not be shared with electrical installations other than those supporting telecommunications or associated equipment. Equipment not related to the support of the distributor room (e.g., piping, ductwork, pneumatic tubing) shall not be installed in, pass through, or enter the space.

Cable Installation Clearances:

1. Cables shall not rest upon any other structure not intended for the direct support of the cable(s).

2. Provide minimum clearance of 6-inches from any electromagnetic interference EMI/radio frequency interference RFI sources.
3. Provide minimum clearance of 4-feet from any motor or transformer.
4. Provide minimum clearance of 12-inches from HVAC ducts, flue, hot water, steam line or other heat-producing source.
5. Copper and Fiber cable separation of any classification shall be 3-inches or as designed.

Cable jacket colors: GREEN - NIPR/VOIP, RED - SIPR, BLUE – Wireless Access Points, YELLOW – SCI, VIOLET – DDC.

NOTE: 7 SFG (A) jacket colors: BLUE – Air Force NIPR/VOIP, GREEN – Army NIPR/VOIP, RED – SIPR, VIOLET - DDC

Commercial Communications: Commercial ISP services shall be installed and terminated in customer owned spaces only. Commercial OSP/ISP services shall not be housed or routed through any 96 CS CERs, spaces, or communication equipment locations (CEL's). The 96 CS CERs shall not contain any user system equipment or cabling such as ACS, A/V, CCTV, CATV, and similar type systems or networks. Facilities acting as distribution facilities for IDS services supporting IDS connectivity to other outlying facilities shall house the IDS network switch only in the 96 CS CERs. For larger facilities with multiple floors acting as an access or distribution facility, the IDS network switch shall be housed in the 96 CS CERs. IDS network switch(s) shall not be installed in 96 CS communication equipment racks. The IDS controller and supporting IDS panel(s) shall always be housed in end user security or IT room. The 96 CS Comm Rooms will only contain equipment relevant to AFNET maintained systems.

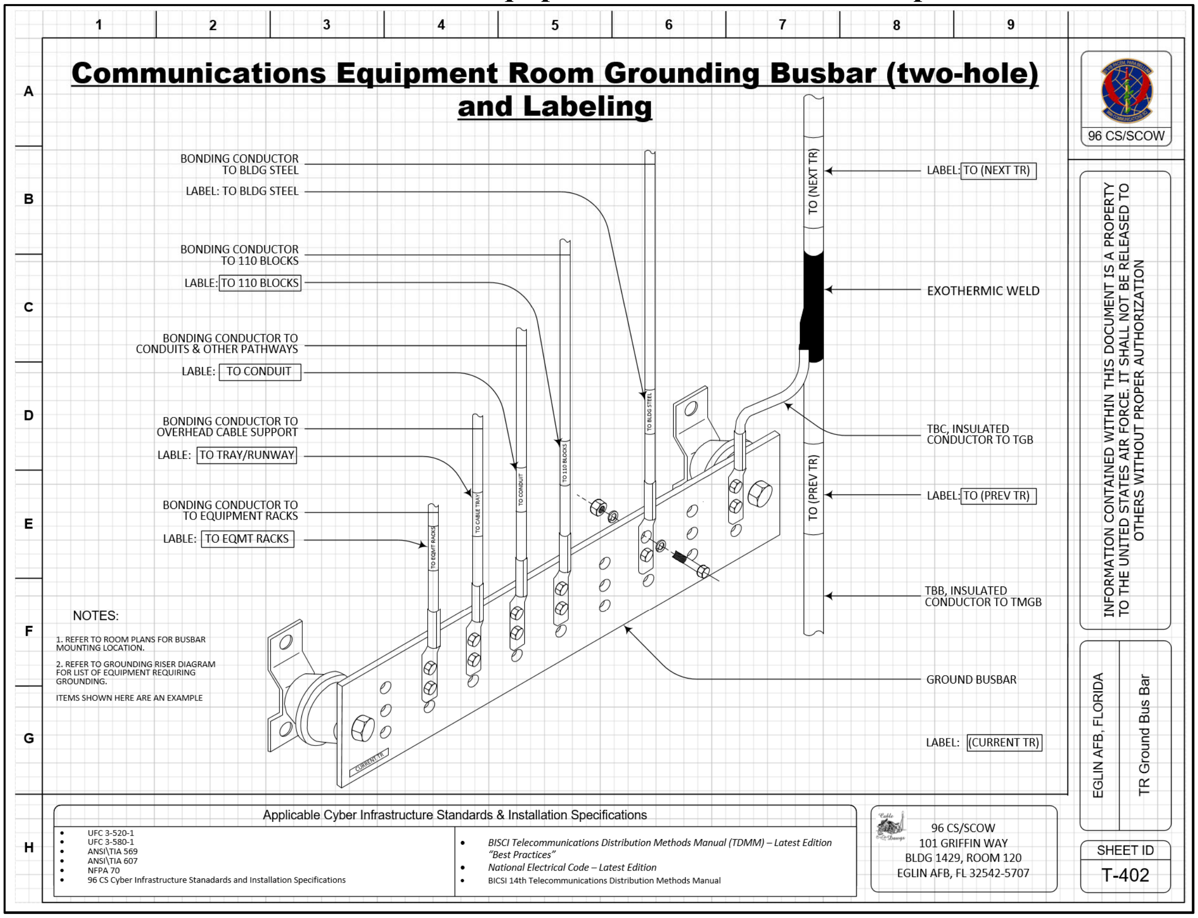
NOTE: Hook and loop straps shall be used to secure/bundle both fiber/copper cables within cable trays, ladders and racks throughout pathway. The hook and loop straps should be evenly spaced (4-feet on center) throughout the dressed length end-to-end. Hook and loop straps shall be used to prevent a change in the physical geometry of the cable that typically results from use of nylon tie wraps. Vinyl tape will not be accepted - Reference drawing T-305:

2.2.11. Grounding, Bonding, Shielding, and Labeling: All grounding shall be performed IAW ANSI/TIA-607-D, 606-D, and Rural Utility Services standards. Cyber infrastructure antenna systems, network equipment, OSP/ISP components, cabinets, racks and lockable enclosures shall be grounded to applicable standards.

Additional specifications for Class 2 Facilities on Eglin

1. On Primary Bonding Busbar (PBB) Label per 606-D, 5.1.12, add Grounding Service Tags
2. On Secondary Bonding Busbar (SBB) Label per 606-D, 5.1.13, add Grounding Service Tags
3. On Telecommunications Bonding Backbone (TBB) Label per 606-D, 5.1.17, add Grounding Service Tags
4. On conductors leaving the Primary Bonding Bar (PBB) Label per 606-D, 5.1.19, add Grounding Service Tags
5. On conductors leaving a Secondary Bonding Bar (SBB) Label per 606-D, 5.1.20, add Grounding Service Tags
6. On Backbone Bonding Conductors (BBC) Label per 606-D, 5.1.18, add Grounding Service Tags
7. On Telecommunications Equipment Bonding Conductor (TEBC), add Grounding Service Tags
8. On Metallic pathways (cable tray sections, conduits), add Grounding Service Tags

Communications Equipment Room Busbar Example:



2.2.12. Work Area Outlets: All recessed gang boxes and surface mount deep device boxes shall be a minimum of 2.5 inches in depth. All faceplates shall be four-port compatible minimum (2-active/2-blanks) fed by a 1-inch EMT conduit stubbed-up to cable pathway above ceiling. Panduit Mini-Com® Classic series single gang downward sloped faceplate that accepts four modular jacks, color shall match cabling jacket. Contractor shall provide fiber and copper cable slack for maintenance within the horizontal cabling system configuration as follows in: CER - cable ladder - UTP/ScTP 10-feet and SM/MM 10-feet, work area outlet - UTP/ScTP 1-foot and SM/MM 3.5-Feet above ceiling. Do not put slack or service loops in communications equipment cabinets or racks. (See attachment G - Applicable Publications)

2.2.13. Cable Specifications: All premise wiring supporting NIPR/VoIP/POTS work area outlets shall be GREEN - NIPR/VOIP, RED - SIPR, BLUE - Wireless Access Points, YELLOW - SCI, VIOLET - DDC.

NOTE: 7 SFG (A) jacket colors: BLUE - Air Force NIPR/VOIP, GREEN - Army NIPR/VOIP, RED - SIPR, YELLOW - SCI, VIOLET - DDC.
Specific color types to support users' classification shall differ from above.

2.2.13.1 All cable subsystems labels shall use a permanent identifier that can be easily traced using methods in Attachment B and ANSI/TIA 606 for other system labeling requirements as described below.

2.2.14. Existing Legacy: CAT-3, 5 & 5e cabling shall not be reutilized, relocated, moved or re-terminated for design planning, construction, or renovation. i.e., modular and cubical furniture. Ensure the Designer of Record (DOR) and Customers are aware of cost/detail requirements prior to Planning, Programming and Budgeting. All Legacy (CAT-3, 5 & 5e) / (OM1) cabling shall be brought to CAT-6/OM3/OM4 or current industry standards and codes during renovations, MILCONs, SABER projects or planned facility upgrades. (See attachment G - Applicable Publications)

2.2.15. New Systems: All cabling shall be CAT-6/OM3/OM4/OS2 for all new installations. Ensure the Designer of Record (DOR) and Customers are aware of cost/detail requirements prior to Planning, Programming and Budgeting. (See attachment G - Applicable Publications)

2.2.16. Abandoned ISP Cables: The accessible portion of all ISP abandoned communications cables shall be removed end-to-end after cut-over and before final inspection. Where cables are identified for future use with a tag, the tag shall be of sufficient durability to withstand the environment involved.

2.2.17. Labeling Standard: Label all ISP/OSP telecommunications infrastructure IAW ANSI/TIA 606-D. Cable tags shall be polyethylene. Handwritten labeling will not be accepted. Stenciled lettering for cable and termination hardware shall be provided using thermal ink transfer process. Existing OSP cable(s) that have been spliced shall be relabeled/retagged back to the origination demark. Label each ISP cable at both ends (patch panels/work area outlets) within 6-inches of each termination.

2.2.17.1. Use the examples in Attachment B to assist with labeling the cable subsystem on (patch panel to equipment outlet) outlets, and patch panels. From left to right the label reads, Telecomm space feeding outlet. Row letter (if there's one row then it's not needed) rack number, Patch panel elevation letter, Port number on patch panel in sequential order.
2.2.17.2. Contractor shall use a period between information to save space.
2.2.17.3. Contractor shall use elevation letter over RU's because older racks aren't marked. (Request deviation approval from 96 CS/SCOW)
2.2.17.4. A "/" is authorized between port numbers if all the previous information is the same in the outlet labeling window. i.e., 129.A1.B.47/48.
2.2.17.5. Each cable, conduit, sleeve, and pathway within the ISP shall be labeled showing TO & FROM information.
2.2.17.6. All labels shall meet requirements for legibility, defacement, and adhesion, specified in UL 969.
2.2.17.7. All outlet jacks, connectors, patch panels, and block hardware shall be labeled.
2.2.17.8. All labels must match design and permanent record as-built documentation.

Example:	RM # 129.	Row # A /Rack# 1.	PP# B.	Port# 44
	129.	A1.	B.	44

NOTE: All ISP/OSP requirements stated shall be used unless otherwise specified and approved during design by maintaining organization. ISP/OSP terminations shall be installed IAW all applicable local standards, industry standards and/or manufacturer specifications with the more stringent applying. (See attachment G - Applicable Publications)

2.2.18. Voice Communications: Work area outlets shall be installed in all telecommunication rooms, break rooms, mechanical rooms, and entryways that are secured vestibules to support phone installation for safety, courtesy, and convenience purposes. Each CER shall have one wall-outlet installed at or near the entry door for emergency and voice communications.

2.3. OUTSIDE PLANT (OSP)

*SEE ATTACHMENT C: FIBER DESIGN NOTES

2.3.1. Fiber Optic Cables (FOCA): All OSP cables installed shall be loose tube design with either water block tape or gel filled. All fiber optic cable installed shall be all dielectric with no metallic content. A minimum 24-strand single-mode fiber shall be installed to support core service for all fiber optic installations. FOCA shall be installed for long distances using a figure-8 to prevent twisting and protect the cable when pulling as one piece (home run) without splices between connections except where the distance exceeds the lengths in which cables are manufactured. Fiber cables may be installed by jetting or blown applications using special installed ducts with compressed air. Where splices are required, install splices only in 96 CS approved lockable maintenance communications holes to maximum extent possible. Avoid all unnecessary splicing to prevent excess attenuation and reflection. Follow manufacturer's instructions and pulling tensions. Ensure fibers are installed using strength members "aramid yarn" during installation. Fiber and Copper cables shall not reside together in a 4-inch conduit/duct within the infrastructure, nor shall fiber and copper cabling be installed or exist within the same innerduct/GEO-textile mesh/Micro-duct. To maximize comm pathway availability and spacing ensure 4-inch conduit and duct systems are populated with innerduct/GEO-textile mesh/Micro-ducts before installing any cables. (Reference NECA 301-16)

2.3.2. Fiber Optic Distribution Panels (FODP) for OSP Termination: Shall be populated for maximum density utilizing LC type connectors. All new FODP's installed in an Information Transfer Building, Main Access Node, and Critical Edge Buildings will be capable of housing 288-strand terminations (Corning CCH-04U Housing with CCH-CS24-A9-P00RE Cassettes) regardless of cable size being installed. Utilize existing 4RU FODP if space is available. All terminations shall be fusion spliced to pre-manufactured cassettes with factory pigtails unless otherwise approved by the maintaining organization. No mechanical terminations shall be used to terminate OSP FOCA.

2.3.3. Fiber Optic Splice Enclosures: All fiber optic OSP underground splices shall be encased in a dome type enclosure with a 50-foot service loop for the main cable and 50-foot for each cable serviced by the splice case. Provide an additional 10-foot for racking of cables and splice case. Additionally, every other maintenance hole starting from the entrance MH shall have a 25-foot service loop installed. (TYCO 450 Fiber Optic Splice Enclosure). Direct buried fiber splices shall NOT be allowed for any permanent or temporary communications requirements or fix actions.

2.3.4. Copper Cables: OSP copper core cables shall be PE-89 OSP Telephone Cable with an expanded polyethylene (Foam Skin) and external layer of solid, high-density polyethylene. Fiber and copper cabling shall not be installed within the same duct, pathway or mesh/inner ducts at any point. Copper design intra-building and cross-connects terminals from the Point-of-Presence (POP) or DMARC campus backbone for house cabling terminals shall utilize CAT 6 plenum rated UTP for connection/terminations. CAT-3, CAT-5, and CAT-5e cabling solution(s) will not be accepted.

NOTE: An entrance transition point shall be required for unlisted OSP cable when the termination point is greater than (50 feet) from the point of entrance, and the cable cannot be installed in a properly rated conduit (e.g., rigid metal conduit or intermediate metal conduit) or as directed by the authority having jurisdiction. This provision does not apply to a listed indoor/outdoor fire-rated optical fiber cable. The OSP cable can be spliced to a building backbone cable to meet local codes for fire-rated cables.

2.3.5. Copper Cable Terminations: OSP copper cable shall be terminated on a Protected Entrance Terminal (PET) 110 type/710 splice connectors or 388 central office connectors with primary protector blocks equipped with 5-pin solid state or gas protector module accessories installed.

2.3.6. Copper Cable Splice Enclosures: All copper cable OSP underground splices shall be encased in an appropriate size and type enclosure and installed IAW manufacturer installation guidelines (Preformed Line Armadillo Stainless Steel Splice Enclosure or equivalent). For Copper OSP no service loop/slack shall be allowed at the terminal or within MHDS. Direct buried cables shall be spliced above ground only in a buried distribution terminal or cabinet for ease of maintenance. Note: Fiber and Copper splices shall be installed in Pre-cast concrete maintenance holes to accommodate the splice case(s) and required splicing service, copper racking and fiber service loop materials.

NOTE: Some splice enclosures may require re-enterable encapsulation compound and shall be determined by the maintaining organization.

2.3.7. Backboards: Fire rated Backboards shall be provided on a minimum of two adjacent walls in the telecommunication spaces near cable entry ports. (Backboards) Provide void-free, interior grade A-C plywood 3/4-inch thick 4-feet by 8-feet. Backboards shall be fire rated by manufacturing process. Painting the backboard is optional however, if paint is applied over fire retardant backboard it shall be UL 723 fire retardant paint. Provide fire retardant paint information via product submittal. When painted, Fire Stamp shall be clearly visible. Permanently mount backboards vertically to the wall by means of a countersunk stainless steel flat head bolt and washer providing a finished flush surface. Drywall screws or any other screw types shall not be acceptable.

2.3.8. Maintenance Holes (MH)**:** The preferred term for communications underground closures or holes on Eglin AFB shall be “Maintenance Hole or Maintenance Vault”, as Manhole or hand hole will not be used. All Maintenance Holes and vaults shall be pre-cast reinforced concrete, multi-directional type with cast-in single or multiple plastic terminators to accept the conduits. Thin concrete knockout sections may be provided for terminating multiple-bore conduits. New MHs shall be placed to support the locations of junction points, offsets, load points, and curvature in the duct line. The contractor shall form and install a 1-foot-wide x 8-inch-deep concrete perimeter around new maintenance holes being installed. The contractor shall ensure the appropriate MHs number is permanently stenciled by the application of paint with 3.5-inch lettering, on the inside top interior within the first 12-inches with a number designated by the 96 CS Authority Having Jurisdiction. All new ducts shall be permanently stenciled by the application of paint with 2-inch lettering on the wall above each duct back and in each building and maintenance hole indicating the connecting building/maintenance hole at the other end of the duct (for example, “To MH-200”). All MHs shall be installed IAW all applicable industry standards.

2.3.8.1. Cast-in-place (site-poured) MHs may be required when overbuilding on existing infrastructure, rebuilding, or enlarging existing MHs that are congested, oddly configured, or contain excessive cables that are improperly routed through the MH.

2.3.8.2. All MHs shall be installed on a leveled, crushed, washed, gravel base of sufficient depth, a minimum thickness of 6-inches under the entire structure and extending past foundation or all outer edges by 6-inches or more, to allow for drainage and stability. In cantonment areas that have or will potentially have multiple cables, they shall not be spaced more than 600-feet apart using the ground plane view. In sparsely populated areas (i.e., range test area) containing only fiber cables, they may be spaced up to 800-feet apart using the ground plain view, providing spacing does not exceed the manufacture's recommended pulling tension for the cables being installed. The above distances (600-feet and 800-feet) may be modified with the approval of the 96 CS. Every effort should be made to implement Jetted or blown fiber optic cabling system designs IAW industry standards to reduce the underground cyber infrastructure and Base Civil Engineering real property footprint towards OSP pathways and maintenance hole requirements. MHs may be placed closer together to accommodate distribution designs when needed. Placed IAW ASTM C891-11 and all other applicable industry and local standards. Accessories shall be designed and provided for use IAW RUS Bulletin 1751F-643, and RUS Bulletin 1753F-151 to support the weight of the cable(s) and splice case(s).

NOTE: Precast polymer concrete or combination of polymers supporting communications cyber infrastructure shall not be utilized on Eglin AFB.

2.3.8.3. New construction shall have a maintenance hole installed within 50-feet of facility telecommunication entrance, CER demarcation point. Furthermore, existing or new conduit feeding a MH or located beyond 50-feet and servicing an Information Transfer Building or Critical Edge Building shall be concrete encased. Additionally, a concrete cap is required when infrastructure backbone cables enter the facility within 40-feet of each other to truly support backbone diversity and protection.

2.3.8.4. In projects where explosive materials may be used or maintained, (such as munition facilities), ensure the last 50-feet of conduit is steel going into the facility to meet building codes.

2.3.9. Maintenance Hole Grounding: MH shall be grounded in accordance with RUS 1751F 802 and NEC, Article 25, the resistance for OSP grounding shall be nominally 25 ohms. All new MHs installed shall include ground rods and bonding ribbon. The surface mounted bonding ribbon may only be omitted when the following conditions apply:

2.3.9.1. MHs are designed and constructed with an integral ground system with all ironwork bonded together.

2.3.9.2. MHs are identified as containing an integral ground system with a manufacturer's label.

2.3.10. Main Distribution Maintenance Holes: The preferred main distribution maintenance holes system interior size is 12-feet (length) x 6-feet (width) x 7-feet. (height) and shall have a load rating of HS-20 for heavy vehicular traffic. (Deviations from this size must be pre-approved by the 96 CS)

2.3.11. Sub-Distribution Maintenance Holes: Other size approved for sub-distribution systems depending on location and project design are pre-cast reinforced concrete interior size 3-feet (width) x 5-feet (length) x 4-feet (height) and shall have a load rating of HS-20 for heavy vehicular traffic. (Deviations from this size must be pre-approved by the 96 CS)

Maintenance holes shall be equipped with all accessories to provide complete system:

2.3.11.1. Torsion assisted rectangular diamond plate covers
2.3.11.2. Self-latching stainless steel slam locks
2.3.11.3. 1/8" raised letters stating "COMMUNICATIONS"
2.3.11.4. A sump pan with insert for drainage, and a grounding/bonding system
2.3.11.5. Corrosion resistant cable racks
2.3.11.6. Pulling irons

2.3.12. Concrete Encasement: In new construction, the duct system shall be concrete encased in all government areas as follows: At a minimum, the duct system shall be encased under all traffic areas; where any bend/sweep exceeds 10 degrees in any direction; in any stream/drainage area subject to washing out; and in major construction zones. Concrete encasement of the ducts for a "core path" shall be required where no alternate paths are present. Concrete encased duct, galvanized RSC, pipe casings, or HDPE duct placed by horizontal directional drilling (HDD) shall also be placed under all paved road surfaces and certain heavy traffic non-surfaced roads as documented in the design package. Concrete forms shall be utilized when encasing ducts into a maintenance hole to limit blockage of empty duct knockouts or windows in the maintenance hole. The encasement/pipe shall be extended a minimum of 6-feet beyond the roadbed for all road crossings. The installer shall use only one brand of Portland cement that conforms to American Society for Testing and Materials (ASTM) C 150. The concrete shall be a wet-type mix and shall be placed in such a manner as to ensure the concrete completely surrounds all ducts and that no air or voids are trapped in the mix. (A dry bag of ready-mix type cement that has not been mixed with water but has been dumped in the trench is not acceptable.) Prior to pouring any concrete over the duct, the installer shall obtain the signature of the on-site U.S. Government AHJ representative to signify the acceptability of the duct placement and spacing. Concrete used to encase conduits shall be a minimum compressive strength of 20,700 kPa (3,000 PSI).

NOTE - Concrete encasement of conduits should be considered for the following conditions:
a. Road or street crossings having earth covers that are equal to or less than 30-inches.
b. Railroad crossings
c. Earth covers parallel to and within street, highway, or road travel areas that are less than 30-inches.
d. Stream crossings, storm canals, ditches, ponds, parking lots and heavy vehicle traffic areas.
e. Bend angles of 20-degress or greater in conduit lengths equal to or greater than 550-feet

2.3.13. Duct Placement: New ducts shall be swept down and installed in the lowest available duct positions within the lowest available duct window in the MH. Duct placement shall not prevent placement of future ducts in the upper duct positions. Conduits shall terminate in bell ends or duct terminators at the point of entrance into the MHs and buildings. Main conduits entering poured-in-place or precast MHs shall be located in the lower portion of the end wall and centered between end walls. Conduits entering sidewalls shall be located a minimum of 4-inches from the end walls that are located farthest from the central office or serving node. Clearances of 12-inches should be maintained between main conduit formations and the roofs or floors of MHs unless the construction drawings indicate otherwise, wall recesses shall be provided at conduit entrances.

Subsidiary conduits entering MHs shall be located to provide clearances of 4-inches from roofs and adjacent walls.

2.3.14. Four Inch Duct Fill: A minimum of one 4-inch or larger conduit/duct installed in any given duct bank/system shall be populated with three each, 3-inch, three cell geotextile or Micro-Ducts for maximum cable placement. Determination will be conducted during design reviews. (Other sizes/options may be used only with 96 CS pre-approval.) When installing conduits near other ducts or electrical, installers shall provide a minimum concrete separation of 3-inches or dirt separation of 12-inches. When installing conduits/ducts parallel other utilities, provide separation of 6 and 12-inches respectively. Other direct buried or underground utilities systems shall not be installed above or over-the-top any communications cables.

2.3.15. Rerouting of Existing Ducts: Existing ducts shall be joined to new MHs (pre- cast or cast-in-place) by rerouting the designated ducts from the demolished or abandoned MH to the new MH. Rerouting shall begin 30-feet from the old MH, to allow for standard bending radius and pulling tension. Continuity of operations on the affected cables shall be maintained during the duct rerouting actions.

2.3.16. Pull String, Rope, and Tape: A pull string, pull rope, or pull tape rated at not less than 600-lbs (2700-newtons (N)) tensile strength shall be installed in each new individual conduit, duct, and/or sub-duct. A minimum of 5-feet shall be provided at each end of the conduit. The string/rope/tape shall be coiled and secured to the closest maintenance hole rack or pulling eye in such a manner as to prevent it from being accidentally pulled back into the duct.

2.3.17. Plugs: All ducts, sub-ducts, HDPE roll pipes and innerducts, whether main or subsidiary runs, shall be plugged using universal duct plugs or removable putty sealants in all MHs, vaults and building entrances. Foam sealant is **not** acceptable in a building. Outdoor-rated ducts (sub-ducts, etc.) entering a building will be fire-stopped IAW the National Electrical Code, local codes, and per manufacturer's instructions.

2.3.18. Duct and Acoustical Sealants: The area between the entrance conduits and the penetrated floors and/or walls of a building or MH shall be sealed to be waterproof or shall be fire-stopped as appropriate. Use of hydraulic cement between the duct and wall is acceptable for waterproofing the duct entry point.

2.3.19. Duct Tie-Downs: Duct systems to be concrete-encased shall be tied down to eliminate movement of the duct system during the placement of concrete. All sections of conduit systems to be concrete-encased shall be tied down using an industry recognized method such as metal rods (four stakes) and metal strapping (for securing the duct system). The metal strapping shall be wrapped completely around the conduit structure and securely attached to the metal rods. The metal rods shall be a minimum of ¼-inch thick. Rods will be driven into the ground a minimum depth of 12-inches and the ducts shall be tied down every 10-feet or closer.

2.3.20. Conduit Spacers: Spacers shall be installed at minimum of one spacer every 5-feet on center. The duct shall not be damaged, cracked, or crushed prior to or during installation:

2.3.20.1. Ensure the integrity of the orientation of the duct bank between MHs. Do not allow the ducts to twist or tangle between MHs.

2.3.20.2. Ducts that are classified as stub-outs shall be plugged inside the MH or building; tagged, identifying them as stub-outs; and capped on the far end to prevent soil and water from entering the duct. An orange communications locator ball shall be placed at the stub-out end location to facilitate future locating of the stub-out.

2.3.21. Joints and Connectors: Ducts shall be joined using manufacturer specific requirements and industry standard such as RUS/ANSI/TIA, to ensure complete end-to-end watertight system and connections. Joints shall not be damaged when pulled past the joint. Joints between dissimilar types of ducts (PVC, HDPE, galvanized steel pipe (GSP), EB, DB, etc.) shall use the appropriate connectors designed for the purpose of providing a seal between the ducts and preventing damage to cables pulled through these joints. All joint surfaces shall be prepared IAW the manufacturer's instructions, and, at a minimum, the mating surfaces shall be wiped clean before they are joined. Locating marker balls shall be placed at all HDPE splice points or duct system repairs.

2.3.22. Bends and Sweeps: Accomplish changes in the direction of runs exceeding a total of 10-degrees, either vertically or horizontally, by long sweeping bends having a minimum radius of 20-feet. Long sweeps may be made up of one or more curved or straight sections and/or combinations thereof. Bends made manually shall not reduce the internal diameter of the conduit. There shall be no more than the equivalent of two 90-degree bends (180-degrees total) between pull points, including offsets and kicks with a curvature radius of less than 10-feet. Back-to-back 90-degree bends shall not be utilized. NOTE: Use a large sweep bend that does not abruptly turn the corner. A sweep bends should have a much larger radius then a standard elbow, this allows for improved cable installation.

NOTE: All bends, sweeps, couplers, bend radius/angles, bell ends, adapters, and connection points shall be inspected during construction and prior to burial, concrete encasement or back-filling operations by 96 CS representative to signify the acceptability of installation, placement, and spacing requirements. Follow Rural Utility Services Underground Plant Design, Underground Plant Construction, Construction of Buried Plant, and ANSI/TIA-758-B Customer-Owned Outside Plant for reference.

The following definitions apply:

2.3.22.1. 90-degree bend: Any radius bends in a piece of pipe that changes the direction of the pipe by 90 degrees.

2.3.22.2. Kick: A bend in a piece of pipe, usually less than 45-degrees, made to change the direction of the pipe.

2.3.22.3. Offset: Two bends usually having the same degree of bend, made to avoid and obstruction blocking the run of the pipe.

2.3.22.4. 90-degree sweep: A bend that exceeds the manufacturer's standard size 90-degree bend (e.g., 24-inches is standard for 4-inch conduit).

2.3.22.5. Back-to-back 90-degree bend: Any two 90-degree bends placed closer together than 10 feet in a conduit run. Utilize radius-manufactured bends to the maximum extent possible. Manufactured bends may be used on subsidiary/lateral conduits at the riser pole or building entrance. Manufactured bends shall have a minimum radius of 10-times the internal diameter of the conduit IAW Chapter 9 of the National Electrical Code and the ANSI/TIA-758 standard. Bends and sweeps shall be concrete encased to protect the duct from the pressures developed while pulling cables. Where a duct enters a building and sweeps up through a floor slab, galvanized RSC shall be used. For ducts transitioning from the lower duct window of a maintenance hole to the nominal trench depth, the transition shall be accomplished in no less than 30-linear feet from the maintenance hole in order to reduce the radius of the bends. The duct shall be concrete encased in the transition area.

2.3.23. **Section Lengths:** Without prior U.S. Government AHJ approval, the section length of conduit shall not exceed 600-feet between pulling points in main conduit runs. The section length of duct is limited mainly by the size of the cable to be pulled into it and by the number of bends it shall contain.

2.3.24. Minimum Duct Bank Sizing: Duct bank sizing shall be a minimum of 4-inches for each design, build, construction, and renovation application:

2.3.24.1. The minimum sizing for new duct banks is listed below. The total number of conduits required shall be determined, including existing conduits, conduits installed by this effort, and known future requirements, along with 50-percent of this total for spares.

2.3.24.2. Ducts between the cable vault and the first maintenance hole shall be based upon the size of the switch, the number of outside cable pairs served from the switch location, the FO requirements, and future growth.

2.3.24.3. A main duct run includes the maintenance holes and ducts from a DCO or node and provides the pathways for large feeder cables and/or core FOCs. New main duct runs shall consist of a minimum of 6-way, 4-inch duct banks.

2.3.24.4. A lateral duct run is defined as a minor branch run from the main duct run between maintenance holes. New lateral duct runs shall be a minimum of four-way, 4-inch duct banks.

2.3.24.5. Entrance ducts are defined as ducts from a maintenance hole or hand hole to an Edge-Building (EB). New EB entrance ducts shall be a minimum of two-way, 4-inch duct bank.

2.3.24.6. Entrance conduits in minor buildings, as listed in the design package, shall be a minimum of two-way, 4-inch ducts if the entrance cables are less than one-inch in diameter and if less than 40-percent of the duct area shall be used.

2.3.24.7. In accordance with the National Electrical Code, cables entering a building from the outside and not rated for inside plant use may not extend beyond 50-feet from the cable's point of entry into the building. The point of entry is defined as the point at which the cable penetrates the exterior wall or floor. The point of entry for metallic cables may be extended beyond the 50-foot limitation by using either rigid metal conduit (RMC) or IMC, both of which shall be grounded. Electrical metallic tubing shall not be used for extending the point of entry of metallic cables (transmission media, shields, or strength members). The point of entry for non-metallic cables may be extended using EMT or PVC. Refer to the National Electrical Code, Sections 770.50 and 800.50.

2.3.25. Depth of Cover: At least 36-inches of cover are required above the top of the duct bank. At least 24-inches of cover are required under roads or sidewalks (if duct is concrete-encased). For ducts installed in solid rock, the cover shall consist of at least 6-inches of concrete. If rock is encountered below grade, the minimum cover above the concrete-encased duct shall be 12-inches.

2.3.26. **Trench Width:** The installer shall engineer the trench width to the minimum width required to support the size of the duct bank being installed. When installing ducts, the trench width depends on the number of ducts, size of ducts, arrangement of ducts, and space around ducts (at least 2-inches). Additional width may be required to work in deep trenches or with large-count duct banks. Shoring of walls or sloping shall be performed as required by the OSHA and/or local requirements. The trench width for direct buried conduit shall be of sufficient width to permit tamping of dirt on the sides of the conduit formation. (See attachment H - Standard Installation Specification Drawings)

2.3.27. Split Duct: Pre-manufactured split ducts shall be of adequate material and approved by the AHJ. Installation shall be done IAW all manufacturer and industry standards.

2.3.28. Existing Ducts: Existing vacant ducts that are to be used in new cable installations, as defined in the design package, shall be cleaned and tested with a test mandrel to detect any obstructions, collapsed ducts, or duct inconsistencies. The installer may need to repair damaged ducts by installing new ducts with couplers, split ducts or cured in place pipe lining solutions

2.3.29. Marking/Warning Tape: The tape shall be a minimum of three inches wide and orange in color with the appropriate warning message and shall not be utilized as the sole tracing capability. Locating tape/wire shall be installed 18-inches above any communications cable or duct system. Copper wire installed in self-supporting duct shall be minimum 14-gauge and shall not be utilized as the sole tracing capability. Shall be installed IAW all applicable standards.

2.3.30. Trace-Safe: Install 24-inches below finished grade directly over the duct banks and 12-inches below the “marking/warning tape”. All new Trace-Safe systems installed shall use an approved splice, termination end, connectors, etc.… where needed and an approved label installed at all wire ends. Each wire end shall be secured to the MHs walls at around 8-inches within the top of the MHs *(rationale: the new clamshell MHs have concrete cap of around 8-inches thick, therefore it is recommended to mount the Trace-Safe below the cap/MH joint (and in the actual MH) to ensure the Trace-Safe will not be damaged in the event of the MH cap moving)*, accessible without having to enter the hole and not connected to grounds. The tracer will be secured to the MHs wall and tagged with a label indicating it as a "Tracer Wire to xxx - Do Not Remove” (where xxx is the other end of the wire). Do not connect to grounding/bonding system.

2.3.31. Marker Poles: Marker Poles: Two route markers shall be installed at every maintenance hole at a height of 4-feet above finished grade. Additional markers are required along all communications pathways at a maximum of 500-feet, line- of-sight or less; whichever is shorter and/or at each change in route direction, on both sides of street crossings at a height of 4-feet above finished grade *(to standardize Height).* Stenciled at the top section of each marker pole:

“*CONTACT EGLIN BASE COMMUNICATIONS PRIOR TO EXCAVATION AT 882.2581”*

2.3.32. Duct and Conduit Mandrelling Requirements

2.3.32.1. Mandrel inspections are a requirement under industry standards for quality control. Prime/Contractor of record shall provide reports on all mandrel tests accomplished for record to ensure compliance with industry standards noted herein.

2.3.32.2. New ducts in main and subsidiary duct runs shall be mandrelled before pulling anything into the duct system with a mandrel that is ¼-inch less than inside diameter of duct. If a design will require installing new cable in existing, empty duct, the OSP designer should consider requiring a mandrel test of the existing duct before installing the cable to verify that the duct is usable.

2.3.32.3. Prior to pouring concrete over the duct, the installer shall obtain the signature of the on-site 96 CS representative to signify the acceptability of the conduit mandrelling, placement and spacing.

2.3.32.4. Duct Cleaning: Duct shall be cleaned with an assembly that consists of a flexible mandrel (manufacturers standard product in lengths recommended for the specific size and type of duct) that is ¼-inch less than inside diameter of duct, 2 wire brushes, and a rag. The cleaning assembly shall be pulled through conduit a minimum of two times or until less than a volume of 8 cubic inches of debris is expelled from the duct. Do not install cables in ducts without an approved witness test and written approval of the 96 CS. (See attachment G - Applicable Publications)

Chapter 3

3. DELIVERABLES

The Contractor shall submit all applicable deliverables and test reports and as-built for review 15-duty days prior to final test and acceptance inspection to the 96 CS/SCXP, Projects and Requirements work center.

3.1. Fiber and Copper Verification Tests

3.1.1. Factory Reel Test/Inspection: The contractor/installer shall provide a copy of the reel tests/physical inspection reports of factory delivered cable(s) verifying good condition upon delivery.

NOTE: 96 CS review/approval of reel tests/physical inspection reports of factory delivered cable(s) is not required.

3.1.2. Pre-Installation Tests: Contractor/installer shall test all existing ISP/OSP cable(s) that will be moved, re-terminated, or spliced before any modification. This testing phase is the sole responsibility of the contractor/installer and should be performed prior to the installation of any ISP/OSP cable(s) as to provide a baseline of the fiber/copper quality. If pre-installation tests show any failures contractor shall provide the test reports to 96CS for corrective actions.

3.1.3. Post-Installation Test: The contractor/installer shall perform final configuration post-installation test and provide all tests results to 96 CS 15-days prior to final QA inspection of all installed ISP/OSP cabling.

NOTE: Optical fibers or copper cable(s) found with damage or defective strands or pairs, shall be replaced (from end to end) and will not be accepted by 96 CS Authority Having Jurisdiction (AHJ).

3.1.4. Copper Testing: End-to-end testing for Unshielded Twisted Pair/Screened Twisted Pair (UTP/ScTP) copper shall be conducted for 100-percent of pairs and shall identify any discrepancies. All new UTP/ScTP copper installations shall be free from any and all cable faults or splicer's errors to allow for 100-percent cable usage. Cat-6 network ISP wiring will require a test report showing DB loss, head room, wire map, length, delay skew, and attenuation. The test results shall be documented, corrections implemented, and retesting conducted and documented as required. In addition, documentation shall be presented to show the length of the cable between the telecommunications room and the work area. Testing shall be per industry standards. Copper cabling shall be tested 100-percent (All Pairs) for DC loop resistance, shorts, opens, intermittent faults, and polarity between conductors, and between conductors and shield, if cable has overall shield. Test operation of shorting bars in connection blocks. Test cables after termination but prior to being cross connected (See attachment G - Applicable Publications)

NOTE: Test report results shall reflect the wiring scheme that was selected during design/installation (i.e. 568A or 568B). Fiber and Copper test equipment **must be** calibrated within one year of test date. Test results shall be test equipment exported products from calibrated device only, fiber links will illustrate bi-directional results. No handwritten or typed out results will be accepted. All test cables shall be factory made.

3.1.5. Fiber Testing: All testing shall be accomplished IAW all applicable industry standards. Attenuation testing for optical fiber shall be performed and documented 1) from manufacturer, 2) upon delivery acceptance/prior to installation, 3) after cable placement/post installation and 4) after all splicing/end terminations have been completed. Any errors or above allowable loss readings will be repaired to bring the faulted fibers to within acceptable parameters. No additional splicing will be allowed in lieu of fiber end-to-end replacement due to manufacturer or installation damage. All strands are to be usable and free of errors providing 100-percent cable usage. Test Results: Certification of the cable(s) being tested is required to ensure it meets/exceeds requirements.

3.1.5.1. Perform 100-percent verification acceptance test for single-mode and multi-mode optical fibers, (all strands) end-to-end attenuation tests IAW OFSTP-14, OFSTP-7, TIA-568-C.3 and TIA-526-7.

3.1.5.2. Installer shall use Tier One Testing using an Optical Power Meter and Light Source for all Inside Plant (ISP) and Outside Plant (OSP) single-mode and multi-mode optical fibers in a bi-directional manner. Fiber test equipment must be calibrated within one year of installation.

3.1.5.3. Installer shall use Tier Two Testing using an Optical Time Domain Reflectometer (OTDR) and Optical Power Meter and Light Source for all Outside Plant (OSP) single-mode and multi-mode optical fiber in a bi-directional manner. Fiber test equipment must be calibrated within one year of installation. All launch and test cables shall be factory made with lengths for OTDR 150-meters (SM/MM) and light source/power meter 7-feet (SM/MM).

NOTE: Optical fibers or copper cable(s) found with damage or defective strands, or pairs will not be accepted by 96 CS Authority Having Jurisdiction (AHJ) and shall be replaced (from end to end).

3.2. As-Built Documentation: The installer shall provide accurate As-Built documentation of the entire OSP and ISP install system to include schedule T-5 documentation (i.e., rack elevations, cable route drawings “T-Sheets”). The Telecommunications Contractor(s) of Record shall maintain “red-lined” drawings at the job site under direct control of the Site POC. The red lines shall represent changes made.

As a minimum, the following information will be on each drawing for OSP/ISP requirements:

3.2.1. Accurate, reasonable facsimile of the OSP/ISP cable pathways and maintenance hole duct/cable tray system as installed
3.2.2. Accurate, reasonable facsimile of the building floor plan
3.2.3. Room and area numbers assigned for identification purposes
3.2.4. Location and designation of all CERs
3.2.5. Telecommunication Room Layout diagram for all CERs
3.2.6. Location and designation of all work area outlets installed
3.2.7. Rack elevations
3.2.8. Location of all vertical/horizontal penetrations
3.2.9. Routes for all cables, including horizontal, tie, and backbone
3.2.10. Location of vertical/horizontal penetrations through firewalls/floors

3.2.11. Geospatial data of new outside plant distribution system with accuracy of the GNSS points no more than 6-12-inches after differential correction/post-processing
3.2.12. Drawing Reference Details (ANSI/TIA 606)

T-1 - Layout of complete building per floor showing: Building area/serving zone boundaries, backbone systems, and horizontal pathways.
T-2 - Serving zone/building area: Drop locations and cable identification.
T-4 - Typical Details: Faceplate labeling, fire stopping, symbols, installation procedures, detail racking and raceways data.
T-5 Schedule: Documentation on cables showing cut overs and cable management, patch panel layouts, faceplate assignments, cross-connects information, and terminal layout as a minimum.

3.3. Shape Files: The installer shall provide Global Navigation Satellite System (GNSS) collected OSP infrastructure features and communications pathways attribute, metadata, and location information shall be converted to, stored, and submitted in an Environmental Systems Research Institute (ESRI) Shape File format. The shape files must be compatible with the Cyberspace Infrastructure Planning System (CIPS) Visualization Component (CVC) web-based application. The shape files shall have a geospatial reference (.prj, .dbf, .shp, .shx and .cor) files included that specifies the parameters of the coordinate system. (See Attachment A for more information)

NOTE: Installer(s) shall coordinate with the 96 CS/SCXP office through a Request for Information (RFI) to ensure they have the latest data dictionary before accomplishing any project GIS actions. The accuracy of the GNSS points shall be no more than 6-12-inches after differential correction/post-processing.:

Coordinate system: UTM
Zone: 16 North
Datum: NAD 1983(conus)
Coordinate units: Meters
Altitude units: Meters
Altitude Reference: HAE

3.4. Test and Acceptance Documentation (AFTO 747): The Contractor shall submit all test reports and as-built deliverables for review 15-duty days prior to final test and acceptance inspection. The test reports shall show the tests performed to verify compliance with the specified performance criteria. Test reports shall include record of the physical parameters verified during testing. As-builts shall show all communications pathways, cabling with correct labeling as installed. The contractor shall correct any errors or performance deficiencies detected by testing. The assigned 96 CS/SCXP Project Manager will sign an AFTO Form 747 in Block 11A upon government QA acceptance of contractor's final test results. The 96 CS reserves the right to refuse final acceptance until all discrepancies have been resolved to the satisfaction of the Authority Having Jurisdiction.

3.5. Projects, Designs, USACE, SABER Requirement Support Timelines:

3.5.1. Task Timelines: Once accepted by SCX and SCO production work center(s).
3.5.1.1. Survey Inputs: 96 CS 5 full duty days (internal use only SCX 1/SCO 4)
3.5.1.2. Project/Design Reviews: 96 CS 12 full duty days (internal use only SCX 2 /SCO 10)
3.5.1.3. Comm path segment verifications: 96 CS 13 full duty days (internal use only SCX 1 / SCO 12)

3.5.1.4. Product submittals: 96 CS 6 full duty days (internal use only SCX 1/SCO 5)
3.5.1.5. Official Request for Interpretation (RFI): 96 CS 5 full duty days (internal use only SCX 1/SCO 4)
3.5.1.6. Request for Escort: 96 CS 5 full duty days (internal use only SCX 1/SCO 4)
3.5.1.7. Deliverables documentation reviews (Shape files, As-built, final test results, reviews: 96 CS 17 full duty days prior to final inspection (internal use only SCX 2/SCO 15)
3.5.1.8. Fiber and copper in-progress test result: 96 CS 9 full duty days (internal use only SCX 1 / SCO 8)
3.5.1.9. Request for in-progress checks or final inspections: 96 CS 6 full duty days (internal use only SCX 1/SCO 5)
3.5.1.10. Rough Order Magnitude (ROM): 96 CS 23 full duty days (internal use only SCX 3/SCO 20)

NOTE: It is imperative on each requirement the 96 CEG, USACE, etc. project manager(s) notifies the required 96 CS discipline in a timely manner.

Chapter 4

4. PARTS AND MATERIALS REGISTER

The salient physical, functional, and performance characteristics of the following telecommunication parts and materials specified shall be adhered to for all installations or like items. Replacement parts shall be standard and readily available through commercial means. Discontinued products will not be accepted unless approved by the Contracting Officer and 96 CS Authority Having Jurisdiction:

NOTE: The term approved is defined in this document as acceptable to the authority having jurisdiction.

4.1. Data Jack: Category 6, RJ45, 8-position, 8-wire UTP Mini-Com® universal jack module has TG-style termination. Color shall match cable jacket.

4.2. Blank Inserts: Mini-Com® 1-port blank module, reserves space for future use, Off-White/International White.

4.3. Surface Mount Raceway System: Tamper resistant two-piece latching surface raceway. Supplied with pre-punched mounting holes. Available in 6', 8', and 10' lengths, Off-White/International White. Compatible with surface mount outlet box. All surface mounted raceway systems shall be screwed to the wall to prevent detachment from the mounted surface.

4.4. Riser CAT-6: CAT-6 (600MHz), 4-Pair, U/UTP-Unshielded, Riser-CMR, Premise Horizontal Cable, 23 AWG Solid Bare Copper Conductors, Polyolefin Insulation, X Spline, Ripcord, PVC Jacket.

4.5. Plenum CAT-6: Copper Cable, Giga SPEED XL 2071E, 23 AWG, 4 Pair, Unshielded, UTP, Solid Bare Copper Conductor, FEP/PVC, CMP. Plenum CAT-6: Copper Cable, Giga SPEED XL 2071, 23 AWG, 4 Pair, Shielded, ScTP, Solid Bare Copper Conductor, FEP/PVC, CMP, (RED).

4.6. Intra-Building Distribution Cables: Used after 15m (50ft) of "exposed" outside plant copper cable enters building. "Fold back" splicing method preferred.

4.7. 25-pair – 3600-pair: CMR rated. Pair count varies. Use applicable count determined by the pair count from the outside plant cable.

4.8. Splice Enclosure: An intra-building splice closure is a strong, lightweight, fire-retardant covering that protects non-pressurized splices. The closure shields the splice against humidity and moisture and may even resist temporary immersion in water. When you install the closure, properly support it, ground it and test it for air leaks according to manufacturer's recommendations. Affix labels to all cables entering the splice, indicating cable number and pair counts. Clearly designate the "In" and "Out" for the spliced cables.

4.9. Building Station Terminal Blocks (110-Type): Terminates intra-building cables and horizontal cables. Must clearly label intra-building cable using stencils above 110 type (IDC) block with applicable information during pre-installation survey.

4.10. Building Entrance Terminal Blocks (110-Type): 16 AWG steel building entrance terminals feature an industry standard 110 - style connector for both the input and output terminals. Also included are multiple external and internal ground lugs. UL approved standard on all terminals and standard 5-pin protection modules.

4.11. Cat-6 Connector Block 24/48 Port (Patch Panel): Constructed for maximum strength and durability. Rack-mount modular panels shall include an integrated cable management requirement for cable routing and strain relieve cables at patch panel and other termination points. Provide a complete modular system from patch panel to work area outlet. **NOTE:** When terminating new Twisted Pair cabling onto existing Cat-6 rated patch panel(s), strain relief requirements will be adhered to as referenced in section 4.12 Strain Relief Requirements.

4.12. Strain Relief Requirements: All Strain relief bars shall consist of a metal bar that mounts to the rear of a standard EIA 19-inch rack to support a minimum of 24 cables exiting from the back of a patch panel with a 2-inch to 5-inch inward mounted offset. Cables shall be secured with integrated adjustable clips, hook and loop strips or cable ties. Optional quick release brackets shall provide an easy way to remove the strain relief bar without the use of tools.

NOTE: Vinyl tape will not be accepted

4.13. Fiber Optic Cabling for Inside Structure Installation: Inside plant single-mode fiber will have a (YELLOW) Polyvinyl Difluoride jacket and multi-mode will have a (ORANGE) Polyvinyl Difluoride jacket for quick identification unless otherwise noted for specified network.) Cable medium and strand count shall be determined by 96 CS Authority Having Jurisdiction and customer requirement(s).

4.14. Fiber Optic Connectors: All new installations requiring the installation of a fiber optic distribution panel will use the connector style below:

4.14.1. **Fiber Optic Connector — LC, SM:** Splice Cassette, 24 fiber strands, LC, UPC, Duplex, Single- Mode (OS2), Single-Fiber (250 µm).

4.14.2. Fiber Optic Connector — LC, MM: Splice Cassette, 24 fiber strands, LC, UPC, Duplex, 50 µm (OM 3 and 4).

4.15. Fiber Optic Patch Panel: All fiber optic housing units shall be compatible to support fiber splice cassettes mentioned in 4.14.

4.16. Fiber Optic Core Cables: Non-Armored ALTOS® / MiniXtend® Fiber (or equivalent) is to be used for new installations. Due to damages caused by lightning, all fiber optic cables will contain zero conductive materials.

4.17. ALTOS® / MiniXtend® Fiber Single-Mode Cable (or equivalent): Minimum 24 strand count to be installed unless otherwise approved by 96 CS.

4.18. Maintenance-Holes: Shall be equipped with all accessories to provide a complete system as or like Oldcastle Precast concreted MH design and meet applicable ASTM standards specification.

4.18.1. Main distribution MH system interior size is 12-feet (length) x 6-feet (width) x 7-feet (height) and shall have a load rating of HS-20 for heavy vehicular traffic.

4.18.2. Sub-distribution MH systems depending on location and project design are pre-cast reinforced concrete interior size 3-feet (width) x 5-feet (length) x 4-feet (height) and shall have a load rating of HS-20 for heavy vehicular traffic.

4.19. Underground Plant Conduit HDPE: UL Listed HDPE is a flexible, non-metallic raceway used to protect underground cables. It has superior crush resistance, low coefficient of friction, and high tensile strength. Size, length and type will be determined during design. Smooth wall, approved/listed for directional boring, minimum Schedule 80 HDPE SLR 11.5, ASTM F2160, NEMA TC 7.

4.20. Underground Plant Conduit Schedule 40/80: Non-metallic conduits shall be encased in concrete of minimum 3,000 lb/in2 (20,700kPa) compressive strength where vehicular traffic (i.e. automotive, railway) is above the pathway or where a bend or sweep is placed.

Chapter 5

5. EMERGENCY REPAIR PROCEDURES

5.1. ISP/OSP Telecommunication Infrastructure Copper/Fiber Repair Guidelines: Contractor shall notify Eglin's 96 CS Communications Focal Point (CFP) at 850-882-2666 or immediately upon discovery of any damaged Eglin communications cyber infrastructure. Extent of repairs required will be assessed and determined by 96 CS/CC or designated Authority Having Jurisdiction (AHJ).

> **NOTE**: All temporary and/or permanent repairs shall be made at no additional cost to the government. Repairs shall be IAW all applicable industry and local standards.

5.2. Temporary Repair Actions: Temporary repairs shall be initiated within 12-hours of reported/identified damage and must restore all circuits (pairs, strands, etc...) to full mission capability within 24-hours unless otherwise approved by AHJ. Contractor shall provide 24 hour/7 day a week on-call maintenance service for temporary repairs until all permanent repairs have been completed and accepted by the AHJ.

5.3. Permanent Repair Actions: All fiber optic and copper communications cyber infrastructure shall be restored to its original state or better prior to damage for all permanent repairs. All damaged communications cyber infrastructure shall be replaced, at a minimum, to the closest, pre-existing, splice/terminal locations regardless of distance and/or cost incurred. New or additional splices shall not be allowed for permanent repairs without written approval from the designated AHJ.

5.3.1. Contractors shall provide a Statement of Work (SOW), test plan and product submittals for all proposed permanent repair solutions within 5 business days from date of reported damage to 96 CS/CFP and AHJ for written approval prior to beginning any permanent repairs.

Chapter 6

TELECOMMUNICATIONS CONTRACTOR(S) QUALIFICATIONS

6.1. Telecommunications Contractor(s) Qualifications Requirements:

6.1.1. Work under communications requirements shall be performed by and the equipment shall be provided by the approved telecommunications contractor and key personnel. Qualifications shall be provided for: The Telecommunications System Contractor, the telecommunications system installer, and the supervisor (if different from the installer). A minimum of 30 days prior to installation, submit documentation of the experience of the Telecommunications Contractor and of the key personnel.

6.1.2. Telecommunications Contractor shall be a firm which is regularly and professionally engaged in the business of the applications, installation, and testing of the specified telecommunications fiber optic and copper OSP/ISP systems and equipment. The Telecommunications Contractor shall demonstrate experience in providing successful telecommunications systems within the past 3 years of similar scope and size. Submit documentation for a minimum of three and a maximum of five successful telecommunication system installations for the Telecommunications Contractor.

6.1.3. Provide key personnel who are regularly and professionally engaged in the business of the application, installation and testing of the specified telecommunications fiber optic and copper OSP/ISP systems and equipment. There may be one key person or more key persons proposed for this solicitation depending upon how many of the key roles each has successfully provided. Each of the key personnel shall demonstrate experience in providing successful telecommunications systems within the past 3 years.

6.1.4. Supervisors and installers assigned to the installation of this system or any of its components shall be Building Industry Consulting Services International (BICSI) Registered Cabling Installers, Technician Level. Submit documentation of current BICSI certification for each of the key personnel. In lieu of BICSI certification, supervisors and installers assigned to the installation of this system or any of its components shall have a minimum of 3-years' experience in the installation of the specified copper and fiber optic cable and components. They shall have factory or factory approved certification from each equipment manufacturer indicating that they are qualified to install and test the provided products. Submit documentation for a minimum of three and a maximum of five successful telecommunication system installations for each of the key personnel. Documentation for each key person shall include at least two successful system installations provided that are equivalent in system size and in construction complexity to the telecommunications system proposed for this solicitation. Include specific experience in installing and testing telecommunications systems and provide the names and locations of at least two project installations successfully completed using optical fiber and copper telecommunications.

6.1.5. Indicate that all key persons are currently employed by the Telecommunications Contractor or have a commitment to the Telecommunications Contractor to work on this Project. All key persons shall be employed by the Telecommunications Contractor at the date of issuance of this solicitation, or if not, have a commitment to the Telecommunications Contractor to work on this Project by the date that the bid was due to the Contracting Officer.

NOTE: Only the key personnel approved by the Contracting Officer in the successful proposal shall do work on this solicitation's telecommunications system. Key personnel shall function in the same roles in this Contract, as they functioned in the offered successful experience. Any substitutions for the Telecommunications Contractor's key personnel requires approval from the Contracting Officer.

NOTE: The term approved is defined in this document and other standards as acceptable to the authority having jurisdiction.

Chapter 7

CRITICAL EDGE BUILDING

7.1. Classification and Criteria

7.1.1. Specific criteria shall be met in order for a facility to be classified as a critical edge building (CEB) on Eglin AFB. Discussions to classify a facility as a CEB will take place during the design kickoff, charrette, or SATAF meetings. If the organization wishes to seek the CEB classification, customer shall complete the Critical Edge Building Classification and Criteria template coordinated by 96 CS/SCOI. Responses to the specified criteria will dictate an approved/disapproved CEB classification. In accordance with current Air Force Base Area Network Specifications (AFBAN) policy, a facility shall be classified as a CEB prior to implementing redundant links to two different Information Transfer Buildings (ITBs) or Core Nodes. If the mission set changes throughout the lifecycle of the facility, customers shall reassess their responses to the criteria to ensure the justification for being a CEB is still warranted. Additionally, if a facility meets compliance to be classified as a CEB, the alternate fiber path shall be physically diverse. If all means necessary have been exhausted to ensure physically diverse fiber paths have been implemented, but physical diversity is still unachievable, logically diverse cable paths are an exception, but are not guaranteed. Physically diverse fiber paths shall be classified as the following: Fiber Point of Entry to the facility for alternate route should be different from primary point of entry, but same point of entry is also authorized up to 50-feet maximum. Then both FOCA's are required to be in separate ducts using different communication pathways in different geographical directions. See current AFBAN for additional pathway information.

7.1.2. Once approval for the classification and criteria document has been completed, the 96 CS network engineers will conduct extensive network assessments to determine the most viable core node infrastructure capable of supporting the customer's new CEB requirement. Following network assessment completion for each core node where logical path and ITB has been determined, the physical path and duct assessment will be conducted by the 96 CS Cyber Infrastructure personnel.

Chapter 8

COMMUNICATIONS EQUIPMENT LOCATION (CEL)

8.1. Eglin AFB CEL Requirements:

8.1.1. CEL's must be locked and secured IAW DoD 5200.08-R, paragraph C6.2.4.

8.1.2. CEL's must be clean and in good order IAW AFMAN 91-203, paragraph 30.1.

8.1.3. CEL's cannot be used as a storage room and must only contain 96 CS information technology equipment IAW UFC 3-580-01, paragraph 2-4.2.1.

8.2. 96 CS managed CEL's house installation network equipment and shall be protected IAW Defense Information Systems Agency (DISA) Traditional Security Guidance.

8.3. Access to CEL's or cohabiting space within a CEL shall only be provided as a last resort.

8.3.1. Cohabiting space within a CEL should only be requested if there is absolutely no other suitable space within the facility to house non-core networking equipment. Valid justification is required and must be accompanied by documentation preventing units from installing non-core equipment elsewhere within the facility.

8.3.2. If a CEL shall be deemed a cohabiting space, specific criteria must be met to retrofit an existing CEL:

- If existing keying mechanism is standard Z5 key lock, then entire door handle and lock mechanism shall be replaced to support cipher lock and Z5 lock keying mechanisms. Cohabiting unit shall use cipher lock for entry and 96 CS will use standard Z5 lock keying mechanism.
- A survey shall be conducted by 796 CES in coordination with 96 CS to assess electrical loads and heating/ventilation air conditioning (HVAC) requirements for proposed unit equipment.
- The requesting unit shall submit a request to 796 CES when current or existing electrical loads and or HVAC loads will be exceeded or limitations to existing provisions will not support user's requirement.
- The requesting unit shall fund for any expansions to electrical, HVAC, door handle retrofits, etc. to satisfy unit's requirement.

8.4. Units requesting space for equipment installation in a CEL shall adhere to all DoD policies and regulations, to include but not limited to:

Air Force Base Area Network Functional Specifications (AFBAN)
DISA Security Technical Implementation Guides (STIGs)
Unified Facilities Criteria (UFC) 3-580-01, Telecommunications Interior Infrastructure Planning and Design
DoD 5200.08.R, Physical Security Program
AFMAN 91-203, Air Force Occupational Safety, Fire, and Health Standards

T.O. 00-33A-1001, General Cyberspace Support Activities Management Procedures and Practice Requirements
AFI 33-200, Air Force Cybersecurity Program Management

8.5. All 96 CS core network equipment shall reside in its own separate lockable enclosure. All non-core network equipment shall reside in a separate enclosure from 96 CS network equipment.

8.5.1. Core network equipment includes: all NIPRNet, SIPRNet, VoIP, and SONET-Transport equipment managed by the 96 CS.

8.5.2. A lockable enclosure is defined as either a lockable equipment rack or lockable wall mount cabinet that is controlled and accessed by 96 CS authorized personnel only. 96 CS lockable enclosures are outlined in Attachment D.

8.6. All network connections must be secured within a locked communications closet or secured within a CEL if room is accessed by non-network personnel.

8.7. Outside Plant cabling infrastructure shall only reside in designated 96 CS lockable enclosures.

8.8. 96 CS managed patch panels and premise wiring shall not be cross utilized with other unit services.

8.9. The final approver for 96 CS CEL usage or cohabiting space within a CEL is the 96 CS/CC.

8.9.1. CEL access requests shall use the 96 CS Communications Focal Point (CFP) Remedy process.

8.9.2. 96 CS personnel shall change the cipher lock code when personnel on the access roster change or when CEL access privileges have been revoked.

8.10. 96 CS shall provide a tech solution in collaboration with 796 CES for all CEL usage requests. CEL usage is not guaranteed and is subject to 96 CS/CC approval.

8.11. CEL building manager shall submit names of personnel requiring CEL access to their unit's security manager for vetting. Unescorted access shall only be granted to personnel with a minimally favorable adjudicated National Agency Check (NAC), appropriate security clearance, and a need-to-know IAW the DISA Traditional Security STIG. Vetted access lists names shall be approved and signed by the submitting unit's commander or appointed representative.

8.11.1. Approved access list personnel shall be provided cipher lock codes for CEL access, but codes may not be shared with other unit members.

8.11.2. When unit member access for cohabiting space is no longer required or personnel no longer require access to the shared space, units shall remove names from the access list and submit updates to the 96 CS.

8.11.3. Units shall audit their access lists every six months IAW the DISA Traditional Security STIG. The unit security managers, facility managers, and work center SMEs shall revalidate each unit's access list.

8.11.4. CEL Inspection

8.11.4.1. 96 CS Policy and Evaluation (96 CS/SCQ) are the lead inspectors for 96 CS managed CELs.

8.11.4.2. Inspection results shall be sent to the associated units for further actions.

8.11.4.3. Any unit in breach of the CEL guidance shall be considered for removal from the 96 CS CEL

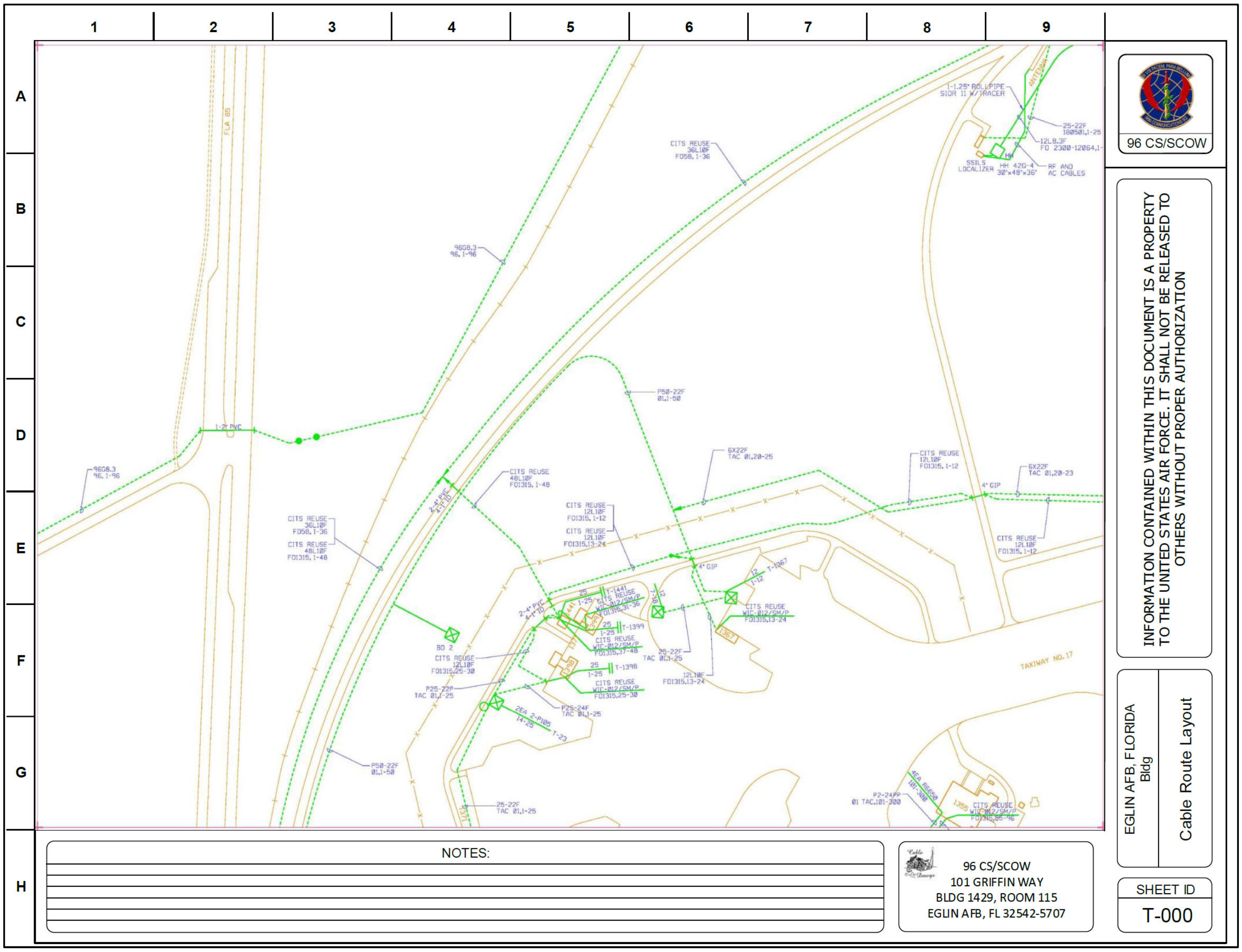
8.12. Any new building projects or facility renovations shall adhere to this guidance and be incorporated into the standard architecture.

Attachment A

6. DRAWING SPECIFICATIONS

A.1. Cable Route: The outside plant communications cable shall be depicted as installed, showing street/road locations and names, building 'footprints' accurately oriented as actually located. Maintenance Holes shall be depicted accurately oriented as located in reference to buildings and streets/roads. Extraneous information of other utility disciplines shall NOT be accepted on the as-built drawings. The information on the as-built drawings shall pertain to COMM specific.

A.2.

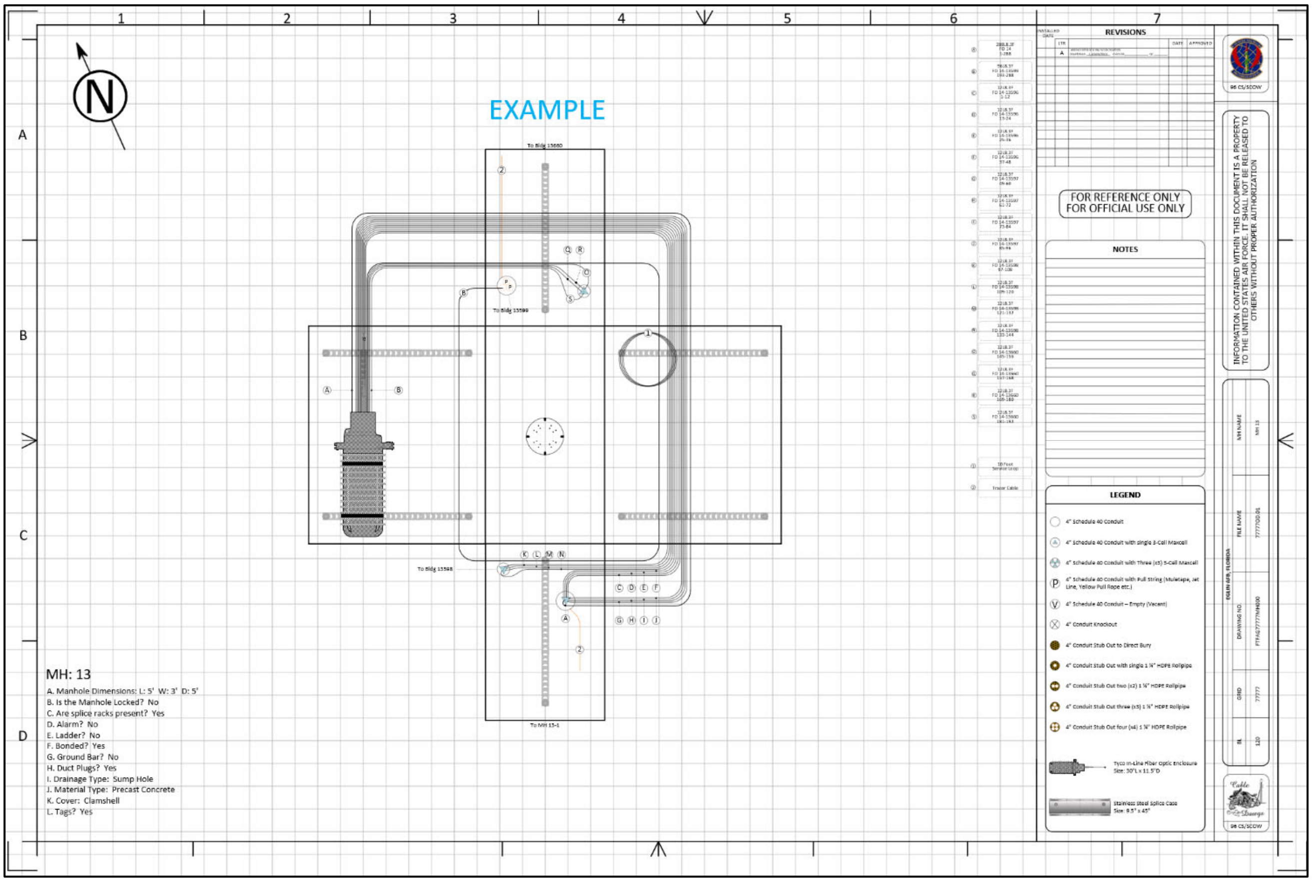


Sample Cable Route Drawing

A.3. Butterfly: Drawing of the interior of individual Maintenance Holes that were installed, passed through, or modified in any way. Reference drawing below.

A.4. The Installer shall augment the GNSS survey by using conventional land surveying equipment and electronic cable locating (underground utility toning) equipment to meet requirements. The Installer shall ensure collected/provided data is compatible with the CVC. The accuracy of the GNSS points shall be no more than 6-12-inches after differential correction/post-processing.

A.5.



Example: Maintenance Hole Butterfly with GIS Metadata

A.6. Geographic Information Systems (GIS) data: Provide technical/field services necessary to locate and perform Geographic Information System (GIS) data collection of Outside Plant (OSP) cable infrastructure and communications pathways for government entry into the Cyberspace Infrastructure Planning System (CIPS) Visualization Component (CVC). Additionally, the Contractor shall enter into all communication "containers" to include communication Maintenance Vaults, Maintenance-Holes (MH), and Pedestals in order to record/document detailed container information by means of field drawings. Outside plant features/containers include vaults, maintenance-holes, pedestals, underground cables, direct buried splices, terminals, etc. The communications pathways include duct routes, aerial and direct-buried cable, trench routes, communication pathway entry points on building exterior walls that lead to interior building entry terminals, etc. The Installer shall augment the GPS survey by using conventional land surveying equipment and electronic cable locating (underground utility toning) equipment to meet requirements. The Installer shall ensure collected/provided data is compatible with the CVC. The accuracy of the GPS points shall be no more than 6-12-inches after differential correction/post-processing.

> **NOTE: Contractor/**Installer(s) shall coordinate with the AHJ through a Request for Information (RFI) to ensure they have the latest data dictionary before accomplishing any project GIS actions.

Shapefile filename extensions:
.prj. = projection description, using a well-known text representation of coordinate reference systems
.dbf = attribute format; columnar attributes for each shape, in dBase IV format
.shp = shape format; the feature geometry itself
.shx = shape index format; a positional index of the feature geometry to allow seeking forwards and backwards quickly
.cor = COR files generated by GPS Pathfinder Office after post processing the positions captured by GPS devices

A.7. GPS_MAINTENANCE HOLE

A.7.1. Definition: An enclosed structure MHs. A butterfly layout is used that shows the floor and walls flattened out so that duct openings can be drawn on the walls. This must be represented as one polygon (one row in the table). The point is used to show the center of the MHs cover.

A.7.2. Geometry type: Site (Point).

A.7.3. Attributes:

Column Name	SDSFIE Common Name	Description	Data Type	Use	Domain Table
MH_NAME	Identifier Name	The standard identifier name (e.g., MH-19)	Char (60)	Required	
MATERIAL		Used to describe the material composition of the maintenance hole	Menu	Required	PreCast Concrete Fiberglass Quazite Unknown Other
SIZE	Dimension of the structure	The width, length, and height (or depth) of the structure measured from the inside	Char (30)	Required	

Column Name	SDSFIE Common Name	Description	Data Type	Use	Domain Table
LID		Shape of the structure lid	Menu	Required	Round Clamshell Rectangle Other
DRAINAGE_TYPE			Menu	Required	Sump Hole Seepage Pit Other None
SPLICE_RACK		Support braces on the side of the structure	Menu	Required	Yes No
LOCK_PRESENT		Is the structure able to be locked	Menu	Required	Yes No
SPLICE_PRESENT		Type of splice case is in the structure	Menu	Required	Copper Fiber Optics Both None
BONDED			Menu		Yes No
GROUND BAR			Menu		Yes No
ARE DUCTS PLUGGED			Menu		All Some None

A.8. COMM_PATH_SEGMENT

A.8.1. Definition: Link that represents an enclosure path of comm, items outside of a building, maintenance hole, General Container, or other enclosed structure. For duct banks, comm-path segment can represent the virtual path, duct bank, duct, and innerducts. For ducts, comm-path segment can represent the virtual path, duct, and innerducts. For direct-buried cables at road-crossings, comm- path segment can represent the virtual path, road-crossing duct, and direct-buried cables. It can also represent the path of aerial cable, cable-bridges, and cable-troughs.

A.8.2. Geometry type: Polyline

A.8.3. Attributes

Column Name	SDSFIE Common Name	Description	Data Type	Use	Domain Table
FROM		Origination	Char (60)	Required	
TO		Destination	Char (60)	Required	
CABLE_ID		A field that describes the originating and end structure this segment is representing	Char (60)	Required	
INSTALL_TYPE		Type of path	Menu	Required	Duct Duct Bank Direct Buried
NUMBER_OF_DUCTS		Condition, Install Type = Duct Bank	Numeric Min=1 Max=20 Default=1		
DUCT_SIZE		Dimension of the duct measured in inches	Numeric Min=1 Max=12 Default=4	Required	
MATERIAL		Composition of the Duct		Required	Schedule 40 PVC Schedule 80 PVC HDPE Micr-Duct
DEPTH		The minimum depth of this part of the path from grade, in inches	Numeric	Required	
COMMENTS					

A.9. PEDESTAL

A.9.1. Definition: An above ground container used as a splice point, testing point, ortermination.

A.9.2. Geometry type: Site (Point).

A.9.3. Attributes:

Column Name	Description	Data Type	Use	Domain Table
TERMINAL_ID	A unique container identifier	Char (60)	Required	
SIZE	Dimensions of the container	Menu	Required	BD1 = 2”x2” BD2 = 4”x4” BD3 = 6”x6” BD4 = 8”x8” BD5 = 10”x10” BD7 = Cabinet – 23”x12” BD8 = Cabinet – 32”x18”
GROUNDED/BONDED		Menu	Required	Yes No
BONDING_SECURED		Menu	Required	Yes No Some
TERMINAL		Menu	Required	Yes No
MATERIAL		Menu	Required	Metal Fiberglass
CABLE TAGS PRESENT		Menu	Required	Yes No Some
COMMENTS		Char (230)		

A.9. MARKER POLE

A.9.1. Definition: An above ground marker used to identify MH or Cable Route.

A.9.2. Geometry type: Site (Point).

A.9.3. Attributes:

Column Name	Description	Data Type	Use	Domain Table
LOCATION		Char (60)	Required	
TYPE	What the marker is used for	Menu	Required	MH/HH Marker Cable Route

A.10. MARKER BALL

A.10.1. Definition: A below ground marker used to identify entrances, road crossings, routes, stub out locations.

A.10.2. Geometry type: Site (Point).

A.10.3. Attributes:

Column Name	Description	Data Type	Use	Domain Table
TYPE	What the marker is used for	Char (60)	Required	Ball Disk
MARKER PURPOSE		Menu	Required	Splice Bldg Entrance Road Crossing Cable/Duct Route MH Stub out
MANUFACTURER		Char (60)	Required	

A.11. SPLICE

A.11.1. Definition: A below ground splice used to connect cables or tracing wire.

A.11.2. Geometry type: Site (Point).

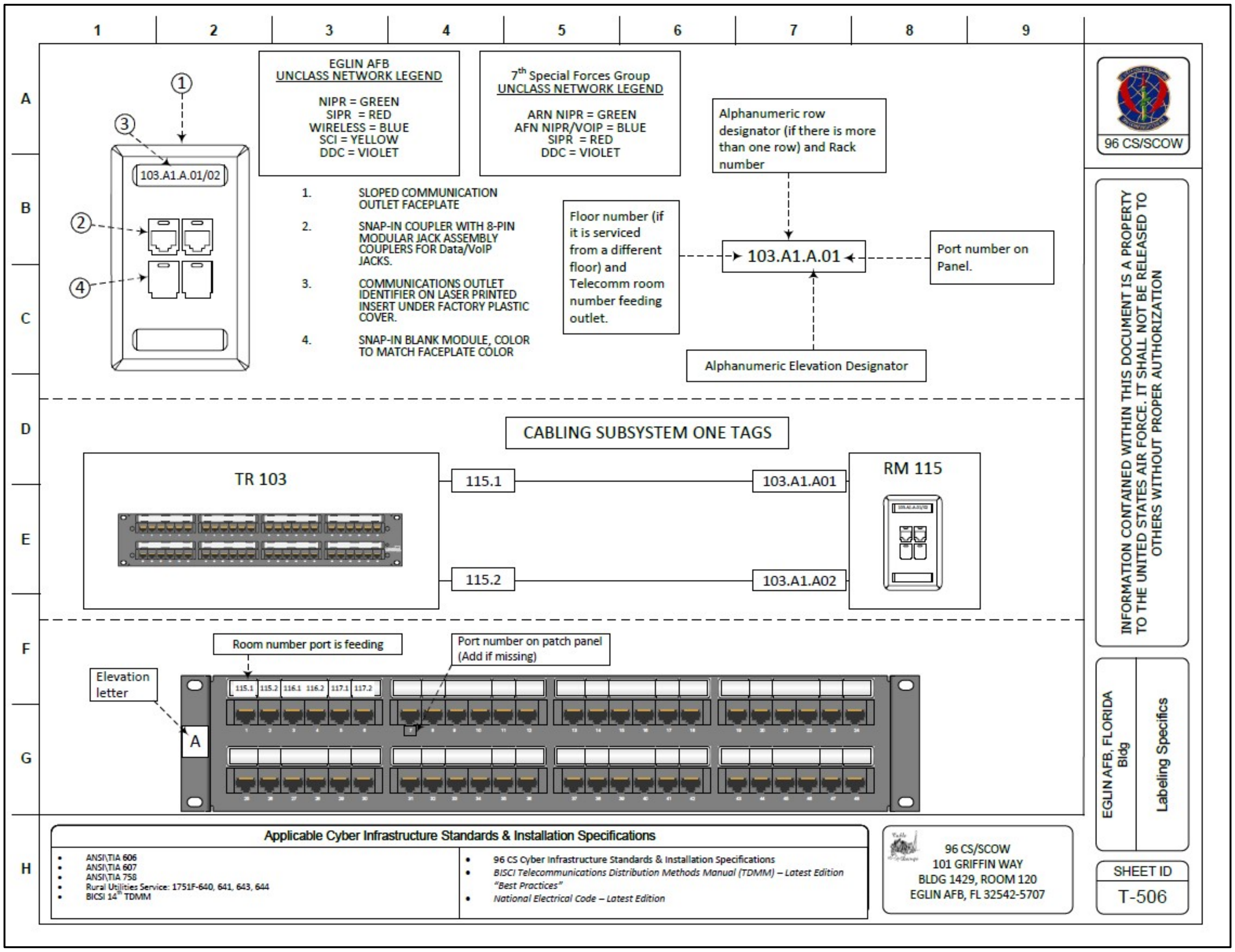
A.11.3. Attributes:

Column Name	Description	Data Type	Use	Domain Table
LOCACTION	Where the splice is	Char (200)	Required	
TYPE	What type of splice	Menu	Required	Auto-Wire Trace Safe Copper Fiber Optic

Attachment B

LABELING SPECIFICATIONS

B.1. LABELING SPECIFICATIONS



Attachment C

FIBER DESIGN REQUIREMENTS

C.1. FIBER DESIGN NOTES

Eglin AFB Core Fiber Optic Baseline

References: (a) AF Base Area Network Functional Specification (AFBAN), dated February 2021

C.1.1. Per the AF Base Area Network Functional Specification (AFBAN), dated February 2021, section 4.1.3.

- New ITB construction shall contain a minimum of 72 single-mode (OS1 and OS2) fiber strand cables, one each Home Run to separate existing (or new) ITBs. Higher strand counts may be used based on known and future requirements.
- Existing ITB-to-ITB cable with less than 18 available strands is a candidate for additional fiber cables between the ITBs.
- Additional fiber cables installed between existing ITBs shall contain a minimum of 48 single-mode (OS1 and OS2) fiber strands. Higher strand counts may be used based on known and future requirements.
- New EB construction shall contain a minimum of 12 single-mode fiber strands dedicated between that EB and its ITB. Higher strand counts may be used based on known and future requirements.
- Existing EB-to-ITB cables with 4 or less available strands is a candidate for additional fiber between the EB and the ITB.
- Additional fiber cables installed between existing EBs and ITBs shall contain a minimum of 12 single-mode (OS1 or OS2) fiber strands. Higher strand counts may be used based on known and future requirements.
- With any cable installation, 10% of the total fiber strands (rounded to the nearest pair of fibers) should be unused to provide emergency routing should the need arise.

Home Run cable design is the recommended method of fiber distribution when adequate OSP pathway is available. In order to conserve preinstalled available pathways, fiber optic trunk design should be considered if ITB to EB fiber routes must traverse existing available pathway routes that are near capacity.

The above standards cover minimum OSP fiber optic requirements needed to provide minimal connectivity and required spare fiber for maintenance purposes only.

C.1.2. The organizational requirements supporting advanced warfighter missions and the demand for increased fiber optic capabilities to support “gray” or “other” networks, Intrusion Detection Systems (IDS), high resolution video graphics imaging and global environmental management control systems has increased. To ensure these requirements and all core services are satisfied and IAW the AFENT architecture specifications and Assured Services LAN (ASLAN), Eglin’s minimum fiber requirements have been determined to be the following:

a) Information Transfer Building to Edge Building = 24 Single Mode fiber optic strands

b) Edge Building main telecommunication room to other downstream communication equipment locations within the same building = 24 Single Mode fiber optic strands

c) Fiber Optic strands 1-18 shall be recorded in the circuit actions installation reporting system as reserved for 96 CS management/use to support and maintain base core services only.

d) Fiber optic strands 19-24 will be available to satisfy design requirements like Intrusion Detection System (IDS) "Alarms" and/or other temporary mission support requirements. All additional fiber optic strand requirements for customer specific use that will deplete or diminish the core service reservations shall be in addition to the baseline 24 strands to include additional maintenance spare fiber optic strands. Final fiber optic cable sizing shall be determined by 96 CS during network design and project requirement reviews.

C.1.3. Cable replacement will be the first design consideration for installation requirements of new cable to existing EBs or through legacy underground plant infrastructure with limited duct availability.

C.1.4. All network designs will be IAW the most current AFBAN, applicable Unified Facilities Criteria, applicable industry standards, and local specifications. (See attachment G - Applicable Publications)

Attachment D

RACK ELEVATION STANDARDS FOR NIPR/SIPR/DATA/VOIP

D.1. FLOOR-MOUNT LOCKABLE NETWORK ENCLOSURE

Standard AF Data/VoIP Rack Elevation for all NIPR TRs

Current as of: 20 Nov 23

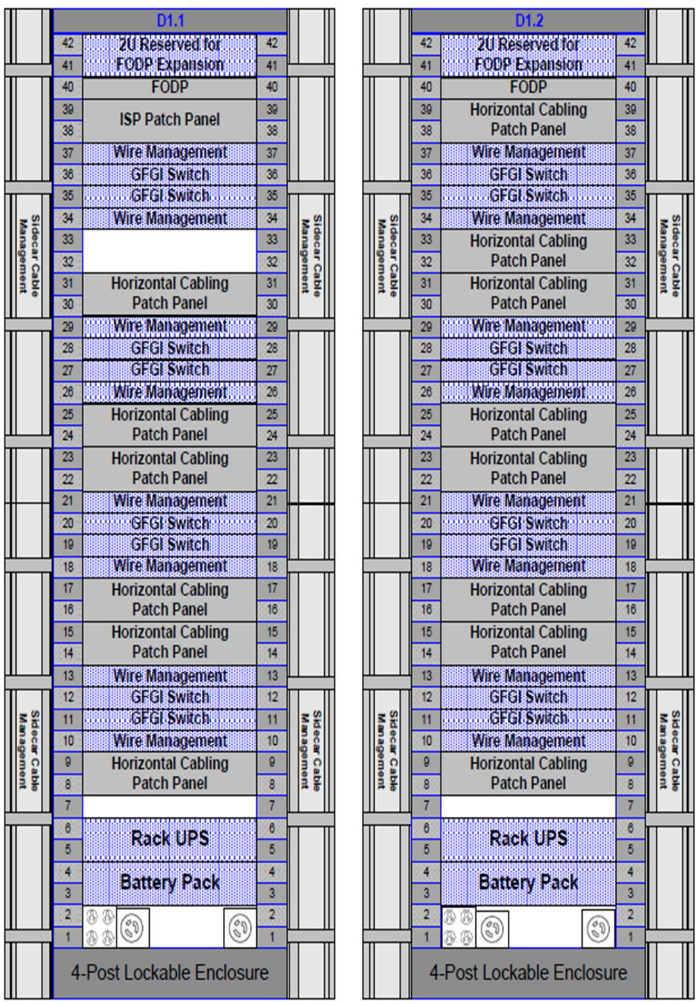


Figure D1.1
AF DN RACK

Figure D1.2
AF AN RACK

Notes:

1. All 4-post lockable enclosures shall be specified by 96CS to ensure proper rack specifications based on customer provided requirements. Racks shall be lockable enclosures with part number GL790ES-2442MS or equivalent.

2. All 72" TR racks shall be 4-post lockable enclosures with vertical sidecar cable management to support wiring on either side. If using the model specified in Note 1, the vertical sidecars include part numbers SC67942, SCP7942, VCT-79, and VTC-79C.

3. Ensure rack's front rails are set back a minimum of 6" from the front of the rack. This ensures all cabling will be unaffected by the door when closing.

4. All 72" TR racks shall follow this elevation layout to comply with Eglin rack elevation standards.

5. Dedicated circuits with power receptacles indicated below and depicted in the rack elevation shall be supplied by onsite contractor. Exact power receptacle shall be identified in the 100% design drawings based on the requirements.

6. A dedicated junction box shall be placed no greater than 2-feet from the 96CS lockable enclosure and appropriate electrical wiring shall be homerun from supporting electrical panel to junction box. A pigtail splice with compatible size wiring shall be run from the 96CS electrical outlet(s) to the junction box and interconnected with dedicated homerun wiring using appropriate wire nuts.

7. No other circuits shall reside in this junction box to ensure survivability of the 96CS dedicated circuits are not interrupted or impacted.

8. Each rack shall require minimum 1-foot patch cables routed from each patch panel port to its corresponding network switch port. All network equipment to provide LAN connectivity is specified by 96CS and funded by the contractor or the occupying customer.

120V / 20A dedicated circuit w/Quad receptacle mounted at base of rack w/receptacles facing towards center of rack

120V / 30A dedicated circuit w/NEMA L5-30R w/ Duplex receptacle mounted at base of rack w/receptacle facing towards center of rack

D.2. WALL-MOUNT LOCKABLE NETWORK ENCLOSURE (VERTICAL EQUIPMENT MOUNT)

Standard AF Data Wall-Mount Lockable Enclosure (WMLE) Elevations for all 96CS TRs

Current as of: 20 Nov 23

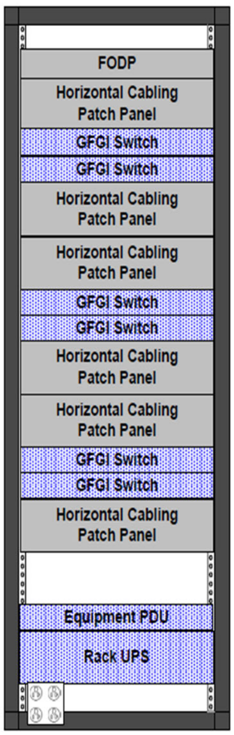


Figure D2.1
GL48WDXM-B-SH-AF
48" x 24" x 32"
350 lbs Weight Capacity
or equivalent

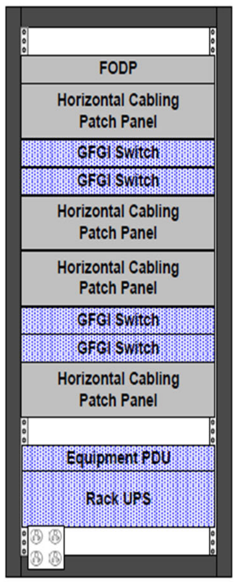


Figure D2.2
GL36WDXM-B-SH-AF
36" x 24" x 32"
300 lbs Weight Capacity
or equivalent

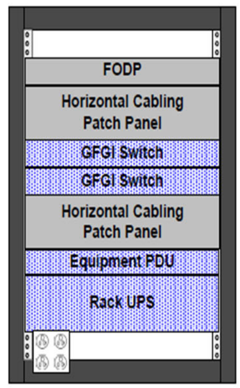


Figure D2.3
GL24WDXM-B-SH-AF
24" x 24" x 32"
250 lbs Weight Capacity
or equivalent

Notes:

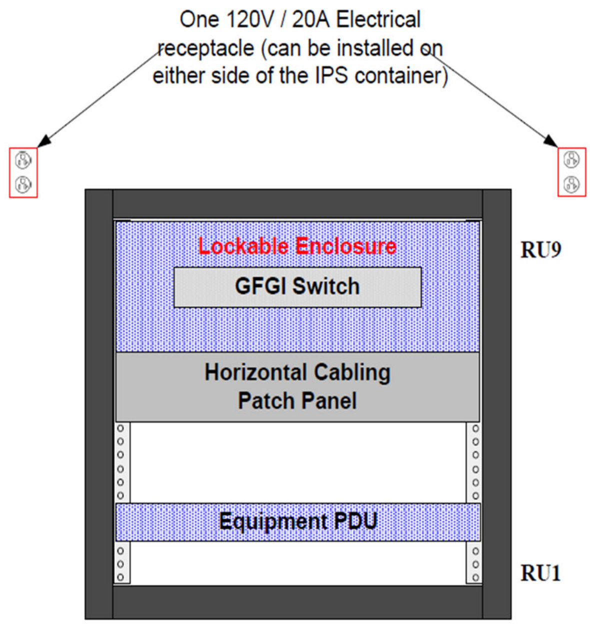
1. WMLE shall be mounted on backer board in TR. All AF network equipment shall be mounted in WMLE.
2. A 120V / 20A dedicated circuit shall be mounted inside WMLE toward the bottom facing the front. Preferably on either side inside the WMLE.
3. Rack elevation shown here is front-view depiction. If UPS is required, it will be placed at the bottom of the WMLE above the electrical receptacle , but 1U below the surge arrestor.
4. A dedicated junction box shall be placed no greater than 2-feet from the 96CS lockable enclosure and appropriate electrical wiring shall be homerun from supporting electrical panel to junction box. A pigtail splice with compatible size wiring shall be run from the 96CS electrical outlet(s) to the junction box and interconnected with dedicated homerun wiring using appropriate wire nuts.
5. No other circuits shall reside in this junction box to ensure survivability of the 96CS dedicated circuits are not interrupted or impacted.
6. Each rack shall require 1-foot patch cables routed from each patch panel port to its corresponding network switch port. All network equipment to provide LAN connectivity is specified by 96CS and funded by the contractor or the occupying customer.
7. All 96CS fiber optic PPs and TP PPs shall also be terminated inside the WMLE.
8. All WMLE's shall be double-hinged with a solid metal front door.
9. All keys to WMLE's shall be turned over to the 96CS upon installation.
10. All WMLE's shall be sized to support 20% growth.
11. All WMLE's shall be grounded IAW UFC 3-580-01.

120V / 20A dedicated circuit w/Quad receptacle mounted at base of rack w/receptacles facing towards front of rack

D.3. IPS CONTAINER

Standard Rack Elevation for 96CS IPS Container

Current as of: 20 Nov 23



Hamilton Class 5 Single Door Model 23-36-19 (or Equivalent)

Notes:

1. IPS container shall be installed in End-User-Area and not in 96CS TR.
2. All 96CS network equipment shall be mounted IAW the diagram to the left.
3. 96CS Network switch shall be housed in IPS container inside a lockable enclosure (such as the Mier Box BW-235) and placed at RU 7-9.
4. A 120V / 20A dedicated circuit shall be mounted outside located at the top left or right of the IPS container, but no further than 1-foot away.
5. Rack elevation shown here is front-view depiction.
6. All network equipment to provide LAN connectivity is specified by 96CS and funded by the occupying customer.
7. All IPS containers shall be Class 5 with single door.
8. All IPS containers shall meet proper clearances from the wall in order to circulate room air through the cabinet for electronic equipment cooling.
9. End User encryption devices will not be housed within IPS container, where feasible, to minimize required access to the container.

120V / 20A dedicated circuit w/duplex receptacle mounted inside enclosure.

Attachment E

CABLE MANAGEMENT ACCESSORIES

E.1. Cable Management.

BGS-79 – Brush grommet to cover rear vertical cable pass through
ESC-K12 – Cable management rail kit for front or rear rails; includes 12 sections of "fingers" (each section 7 RMU); rails will need to be recessed 4.5"
GL790ES-2242MS - Great Lakes 79" x 24" x 42" D Complete Rack Mount Enclosure, Black
SC67942 - Great Lakes External Cable Manager/Sidecar
SCP7942 Great Lakes Side Car End Panel
VCT-79 – Vertical cable trough
VCT-79C – Cover for VCT-79
VCB-7936 – Vertical cable bar kit (includes 1 vertical cable bar, 2 horizontal bars and 6-inch straps); use with optional ¼ turn "D" rings
CM-26 – Kit of 10, ¼ turn "D" rings, 3.5"x 5"

E.2. Other Accessories.

HDW-105-50 – Package of 50 M6 cage nuts with screws (12mm screw length)

Attachment F

SECURITY TECHNICAL IMPLEMENTATION GUIDE

F.1. PHYSICAL SECURITY

Based on the AFI 31-101 section 2.7.1.3 all locations where active communications equipment is used are designed as Protection Level 4 (PL) and have to be secured as such.

Every data switch in the network shall reside in a physically locked CEL closet, data center, or a lockable enclosure. Controlled areas are legally defined areas containing PL4 resources. Only authorized personnel, designated by a unit commander, have access to controlled areas.

The designation "controlled area" carries the same legal and moral restrictions as a physical barrier. Unless physical barriers are specifically required, the actual effectiveness of a controlled area may depend entirely on the security awareness of the people working in it. Installation commanders must designate areas containing the resources identified below.

APPLICABLE AFI REFERENCES

AFI 31-101, Section 2.7.1.3. - Mission essential communications facilities and computer centers, RAPCONs to include off installation navigational aids and related resources, control towers, power plants, and environmental control systems critical to operational capability.

The protection implemented shall be sufficient to protect the network from unauthorized personnel. The keys to the locked cabinets and dedicated communications rooms shall be controlled and only provided to authorized individuals appointed by 96 CS leadership.

APPLICABLE STIG REFERENCES

CAT III: NET0140 - The IAO/NSO will ensure the connection between the CSU/DSU and the local exchange carriers (LEC) data service jack (i.e., demarc) is in a secured environment.
CAT II: NET0210 - The IAO/NSO will ensure that all network devices (i.e., IDS, routers, RAS, NAS, firewalls, etc.) are located in a secure room with limited access.
CAT II: NET1730 - The IAO/NSO will ensure that the management workstation (NMS) is located in a secure environment.
CAT II: NET1832 - The ISSM will ensure the VPN tunnel demarcation is located in facilities authorized to process classified US government information, classified at the Secret Level (for SIPRNet).
CAT II: NET-VLAN-001 - The IAO/NSO will ensure that all switches and associated cross-connects hardware are kept in a secured IDF or an enclosed cabinet that is kept locked.

Attachment G

APPLICABLE PUBLICATIONS

Publications current time of contract or design build award or latest editions of the following publications shall apply and be utilized as applicable for engineering, installations, progress checks, quality controls, and final acceptance quality assurance inspections.

- Air Force Systems Security Instruction 7700, Emission Security
- Air Force Systems Security Instruction 7702, Emission Security Countermeasures Reviews
- Air Force Systems Security Instruction 7703, Communications Security: Protected Distribution Systems (PDS)
- ANSI C2-1997, National Electric Safety Code (NESC)
- ANSI/NEMA WC 66, Performance Standard for Category 6 and Category 7 100 Ohm Shielded and Unshielded Twisted Pairs
- ANSI/TIA-526-7, OFSTP-7 Measurement of Optical Power Loss of Installed Single-Mode Fiber Cable Plant
- ANSI/TIA-568-E.0, Generic Telecommunications Cabling for Customer Premises
- ANSI/TIA-568-E.1, Commercial Building Telecommunications Cabling Standard
- ANSI/TIA-568-E.2, Balanced Twisted-Pair Telecommunications Cabling and Components Standards
- ANSI/TIA-568-E.3, Optical Fiber Cabling Components Standard
- ANSI/TIA-568-E, Commercial Building Telecommunications Cabling Standard
- ANSI/TIA-569-E, Commercial Building Standard for Telecom Pathways & Spaces Wiring
- ANSI/TIA-570-D, Residential Telecommunications Cabling Standard
- ANSI/TIA-598, Optical Fiber Cable Color Coding
- ANSI/TIA-604-10, FOCIS 10 Fiber Optic Connector Intermateability Standard - Type LC
- ANSI/TIA-606-D, Administration Standard for the Telecommunications Infrastructure
- ANSI/TIA-607-D, Commercial Building Grounding and Bonding Requirements for Telecommunications
- ANSI/TIA-758, Customer-Owned Outside Plant Telecommunications Cabling Standard
- ANSI/TIA-1152, Requirements for Field Test
- ANSI/TIA 942 B DATA CENTER INFRASTRUCTURE
- ASTM C 478, Standard Specification for Precast Reinforced Concrete Maintenance Hole Sections
- ASTM D 709, Laminated Thermosetting Materials
- ASTM C 789, Standard Specification for Precast Reinforced Concrete Box Sections for Culverts, Storm Drains, and Sewers

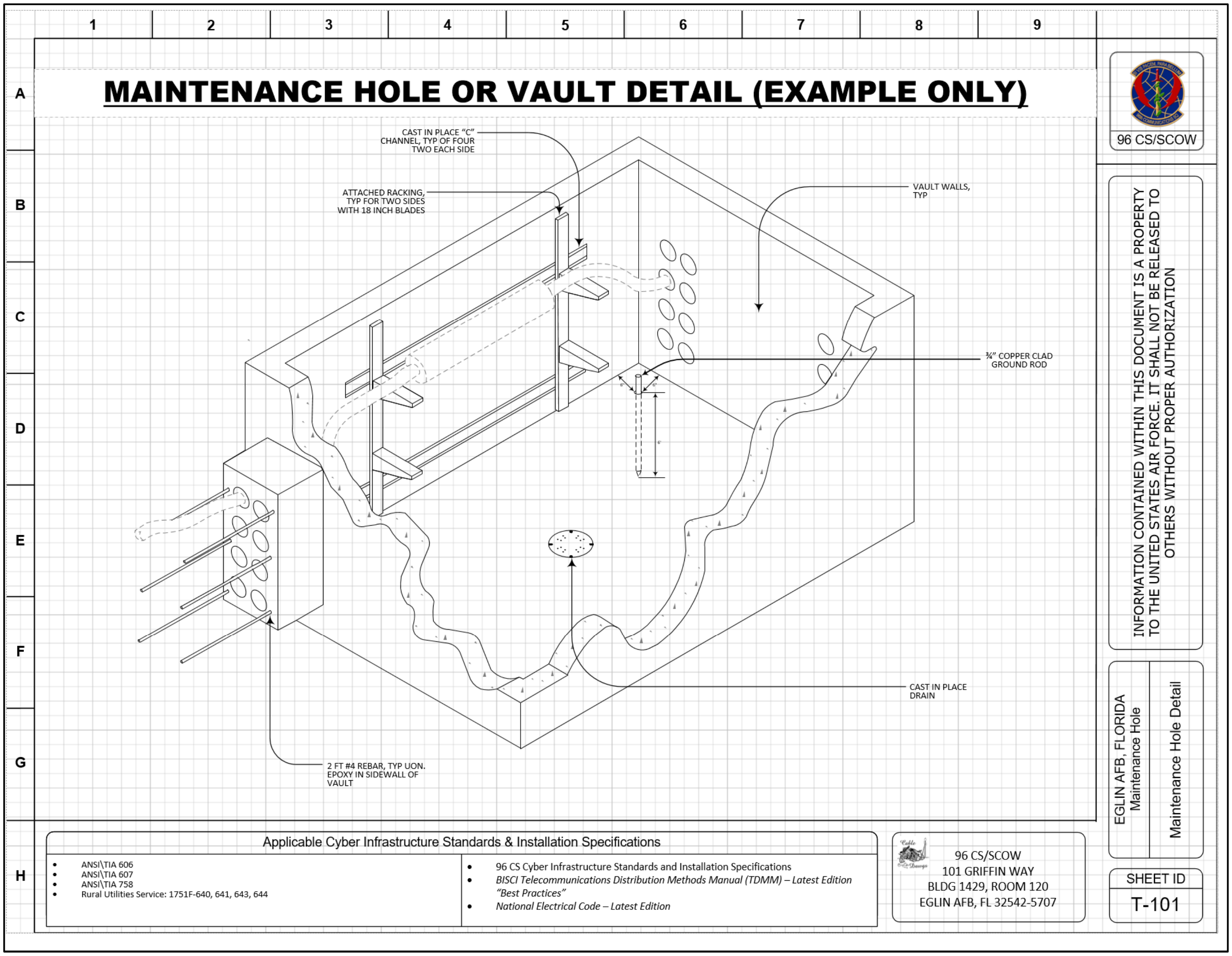
- ASTM C 850, Standard Specification for Precast Reinforced Concrete Box Sections for Culverts, Storm Drains, and Sewers with Less Than 2 Ft of Cover Subjected to Highway Loadings
- ASTM C 857, Standard Practice for Minimum Structural Design Loading for Underground Precast Utility Structures
- ASTM C 858, Standard Specification for Underground Precast Concrete Utility Structures
- ASTM C 890, Standard Practice for Minimum Structural Design Loading for Monolithic or Sectional Precast Concrete Water and Wastewater Structures
- ASTM C 891, Standard Practice for Installation of Underground Precast Concrete Utility Structures
- ASTM C 891.11, Standard Practice for Installation of Underground Precast Concrete Utility Structures
- ASTM C 913, Standard Specification for Precast Concrete Water and Wastewater Structures
- ASTM C 1037, Standard Practice for Inspection of Underground Precast Concrete Utility Structures
- CFR Title 47, Parts 68, Telecommunications, Federal Communications Commission Connection of terminal equipment to the telephone network
- DODI 5000.2, Part 6, System Safety, Health Hazards, and Environmental Impact
- ECA EIA/ECA 310, Cabinets, Racks, Panels, and Associated Equipment
- EPA CFR 40, Parts 1500-1508, Protection of Environment, Council on Environment Quality
- EPA CFR 40, Parts 260, 261, 262, 263, 264, 265, Hazardous Waste Generation and Transportation
- EPS-98-38EITS-001, Equipment Performance Specification for Maintenance and Operations Services for Base Telecommunications System
- FCC Part 68, Connection of Terminal Equipment to the Telephone Network (47 CFR 68)
- ICEA S-83-596, Indoor Optical Fiber Cables
- IEEE 100, The Authoritative Dictionary of IEEE Standards Terms
- MIL-STD-188-124B, Grounding, Bonding, and Shielding for Common/ Long Haul/ Tactical Systems Including Ground Based Communications-Electronics Facilities and Equipment
- MIL-STD-882-D, System Safety Program
- NECA/FOA 301-2016 Standard for Installing and Testing Fiber Optics
- NECA/NEMA 605-201X Standard for Installing Underground Nonmetallic Utility Duct
- NEMA Standards Publication TC-7
- NEMA Standards Publication TC-2
- NFPA 70, National Electrical Code
- NFPA 70-2002, National Electrical Code (NEC)
- OSHA CFR 29, Asbestos
- OSHA CFR 29, Excavation
- OSHA CFR 29, Hazardous Waste Operation and Emergency Response
- OSHA CFR 29, Occupational Safety and Health Standards

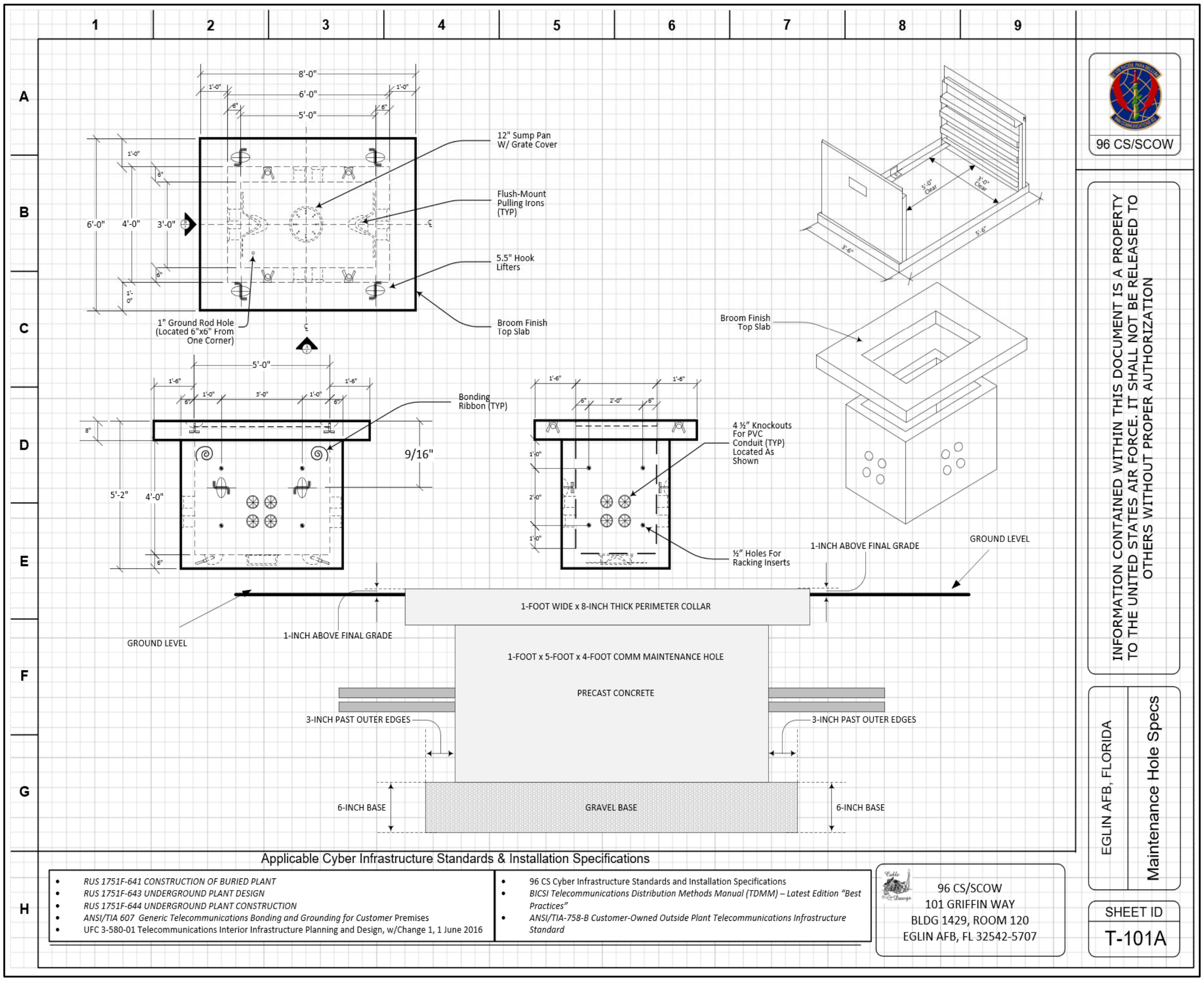
- OSHA CFR 29, Part 1910.1200, Hazard Communications
- OSHA CFR 29, Part 1910.147, The Control of Hazardous energy (Lockout/Tagout)
- OSHA CFR 29, Permit-required Confined Spaces
- OSHA CFR 29, Telecommunications
- REA Standard PC-5A, Bulletin 345-52, REA Standard for Service Entrance
- REA TE & CM Section 451.2, Shield Continuity
- REA TE & CM Section 644, Design and Construction of Underground Cable (Physical Plant)
- REA TE & CM Section 823, Electrical Protection by Use of Gas Tube Arresters
- REA TE & CM, Section 643, Underground Conduit and Maintenance hole Design and Construction
- REA TE & CM, Section 810, Electrical Protection of Electronic Analog Section Digital Central Office Equipment
- REA TE & CM, Section 825, Situations Requiring Special Protection
- Unified Facilities Criteria (UFC) 3-520-1 Interior Electrical Systems
- Unified Facilities Criteria (UFC) 3-580-1, Telecommunications Interior Infrastructure Planning and Design

- Unified Facilities Criteria (UFC) 4-010-05 - Sensitive Compartmented Information Facilities Planning, Design, and Construction
- Unified Facilities Criteria (UFC) 4-010-06 Cybersecurity of Facility
- Unified Facilities Criteria (UFC) Facilities Criteria (UFC) 4-510-01 Design: Military Medical Facilities
- Unified Facilities Criteria (UFC) 4-711-01 Family Housing
- UL 1286, Office Furnishings
- UL 1863, Communication Circuit Accessories
- UL 444, Communications Cables
- UL 467, Grounding and Bonding Equipment
- UL 50, Enclosures for Electrical
- UL 514C, Nonmetallic Outlet Boxes, Flush-Device Boxes, and Covers
- UL 723, Test for Surface Burning Characteristics of Building Materials
- UL 969, Standard for Marking and Labeling Systems

Attachment H

STANDARD INSTALLATION DRAWINGS




12" Sump Pan W/ Grate Cover
Flush-Mount Pulling Irons (TYP)
5.5" Hook Lifters
Broom Finish Top Slab
1" Ground Rod Hole (Located 6"x6" From One Corner)
8'-0"
6'-0"
5'-0"
4'-0"
3'-0"
Bonding Ribbon (TYP)
9/16"
5'-2"
4 ½" Knockouts For PVC Conduit (TYP) Located As Shown
½" Holes For Racking Inserts
1-INCH ABOVE FINAL GRADE
GROUND LEVEL
1-FOOT WIDE x 8-INCH THICK PERIMETER COLLAR
1-FOOT x 5-FOOT x 4-FOOT COMM MAINTENANCE HOLE
PRECAST CONCRETE
3-INCH PAST OUTER EDGES
6-INCH BASE
GRAVEL BASE
96 CS/SCOW
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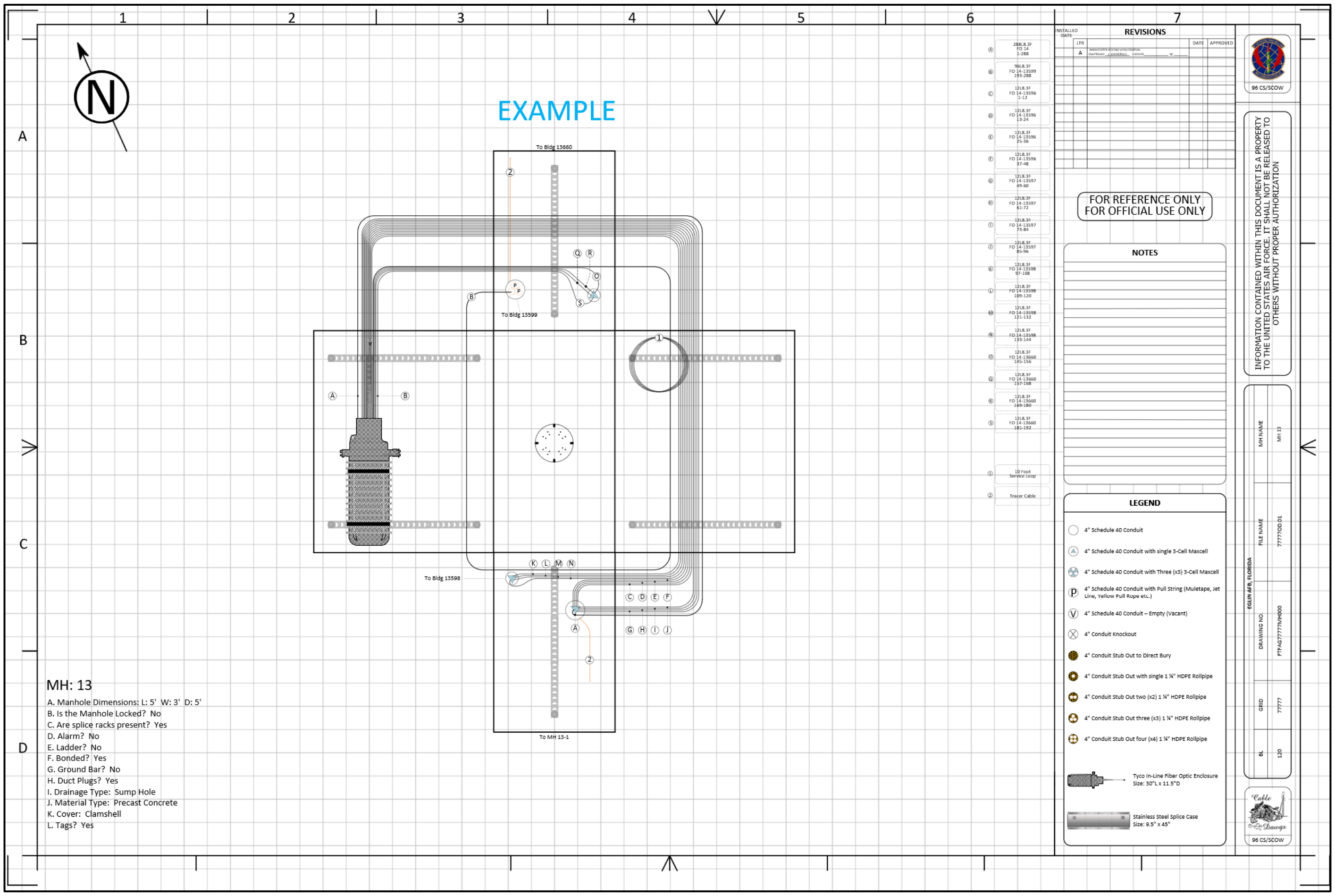
EGLIN AFB, FLORIDA
Maintenance Hole Specs
Applicable Cyber Infrastructure Standards & Installation Specifications
RUS 1751F-641 CONSTRUCTION OF BURIED PLANT
RUS 1751F-643 UNDERGROUND PLANT DESIGN
RUS 1751F-644 UNDERGROUND PLANT CONSTRUCTION
ANSI/TIA 607 Generic Telecommunications Bonding and Grounding for Customer Premises
UFC 3-580-01 Telecommunications Interior Infrastructure Planning and Design, w/Change 1, 1 June 2016
96 CS Cyber Infrastructure Standards and Installation Specifications
BICSI Telecommunications Distribution Methods Manual (TDMM) – Latest Edition "Best Practices"
ANSI/TIA-758-B Customer-Owned Outside Plant Telecommunications Infrastructure Standard
96 CS/SCOW
101 GRIFFIN WAY
BLDG 1429, ROOM 120
EGLIN AFB, FL 32542-5707
SHEET ID
T-101A


EXAMPLE
N
To Bldg 13660
To Bldg 13599
To Bldg 13598
To MH 13-1
FOR REFERENCE ONLY
FOR OFFICIAL USE ONLY
REVISIONS
NOTES
INFORMATION CONTAINED WITHIN THIS DOCUMENT IS A PROPERTY TO THE UNITED STATES AIR FORCE. IT SHALL NOT BE RELEASED TO OTHERS WITHOUT PROPER AUTHORIZATION
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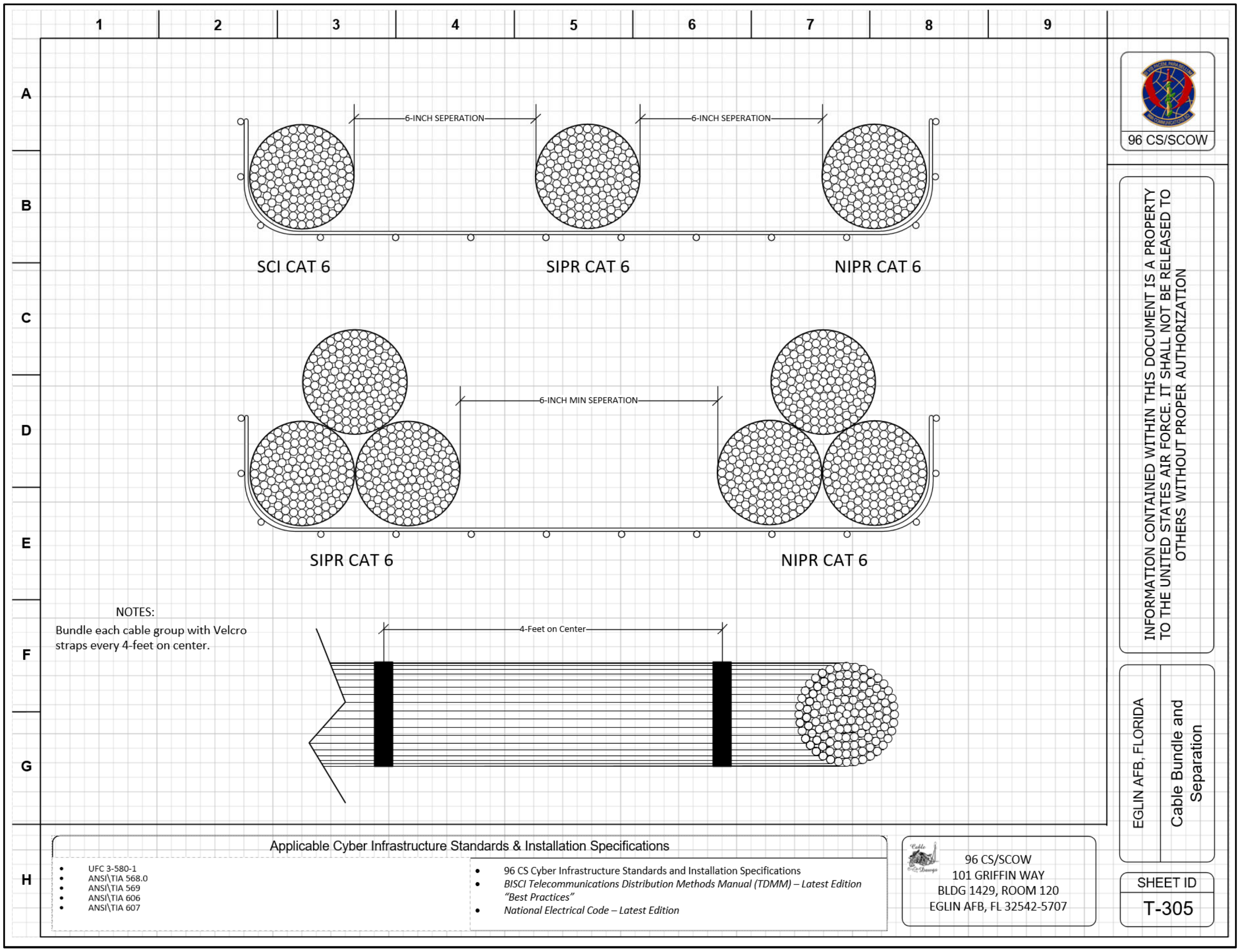
MH: 13
A. Manhole Dimensions: L: 5' W: 3' D: 5'
B. Is the Manhole Locked? No
C. Are splice racks present? Yes
D. Alarm? No
E. Ladder? No
F. Bonded? Yes
G. Ground Bar? No
H. Duct Plugs? Yes
I. Drainage Type: Sump Hole
J. Material Type: Precast Concrete
K. Cover: Clamshell
L. Tags? Yes
LEGEND
4" Schedule 40 Conduit
4" Schedule 40 Conduit with single 3-Cell Maxcell
4" Schedule 40 Conduit with Three (x3) 3-Cell Maxcell
4" Schedule 40 Conduit with Pull String (Muletape, Jet Line, Yellow Pull Rope etc.)
4" Schedule 40 Conduit – Empty (Vacant)
4" Conduit Knockout
4" Conduit Stub Out to Direct Bury
4" Conduit Stub Out with single 1 ¼" HDPE Rollpipe
4" Conduit Stub Out two (x2) 1 ¼" HDPE Rollpipe
4" Conduit Stub Out three (x3) 1 ¼" HDPE Rollpipe
4" Conduit Stub Out four (x4) 1 ¼" HDPE Rollpipe
Tyco In-Line Fiber Optic Enclosure
Size: 30"L x 11.5"D
Stainless Steel Splice Case
Size: 9.5" x 45"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6-INCH SEPERATION
6-INCH SEPERATION
SCI CAT 6
SIPR CAT 6
NIPR CAT 6
6-INCH MIN SEPERATION
SIPR CAT 6
NIPR CAT 6
NOTES:
Bundle each cable group with Velcro straps every 4-feet on center.
4-Feet on Center
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EGLIN AFB, FLORIDA
Cable Bundle and Separation
Applicable Cyber Infrastructure Standards & Installation Specifications
UFC 3-580-1
ANSI\TIA 568.0
ANSI\TIA 569
ANSI\TIA 606
ANSI\TIA 607
96 CS Cyber Infrastructure Standards and Installation Specifications
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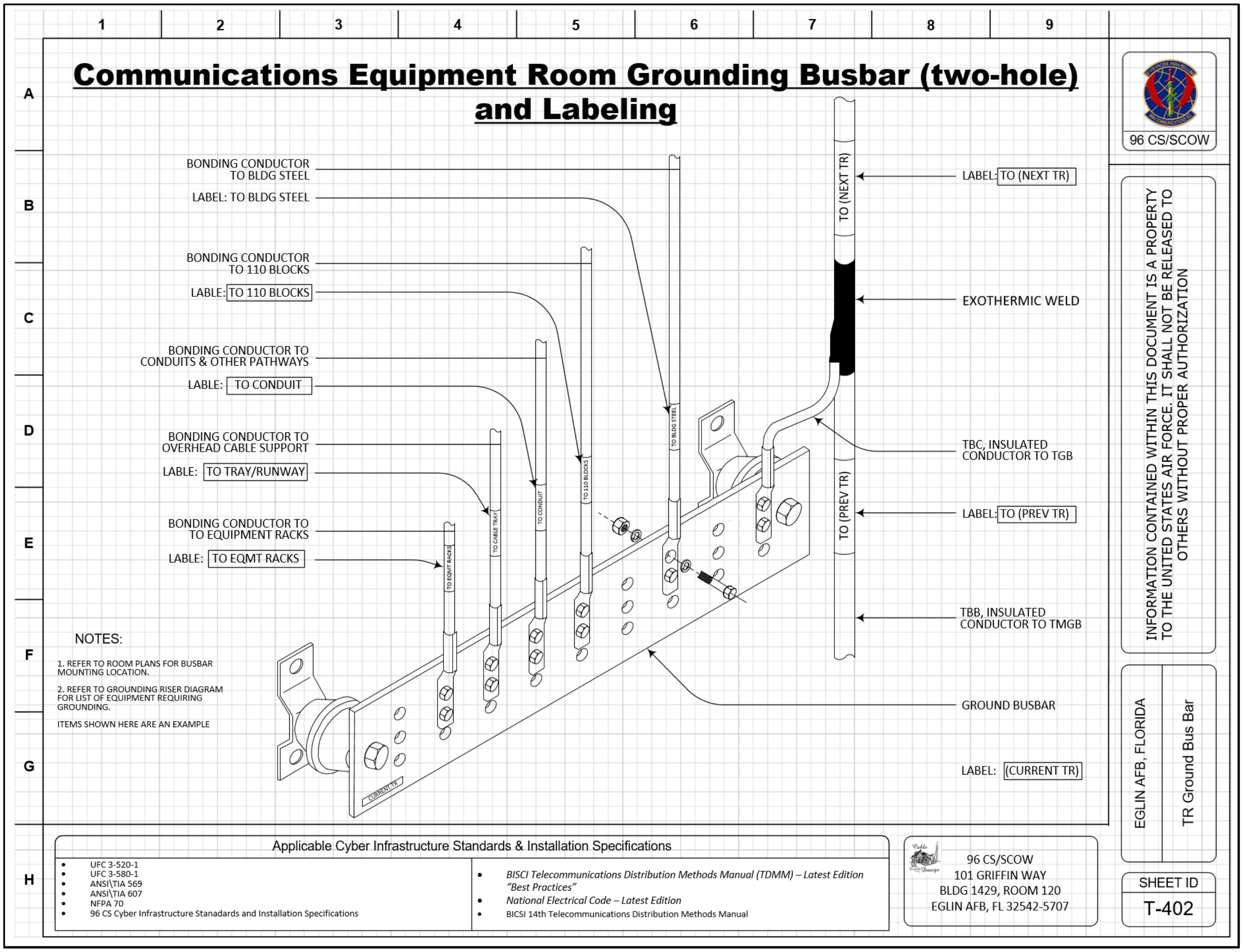
SHEET ID
T-305


Communications Equipment Room Grounding Busbar (two-hole) and Labeling
BONDING CONDUCTOR TO BLDG STEEL
LABEL: TO BLDG STEEL
BONDING CONDUCTOR TO 110 BLOCKS
LABLE: TO 110 BLOCKS
BONDING CONDUCTOR TO CONDUITS & OTHER PATHWAYS
LABLE: TO CONDUIT
BONDING CONDUCTOR TO OVERHEAD CABLE SUPPORT
LABLE: TO TRAY/RUNWAY
BONDING CONDUCTOR TO TO EQUIPMENT RACKS
LABLE: TO EQMT RACKS
TO (NEXT TR)
LABEL: TO (NEXT TR)
EXOTHERMIC WELD
TBC, INSULATED CONDUCTOR TO TGB
TO (PREV TR)
LABEL: TO (PREV TR)
TBB, INSULATED CONDUCTOR TO TMGB
GROUND BUSBAR
LABEL: (CURRENT TR)
CURRENT TR
NOTES:
1. REFER TO ROOM PLANS FOR BUSBAR MOUNTING LOCATION.
2. REFER TO GROUNDING RISER DIAGRAM FOR LIST OF EQUIPMENT REQUIRING GROUNDING.
ITEMS SHOWN HERE ARE AN EXAMPLE
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EGLIN AFB, FLORIDA
TR Ground Bus Bar
Applicable Cyber Infrastructure Standards & Installation Specifications
UFC 3-520-1
UFC 3-580-1
ANSI\TIA 569
ANSI\TIA 607
NFPA 70
96 CS Cyber Infrastructure Stanadards and Installation Specifications
BISCI Telecommunications Distribution Methods Manual (TDMM) – Latest Edition "Best Practices"
National Electrical Code – Latest Edition
BICSI 14th Telecommunications Distribution Methods Manual
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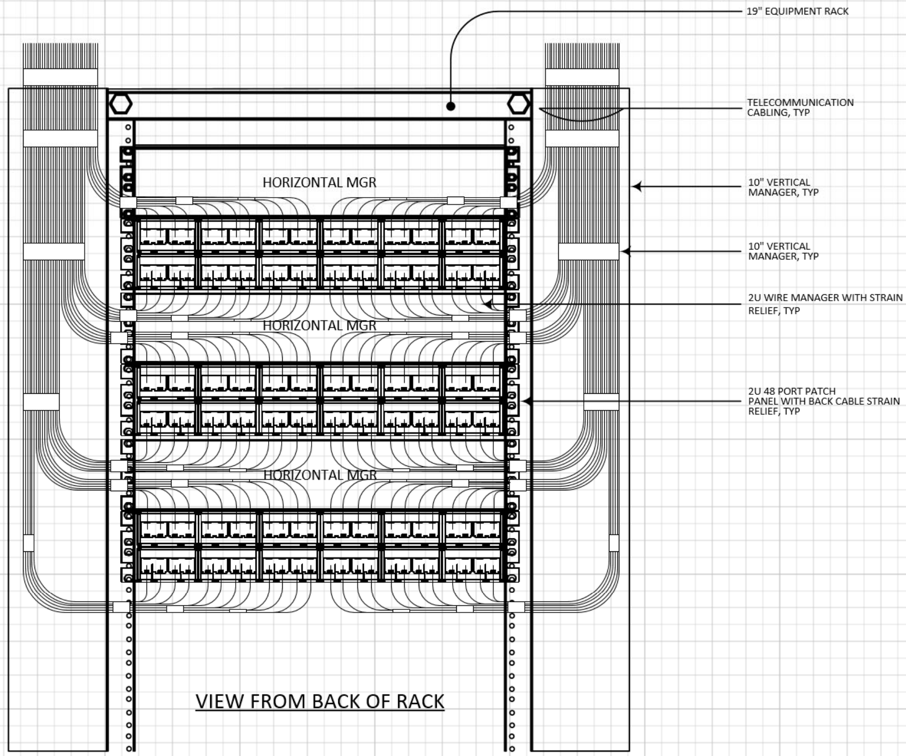
SHEET ID
T-402

TELECOMMUNICATIONS HORIZONTAL CABLE ROUTING AT EQUIPMENT CABINET OR RACK ASSEMBLY

NOTES:

1. ALL CABLES ROUTED TO CORRESPONDING PATCH PANELS SHALL BE SECURED ON A STRAIN RELIEF BAR PROVIDED WITH PATCH PANEL.



VIEW FROM BACK OF RACK

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EGLIN AFB, FLORIDA

Telecom Rm – Rack Horizontal Routing

SHEET ID

T-203A

Applicable Cyber Infrastructure Standards & Installation Specifications

- ANSI\TIA 568
- ANSI\TIA 569
- ANSI\TIA 606
- ANSI\TIA 607
- Unified Facilities Criteria (UFC) 3-580-1 Telecommunications interior Infrastructure Planning and Design
- Unified Facilities Criteria (UFC) 4-010-06 Cybersecurity of Facility
- 96 CS Cyber Infrastructure Standards and Installation Specifications
- BISCI Telecommunications Distribution Methods Manual (TDMM) – Latest Edition "Best Practices"
- National Electrical Code – Latest Edition

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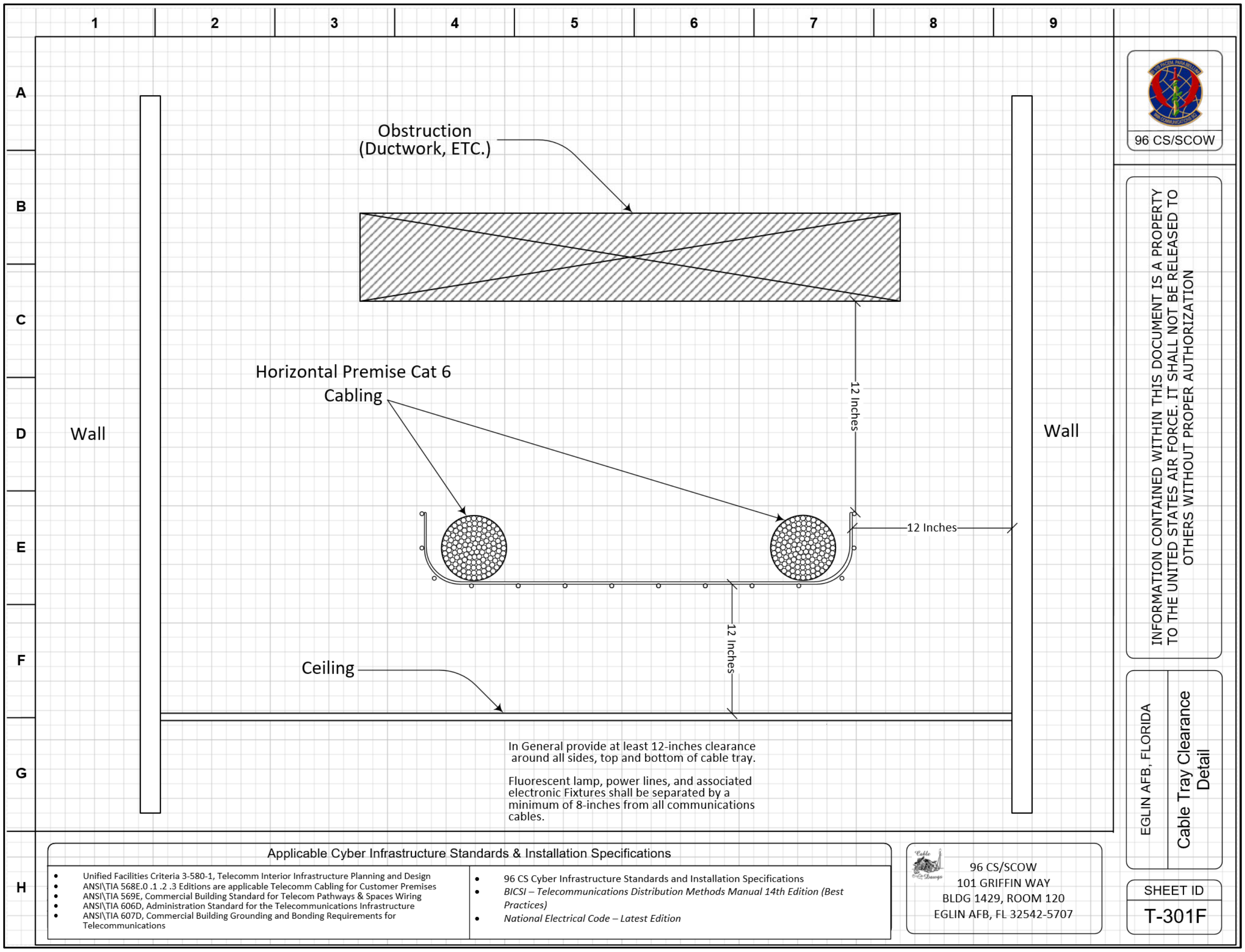
101 GRIFFIN WAY
BLDG 1429, ROOM 120
EGLIN AFB, FL 32542-5707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Obstruction
(Ductwork, ETC.)
Horizontal Premise Cat 6
Cabling
Wall
Wall
12 Inches
12 Inches
12 Inches
Ceiling
In General provide at least 12-inches clearance around all sides, top and bottom of cable tray.
Fluorescent lamp, power lines, and associated electronic Fixtures shall be separated by a minimum of 8-inches from all communications cables.
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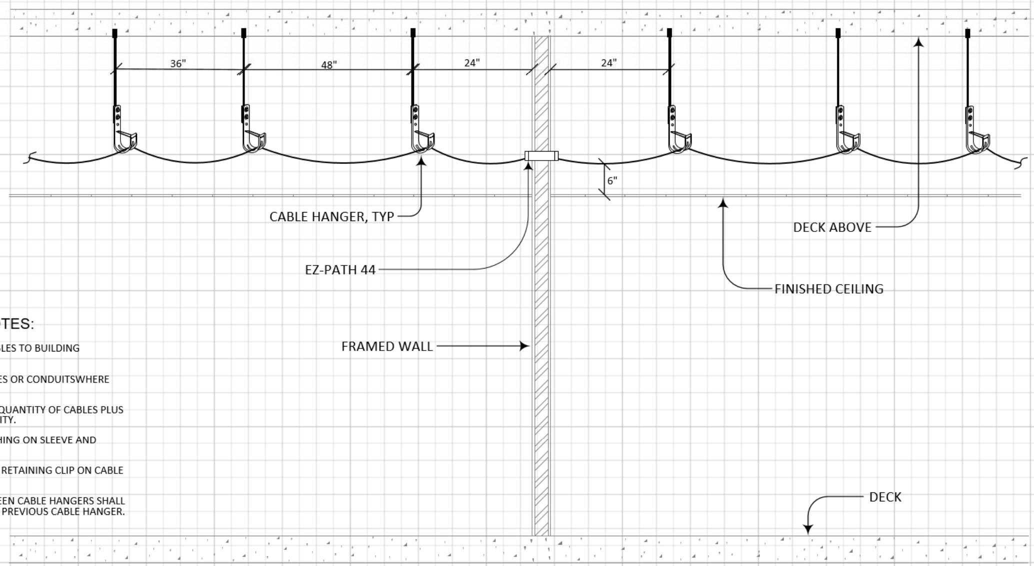
EGLIN AFB, FLORIDA
Cable Tray Clearance Detail
Applicable Cyber Infrastructure Standards & Installation Specifications
• Unified Facilities Criteria 3-580-1, Telecomm Interior Infrastructure Planning and Design
• ANSI\TIA 568E.0 .1 .2 .3 Editions are applicable Telecomm Cabling for Customer Premises
• ANSI\TIA 569E, Commercial Building Standard for Telecom Pathways & Spaces Wiring
• ANSI\TIA 606D, Administration Standard for the Telecommunications Infrastructure
• ANSI\TIA 607D, Commercial Building Grounding and Bonding Requirements for Telecommunications
• 96 CS Cyber Infrastructure Standards and Installation Specifications
• BICSI – Telecommunications Distribution Methods Manual 14th Edition (Best Practices)
• National Electrical Code – Latest Edition
Cable Dawgs
96 CS/SCOW
101 GRIFFIN WAY
BLDG 1429, ROOM 120
EGLIN AFB, FL 32542-5707
SHEET ID
T-301F

TELECOMMUNICATIONS CABLE ROUTING DETAIL USING J-HOOKS SUPPORT THROUGH FULL HEIGHT PARTITIONS



NOTES:

1. DO NOT TIE CABLES TO BUILDING STRUCTURES.
2. PROVIDE SLEEVES OR CONDUITSWHERE REQUIRED.
3. SIZE BASED ON QUANTITY OF CABLES PLUS 40% SPARE CAPACITY.
4. PROOVIDE BUSHING ON SLEEVE AND COONDUIT ENDS.
5. PROVIDE CABLE RETAINING CLIP ON CABLE HANGERS.
6. SPACING BETWEEN CABLE HANGERS SHALL NOT BE EQUAL TO PREVIOUS CABLE HANGER.

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EGLIN AFB, FLORIDA

Cable Routing – Full Height Wall

Applicable Cyber Infrastructure Standards & Installation Specifications

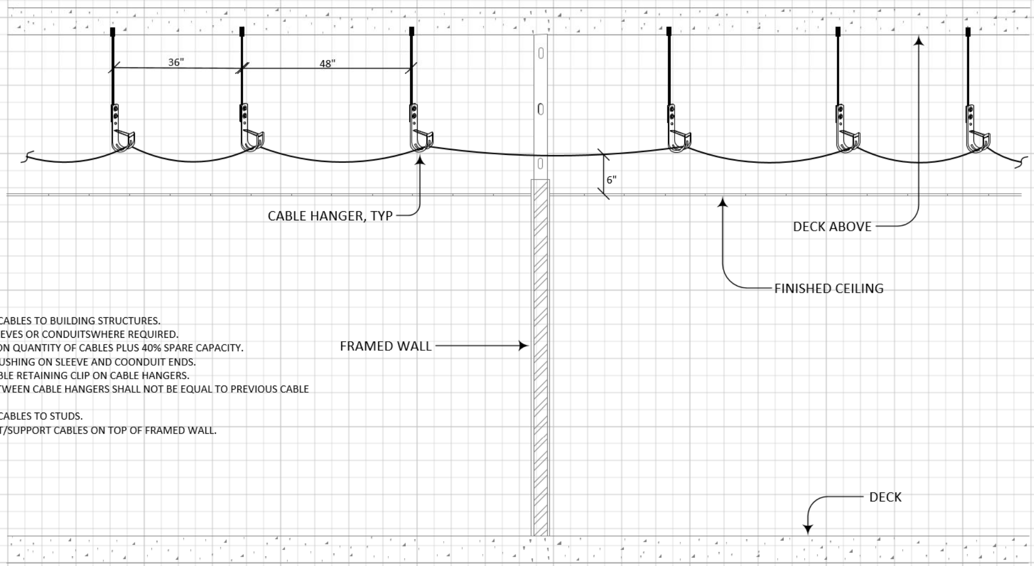
- Unified Facilities Criteria 3-580-1, Telecomm Interior Infrastructure Planning and Design
- ANSI\TIA 568E.0 .1 .2 .3 Editions are applicable Telecomm Cabling for Customer Premises
- ANSI\TIA 569E, Commercial Building Standard for Telecom Pathways & Spaces Wiring
- ANSI\TIA 606D, Administration Standard for the Telecommunications Infrastructure
- ANSI\TIA 607D, Commercial Building Grounding and Bonding Requirements for Telecommunications
- 96 CS Cyber Infrastructure Standards and Installation Specifications
- BICSI – Telecommunications Distribution Methods Manual 14th Edition (Best Practices)
- National Electrical Code – Latest Edition

96 CS/SCOW
101 GRIFFIN WAY
BLDG 1429, ROOM 120
EGLIN AFB, FL 32542-5707

SHEET ID
T-302

TELECOMMUNICATIONS CABLE ROUTING DETAIL USING J-HOOKS SUPPORT FOR LOW PROFILE PARTITIONS

96 CS/SCOW



NOTES:

1. DO NOT TIE CABLES TO BUILDING STRUCTURES.
2. PROVIDE SLEEVES OR CONDUITSWHERE REQUIRED.
3. SIZE BASED ON QUANTITY OF CABLES PLUS 40% SPARE CAPACITY.
4. PROOVIDE BUSHING ON SLEEVE AND COONDUIT ENDS.
5. PROVIDE CABLE RETAINING CLIP ON CABLE HANGERS.
6. SPACING BETWEEN CABLE HANGERS SHALL NOT BE EQUAL TO PREVIOUS CABLE HANGER.
7. DO NOT TIE CABLES TO STUDS.
8. DO NOT REST/SUPPORT CABLES ON TOP OF FRAMED WALL.

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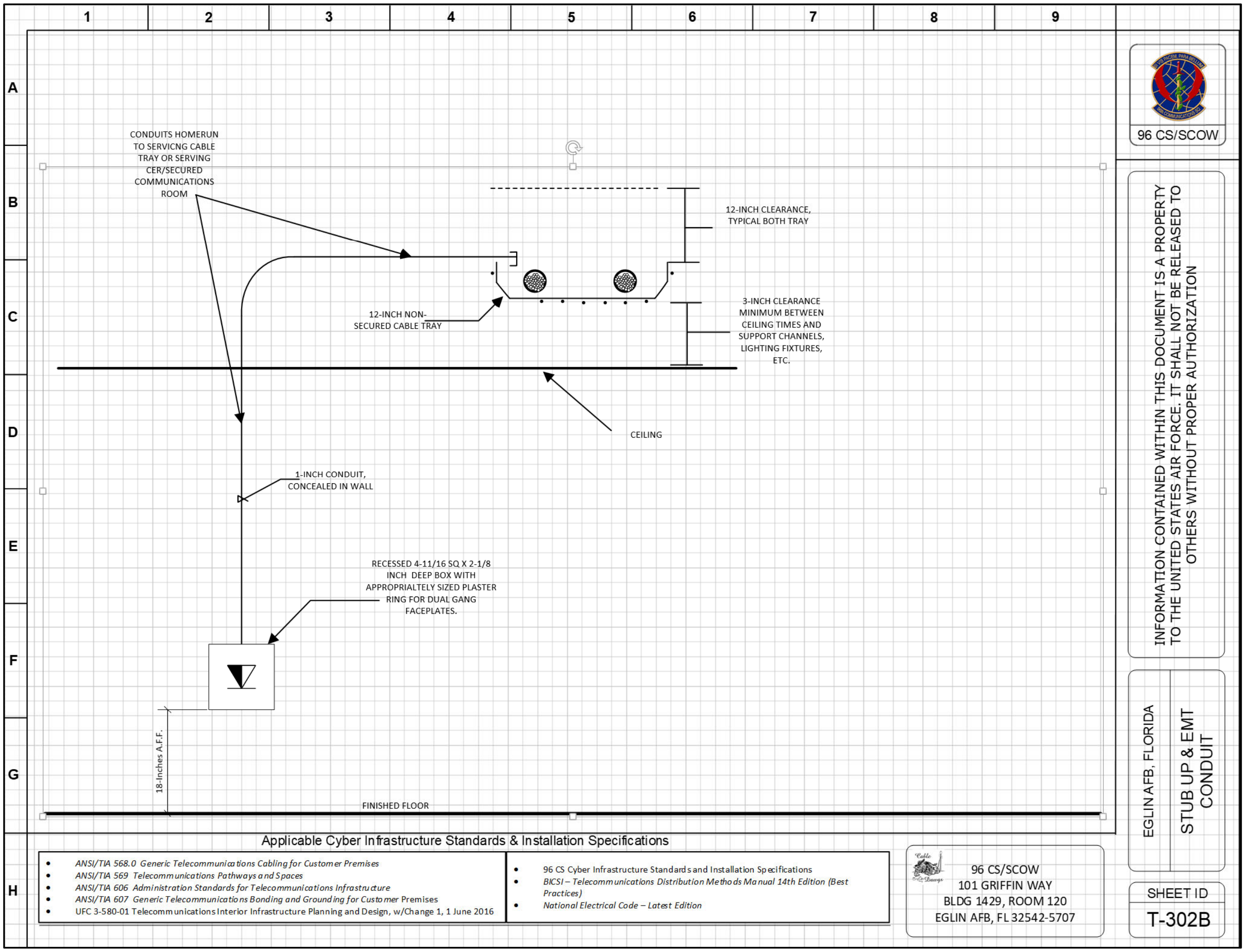
Cable Routing – Partition Wall

Applicable Cyber Infrastructure Standards & Installation Specifications

- Unified Facilities Criteria 3-580-1, Telecomm Interior Infrastructure Planning and Design
- ANSI\TIA 568E.0 .1 .2 .3 Editions are applicable Telecomm Cabling for Customer Premises
- ANSI\TIA 569E, Commercial Building Standard for Telecom Pathways & Spaces Wiring
- ANSI\TIA 606D, Administration Standard for the Telecommunications Infrastructure
- ANSI\TIA 607D, Commercial Building Grounding and Bonding Requirements for Telecommunications
- 96 CS Cyber Infrastructure Standards and Installation Specifications
- BICSI – Telecommunications Distribution Methods Manual 14th Edition (Best Practices)
- National Electrical Code – Latest Edition

96 CS/SCOW
101 GRIFFIN WAY
BLDG 1429, ROOM 120
EGLIN AFB, FL 32542-5707

SHEET ID
T-302A



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CONDUITS HOMERUN TO SERVICNG CABLE TRAY OR SERVING CER/SECURED COMMUNICATIONS ROOM
12-INCH CLEARANCE, TYPICAL BOTH TRAY
12-INCH NON-SECURED CABLE TRAY
3-INCH CLEARANCE MINIMUM BETWEEN CEILING TIMES AND SUPPORT CHANNELS, LIGHTING FIXTURES, ETC.
CEILING
1-INCH CONDUIT, CONCEALED IN WALL
RECESSED 4-11/16 SQ X 2-1/8 INCH DEEP BOX WITH APPROPRIALTELY SIZED PLASTER RING FOR DUAL GANG FACEPLATES.
18-Inches A.F.F.
FINISHED FLOOR
96 CS/SCOW
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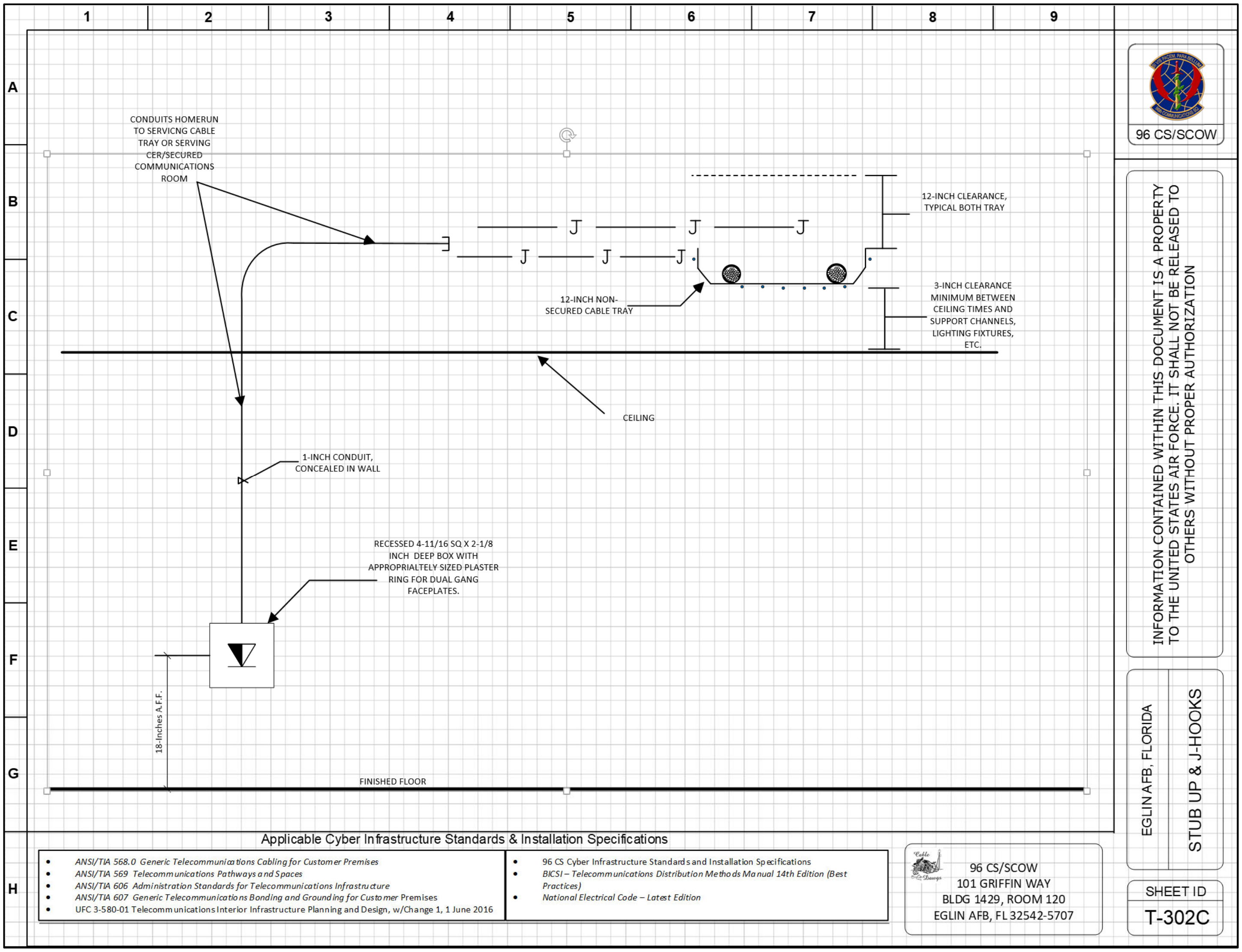
EGLIN AFB, FLORIDA
STUB UP & EMT CONDUIT
Applicable Cyber Infrastructure Standards & Installation Specifications
ANSI/TIA 568.0 Generic Telecommunications Cabling for Customer Premises
ANSI/TIA 569 Telecommunications Pathways and Spaces
ANSI/TIA 606 Administration Standards for Telecommunications Infrastructure
ANSI/TIA 607 Generic Telecommunications Bonding and Grounding for Customer Premises
UFC 3-580-01 Telecommunications Interior Infrastructure Planning and Design, w/Change 1, 1 June 2016
96 CS Cyber Infrastructure Standards and Installation Specifications
BICSI – Telecommunications Distribution Methods Manual 14th Edition (Best Practices)
National Electrical Code – Latest Edition
96 CS/SCOW
101 GRIFFIN WAY
BLDG 1429, ROOM 120
EGLIN AFB, FL 32542-5707
SHEET ID
T-302B


1
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A
B
C
D
E
F
G
H
CONDUITS HOMERUN TO SERVICNG CABLE TRAY OR SERVING CER/SECURED COMMUNICATIONS ROOM
12-INCH CLEARANCE, TYPICAL BOTH TRAY
12-INCH NON-SECURED CABLE TRAY
3-INCH CLEARANCE MINIMUM BETWEEN CEILING TIMES AND SUPPORT CHANNELS, LIGHTING FIXTURES, ETC.
CEILING
1-INCH CONDUIT, CONCEALED IN WALL
RECESSED 4-11/16 SQ X 2-1/8 INCH DEEP BOX WITH APPROPRIALTELY SIZED PLASTER RING FOR DUAL GANG FACEPLATES.
18-Inches A.F.F.
FINISHED FLOOR
96 CS/SCOW
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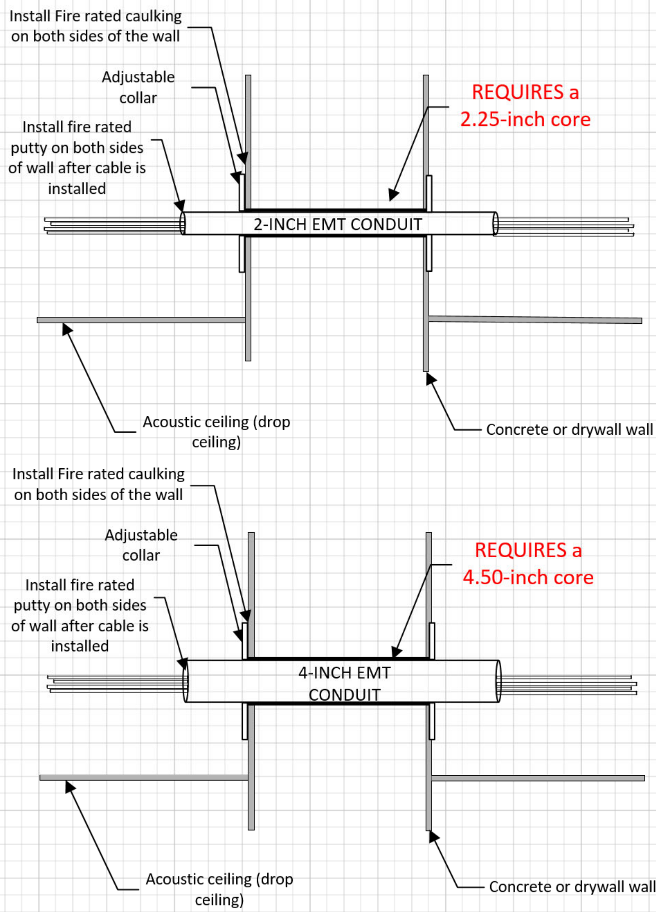
EGLIN AFB, FLORIDA
STUB UP & J-HOOKS
Applicable Cyber Infrastructure Standards & Installation Specifications
ANSI/TIA 568.0 Generic Telecommunications Cabling for Customer Premises
ANSI/TIA 569 Telecommunications Pathways and Spaces
ANSI/TIA 606 Administration Standards for Telecommunications Infrastructure
ANSI/TIA 607 Generic Telecommunications Bonding and Grounding for Customer Premises
UFC 3-580-01 Telecommunications Interior Infrastructure Planning and Design, w/Change 1, 1 June 2016
96 CS Cyber Infrastructure Standards and Installation Specifications
BICSI – Telecommunications Distribution Methods Manual 14th Edition (Best Practices)
National Electrical Code – Latest Edition
96 CS/SCOW
101 GRIFFIN WAY
BLDG 1429, ROOM 120
EGLIN AFB, FL 32542-5707
SHEET ID
T-302C



Applicable Standards

- *ANSI/TIA 568.0 Generic Telecommunications Cabling for Customer Premises*
- *ANSI/TIA 569 Telecommunications Pathways and Spaces*
- *ANSI/TIA 606 Administration Standards for Telecommunications Infrastructure*
- *ANSI/TIA 607 Generic Telecommunications Bonding and Grounding for Customer* Premises
- UFC 3-580-01 Telecommunications Interior Infrastructure Planning and Design, w/Change 1, 1 June 2016
- 96 CS Cyber Infrastructure Standards and Installation Specifications
- *BICSI – Telecommunications Distribution Methods Manual 14th Edition (Best Practices)*
- *National Electrical Code – Latest Edition*

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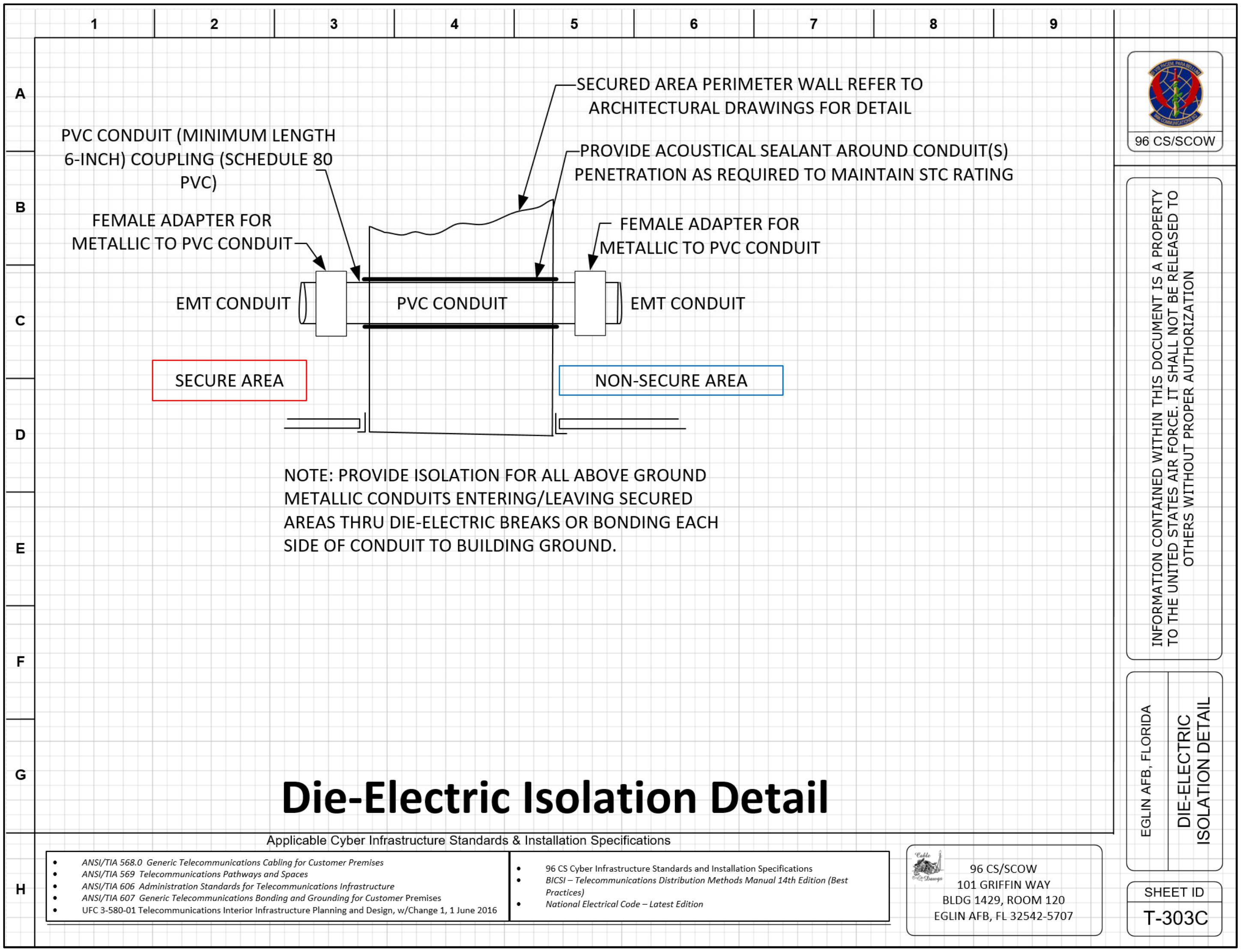
Wall Penetrations

SHEET ID
T-303A


1
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C
D
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F
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H
SECURED AREA PERIMETER WALL REFER TO ARCHITECTURAL DRAWINGS FOR DETAIL
PVC CONDUIT (MINIMUM LENGTH 6-INCH) COUPLING (SCHEDULE 80 PVC)
PROVIDE ACOUSTICAL SEALANT AROUND CONDUIT(S) PENETRATION AS REQUIRED TO MAINTAIN STC RATING
FEMALE ADAPTER FOR METALLIC TO PVC CONDUIT
FEMALE ADAPTER FOR METALLIC TO PVC CONDUIT
EMT CONDUIT
PVC CONDUIT
EMT CONDUIT
SECURE AREA
NON-SECURE AREA
NOTE: PROVIDE ISOLATION FOR ALL ABOVE GROUND METALLIC CONDUITS ENTERING/LEAVING SECURED AREAS THRU DIE-ELECTRIC BREAKS OR BONDING EACH SIDE OF CONDUIT TO BUILDING GROUND.
Die-Electric Isolation Detail
Applicable Cyber Infrastructure Standards & Installation Specifications
• ANSI/TIA 568.0 Generic Telecommunications Cabling for Customer Premises
• ANSI/TIA 569 Telecommunications Pathways and Spaces
• ANSI/TIA 606 Administration Standards for Telecommunications Infrastructure
• ANSI/TIA 607 Generic Telecommunications Bonding and Grounding for Customer Premises
• UFC 3-580-01 Telecommunications Interior Infrastructure Planning and Design, w/Change 1, 1 June 2016
• 96 CS Cyber Infrastructure Standards and Installation Specifications
• BICSI – Telecommunications Distribution Methods Manual 14th Edition (Best Practices)
• National Electrical Code – Latest Edition
96 CS/SCOW
101 GRIFFIN WAY
BLDG 1429, ROOM 120
EGLIN AFB, FL 32542-5707
96 CS/SCOW
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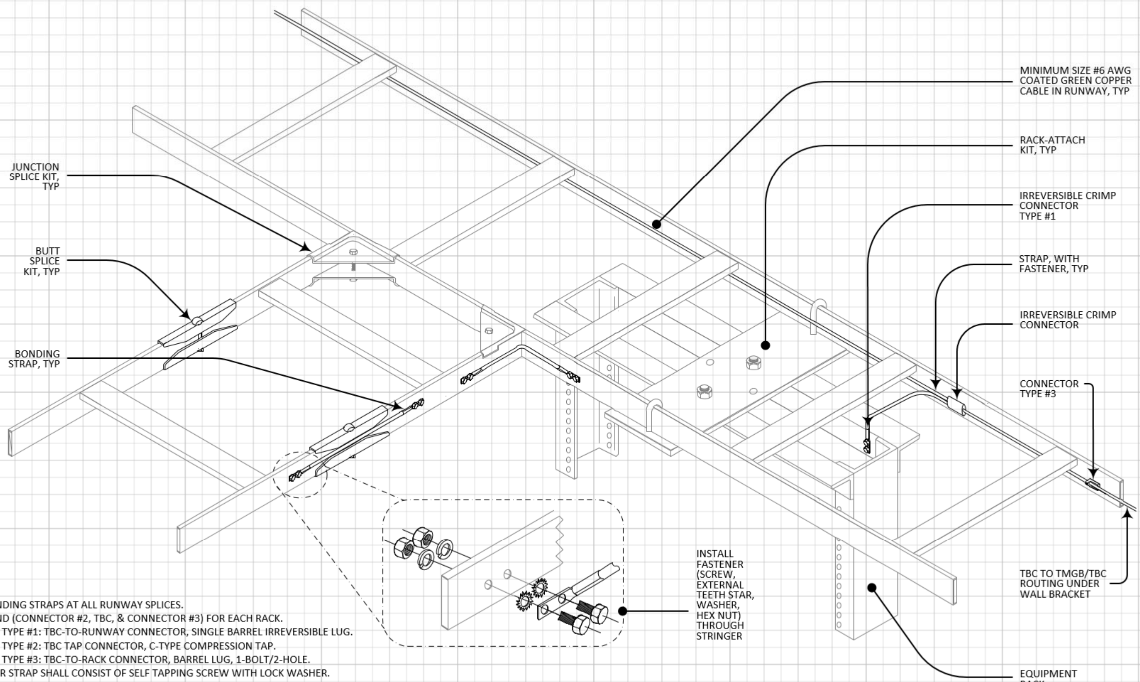
EGLIN AFB, FLORIDA
DIE-ELECTRIC ISOLATION DETAIL
SHEET ID
T-303C

1	2	3	4	5	6	7	8	9

TELECOMMUNICATIONS CABLE RUNWAY BONDING



NOTES:
1. PROVIDE BONDING STRAPS AT ALL RUNWAY SPLICES.
2. PROVIDE BOND (CONNECTOR #2, TBC, & CONNECTOR #3) FOR EACH RACK.
3. CONNECTOR, TYPE #1: TBC-TO-RUNWAY CONNECTOR, SINGLE BARREL IRREVERSIBLE LUG.
4. CONNECTOR, TYPE #2: TBC TAP CONNECTOR, C-TYPE COMPRESSION TAP.
5. CONNECTOR, TYPE #3: TBC-TO-RACK CONNECTOR, BARREL LUG, 1-BOLT/2-HOLE.
6. FASTENER FOR STRAP SHALL CONSIST OF SELF TAPPING SCREW WITH LOCK WASHER. FASTENER LENGTH SHALL NOT IMPEDE ON OPPOSITE SIDE OF STRINGER.
7. GROUND WIRE SHALL BE SEPARATED BY 2-INCHES FROM OTHER CONDUCTORS OR CABLE GROUPS OR INSTALLED UNDER OR OFF THE SIDE OF THE CABLE TRAY.
8. TAG OR LABEL ALL GROUND CONNECTIONS IW ANSI/TIA 606 AND ANSI/TIA 607

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Cable Runway Section Bonding

Applicable Cyber Infrastructure Standards & Installation Specifications

• Unified Facilities Criteria 3-580-1, Telecomm Interior Infrastructure Planning and Design • Unified Facilities Criteria 3-520-1, Interior Electrical Systems • ANSI\TIA 569E, Commercial Building Standard for Telecom Pathways & Spaces Wiring • ANSI\TIA 606D, Administration Standard for the Telecommunications Infrastructure • ANSI\TIA 607D, Commercial Building Grounding and Bonding Requirements for Telecommunications	• 96 CS Cyber Infrastructure Standards and Installation Specifications • BICSI – Telecommunications Distribution Methods Manual 14th Edition (Best Practices) • National Electrical Code – Latest Edition

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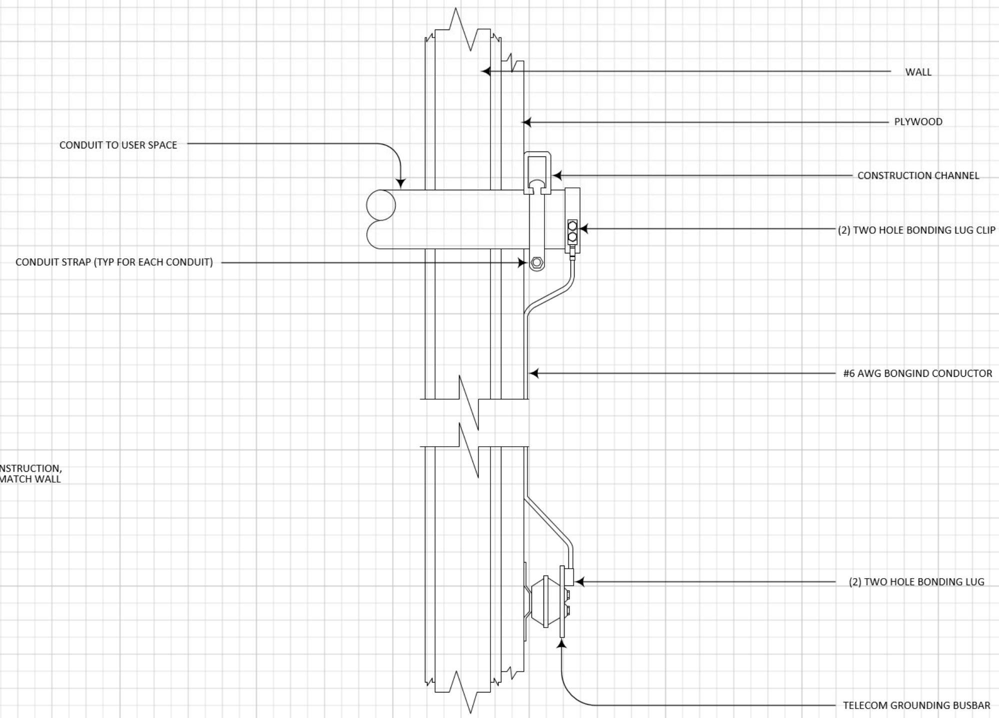
SHEET ID
T-405

1 2 3 4 5 6 7 8 9

A B C D E F G H

TELECOMMUNICATIONS CONDUIT BONDING



NOTES:

1. FOR FIRE RATED WALL CONSTRUCTION, PROVIDE FIRESTOPPING TO MATCH WALL RATING.

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Conduit Bonding

Applicable Cyber Infrastructure Standards & Installation Specifications

- Unified Facilities Criteria 3-580-1, Telecomm Interior Infrastructure Planning and Design
- ANSI\TIA 569E, Commercial Building Standard for Telecom Pathways & Spaces Wiring
- ANSI\TIA 606D, Administration Standard for the Telecommunications Infrastructure
- ANSI\TIA 607D, Commercial Building Grounding and Bonding Requirements for Telecommunications

- 96 CS Cyber Infrastructure Standards and Installation Specifications
- BICSI – Telecommunications Distribution Methods Manual 14th Edition (Best Practices)
- National Electrical Code – Latest Edition

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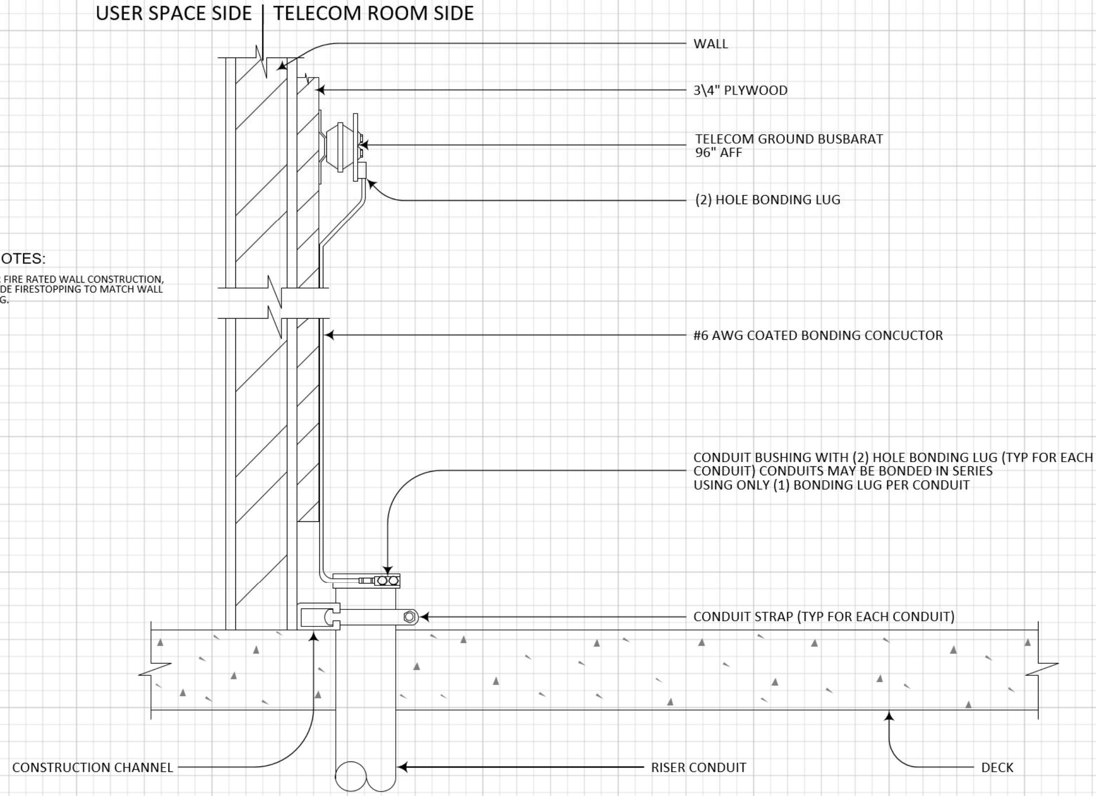
BLDG 1429, ROOM 120
EGLIN AFB, FL 32542-5707

SHEET ID

T-406

TELECOMMUNICATIONS RISER CONDUIT BONDING BETWEEN FLOORS



NOTES:

1. FOR FIRE RATED WALL CONSTRUCTION, PROVIDE FIRESTOPPING TO MATCH WALL RATING.

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Riser Conduit Bonding

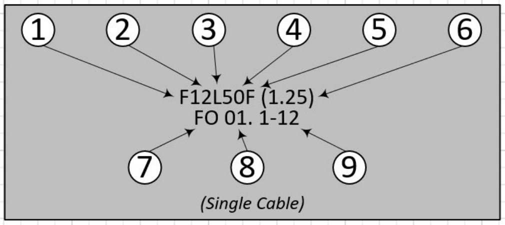
Applicable Cyber Infrastructure Standards & Installation Specifications

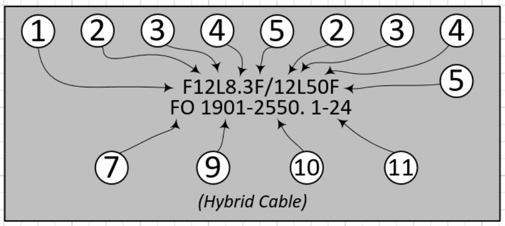
- Unified Facilities Criteria 3-580-1, Telecomm Interior Infrastructure Planning and Design
- ANSI\TIA 568E.0 .1 .2 .3 Editions are applicable Telecomm Cabling for Customer Premises
- ANSI\TIA 569E, Commercial Building Standard for Telecom Pathways & Spaces Wiring
- ANSI\TIA 606D, Administration Standard for the Telecommunications Infrastructure
- ANSI\TIA 607D, Commercial Building Grounding and Bonding Requirements for Telecommunications
- 96 CS Cyber Infrastructure Standards and Installation Specifications
- BICSI – Telecommunications Distribution Methods Manual 14th Edition (Best Practices)
- National Electrical Code – Latest Edition

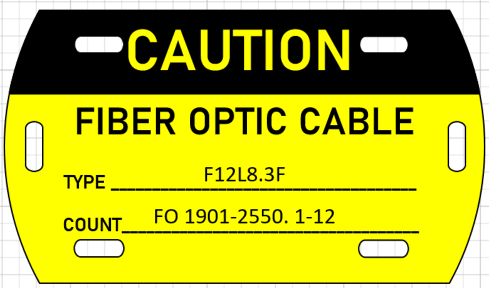
96 CS/SCOW
101 GRIFFIN WAY
BLDG 1429, ROOM 120
EGLIN AFB, FL 32542-5707

SHEET ID
T-406A

FIBER CABLE TAG INFORMATION







Fiber Optic Cable

1	-	P = Plenum (Else Leave Blank) R = Riser Rated (Else Leave Blank) F = Indoor/Outdoor
2	-	12 = 12 Strand Fiber Cable (Range is 1-288)
3	-	L = Loose Tube Buffer T = Tight Tube Buffer
4	-	Core Size in Microns Multimode = 50 and 62.5 (UNKNOWN = MM) Singlemode = 8.3, 9.2 or 10 (UNKNOWN = SM) (Cladding is assumed to be 125um, If different include after core size, separated with slash "/")
5	-	F = Filled Core (leave blank for Air Core)
6	-	(1.25) = Cable installed in 1.25" I.D. innerduct 1 = Cable installed in 1" I.D. innerduct Blank = No innerduct
7	-	FO – Fiber Optic Cable
8	-	##### - Cable Number (Range is 01 – 99999)
9	-	#### - Source Building Number
10	-	#### - Destination Building Number
11	-	1 – 12 = Conductor Count

CABLE NUMBERS WILL EITHER USE A SEQUENTIAL NUMBERING PATTERN
OR
SOURCE AND DESTINATION BUILDING NUMBERS

IF THE BUILDING NUMBER METHOD IS USED, THE SOURCE BUILDING WILL BE THE ITN AND DESTINATION WILL BE THE EBN
(BACKBONE CABLES MAY USE EITHER ITN AS THE SOURCE BUILDING)

Applicable Cyber Infrastructure Standards & Installation Specifications

- Unified Facilities Criteria 3-580-1, Telecomm Interior Infrastructure Planning and Design
- ANSI\TIA 606D, Administration Standard for the Telecommunications Infrastructure
- 96 CS Cyber Infrastructure Standards and Installation Specifications
- BICSI – Telecommunications Distribution Methods Manual 14th Edition (Best Practices)
- National Electrical Code – Latest Edition

- Cables shall be label/tagged at ducts, Conduits, service loops and transition entrance and exit points throughout the cable pathway to clearly identify ISP/OSP circuits.

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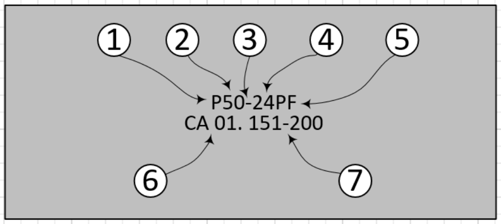
Fiber Cable Tag Information

SHEET ID
T-501B

COPPER CABLE TAG INFORMATION



Central Office Copper Cable

1 - Cable Outer Protection
P = Plastic Sheath Cable
PP = Double Layer Plastic Sheath Core
Blank = Lead Sheath Cable
A = ABAM Cable
WA = Wire Armored Cable
JP = Jute Protected Cable
TA = Tape Armored Cable
DTA = Double Tape Armored Cable

2 - (Size) Number of Cable Pairs in Sheath
(For Greater than 100 pairs Exclued “00”s when labeling cables)

3 - “X” = 24 Pair (or less) Cables
“-“ = 25 pair (or greater) cables

4 - Wire Gauge Size (19, 22, 24, or 26)

5 - Conductor Protection
PF = Plastic Insulated Filled Core Cable
FF = Foam Insulated Filled Core Cable
P = Plastic Insulated Air Core Cable

6 - Cable Number (Two Numeric Digits) “CA” Optional

7 - Inclusive Cable Count(s)
(If pairs are Dead/Dead Ended/Abandoned they are on a separate line below and denoted with a plus sign “+” followed by an Alpha Character (Sequential if Multiples) a comma “,” and the Inclusive pair count)

Applicable Cyber Infrastructure Standards & Installation Specifications

- Unified Facilities Criteria 3-580-1, Telecomm Interior Infrastructure Planning and Design
- ANSI\TIA 606D, Administration Standard for the Telecommunications Infrastructure
- 96 CS Cyber Infrastructure Standards and Installation Specifications
- BICSI – Telecommunications Distribution Methods Manual 14th Edition (Best Practices)
- National Electrical Code – Latest Edition

- Cables shall be label/tagged at ducts, conduits, service loops and transition entrance and exit points throughout the cable pathway to clearly identify ISP/OSP circuits.

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BLDG 1429, ROOM 120
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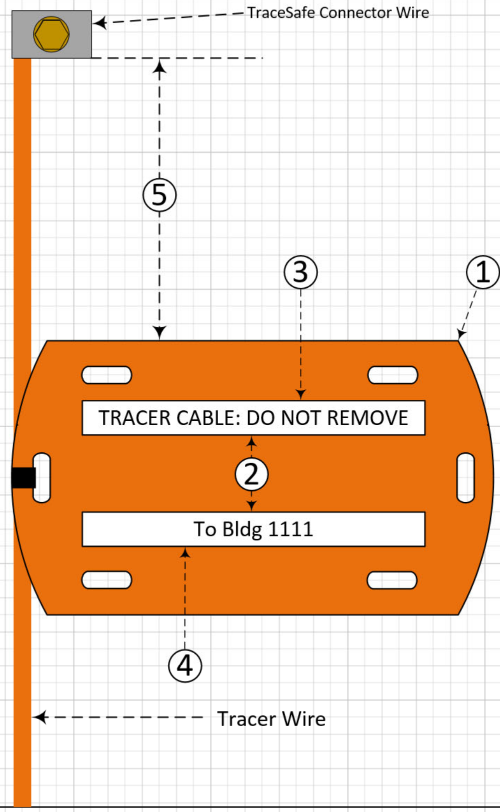
Copper Cable Tag Information

SHEET ID
T-501C



TRACER WIRE LABELING SPECS

① Use blank orange self-laminating tag measuring 2"x3.5" (part # TG-2284 or Telecommunications tag)

② Identifier on laser printed adhesive backed label

③ Tag to read: TRACER CABLE: DO NOT REMOVE

④ Identifier to next Maintenance hole, pedestal, building, surface mount equipment, etc.

⑤ Distance Shall Be No Less than 6 Inches and No Greater than 12 Inches

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OSP Tracer Wire Tag

Applicable Cyber Infrastructure Standards & Installation Specifications

- ANSI\TIA 606D, Administration Standard for the Telecommunications Infrastructure
- ANSI\TIA 607D, Commercial Building Grounding and Bonding Requirements for Telecommunications
- ANSI/TIA-758-B Customer-Owned Outside Plant Telecommunications Infrastructure Standard
- 96 CS Cyber Infrastructure Standards and Installation Standards
- *BISCI Telecommunications Distribution Methods Manual (TDMM) – Latest Edition "Best Practices"*
- *National Electrical Code – Latest Edition*

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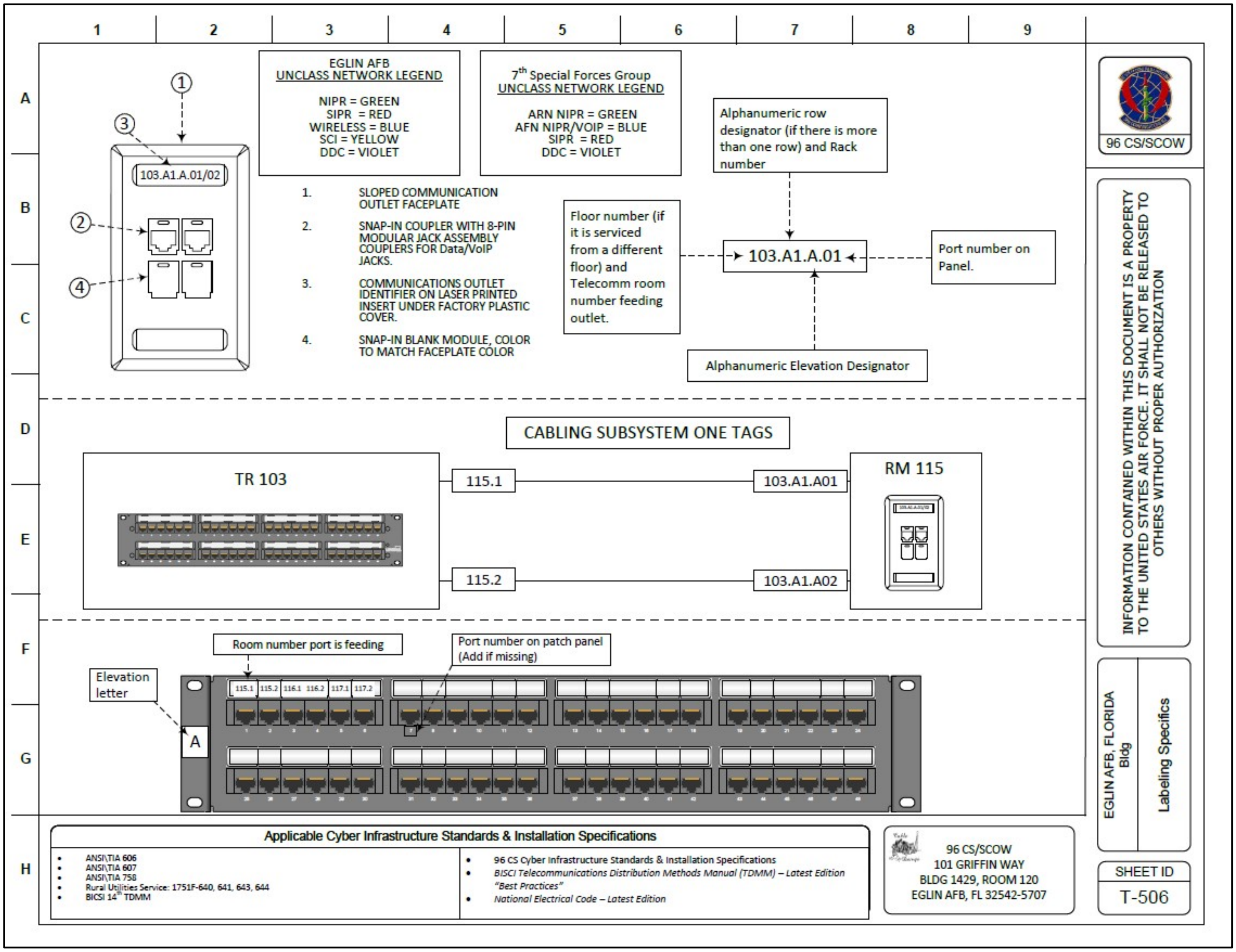
101 GRIFFIN WAY
BLDG 1429, ROOM 120
EGLIN AFB, FL 32542-5707

SHEET ID

T-501D



EGLIN AFB
UNCLASS NETWORK LEGEND
NIPR = GREEN
SIPR = RED
WIRELESS = BLUE
SCI = YELLOW
DDC = VIOLET
7th Special Forces Group
UNCLASS NETWORK LEGEND
ARN NIPR = GREEN
AFN NIPR/VOIP = BLUE
SIPR = RED
DDC = VIOLET
103.A1.A.01/02
1. SLOPED COMMUNICATION OUTLET FACEPLATE
2. SNAP-IN COUPLER WITH 8-PIN MODULAR JACK ASSEMBLY COUPLERS FOR Data/VoIP JACKS.
3. COMMUNICATIONS OUTLET IDENTIFIER ON LASER PRINTED INSERT UNDER FACTORY PLASTIC COVER.
4. SNAP-IN BLANK MODULE, COLOR TO MATCH FACEPLATE COLOR
Alphanumeric row designator (if there is more than one row) and Rack number
Floor number (if it is serviced from a different floor) and Telecomm room number feeding outlet.
103.A1.A.01
Port number on Panel.
Alphanumeric Elevation Designator
CABLING SUBSYSTEM ONE TAGS
TR 103
115.1
115.2
103.A1.A01
103.A1.A02
RM 115
Room number port is feeding
Port number on patch panel (Add if missing)
Elevation letter
A
115.1 115.2 116.1 116.2 117.1 117.2
Applicable Cyber Infrastructure Standards & Installation Specifications
ANSI\TIA 606
ANSI\TIA 607
ANSI\TIA 758
Rural Utilities Service: 1751F-640, 641, 643, 644
BICSI 14th TDMM
96 CS Cyber Infrastructure Standards & Installation Specifications
BISCI Telecommunications Distribution Methods Manual (TDMM) – Latest Edition "Best Practices"
National Electrical Code – Latest Edition
96 CS/SCOW
101 GRIFFIN WAY
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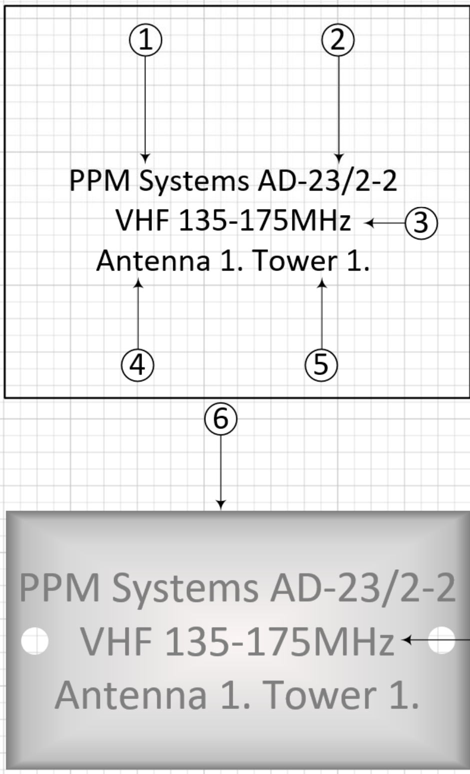
EGLIN AFB, FLORIDA
Bldg
Labeling Specifics
SHEET ID
T-506

ANTENNA IDENTIFICATION TAG INFORMATION



1 - Antenna make

2 - Antenna model number

3 - Frequency Range

4 - Antenna #

5 - Structure (pole 1, pole 2, tower 1, tower 2, etc.)

6 - Antenna identification Data Tag for Exterior Items (must be UV resistant and designed for outside use; typically stainless steel) Minimum size shall be 1.5" x 3".

7 - Tag information shall be stamped or embossed onto tag.

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Antenna Identification Tag

Applicable Cyber Infrastructure Standards & Installation Specifications

- Unified Facilities Criteria 3-580-1, Telecomm Interior Infrastructure Planning and Design
- ANSI\TIA 568E.0 .1 .2 .3 Editions are applicable Telecomm Cabling for Customer Premise
- ANSI\TIA 569E, Commercial Building Standard for Telecom Pathways & Spaces Wiring
- ANSI\TIA 606D, Administration Standard for the Telecommunications Infrastructure
- ANSI\TIA 607D, Commercial Building Grounding and Bonding Requirements for Telecommunications
- 96 CS Cyber Infrastructure Standards and Installation Standards
- *BISCI Telecommunications Distribution Methods Manual (TDMM) – Latest Edition "Best Practices"*
- *National Electrical Code – Latest Edition*
- Technical Order 00-33A-1001 Methods & Procedures General Cyberspace Support

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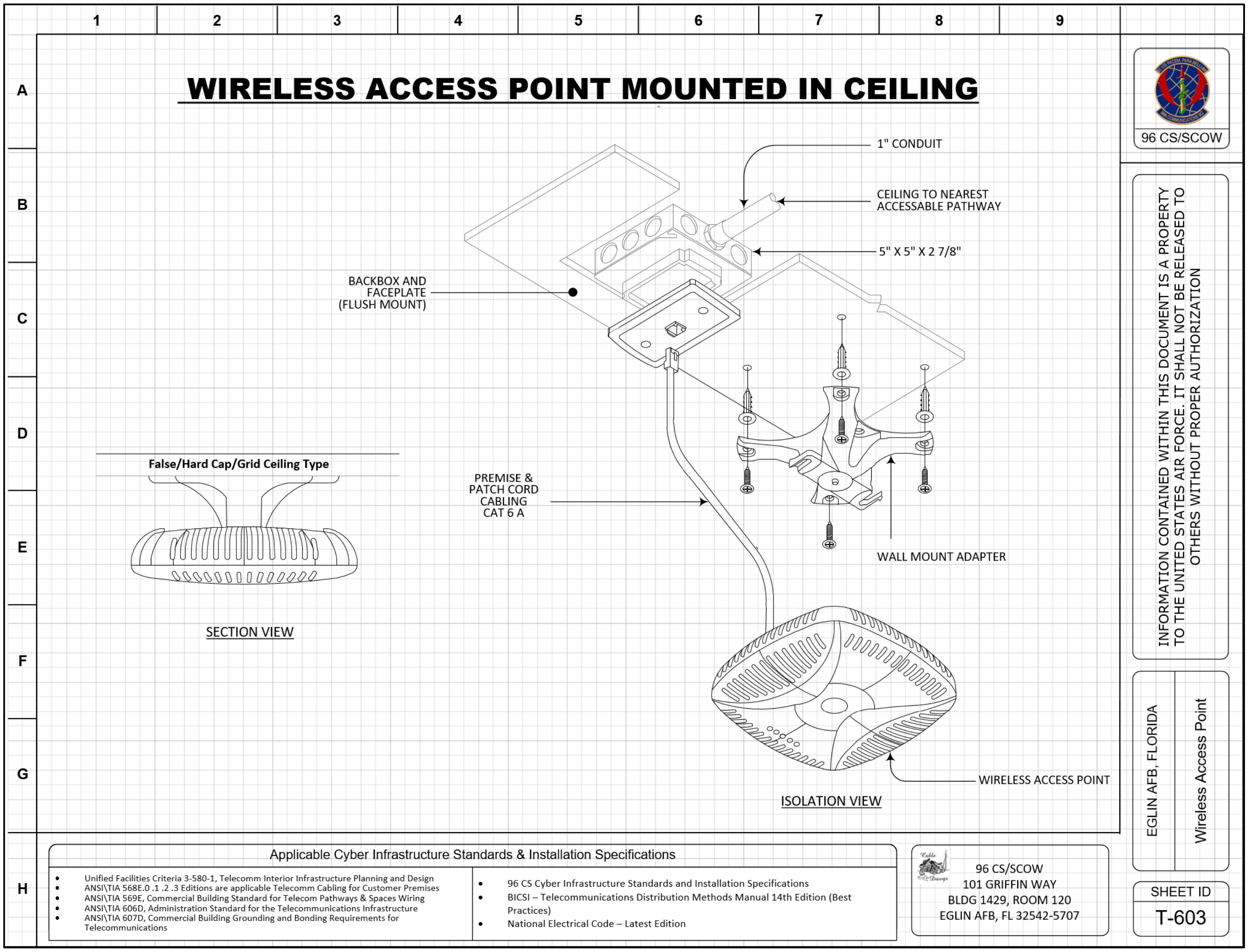
SHEET ID
T-507


WIRELESS ACCESS POINT MOUNTED IN CEILING
96 CS/SCOW
1" CONDUIT
CEILING TO NEAREST ACCESSABLE PATHWAY
5" X 5" X 2 7/8"
BACKBOX AND FACEPLATE (FLUSH MOUNT)
PREMISE & PATCH CORD CABLING CAT 6 A
WALL MOUNT ADAPTER
False/Hard Cap/Grid Ceiling Type
SECTION VIEW
WIRELESS ACCESS POINT
ISOLATION VIEW
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EGLIN AFB, FLORIDA
Wireless Access Point
Applicable Cyber Infrastructure Standards & Installation Specifications
Unified Facilities Criteria 3-580-1, Telecomm Interior Infrastructure Planning and Design
ANSI\TIA 568E.0 .1 .2 .3 Editions are applicable Telecomm Cabling for Customer Premises
ANSI\TIA 569E, Commercial Building Standard for Telecom Pathways & Spaces Wiring
ANSI\TIA 606D, Administration Standard for the Telecommunications Infrastructure
ANSI\TIA 607D, Commercial Building Grounding and Bonding Requirements for Telecommunications
96 CS Cyber Infrastructure Standards and Installation Specifications
BICSI – Telecommunications Distribution Methods Manual 14th Edition (Best Practices)
National Electrical Code – Latest Edition
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EGLIN AFB, FL 32542-5707
SHEET ID
T-603

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APPENDIX C

GEOTECHNICAL REPORT

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GEOTECHNICAL EXPLORATION REPORT

D51 HANGAR CONVERSION,
HUMAN PERFORMANCE CENTER
FTFA 23-VH59
EGLIN AFB, WALTON COUNTY, FLORIDA

UES PROJECT NO. 1730.2300082.0000
UES REPORT NO. 2074984

MARCH 5, 2024

Prepared For:

Bullock Tice Associates, LLC
909 East Cervantes Street
Pensacola, Florida 32501

Prepared By:

Universal Engineering Sciences
1985 Cope Lane
Pensacola, Florida 32526

March 5, 2024

Bullock Tice Associates, LLC
909 East Cervantes Street
Pensacola, Florida 32501

Attention: Mr. Bob Maggiore, R.A.
b.maggiore@bulltice.com

Reference: **Geotechnical Exploration Report**
D51 Hangar Conversion, Human Performance Center
FTFA 23-VH59
Eglin AFB, Walton County, Florida
UES Project Number 1730.2300082.0000
UES Report Number 2074984

Mr. Maggiore:

Universal Engineering Sciences (UES) has completed a geotechnical exploration of the above referenced site at Eglin Air Force Base in Walton County, Florida. These services were performed in general accordance with our authorized Proposal Number 2038958 dated September 7, 2023.

The following report presents the results of our field exploration, and a geotechnical engineering interpretation of those results with respect to the project characteristics provided to us. We have included our estimates of the seasonal high groundwater level at the boring locations, and geotechnical recommendations for building addition foundation design, stormwater management system design, site preparation, and construction related services.

We appreciate the opportunity to have worked with you on this project and look forward to a continued association. Please contact us if you have any questions, or if we may further assist you as your plans proceed.

Respectfully Submitted,
UNIVERSAL ENGINEERING SCIENCES
Certificate of Authorization No. 549

Garrett Smith

Garrett P. Smith, E.I.
Geotechnical Staff Professional
Florida E.I. No. 1100024070

Travis W. Monsalvatge, P.E.
Pensacola Branch Manager
Florida P.E. No. 82244

This item has been electronically signed and sealed by Travis W. Monsalvatge, P.E. using a digital signature. Printed copies of this document are not considered signed and sealed, and the signature must be verified on any electronic copies.

TABLE OF CONTENTS

LIST OF APPENDICES

1.0 INTRODUCTION

1.1 GENERAL

In this report, we have presented the results of the geotechnical exploration of the site for the proposed project. We have divided this report into the following sections:

- SCOPE OF SERVICES – Discusses what we did;
- FINDINGS – Discusses what we encountered;
- RECOMMENDATIONS – Discusses what we encourage you to do;
- LIMITATIONS – Discusses the restrictions inherent in this report; and
- APPENDICES – Presents support materials referenced in this report.

2.0 SCOPE OF SERVICES

2.1 PROJECT DESCRIPTION

Project information was provided to us by the Client via email correspondence on September 6, 2023. Included in this correspondence were documents including a diagram entitled "D51 Hangar Add Alter Eglin Geotech Diagram" prepared by the Client and dated August 30, 2023, and an undated map with the vicinity of the site for the facility marked. The provided documents were used in conjunction with the performance of this exploration and report.

The project site was located adjacent to the existing Facility 59040 Hangar in the D51 Hangar area on Eglin Air Force Base in Walton County, Florida. At the time of our field exploration, the site was developed with the existing Facility 59040 Hangar and its associated paved entrance drive.

Based on the provided information, UES has understood the proposed construction will include renovating approximately 7,800 square feet of the existing Facility 59040 Hangar and constructing an approximately 5,200 square foot addition to the northwest side of the existing building, as well as one stormwater management pond. The existing facility was previously used as a training façade to represent an airplane hangar and was never meant to serve as a manned facility. The facility now requires modification to support the Human Performance (HP) STRIKE Program mission requirements. Per the Client's request, our geotechnical exploration and this report have addressed the proposed building addition and stormwater management pond areas only.

Structural loading and final grading information was not provided to UES. It was assumed for purposes of our exploration and this report that the proposed building addition could be supported using conventional shallow foundation systems with maximum loads of 200 kips per column. It was further assumed that minimal amounts (i.e., 2 feet or less) of fill and/or excavation would be required to achieve finished grades in the proposed building addition area, and that the proposed stormwater management pond would be relatively shallow (i.e., approximately 5 feet deep or less).

Our recommendations have been based upon the previously discussed supplied or assumed information. If any of this information should be incorrect or changes, please inform UES so that we may review our recommendations. Without such a review, the recommendations herein may not be valid. No other site or project facilities should be designed using the soil information contained herein. As such, UES would not be responsible for the performance of any other site improvement designed using the data in this report.

2.2 PURPOSES

The purposes of this exploration program were:

- To explore the general subsurface conditions in the proposed building addition and stormwater management areas of the site;
- To interpret and review the subsurface conditions with respect to the proposed construction;
- To perform a series of laboratory tests on selected subsurface soil samples to assist with engineering soil classification and to establish relevant soil engineering characteristics; and
- To provide geotechnical engineering recommendations for groundwater control, building addition foundation design, stormwater management pond design, and site preparation, as well as a discussion of the Seismic Site Classification.

This report has presented an evaluation of site conditions on the basis of traditional geotechnical engineering procedures for site characterization. The recovered samples were not examined, either visually or analytically, for chemical composition or environmental hazards. UES would be pleased to perform these services, if desired.

The exploration was confined to the zone of soil likely to be stressed by the proposed construction. The exploration has not addressed the potential for surface expression of deep geological conditions. Such an evaluation would require a more extensive range of field services than was performed for this exploration. UES would be pleased to provide a proposal for an exploration to evaluate the probable effect of the regional geology upon the proposed construction, if desired.

2.3 GEOTECHNICAL EXPLORATION

The field exploration program was initiated on February 6, 2024 and completed on February 7, 2024. The approximate boring locations have been shown on the attached Boring Location Plan in Appendix B. The approximate boring locations were determined in the field using the provided site aerial plan, a hand-held GPS, Google Earth aerial imagery, and existing field reference points on and adjacent to the site. The boring locations should be considered accurate only to the degree implied by the method of measurement used.

UES was not provided with topographic information for the project site. As such, the elevations at the boring locations have not been presented and/or discussed in this report or on the attachments.

Upon completion of the field tests and sampling, recovered soil samples were placed in labeled plastic containers, sealed, and transported to our laboratory where they were examined by a member of the UES geotechnical engineering staff. Select samples of the soils were then chosen for specific laboratory tests. The recovered soil samples not used for laboratory testing would be held in our laboratory for the Client's inspection for 90 days following the issue date of this report. The samples would then be discarded unless UES has been notified, and other arrangements have been made.

2.4 FIELD EXPLORATION

The field exploration for this project consisted of the following:

- Performing three (3) Standard Penetration Test (SPT) borings, with two borings advanced to depths of 30 feet below existing grade (BEG) and one boring advanced to a depth of 80 feet BEG, in the proposed building addition area; and
- Performing two (2) SPT borings, each boring advanced to depths of 30 feet BEG, in the proposed stormwater management pond area.

Descriptions of the procedures used to perform the borings have been presented in the Field Procedures attachment in Appendix B.

2.5 LABORATORY TESTING PROGRAM

2.5.1 Visual Classification

In the laboratory, the soil samples recovered from the field exploration were visually and physically examined by a member of the UES geotechnical engineering staff. Approximate soil classifications were estimated in general accordance with the Unified Soil Classification System (ASTM D2487). The resulting soil descriptions and estimated soil classifications have been presented on the Boring Logs in Appendix B. Where applicable, the descriptions and classifications presented on the Boring Logs have been revised to reflect the results of any laboratory testing performed on the samples.

2.5.2 Laboratory Index Testing

Laboratory soil tests were performed on selected soil samples recovered during the field exploration to aid in the classification of the soils, and to help in the evaluation of pertinent engineering characteristics of the soils. The classifications and laboratory testing completed for this project consisted of performing the following procedures/tests in general accordance with the methods listed.

- Soil Classification per the Unified Soil Classification System – ASTM D2487
- Natural Moisture Content Tests – ASTM D2216
- Percent -200 Soil Fines Content Tests – ASTM D1140
- Atterberg Limits Tests – ASTM D4318
- Laboratory Remolded Falling-Head Permeability Tests – FM 5-513

Detailed descriptions of these test procedures have been presented in the Laboratory Testing Procedures attachment in Appendix C. The results of the tests have been summarized on the boring logs attached in Appendix B.

3.0 FINDINGS

3.1 USDA NRCS SOIL SURVEY

Based on the published and Web Soil Surveys for Walton County, Florida, as prepared by the USDA NRCS, the predominant, soil type at the site has been identified as 17 – Lakeland sand, 0 to 5 percent slopes. A summary of the characteristics of this soil type was obtained from the Soil Surveys and has been included in Table 1. Please note the soils presented in the following table are the pre-development soils and have been altered during past development of the site.

Table 1 – Summary of USDA NRCS Soil Survey Information

Soil Type	Constituents (Depth-in.)	Internal Drainage	Hydrologic Soil Group	Soil Permeability		Seasonal High Water Table (ft)	Corrosion Potential	
				Depth (in)	Perm (in/hr)		Uncoated Steel	Concrete
17– Lakeland sand, 0% to 5% slopes	SP-SM (0-42) SP, SP-SM (42-80)	Excessively drained	A	0-42 42-80	6.0-20 6.0-20	>6.0	Low	Moderate

Fill and/or possible fill materials consisting of sands with silt [SP-SM], occasionally with trace gravel, were encountered in the upper 2 to 4 feet below the existing ground surface in each of the boring locations. Below the fill materials, the subsurface conditions encountered were generally similar to those presented in Table 1.

3.2 SURFACE CONDITIONS

UES personnel visited the project site during the performance of the field exploration. At the time of the field exploration program, the site was developed with an existing hangar building and paved driveway, and the remainder of the site consisted of grassed land.

As discussed previously, existing topographic information for the project site was not provided. Based on available elevation data from Google Earth, elevations on the site ranged from approximately 61 to 63 feet. Based on observation of the site during the field exploration, the existing building and driveway sat a few feet higher in elevation than the surrounding grassed areas, indicating that grades were likely raised with fill during previously development.

3.3 SUBSURFACE CONDITIONS

The general subsurface conditions encountered during the subsurface exploration have been described in Table 2. For more detailed soil descriptions and stratifications at the boring locations, the Boring Logs attached in Appendix B should be reviewed. Also, see the Key to Boring Logs in Appendix B for further explanation of the symbols and placement of data on the Boring Logs.

The Boring Logs represented our interpretation of the subsurface conditions based on a review of the field logs, an engineering examination of the samples, and a limited number of laboratory tests. The horizontal stratification lines designating the interface between various strata represented approximate boundaries. Transition between different strata in the field may be gradual in both the horizontal and vertical directions. Groundwater, or lack thereof, encountered in the borings, and noted on the Boring Logs, represented conditions only at the time of the exploration.

Table 12– General Soil Profile

Stratum No.	Typical depth (ft) From	Typical depth (ft) To	Soil Descriptions	Range of SPT "N" Blow Counts
1	0	0.1	Sandy TOPSOIL with roots and organics[1]	---
2	0.1	2 to 4	Medium dense to loose FILL consisting of SAND with silt [SP-SM], occasionally with trace gravel	6 to 22
3	2 to 4	17 to 22	Loose to medium dense relatively clean SAND [SP] and occasionally SAND with silt [SP-SM]	5 to 28
4	17 to 22	77	Dense to very dense relatively clean SAND [SP] and occasionally SAND with silt [SP-SM]	36 to 50/4"
5	77	80[2]	Dense silty SAND [SM]	31

[1] Topsoil is a term used to describe organic soils, which are usually dark in color, and typically suitable for the support of plant life.

[2] Termination depth of the deepest boring B-3.

[ ] Brackets indicate Unified Soil Classification System (ASTM D2487)

At the time of our field exploration, groundwater was not apparent in the borings during drilling activities or upon completion of the borings. Please refer to Section 4.2 for further discussion of the groundwater conditions at the time of our field exploration.

3.3.1 Notable Findings – Existing Fill Materials

Existing fill materials were encountered in each of the borings during the field exploration, beginning below the topsoil and continuing to approximate depths of up to 2 to 4 feet BEG. Based on our examination of the samples recovered, the existing fill materials appeared to be sands with silt [SP-SM], occasionally with trace gravel.

<u>On sites where undocumented/uncontrolled fill materials have been encountered, it should be anticipated that the undocumented/uncontrolled fill materials may vary in quality, relative density, and consistency from what was observed at the time of our field exploration. As such, unsuitable and/or unstable conditions may be encountered during construction requiring remediation consisting of removal of unsuitable soils and replacement with structural fill, and/or re-working of the on-site soils.</u>

4.0 RECOMMENDATIONS

4.1 GEOTECHNICAL ASSESSMENT

In this section of the report, UES has presented recommendations for building addition foundation design, stormwater management system design, site preparation, and construction related services. The following geotechnical design recommendations have been developed on the basis of the previously described project characteristics, and the subsurface conditions encountered. If there should be any changes in these project criteria, including the locations of the proposed building addition and/or stormwater pond, a review should be made by UES to determine if modifications to the recommendations are warranted.

After final design plans and specifications have been completed, a general review by UES has been recommended. The review would be a means to check that the evaluations made in the preparation of this report have been correct, and that earthwork recommendations have been properly interpreted and implemented.

4.2 GROUNDWATER CONSIDERATIONS

The groundwater level would fluctuate seasonally depending upon local rainfall. The typical wet season groundwater level has been defined as the highest groundwater level sustained for a period of 2 to 4 weeks during the "wet" season of the year, for existing site conditions, in a year with average normal rainfall amounts. Based on historical data and the Web Soil Survey, the rainy season in Northwest Florida would typically be between June and September of any given year.

At the time of our field exploration, groundwater was not apparent in the borings. However, mud rotary drilling methods were used to advance Boring B-3 starting at 15 feet BEG. When using mud rotary techniques, the borehole is filled with a slurry of bentonite drilling fluid and soil cuttings which stabilizes the borehole to prevent it from collapsing. However, the drilling fluid coats the sides of the borehole with low permeability bentonite and greatly slows the rate at which the fluid level within the borehole equalizes with the surrounding groundwater level. Therefore, a stabilized groundwater reading was not obtained from Boring B-3. Because groundwater was not encountered to the termination depths of 30 feet in the rest of the borings performed during this exploration, UES has estimated the normal stabilized seasonal high groundwater level at the boring locations to be at a depth greater than 30 feet BEG. The presented best estimates for seasonal high groundwater level have been based upon Walton County Soil Survey information, data obtained from the UES exploration, regional hydrogeology, local climate/rainfall data, experience, and a review of USGS data.

It should be noted that the estimated seasonal high water levels would not provide any assurance that groundwater levels would not be higher/shallower than the estimated levels in the future. Should impediments to surface water drainage be present, or should rainfall intensity, duration, and/or quantities, exceed the normally anticipated rainfall conditions, then groundwater levels could be higher/shallower than our seasonal high estimates. Furthermore, it should be understood that changes in the surface hydrology and subsurface drainage from on-site, and/or off-site improvements could have significant effects on the normal and seasonal high groundwater levels.

UES has recommended that positive drainage be established and maintained on the site during construction. UES has further recommended that permanent measures be constructed to maintain positive drainage throughout the life of the project. All site improvement designs should incorporate the seasonal high groundwater levels as appropriate.

4.3 BUILDING ADDITION FOUNDATIONS

4.3.1 General

Based on the results of the exploration, UES has considered the subsurface/subsoil conditions on the site to be adaptable for support of the proposed building addition when constructed on properly designed conventional shallow foundation systems. Provided the site preparation and earthwork construction recommendations outlined in Section 4.6 of this report have been performed, the information presented in the following sections may be used for building addition foundation design.

As noted previously, the building addition foundation recommendations provided in this report have been predicated on the following assumptions: fill/excavation depths required to achieve finished site elevations not exceeding 2 feet; single-story building construction with concrete slab-on-grade floor system; and assumed maximum structural loading of 200 kips per column.

When the actual structural loads and finished elevations have been finalized, UES should be provided this information. The recommendations presented in this report should be reviewed and verified or revised accordingly based on the provided final design information or the recommendations presented in this report would not be considered valid.

4.3.2 Allowable Net Soil Bearing Pressure

The maximum allowable net soil bearing pressure for use in the shallow foundation design should not exceed <u>2,000 psf for the foundations</u> for code dead and live loads plus any short duration loadings. <u>This bearing pressure has been predicated on the bearing subgrade soils to a depth of 1 foot below the foundation bearing elevation(s) being densified to at least 95 percent of the modified Proctor maximum dry density (ASTM D1557) prior to foundation construction.</u>

Net bearing pressure has been defined as the soil bearing pressure at the base of the foundation in excess of the natural overburden pressure. The building addition foundations should be designed based upon the maximum load that could be imposed by all loading conditions.

<u>The building addition foundations in areas adjacent to the existing structure may need special consideration.</u> It is recommended that the addition be structurally independent of the existing building since additional loads of the new structure on existing footings may cause detrimental settlement and unsightly cracking. For the same reason, new footings should be located in such a way that the stresses under new footings will not overstress the soil under existing footings. This applies to new footings in the critical zone which extends about 5 feet laterally from the existing footings.

4.3.3 Foundation Size

The minimum width recommended for isolated column foundations would be 24 inches. Even though the maximum allowable net soil bearing pressure may not be achieved, this width recommendation would control the minimum size of the foundations to prevent "shear punch" deformations.

4.3.4 Bearing Depths

The building addition foundations should bear at a depth of at least 24 inches below the finished exterior grades, and the interior foundations should bear at a depth of at least 18 inches below the finish floor elevation, to provide confinement to the bearing level soils. Stormwater should be diverted away from the building exteriors to reduce the possibility of erosion beneath the exterior foundations.

4.3.5 Bearing Material

The building addition foundations may bear in either the compacted native soils or compacted structural fill. The foundation excavation bottoms should be level or suitably benched, and free of any loose soils that have been disturbed by seepage or the construction process. Furthermore, the foundation excavation bottoms should be free of ponded water. The bearing level soils, after compaction, should exhibit densities equivalent to at least 95 percent of the modified Proctor maximum dry density (ASTM D1557) to a depth of at least 1 foot below the foundation bearing level.

4.3.6 Settlement Estimates

Post-construction settlement of the proposed building addition structure would be influenced by several interrelated factors, such as: subsurface stratification and strength/compressibility characteristics; foundation sizes, bearing levels, applied loads, and resulting bearing pressures beneath the foundations; and site preparation and earthwork construction techniques used by the Contractor. Our settlement estimates for the proposed structure have been based on the assumed structural loading information, and compliance with the site preparation/earthwork recommendations presented in Section 4.6. Any deviation from these recommendations could result in an increase in the estimated post-construction settlement of the building addition structure.

Based on the subsurface/subsoil conditions encountered by the exploration and the recommended earthwork operations, UES would expect the majority of settlement to occur fairly rapidly during construction. Using the recommended maximum net allowable bearing pressure, the assumed maximum structural loading conditions, and the field data which has been correlated with geotechnical engineering strength and compressibility characteristics of the subsurface soils, UES has estimated that <u>total settlement of the proposed building addition structure would be approximately 1 inch or less</u>.

Differential settlements result from differences in applied bearing pressures and variations in the compressibility characteristics of the subsurface soils. Because of the general uniformity of the subsurface/subsoil conditions encountered by the exploration, and pending compliance with the site preparation and earthwork construction recommendations presented in Section 4.6, UES has estimated that differential settlement of the proposed building addition structure should be within tolerable magnitudes on the order of about ½ inch or less between isolated foundations spaced approximately 40 feet apart.

Based on experience, the estimated differential settlements would typically be considered to be structurally tolerable. However, aesthetic cracking in masonry and brick walls or stucco finishes could occur. If such cracking was to be undesirable, then the Structural Engineer would need to design the wall/foundation system with sufficient stiffness as to minimize such cracking.

4.3.7 Foundation Evaluations

Foundation excavations should be evaluated by the Geotechnical Engineer of Record, or his Representative, to determine that the soils present at and immediately below the bearing levels would be capable of supporting the recommended design bearing pressure. We have recommended that the bearing soils at the bottom of and below the foundation excavations be checked using a hand-held steel probe rod and/or dynamic cone penetrometer to assess the suitability of the soils. Foundation evaluations should be performed prior to steel reinforcement and concrete placement.

It should be anticipated that undercutting of select areas may be required because of variations in the soil matrix, fill quality, and/or Contractor means and methods. If unsuitable bearing soils should be undercut and removed, then the foundations can then be established at the new, lower bearing elevation (pending compaction of the upper 1 foot of soils at the newer bearing elevation) or backfilled with lean concrete or flowable fill. If compacted structural fill should be used as backfill, then the undercut excavations to remove unsuitable materials should be centered beneath the foundations and widened 1 foot for each foot of undercut depth. If number 57 crushed stone should be used as backfill, then the foundation excavations need not be widened. However, depending on finished elevations, the number 57 stone may have to be placed/wrapped within a suitable filter fabric material to prevent the migration of surrounding soil materials into the stone fill.

4.4 FLOOR SLABS

Conventional concrete floor slab systems may be supported upon the compacted fill and/or site subgrade soils and should be structurally isolated from other foundation elements or adequately reinforced to prevent distress due to differential movements. For the slab design, UES has recommended using a subgrade modulus (k) of 125 pounds per cubic inches, which can be achieved by compacting the subgrade soils as recommended in this report.

UES has recommended the use of a vapor barrier which would cover the bearing soils beneath ground supported floor slabs in accordance with Florida Building Code (FBC) requirements. The FBC has recommended a minimum 6-mil thick polyvinyl chloride or polyethylene sheet membrane for this purpose. The performance of the vapor barrier has often been ultimately dependent upon its proper installation, including lapping and sealing plus repair of tears and punctures prior to placement of concrete. In addition, stormwater should be diverted away from all floor slab areas to prevent the infiltration of water into the slab subgrade soils, and the associated deterioration of the slab subgrade(s).

4.5 STORMWATER DESIGN CONSIDERATIONS

As discussed previously, UES understood that one stormwater management pond has been planned to be constructed as part of the proposed development. Based on the provided diagram and project assumptions, it was anticipated that the proposed stormwater management pond would be relatively shallow (i.e., 5 feet or less below existing grades). UES advanced two borings (SW-1 and SW-2) to depths of 30 feet BEG in the proposed stormwater management pond area. The soils encountered in the borings generally consisted of possible fill [SP-SM] extending from the ground surface to approximately 2 feet BEG, underlain by relatively clean sands and sands with silt [SP, SP-SM] to the approximate termination depth of 30 feet BEG. Groundwater was not apparent in the stormwater borings at the time of the field exploration. For pond design purposes, seasonal high groundwater levels at the stormwater boring locations have been estimated to be at a depth 29 ½ feet BEG. Based on the boring data obtained, the site conditions were suitable for the use of a conventional shallow dry pond for stormwater management.

In the following sections, soil design parameters, along with discussions of the possible design considerations, have been presented for the proposed stormwater pond area. The soil design parameters presented/discussed in this section have been predicated upon the following.

- UES has recommended considering the remolded permeability values to be representative of the saturated vertical coefficient of permeability (K_{vs}). Unsaturated vertical permeability (K_{vu}) is generally less than saturated values due to the lack of laminar flow through the soil. The Northwest Florida Water Management District (NWFWMD) has suggested that the unsaturated vertical permeability may be estimated as about 2/3 of the saturated values.

- The saturated horizontal coefficient of permeability (K_{hs}) would typically range from 1 to 10 times the saturated vertical permeability rate (K_{vs}), because the flow direction would be parallel to the direction of depositional planes.

- The results of the individual laboratory permeability tests performed on samples recovered from the boring locations have been presented on the boring logs included in Appendix B. It should be noted that the coefficients of permeability indicated on the boring logs were not an infiltration rate. The actual infiltration rate would be influenced by the coefficient of permeability as well as several other factors, including the elevation of the pond bottom, the water level in the pond, the elevation of the wet season water table, and the confining layer. These factors must be accounted for in an appropriate groundwater model to determine the infiltration rate of a given soil stratum.

- Based upon our visual and physical examination of the soil samples recovered from the pond area, the results of our laboratory testing, and observation of the existing site conditions, we have recommended, where applicable, a fillable porosity for the estimated drainage stratum.

- <u>No Factor of Safety has been applied to any of the values presented in the subsequent tables.</u>

- UES performed the hydraulic conductivity/remolded laboratory permeability testing using generally accepted practices of the local engineering community. This common test has been the quickest and most economical for stormwater management system design. However, the User of this information should be cautioned that the potential variability of results and reproducibility associated with this type of test can be significant. It would be important to note that there are many factors influencing the permeability of a soil. These factors include, but would not be limited to, soil grain size, soil particle arrangement and structure, dispersion of soil fines, density, degree of saturation, soil heterogeneity, and soil anisotropy. Also, the permeability measured by such a test may not be representative of the total effective aquifer thickness. Factors of safety can compensate for part of the inherent test limitations but the Designer must exercise judgment regarding final selection and applicability of provided soil design input parameters.

- Should the modeling analysis indicate marginally acceptable compliance with NWFWMD design criteria, it may be advisable to perform more extensive and representative in-situ permeability testing by collecting "undisturbed" horizontal and vertical soil samples and/or installing grouted piezometers or wells for slug testing. UES can perform these field tests, if desired.

- The actual exfiltration rates from the pond may be influenced by the pond geometry, natural soil variability, in-situ depositional characteristics in-situ soil density, retention volume, and groundwater mounding effects. Due to the previously noted numerous factors, published literature suggests that the permeability of a soil can only be estimated to within an order of magnitude. Therefore, appropriate factors of safety should be incorporated into the design process.

UES performed laboratory falling-head permeability testing on two remolded test specimens prepared using bulk samples of representative soils obtained from 4 to 6 feet BEG in borings SW-1 and SW-2. The saturated vertical permeability rates were approximately 27 feet per day for sands with 3.6 percent silt-clay fines for the sample from SW-1 and 22 feet per day for sands with 2.9 percent silt-clay fines for the sample from SW-2. Additionally, UES performed a third laboratory falling-head permeability test on a remolded test specimen prepared by compositing split-spoon samples obtained from Borings SW-1 and SW-2 between 12 and 30 feet BEG. The saturated vertical permeability rate was approximately 19 feet per day for sands with 2.3 percent silt-clay fines. However, it is important to note that due to the relatively high density of the sands encountered at and below approximately 17 feet BEG, the sands below that depth may be less permeable than the results of the remolded permeability test would indicate for that stratum. The results of the laboratory permeability tests performed have been presented on the Boring Logs attached in Appendix B.

The results of the permeability tests on the bulk samples indicated that the stratum of clean sands [SP] from 4 to 8 feet BEG in Boring SW-1 and from 4 to 6 feet BEG in SW-2 would be suitable for drainage. However, these clean sands [SP] were underlain by a layer of sands with silt [SP-SM] from 8 to 9 feet BEG in Boring SW-1 and from 6 to 9 feet in Boring SW-2. It has been anticipated that these sands with silt [SP-SM] would be marginally less permeable than the clean sands [SP] which were tested. Therefore, the third permeability test was performed on the composite sample in order to provide data for the option of deepening the pond such that the bottom elevation will be below the stratum of sands with silt [SP-SM] if that should be determined to be necessary by the pond Designer.

A summary of recommended dry shallow pond design soil parameters has been presented in Table 3. Please note that a Factor of Safety has not been applied to the values presented in the table.

Table 3 – Soil Design Parameters for Dry Shallow Pond Design

Corresponding Soil Boring Locations	SW-1	SW-2	SW-1 and SW-2
Estimated Drainage Stratum Depths (ft. BEG)	4 to 8	4 to 6	12 to 30
Saturated Horizontal Hydraulic Conductivity K_{hs} (ft./day)	27	22	19
Saturated Vertical Hydraulic Conductivity, K_{vs} (ft./day)	27	22	19
Unsaturated Vertical Hydraulic Conductivity, K_{vu} (ft./day)	18	15	12
Estimated Fillable Porosity of Soil (percentage)	25	25	25
Depth of Measured Groundwater Table (ft.)	>30	>30	>30
Estimated Seasonal High Groundwater Table (ft.)	29.5[2]	29.5[2]	29.5[2]
Base of aquifer (ft.)	30[3]	30[3]	30[3]

General Notes:

1) A factor of safety (F.O.S) has not been applied to the values presented in this Table.

2) Estimated Seasonal High Groundwater Table assumed 6 inches above the SW-1 and SW-2 boring termination depths.

3) Base of Aquifer has been set as the termination depth of the borings.

4.6 SITE PREPARATION

We have recommended normal, good practice site preparation procedures. These procedures include: stripping the proposed construction areas of surficial vegetation, roots, topsoil, existing site improvements including pavements not intended to remain, and other deleterious materials present; proofrolling and compacting the exposed subgrade; verifying subgrade compaction; and placing engineered fill to the desired grades. An expanded and more detailed synopsis of this work is provided in the following sections.

4.6.1 Nearby Structures and Vibrations

Care should be exercised to avoid damaging any nearby structures while the site preparation and earthwork operations are underway. Prior to commencing site work operations in areas of this site that will be constructed near adjacent structures and/or developments, we have recommended that occupants of adjacent structures should be notified, and the existing conditions of the structures should be documented with photographs and survey. Compaction should cease if deemed detrimental to adjacent structures.

In the absence of pre-construction building surveys of all on-site/off-site adjacent structures and the performance of vibration monitoring, we have recommended that the vibratory function of any vibratory compaction equipment used on the site be turned off when operating within 50 feet of any adjacent structures. UES can provide vibration monitoring services to help document and evaluate the effects of the surface compaction operations on existing structures.

4.6.2 Existing Underground Utilities

It has been our experience that poorly compacted backfill has commonly been found above and around underground utilities. Therefore, it has been recommended that the location of any existing underground utility lines within the proposed construction areas be established prior to initiating construction. Where feasible, provisions should be made to relocate or abandon interfering utilities. It should be noted that if abandoned underground pipes are not properly removed or plugged, they might serve as conduits for subsurface erosion, which may subsequently lead to excessive settlement of overlying pavements and structures.

Any trenches/excavations required to remove the abandoned utilities should be backfilled in accordance with recommendations presented in subsequent sections of this report. Whether existing utility lines are abandoned or not, it has been recommended that existing trench and excavation fill materials be excavated to undisturbed native soils; the exposed utilities be evaluated for any deterioration or damage (pressure testing being recommended for any water bearing utilities); any damage or deterioration discerned be properly repaired; and the utility trenches be backfilled to finished elevations in accordance with recommendations presented in subsequent sections of this report.

4.6.3 Site Preparation and Grading

Strip the proposed construction limits of all deleterious materials including any root systems greater than ½-inch in diameter, surficial vegetation, topsoil, existing site improvements including pavements not intended to remain, and any other deleterious materials present within and 5 feet beyond the limits of construction. All excavations required to remove any underground appurtenances (i.e. stumps and associated root systems, utilities, etc.) should be extended down to undisturbed soils, and the excavations backfilled to finished elevations in accordance with the recommendations presented in subsequent sections of this report. Expect typical stripping at this site to depths of 1 inch over most of the site. However, significant areas of possibly greater stripping depths may be required to remove localized areas of greater thicknesses of organic surficial soils. All materials removed in conjunction with the initial stripping operations should be hauled offsite.

After stripping, removal of unsuitable surface soils, and rough excavation grading, we have recommended that areas to provide support for structural fill be evaluated carefully for the presence of soft, surficial soils, and/or excessively plastic soils. In addition, finished subgrade elevations in cut areas should also be carefully evaluated after excavation operations. Such evaluation should include observing, probing, and proofrolling operations performed by others and witnessed by the Geotechnical Engineer of Record or his designated representative.

The proofrolling should be performed using a loaded tandem axle dump truck, or similar rubber-tired equipment, weighing between 15 and 20 tons. The vehicle should make at least four passes over each location, with the last two passes being perpendicular to the first two. In areas where sufficient space is not available, the proofrolling pattern may be limited to overlapping passes in a parallel direction. Areas that wave, rut, or deflect significantly, and continue to do so after several passes of the proofrolling equipment, should be undercut to firmer soils. Undercut areas should be backfilled in thin lifts with approved, compacted fill materials. For any required undercutting operations, undercut volumes should be determined by field measurement. Methods such as counting trucks should not be used for determination of undercut volume, as they are less accurate.

It has been recommended that all proofrolled subgrades be moisture conditioned and compacted to at least 95 percent of the materials' modified Proctor (ASTM D1557) maximum dry densities to a depth of at least 12 inches below the proofrolled subgrade elevations. This should be done prior to placement of fill on the proofrolled subgrades.

Based on our understanding of the proposed construction, it has been anticipated that there will most likely not be extensive areas where excavation operations, beyond the initial site stripping operations, will be required to achieve final site grades. However, in areas where excavation operations will be required to achieve final site grades, it has been recommended that the final exposed subgrade elevations be checked and proofrolled in a manner similar to the operations discussed in the previous paragraphs.

All proofrolling operations should be witnessed and monitored carefully by the Geotechnical Engineer of Record or his designated representative. It is imperative to the success of the site and subgrade preparation operations that the UES Geotechnical Engineer or Representative be on the site immediately prior to, and during the performance of any proofrolling operations on the project site. The Engineer/Representative will be able to observe site conditions at the time of the proofrolling operations and be immediately available to make recommendations regarding subgrade preparation or assist in developing appropriate stabilization procedures based on the observed conditions encountered during construction.

During general construction operations, loose sandy soils will likely be encountered at the stripped subgrade level. As a result, unstable subgrade conditions may be anticipated during general construction operations. The use of light construction equipment would aid in reducing subgrade disturbance. The use of remotely operated equipment, such as a backhoe, would be beneficial to perform cuts and reduce subgrade disturbance. Where unstable subgrade conditions develop, stabilization measures will need to be employed.

Subgrade improvement should include scarification, moisture conditioning (e.g., aerate or wet), and compaction of the exposed subgrade soils. The success of this procedure will depend primarily upon favorable weather conditions. Even with adequate time and favorable weather conditions, stable subgrades may not be achieved if the thickness of the unstable material is greater than about 1 to 1.5 feet. A UES representative should observe subgrade preparation and could assist in developing appropriate stabilization procedures based on conditions encountered during construction.

Upon completion of grading, care should be taken to maintain the subgrade moisture contents prior to subsequent construction. Construction traffic over the completed subgrade(s) should be avoided to the extent practical. The site should also be graded to prevent ponding of surface water on the prepared subgrades or in excavations. If the subgrade(s) should become frozen, desiccated, saturated, or disturbed, the affected materials should be removed or these materials should be scarified, moisture conditioned, and re-compacted prior to any subsequent construction.

4.6.4 Fill Placement

Once the site has been stripped and prepared, place fill material as required to meet finished grades. The recommended criteria for soil fill characteristics (both on-site and imported materials) and compaction procedures are listed in Sections 4.6.6 and 4.6.7. The project design documents should include the following recommendations to address proper placement and compaction of project fill materials. Earthwork operations should not begin until representative samples of native and proposed fill soils to be compacted and/or used have been collected and tested (allow 3 to 4 days for sampling and testing). The maximum dry density and optimum moisture content should be determined. In addition, gradation, organic content, and Atterberg limits testing may be necessary, and should be performed at the Geotechnical Engineer's discretion.

4.6.5 Earth Fill Materials

Engineered fill should meet the following material properties:

- Imported and on-site material satisfactory for use as structural fill should include granular soils containing less than 12 percent passing the number 200 sieve and be non-plastic. Suitable soils will have USCS classifications of SP and SP-SM. <u>Excavated on-site soils that exceed the recommended fines content and plastic soils should not be used as structural fill material. These excavated soils should be hauled off-site and replaced with suitable fill materials with suitable moisture contents.</u> The fill material should have a modified Proctor (ASTM D1557) maximum dry density of at least 100 pcf.

- Organic content or other foreign matter (debris) should be no greater than 5 percent by dry weight, and no large roots (greater than ¼ inch in diameter) should be allowed. <u>Excavated on-site soils that exceed the recommended organics content should not be re-used as structural fill material. These excavated soils should be hauled off-site and replaced with suitable fill materials with suitable moisture contents.</u>

- Material utilized as fill should not contain rocks greater than 3 inches in diameter or greater than 30 percent retained on the ¾-inch sieve.

4.6.6 Compaction Recommendations

The following recommendations have been presented for fill placement and compaction. The recommendations are also applicable for the compaction of existing soil materials on the project site.

- Maximum loose lift thicknesses – 12 inches with 10-inch thick compacted lifts, mass fill. Loose lifts of 4 to 6 inches in trenches and other confined spaces where hand operated equipment is used.

- Minimum Compaction requirements – Unless noted otherwise in other sections of this report, 95 percent of the maximum dry density as determined by the modified Proctor (ASTM D1557) test. Under lawn or unpaved areas, compact each layer of backfill or fill material to at least 92 percent of the modified Proctor maximum dry density.

- Soil moisture content at time of compaction should be within ±2 percent of the optimum moisture content.

- Where required, aerate or add moisture to the fill soils until they are within the previously recommended moisture range prior to placement and compaction.

- Work in small areas that are graded to shed water and avoid ponding. Positive drainage must be maintained both during and after construction in order to direct rainwater off the compacted fill area as quickly as possible.

- Disc and aerate areas that are subjected to rainfall or otherwise become wet. Do not leave these soils exposed to the elements for long periods of time as soils that have already been compacted may become wet and unstable. Protect the fill soil each night and before rain events by methods such as mounding the soil or grading the surface to positive outfall and smooth-rolling to minimize water infiltration.

4.6.7 Test Criteria to Evaluate Fill and Compaction

The following minimum criteria for the evaluation and compaction of fill materials has been recommended. The recommendations are also applicable for the evaluation and compaction of existing soil materials on the project site.

- One modified Proctor compaction test for each soil type compacted and/or used as project fill. Gradation, organic content, and Atterberg limits testing may be necessary, and should be performed at the Geotechnical Engineer's discretion.

- Trench fill areas – One density test for every 75 linear feet per lift, or two tests per lift, whichever is greater.

- Building Addition Area – For every fill lift, one density test for every 2,500 square feet, or three tests per lift, whichever is greater.

- Foundation areas – Test all foundation bearing subgrades for compaction to a depth of 1 foot below bearing subgrade elevation(s) prior to the placement of reinforcing steel and concrete. We have recommended testing every column foundation, and one test per every 50 linear feet of wall foundation. Recompaction of the foundation excavation bearing level soils, if loosened by the excavation process, can typically be achieved by making several passes with a walk-behind vibratory sled or jumping jack compactor, or by undercutting to more firm underlying soils and backfilling with compacted structural fill, flowable fill, lean concrete, or compacted No. 57 stone. If number 57 crushed stone should be used as backfill, then the foundation excavations need not be widened. However, depending on finished elevations, the number 57 stone may have to be placed/wrapped within a suitable filter fabric material to prevent the migration of surrounding soil materials into the stone fill.

4.7 FILL SUITABILITY EVALUATION

Often soils excavated from stormwater pond areas are re-used as structural fill throughout the development. Refer to Table 4 for suitability for re-use as fill based on percent fines content.

Table 4 – Suitability of Excavated Soils for Re-use as Fill			
Designation*	% fines passing No. 200 sieve	USCS Soil Classification	Suitability for re-use as fill material
Group A	0 – 5	SP	Favorable, freely draining, clean sands
Group B	5 – 12	SP - SM, SP - SC	Suitable, will require some aeration and moisture control
Group C	12 – 50	SM, SC, SC-SM	Poor, impedes infiltration, limit overall use, use with caution in pavement or pond areas
Group D	> 50	CL, CH, ML, MH, CL-ML	Very Poor, not recommended for fill material, may be used as stabilizing material in pavement subgrade
Group E	Organic	PT, OL, OH, SP-OL, SM-OL	Unsuitable, must be completely removed/demucked and replaced with Group A or B soils

Based on the results of our exploration, the soils to be excavated at the stormwater boring locations would consist of Groups A and B soils. More detailed discussions concerning these soils Groups, as well as the other Group designations presented in Table 4, have been presented in the following paragraphs.

Clean sandy soils (Group A) with less than 5 percent soil fines would typically be best suited for fill usage. They would typically be free-draining and would require minimal moisture control during placement and compaction. The sands with silt and clay (Group B), with contents of 5 to 12 percent soil fines, would require some extra care during placement and compaction. These soils would be less freely-draining and might require aeration and drying prior to usage, during use in the rainy season and when placed near the groundwater table. We have recommended that imported fill material meet the Group A and non-plastic Group B qualifications.

Soils classified as silty or clayey, Group C and D (greater than 12 percent fines), will impede infiltration and cause a perched water condition. These soils will require stringent moisture control during stockpiling, placement, and compaction. Group C and Group D soils have not been recommended for re-use as structural fill at the site.

Although not encountered in the borings during this exploration, Group E soils include excessively organic soils. Group E soils would not be suitable for use as structural fill. Depending upon the organic content and composition of the material, it may be possible for Group E soils to be blended with Group A and B soils and reused in landscape and green areas (i.e. not suitable for use in pond berms, pavements, building pads, and utility support). Please note these soils will tend to retain moisture and will not be freely draining and may lead to soggy ground conditions following rainfall and irrigation. Drainage improvements (i.e. underdrains) may be required in areas adjacent to these soils.

4.8 SEISMIC SITE CLASSIFICATION

UES attempted to advance one boring (B-3) to a depth of 100 feet BEG to provide information for seismic site classification purposes. However, the boring was terminated at 80 feet BEG due to having insufficient time to complete the boring before the Naval School Explosive Ordnance Demolition (NAVSCOLEOD) facility closed and our personnel would be required to leave the D51 hangar site. Because of the inability to advance a boring to the required depth of 100 feet below existing grade, calculations to determine the seismic site class were performed by extrapolating the SPT "N" value encountered at 80 feet to a depth of 100 feet. Using this extrapolation and the calculation procedure presented in ASCE 7-16, we have determined that the subsurface conditions within the site will be consistent with the characteristics of Site Class D.

4.9 CONSTRUCTION RELATED SERVICES

UES would recommend that the Owner retain UES to provide construction monitoring and testing services during the site preparation procedures for confirmation of the adequacy of the earthwork operations. Field tests and observations would include proofroll observation and performing quality assurance tests during the placement of compacted structural fill. We can also provide other material testing and general construction observation services.

The geotechnical engineering design has not ended with the advertisement of the construction documents. The design would be an on-going process throughout construction. Because of our familiarity with the site conditions and the intent of the engineering design, UES would be most qualified to address problems that might arise during construction in a timely and cost-effective manner.

4.10 EXCAVATION AND SAFETY

In Federal Register, Volume 54, No. 209 (October 1989), the United States Department of Labor, Occupational Safety and Health Administration (OSHA) amended its "Construction Standards for Excavations, 29 CFR, Part 1926, Subpart P". This document was issued to better allow for the safety of workers entering trenches or excavations. It has been mandated by this federal regulation that excavations, whether they be utility trenches, basement excavations or footing excavations, be constructed in accordance with the new OSHA guidelines. It has been UES' understanding that these regulations have been strictly enforced and if they were not closely followed, the Owner and the Contractor have been liable for substantial penalties.

The Contractor would be solely responsible for designing and constructing stable, temporary excavations and should shore, slope, or bench the sides of the excavations as required to maintain stability of both the excavation sides and bottom. The Contractor's "responsible person", as defined in 29 CFR Part 1926, should evaluate the soil exposed in the excavations as part of the Contractor's safety procedures. In no case should slope height, slope inclination, or excavation depth, including utility trench excavation depth, exceed those specified in all local, state, and federal safety regulations.

UES has provided this information solely as a service to our Client. UES has not assumed responsibility for construction site safety or the Contractor's or other parties' compliance with local, state, and federal safety or other regulations.

5.0 LIMITATIONS

This report has been prepared for the exclusive use of ***Bullock Tice Associates, LLC*** and other designated members of their Design/Construction Team associated with the proposed construction, for the specific project discussed in this report. No other site or project facilities should be designed using the soil information contained in this report. As such, UES would not be responsible for the performance of any other site improvement designed using the data in this report.

This report should not be relied upon for final design recommendations or professional opinions by unauthorized third parties without the expressed written consent of UES. Unauthorized third parties that rely upon the information contained herein without the expressed written consent of UES would have assumed all risk and liability for such reliance.

The recommendations submitted in this report have been based upon the data obtained from the soil borings performed at the locations indicated on the Boring Location Plan and from other information as referenced. This report has not reflected any variations which may occur between performance of construction operations. If variations became evident, it would then be necessary for a re-evaluation of the recommendations of this report to be performed after performing on-site observations during the construction period and noting the characteristics of the variations.

Borings for a typical geotechnical report have been widely spaced, and generally were not sufficient for reliably detecting the presence of isolated, anomalous surface or subsurface conditions, or reliably estimating unsuitable or suitable material quantities. Accordingly, UES has recommended that the boring information from this exploration not be relied upon for estimation of material quantities. Therefore, UES would not be responsible for any extrapolation or use of our data by others beyond the purpose(s) for which it was applicable or intended.

All users of this report should be cautioned that there was no requirement for UES to attempt to locate any man-made buried objects or identify any other potentially hazardous conditions that may exist at the site during the course of this exploration. Therefore, no attempt was made by UES to locate or identify such concerns. UES would not be responsible for any buried man-made objects or environmental hazards which may be subsequently encountered during construction that were not discussed within the text of this report. UES can provide this service, if desired, and would be pleased to provide the Client with a proposal to perform this service.

During the early stages of most construction projects, geotechnical issues not addressed in this report may arise. Because of the natural limitations inherent in working with the subsurface, it would not be possible for a geotechnical engineer to predict and address all possible problems. A Geotechnical Business Council (GBC) document, entitled "Important Information About Your Geotechnical Engineering Report", has been attached in Appendix D, and would help explain the nature of geotechnical issues. Further, UES has presented a document in Appendix D, entitled “Constraints and Restrictions”, that would bring to the reader’s attention the potential concerns and the basic limitations of a typical geotechnical engineering report.

* * * * * * * * * * * * *

APPENDIX A

D51 HANGAR CONVERSION-HUMAN PERFORMANCE CENTER
EGLIN AIR FORCE BASE
WALTON COUNTY, FLORIDA

SITE LOCATION MAP

DRAWN BY: KD	DATE: 2/20/24	CHECKED BY: GPS	DATE: 2/20/24
SCALE: NTS	PROJECT NO:1730.2300082.0000	REPORT NO:	PAGE NO: A - 1

UES

1730.2300082-A

D51 HANGAR CONVERSION-HUMAN PERFORMANCE CENTER

EGLIN AIR FORCE BASE

WALTON COUNTY, FLORIDA

USDA NRCS SOIL SURVEY MAP

DRAWN BY: KD	DATE: 2/20/24	CHECKED BY: GPS	DATE: 2/20/24
SCALE: NTS	PROJECT NO:1730.2300082.0000	REPORT NO:	PAGE NO: A - 2

UES

1730.2300082-A

APPENDIX B

UES

LEGEND

BORING LOCATION

NOTE: ALL BORING LOCATIONS SHOWN ARE APPROXIMATE.

1730.2300082-A

UES

D51 HANGAR CONVERSION-HUMAN PERFORMANCE CENTER
EGLIN AIR FORCE BASE
WALTON COUNTY, FLORIDA

BORING LOCATION PLAN

DRAWN BY: KD	DATE: 2/20/24	CHECKED BY: GPS	DATE: 2/20/24
SCALE: NTS	PROJECT NO:1730.2300082.0000	REPORT NO:	PAGE NO: B - 1

UNIVERSAL ENGINEERING SCIENCES
BORING LOG

UES

PROJECT NO.: 1730.2300082.0000
REPORT NO.:
PAGE: B-2

PROJECT: D51 HANGAR CONVERSION-HUMAN PERFORMANCE CENTER
EGLIN AIR FORCE BASE
WALTON COUNTY, FLORIDA

BORING DESIGNATION: **B-1** SHEET: **1 of 1**
SECTION: TOWNSHIP: RANGE:

CLIENT: BULLOCK TICE ASSOCIATES, INC.
LOCATION: SEE BORING LOCATION PLAN
REMARKS:

G.S. ELEVATION (ft):
WATER TABLE (ft): NE
DATE OF READING: 2/6/24
EST. W.S.W.T. (ft):

DATE STARTED: 2/6/24
DATE FINISHED: 2/6/24
DRILLED BY: E. MARCEV
TYPE OF SAMPLING: ASTM D1586

DEPTH (FT.)	SAMPLE	BLOWS PER 6" INCREMENT	N VALUE	W.T.	SYMBOL	DESCRIPTION	-200 (%)	MC (%)	ATTERBERG LIMITS LL	PI	K (FT./ DAY)	ORGANIC CONTENT (%)
0						Approximately 1" of Topsoil / Root mat						
0–4	X	3-6-7-7	13			Medium dense to loose brown SAND, with silt [SP-SM], with trace roots, gravel (Fill)	7.9	7.7				
	X	2-3-3-3	6									
4–8	X	3-3-2-4	5			Loose light tan SAND [SP]	3.0	4.5				
	X	3-3-4-4	7									
8–12	X	3-4-4-4	8			Loose light tan to orangish brown SAND, with silt [SP-SM]	6.2	6.6				
12–22	X	6-8-10	18			Medium dense brown to white SAND [SP]						
	X	11-12-16	28									
22–27	X	16-25-37	62			Very dense gray SAND, with silt [SP-SM]						
27–30	X	17-34-44	78			Very dense gray to white SAND [SP]						
30						Boring Terminated at 30'						

NEW LOGO BORING LOG D51 HANGAR CONVERSION.GPJ GAINESVILLE TEMPLATE.GDT 3/4/24

UNIVERSAL ENGINEERING SCIENCES
BORING LOG

PROJECT NO.: 1730.2300082.0000
REPORT NO.:
PAGE: B-3

PROJECT: D51 HANGAR CONVERSION-HUMAN PERFORMANCE CENTER
EGLIN AIR FORCE BASE
WALTON COUNTY, FLORIDA

BORING DESIGNATION: **B-2**
SHEET: **1 of 1**
SECTION:
TOWNSHIP:
RANGE:

CLIENT: BULLOCK TICE ASSOCIATES, INC.
LOCATION: SEE BORING LOCATION PLAN
REMARKS:

G.S. ELEVATION (ft):
WATER TABLE (ft): NE
DATE OF READING: 2/6/24
EST. W.S.W.T. (ft):

DATE STARTED: 2/6/24
DATE FINISHED: 2/6/24
DRILLED BY: E. MARCEV
TYPE OF SAMPLING: ASTM D1586

DEPTH (FT.)	SAMPLE	BLOWS PER 6" INCREMENT	N VALUE	W.T.	SYMBOL	DESCRIPTION	-200 (%)	MC (%)	ATTERBERG LIMITS LL	PI	K (FT./ DAY)	ORGANIC CONTENT (%)
0	X					Approximately 1" of Topsoil / Root mat						
0–2	X	6-8-14-15	22			Medium dense brown SAND, with silt [SP-SM], with trace roots (Likely Fill)						
2–4	X	7-7-6-6	13			Medium dense brown SAND, with silt [SP-SM] (Likely Fill)	6.8	5.3				
4–6	X	5-4-4-5	8			Loose light brown SAND [SP]	4.5	4.8				
6–8	X	5-4-4-4	8			Loose light tan SAND [SP]						
8–10	X	4-4-4-4	8									
12						Medium dense light tan to white SAND [SP]						
14–15	X	7-7-8	15									
19–20	X	5-9-13	22									
22						Dense gray SAND [SP]						
24–25	X	9-16-20	36				2.5	8.0				
29–30	X	9-18-25	43									
30						Boring Terminated at 30'						

UNIVERSAL ENGINEERING SCIENCES
BORING LOG

PROJECT NO.: 1730.2300082.0000
REPORT NO.:
PAGE: B-4

PROJECT: D51 HANGAR CONVERSION-HUMAN PERFORMANCE CENTER
EGLIN AIR FORCE BASE
WALTON COUNTY, FLORIDA

BORING DESIGNATION: **B-3** SHEET: **1 of 2**
SECTION: TOWNSHIP: RANGE:

CLIENT: BULLOCK TICE ASSOCIATES, INC.
LOCATION: SEE BORING LOCATION PLAN
REMARKS:

G.S. ELEVATION (ft):
WATER TABLE (ft): NE
DATE OF READING: 2/7/24
EST. W.S.W.T. (ft):

DATE STARTED: 2/7/24
DATE FINISHED: 2/7/24
DRILLED BY: E. MARCEV
TYPE OF SAMPLING: ASTM D1586

DEPTH (FT.)	SAMPLE	BLOWS PER 6" INCREMENT	N VALUE	W.T.	SYMBOL	DESCRIPTION	-200 (%)	MC (%)	ATTERBERG LIMITS LL	ATTERBERG LIMITS PI	K (FT./DAY)	ORGANIC CONTENT (%)
0						Approximately 1" of Topsoil/Root Mat						
0–2	X	6-8-10-11	18			Medium dense brown SAND, with silt [SP-SM], with trace roots (Fill)	8.7	9.7				
2–4	X	7-6-5-5	11									
4–6	X	4-3-4-4	7			Loose light brown SAND [SP]						
6–8	X	3-4-4-4	8			Loose light tan SAND [SP]						
8–10	X	3-4-3-3	7									
12						Medium dense light brown to white SAND [SP]						
13.5–15	X	5-6-6	12				4.3	5.2				
17						Very dense light tan to gray SAND, with silt [SP-SM]						
18.5–20	X	11-25-35	60									
23.5–25	X	21-30-39	69									
28.5–30	X	31-50/6"	50/6"									
33.5–35	X	31-50/5"	50/5"				5.8	21				
37						Very dense light tan to white SAND [SP]						
38.5–40	X	50/6"	50/6"									
43.5–45	X	50/6"	50/6"									

UNIVERSAL ENGINEERING SCIENCES
BORING LOG

PROJECT NO.:	1730.2300082.0000
REPORT NO.:	
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PROJECT: D51 HANGAR CONVERSION-HUMAN PERFORMANCE CENTER
EGLIN AIR FORCE BASE
WALTON COUNTY, FLORIDA

BORING DESIGNATION: **B-3** SHEET: **2 of 2**
SECTION: TOWNSHIP: RANGE:

DEPTH (FT.)	SAMPLE	BLOWS PER 6" INCREMENT	N VALUE	W.T.	SYMBOL	DESCRIPTION	-200 (%)	MC (%)	ATTERBERG LIMITS LL	ATTERBERG LIMITS PI	K (FT./ DAY)	ORGANIC CONTENT (%)
45												
47						Very dense white SAND [SP]						
50	X	44-50/4"	50/4"									
55	X	50/5"	50/5"									
60	X	50/6"	50/6"									
65	X	45-50/6"	50/6"									
67						Very dense orangish brown SAND [SP]						
70	X	20-28-33	61									
72						Very dense orange SAND, with silt [SP-SM]						
75	X	19-29-30	59									
77						Dense orange silty SAND [SM]						
80	X	11-15-16	31			Boring Terminated at 80'	18	26		NP		

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BORING LOG

PROJECT NO.:	1730.2300082.0000
REPORT NO.:	
PAGE:	B-6

PROJECT: D51 HANGAR CONVERSION-HUMAN PERFORMANCE CENTER
EGLIN AIR FORCE BASE
WALTON COUNTY, FLORIDA

BORING DESIGNATION: **SW-1** SHEET: **1 of 1**
SECTION: TOWNSHIP: RANGE:

CLIENT: BULLOCK TICE ASSOCIATES, INC.
LOCATION: SEE BORING LOCATION PLAN
REMARKS:

G.S. ELEVATION (ft):
WATER TABLE (ft): NE
DATE OF READING: 2/6/24
EST. W.S.W.T. (ft):

DATE STARTED: 2/6/24
DATE FINISHED: 2/6/24
DRILLED BY: E. MARCEV
TYPE OF SAMPLING: ASTM D1586

DEPTH (FT.)	SAMPLE	BLOWS PER 6" INCREMENT	N VALUE	W.T.	SYMBOL	DESCRIPTION	-200 (%)	MC (%)	ATTERBERG LIMITS LL	PI	K (FT./ DAY)	ORGANIC CONTENT (%)
0						Approximately 1" of Topsoil / Root mat						
0–2	X	5-7-7-6	14			Medium dense brown SAND, with silt [SP-SM] (Possible Fill)						
2–4	X	4-3-3-4	6			Loose light brown SAND, with silt [SP-SM]	7.4	5.0				
4–6	X	3-3-4-4	7			Loose light tan SAND [SP]	3.6	4.3			27	
6–8	X	3-3-4-5	7				3.3	4.4				
8–9						Loose orangish brown SAND, with silt [SP-SM]	9.3	6.8				
8–10	X	3-4-4-4	8			Loose light brown SAND [SP]						
12						Medium dense to very dense light tan to white SAND [SP]						
14–15	X	6-6-8	14				1.9	4.4				
19–20	X	15-22-32	54				3.1	6.8				
24–25	X	18-25-30	55				1.1	4.1				
29–30	X	25-50/6"	50/6"				3.2	5.2				
30						Boring Terminated at 30'						

NEW LOGO BORING LOG D51 HANGAR CONVERSION.GPJ GAINESVILLE TEMPLATE.GDT 3/4/24

UNIVERSAL ENGINEERING SCIENCES
BORING LOG

PROJECT NO.: 1730.2300082.0000
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PROJECT: D51 HANGAR CONVERSION-HUMAN PERFORMANCE CENTER
EGLIN AIR FORCE BASE
WALTON COUNTY, FLORIDA

BORING DESIGNATION: **SW-2**
SHEET: **1 of 1**
SECTION:
TOWNSHIP:
RANGE:

CLIENT: BULLOCK TICE ASSOCIATES, INC.
LOCATION: SEE BORING LOCATION PLAN
REMARKS:

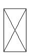
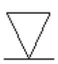
G.S. ELEVATION (ft):
WATER TABLE (ft): NE
DATE OF READING: 2/6/24
EST. W.S.W.T. (ft):

DATE STARTED: 2/6/24
DATE FINISHED: 2/6/24
DRILLED BY: E. MARCEV
TYPE OF SAMPLING: ASTM D1586

DEPTH (FT.)	SAMPLE	BLOWS PER 6" INCREMENT	N VALUE	W.T.	SYMBOL	DESCRIPTION	-200 (%)	MC (%)	ATTERBERG LIMITS LL	PI	K (FT./ DAY)	ORGANIC CONTENT (%)
0						Approximately 1" of Topsoil / Root mat						
1	X					Medium dense brown SAND, with silt [SP-SM] (Possible Fill)						
2		6-6-5-5	11				7.3	6.6				
3	X					Loose light brown SAND, with silt [SP-SM]						
4		2-2-3-3	5									
5	X					Loose light tan SAND [SP]						
6		2-2-3-3	5				2.9	3.5			22	
7	X					Loose light tan SAND, with silt [SP-SM]						
8		3-3-4-4	7				7.1	6.4				
9	X					Loose orangish brown SAND, with silt [SP-SM]	8.2	7.1				
10		4-4-4-5	8			Loose to medium dense light tan to white SAND [SP]						
11–13												
14	X											
15		5-6-8	14				1.8	4.3				
16												
17						Dense gray SAND [SP]						
18												
19	X											
20		11-17-23	40				1.9	4.5				
21–23												
24	X											
25		13-18-31	49				1.5	5.7				
26												
27						Very dense gray to white SAND [SP]						
28												
29	X											
30		10-30-49	79			Boring Terminated at 30'	1.9	4.4				

KEY TO BORING LOGS

SYMBOLS AND ABBREVIATIONS

SYMBOL	DESCRIPTION
N-Value	No. of Blows of a 140-lb. Weight Falling 30 Inches Required to Drive a Standard Spoon 1 Foot
WOR	Weight of Drill Rods
WOH	Weight of Drill Rods and Hammer
	Sample from Auger Cuttings
	Standard Penetration Test Sample
	Thin-wall Shelby Tube Sample (Undisturbed Sampler Used)
RQD	Rock Quality Designation
	Stabilized Groundwater Level
	Seasonal High Groundwater Level (also referred to as the W.S.W.T.)
NE	Not Encountered
GNE	Groundwater Not Encountered
BT	Boring Terminated
-200 (%)	Fines Content or % Passing No. 200 Sieve
MC (%)	Moisture Content
LL	Liquid Limit (Atterberg Limits Test)
PI	Plasticity Index (Atterberg Limits Test)
NP	Non-Plastic (Atterberg Limits Test)
K	Coefficient of Permeability
Org. Cont.	Organic Content
G.S. Elevation	Ground Surface Elevation

UNIFIED SOIL CLASSIFICATION SYSTEM

MAJOR DIVISIONS			GROUP SYMBOLS	TYPICAL NAMES
COARSE GRAINED SOILS More than 50% retained on the No. 200 sieve*	GRAVELS 50% or more of coarse fraction retained on No. 4 sieve	CLEAN GRAVELS	GW	Well-graded gravels and gravel-sand mixtures, little or no fines
			GP	Poorly graded gravels and gravel-sand mixtures, little or no fines
		GRAVELS WITH FINES	GM	Silty gravels and gravel-sand-silt mixtures
			GC	Clayey gravels and gravel-sand-clay mixtures
	SANDS More than 50% of coarse fraction passes No. 4 sieve	CLEAN SANDS 5% or less passing No. 200 sieve	SW**	Well-graded sands and gravelly sands, little or no fines
			SP**	Poorly graded sands and gravelly sands, little or no fines
		SANDS with 12% or more passing No. 200 sieve	SM**	Silty sands, sand-silt mixtures
			SC**	Clayey sands, sand-clay mixtures
FINE-GRAINED SIOLS 50% or more passes the No. 200 sieve*	SILTS AND CLAYS Liquid limit 50% or less		ML	Inorganic silts, very fine sands, rock flour, silty or clayey fine sands
			CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, lean clays
			OL	Organic silts and organic silty clays of low plasticity
	SILTS AND CLAYS Liquid limit greater than 50%		MH	Inorganic silts, micaceous or diamicaceous fine sands or silts, elastic silts
			CH	Inorganic clays or clays of high plasticity, fat clays
			OH	Organic clays of medium to high plasticity
			PT	Peat, muck and other highly organic soils

*Based on the material passing the 3-inch (75 mm) sieve
** Use dual symbol (such as SP-SM and SP-SC) for soils with more than 5% but less than 12% passing the No. 200 sieve

RELATIVE DENSITY
(Sands and Gravels)
Very loose – Less than 4 Blow/Foot
Loose – 4 to 10 Blows/Foot
Medium Dense – 11 to 30 Blows/Foot
Dense – 31 to 50 Blows/Foot
Very Dense – More than 50 Blows/Foot

CONSISTENCY
(Silts and Clays)
Very Soft – Less than 2 Blows/Foot
Soft – 2 to 4 Blows/Foot
Firm – 5 to 8 Blows/Foot
Stiff – 9 to 15 Blows/Foot
Very Stiff – 16 to 30 Blows/Foot
Hard – More than 30 Blows/Foot

RELATIVE HARDNESS
(Limestone)
Soft – 100 Blows for more than 2 Inches
Hard – 100 Blows for less than 2 Inches

MODIFIERS

These modifiers Provide Our Estimate of the Amount of Minor Constituents (Silt or Clay Size Particles) in the Soil Sample
Trace – 5% or less
With Silt or With Clay – 6% to 11%
Silty or Clayey – 12% to 30%
Very Silty or Very Clayey – 31% to 50%

These Modifiers Provide Our Estimate of the Amount of Organic Components in the Soil Sample
Trace – Less than 3%
Few – 3% to 4%
Some – 5% to 8%
Many – Greater than 8%

These Modifiers Provide Our Estimate of the Amount of Other Components (Shell, Gravel, Etc.) in the Soil Sample
Trace – 5% or less
Few – 6% to 12%
Some – 13% to 30%
Many – 31% to 50%

FIELD PROCEDURES

Standard Penetration Test (SPT) Borings (Flight Auger Advanced)

Borings B-1, B-2, SW-1, and SW-2 were advanced to an approximate depth of 30 feet below existing grade (BEG) and Boring B-3 was advanced to an approximate depth of 15 feet BEG by mechanically twisting continuous flight augers in to the soils. On intervals of 2 feet down to a depth of 10 feet BEG and intervals of 5 feet thereafter, Standard Penetration Testing and split-barrel sampling were performed in the borings. At the selected test/sampling depth, a split-barrel sampler was inserted to the bottom of the boring and driven 18 or 24-inches into the soil using a manual safety hammer with a 140-pound hammer falling an average of 30 inches per hammer blow. The blow counts for every 6 inches of penetration/driving were recorded. The sum of the hammer blow counts for the second and third 6-inch intervals of penetration is termed the standard penetration resistance blow count or N-value. This value is an index of several in-situ geotechnical engineering properties of the material tested, such as relative density and Young's Modulus.

After driving the sampler 18 or 24 inches, the sampler was retrieved from the boring, and a representative sample of the material within the split-barrel sampler was placed in a labeled plastic container and sealed. The samples obtained from the borings were transported to the laboratory where they were examined by members of the UES geotechnical engineering staff. This procedure was performed in general accordance with the latest revision of ASTM Designation D1586 entitled "Standard Test Method for Standard Penetration Test (SPT) and Split-Barrel Sampling of Soils".

Standard Penetration Test (SPT) Borings (Mud-Rotary Advanced)

Below an approximate depth of 15 feet BEG, Boring B-3 was extended to an approximate termination depths of 80 feet BEG by means of rotary drilling techniques using a circulating bentonite fluid/"mud" for borehole flushing and stability. On intervals of 5 feet in the rotary portion of the borings, the drilling tools were removed from each boring, and a split-barrel sampler was inserted to the boring bottom. The sampler was then driven 18 inches in to the soils using a manual safety hammer with a 140-pound hammer falling 30 inches per hammer blow. The blow counts for every 6 inches of penetration/driving were recorded. The sum of the hammer blow counts for the second and third 6-inch intervals of penetration is termed the standard penetration resistance blow count or "N-value". This value is an index of several in-situ geotechnical engineering properties of the materials tested, such as relative density and Young's Modulus.

After driving the sampler 18 inches, the sampler was retrieved from each boring, and a representative sample of the material within the split-barrel sampler was placed in a labeled plastic container and sealed. The samples obtained from the borings were transported to the laboratory where they were examined by members of the UES geotechnical engineering staff. This procedure was performed in general accordance with the latest revision of the ASTM Designation D1586 entitled "Standard Test Method for Standard Penetration Test (SPT) and Split-Barrel Sampling of Soils".

APPENDIX C

LABORATORY PROCEDURES

Natural Moisture Content Test

A number of the soil samples recovered during the field exploration were chosen for natural moisture content testing. In this test, the soil sample is placed into a metal pan of known weight, weighed, dried for a minimum of 12 hours in a 110 ± 5°C oven, and then weighed again to record the weight of water released during drying. The natural moisture content of the soil is termed the ratio of "pore" or "free" water in a given mass of material to the mass of solid material particles. This test was conducted in general accordance with ASTM Designation D2216 entitled "Standard Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass".

Percent -200 Soil Fines Content Test

A number of the soil samples recovered during the subsurface exploration were chosen to determine the percentage of silt and clay fines present in the individual samples. In this test, the Natural Moisture Content test (ASTM D2216) was performed and the sample was then washed over a No. 200 mesh sieve. The materials present in the sample that did not pass through the No. 200 sieve was then placed back in its original pan and dried until the water retained from the wet-sieve process was totally evaporated. Once dried, the sample was weighed again to determine the weight of fines removed during the wet-sieve process. The percent of soil by weight passing the No. 200 sieve is termed the percentage of fines or portion of the sample in the silt and clay size range. This test was conducted in general accordance with ASTM D1140, Standard Test Methods for Determining the Amount of Material Finer than the No. 200 (75-µm) Sieve in Soils by Washing.

Falling-Head Permeability Testing

Using bulk samples of auger cuttings recovered from specific depth intervals in the stormwater pond borings during the field exploration, laboratory falling head permeability testing was performed to determine the permeability rate (a.k.a., hydraulic conductivity values) of the soils. In this test, the sampled material was compacted in three lifts in a 4-in permeability mold of known weight and volume. Once the material was compacted into the mold, the mold and material were then weighed. In addition to weighing the mold and soil, the natural moisture content test (ASTM D2216) was performed on the trimmings left over from the sample compaction. The dry density of the material was then calculated using the volume, weight, and moisture content of the compacted sample.

Once the density procedure was performed, the permeability mold with the compacted material was then covered with a porous stone and spring system to control loosening of the materials during the permeability test. A support collar and top plate was then placed atop the permeability mold (the top plate is equipped with a vent port to allow air to escape the mold/sample as well as an influent port to allow water to saturate the compacted sample). Once the apparatus was assembled and properly tightened, a one-half inch diameter vertical tube, marked with one-foot increments, was attached to the influent port. The tubing was then filled with water and permitted to drain into the influent port, through the sample, and out of the effluent tube at the bottom of the apparatus. Once the sample was saturated and nearly devoid of air, the tubing was filled with water to seven feet above the apparatus and allowed to drain thrrough the sample while the time (in seconds) it took for the water to drop each one foot increment was recorded. The vertical permeability rate of the compacted soils was then calculated using data obtained from the procedure. This test was conducted in general accordance with the State of Florida Department of Transportation test procedure Designation FM 5-513 entitled "Florida Method of Test for Coefficient of Permeability – Falling Head Method".

APPENDIX D

UES

Important Information about This

Geotechnical-Engineering Report

Subsurface problems are a principal cause of construction delays, cost overruns, claims, and disputes.

While you cannot eliminate all such risks, you can manage them. The following information is provided to help.

Geotechnical Services Are Performed for Specific Purposes, Persons, and Projects

Geotechnical engineers structure their services to meet the specific needs of their clients. A geotechnical-engineering study conducted for a civil engineer may not fulfill the needs of a constructor — a construction contractor — or even another civil engineer. Because each geotechnical- engineering study is unique, each geotechnical-engineering report is unique, prepared *solely* for the client. No one except you should rely on this geotechnical-engineering report without first conferring with the geotechnical engineer who prepared it. *And no one — not even you* — should apply this report for any purpose or project except the one originally contemplated.

Read the Full Report

Serious problems have occurred because those relying on a geotechnical-engineering report did not read it all. Do not rely on an executive summary. Do not read selected elements only.

Geotechnical Engineers Base Each Report on a Unique Set of Project-Specific Factors

Geotechnical engineers consider many unique, project-specific factors when establishing the scope of a study. Typical factors include: the client's goals, objectives, and risk-management preferences; the general nature of the structure involved, its size, and configuration; the location of the structure on the site; and other planned or existing site improvements, such as access roads, parking lots, and underground utilities. Unless the geotechnical engineer who conducted the study specifically indicates otherwise, do not rely on a geotechnical-engineering report that was:

- not prepared for you;
- not prepared for your project;
- not prepared for the specific site explored; or
- completed before important project changes were made.

Typical changes that can erode the reliability of an existing geotechnical-engineering report include those that affect:

- the function of the proposed structure, as when it's changed from a parking garage to an office building, or from a light-industrial plant to a refrigerated warehouse;
- the elevation, configuration, location, orientation, or weight of the proposed structure;
- the composition of the design team; or
- project ownership.

As a general rule, *always* inform your geotechnical engineer of project changes—even minor ones—and request an assessment of their impact. *Geotechnical engineers cannot accept responsibility or liability for problems that occur because their reports do not consider developments of which they were not informed.*

Subsurface Conditions Can Change

A geotechnical-engineering report is based on conditions that existed at the time the geotechnical engineer performed the study. *Do not rely on a geotechnical-engineering report whose adequacy may have been affected by*: the passage of time; man-made events, such as construction on or adjacent to the site; or natural events, such as floods, droughts, earthquakes, or groundwater fluctuations. *Contact the geotechnical engineer before applying this report to determine if it is still reliable.* A minor amount of additional testing or analysis could prevent major problems.

Most Geotechnical Findings Are Professional Opinions

Site exploration identifies subsurface conditions only at those points where subsurface tests are conducted or samples are taken. Geotechnical engineers review field and laboratory data and then apply their professional judgment to render an opinion about subsurface conditions throughout the site. Actual subsurface conditions may differ — sometimes significantly — from those indicated in your report. Retaining the geotechnical engineer who developed your report to provide geotechnical-construction observation is the most effective method of managing the risks associated with unanticipated conditions.

A Report's Recommendations Are Not Final

Do not overrely on the confirmation-dependent recommendations included in your report. *Confirmation-dependent recommendations are not final,* because geotechnical engineers develop them principally from judgment and opinion. Geotechnical engineers can finalize their recommendations *only* by observing actual subsurface conditions revealed during construction. *The geotechnical engineer who developed your report cannot assume responsibility or liability for the report's confirmation-dependent recommendations if that engineer does not perform the geotechnical-construction observation required to confirm the recommendations' applicability.*

A Geotechnical-Engineering Report Is Subject to Misinterpretation

Other design-team members' misinterpretation of geotechnical-engineering reports has resulted in costly problems. Confront that risk by having your geotechnical engineer confer with appropriate members of the design team after submitting the report. Also retain your geotechnical engineer to review pertinent elements of the design team's plans and specifications. Constructors can also misinterpret a geotechnical-engineering report. Confront that risk by having your geotechnical engineer participate in prebid and preconstruction conferences, and by providing geotechnical construction observation.

Do Not Redraw the Engineer's Logs

Geotechnical engineers prepare final boring and testing logs based upon their interpretation of field logs and laboratory data. To prevent errors or omissions, the logs included in a geotechnical-engineering report should *never* be redrawn for inclusion in architectural or other design drawings. Only photographic or electronic reproduction is acceptable, *but recognize that separating logs from the report can elevate risk.*

Give Constructors a Complete Report and Guidance

Some owners and design professionals mistakenly believe they can make constructors liable for unanticipated subsurface conditions by limiting what they provide for bid preparation. To help prevent costly problems, give constructors the complete geotechnical-engineering report, *but* preface it with a clearly written letter of transmittal. In that letter, advise constructors that the report was not prepared for purposes of bid development and that the report's accuracy is limited; encourage them to confer with the geotechnical engineer who prepared the report (a modest fee may be required) and/or to conduct additional study to obtain the specific types of information they need or prefer. A prebid conference can also be valuable. *Be sure constructors have sufficient time* to perform additional study. Only then might you be in a position to give constructors the best information available to you, while requiring them to at least share some of the financial responsibilities stemming from unanticipated conditions.

Read Responsibility Provisions Closely

Some clients, design professionals, and constructors fail to recognize that geotechnical engineering is far less exact than other engineering disciplines. This lack of understanding has created unrealistic expectations that have led to disappointments, claims, and disputes. To help reduce the risk of such outcomes, geotechnical engineers commonly include a variety of explanatory provisions in their reports. Sometimes labeled "limitations," many of these provisions indicate where geotechnical engineers' responsibilities begin and end, to help others recognize their own responsibilities and risks. *Read these provisions closely.* Ask questions. Your geotechnical engineer should respond fully and frankly.

Environmental Concerns Are Not Covered

The equipment, techniques, and personnel used to perform an *environmental* study differ significantly from those used to perform a *geotechnical* study. For that reason, a geotechnical-engineering report does not usually relate any environmental findings, conclusions, or recommendations; e.g., about the likelihood of encountering underground storage tanks or regulated contaminants. *Unanticipated environmental problems have led to numerous project failures.* If you have not yet obtained your own environmental information, ask your geotechnical consultant for risk-management guidance. *Do not rely on an environmental report prepared for someone else.*

Obtain Professional Assistance To Deal with Mold

Diverse strategies can be applied during building design, construction, operation, and maintenance to prevent significant amounts of mold from growing on indoor surfaces. To be effective, all such strategies should be devised for the *express purpose* of mold prevention, integrated into a comprehensive plan, and executed with diligent oversight by a professional mold-prevention consultant. Because just a small amount of water or moisture can lead to the development of severe mold infestations, many mold- prevention strategies focus on keeping building surfaces dry. While groundwater, water infiltration, and similar issues may have been addressed as part of the geotechnical- engineering study whose findings are conveyed in this report, the geotechnical engineer in charge of this project is not a mold prevention consultant; *none of the services performed in connection with the geotechnical engineer's study were designed or conducted for the purpose of mold prevention. Proper implementation of the recommendations conveyed in this report will not of itself be sufficient to prevent mold from growing in or on the structure involved.*

Rely, on Your GBC-Member Geotechnical Engineer for Additional Assistance

Membership in the Geotechnical Business Council of the Geoprofessional Business Association exposes geotechnical engineers to a wide array of risk-confrontation techniques that can be of genuine benefit for everyone involved with a construction project. Confer with you GBC-Member geotechnical engineer for more information.

GBC GEOTECHNICAL BUSINESS COUNCIL
of the Geoprofessional Business Association

8811 Colesville Road/Suite G106, Silver Spring, MD 20910
Telephone: 301/565-2733 Facsimile: 301/589-2017
e-mail: info@geoprofessional.org www.geoprofessional.org

CONSTRAINTS & RESTRICTIONS

The intent of this document is to bring to your attention the potential concerns and the basic limitations of a typical geotechnical report.

WARRANTY

Universal Engineering Sciences has prepared this report for our client for his exclusive use, in accordance with generally accepted soil and foundation engineering practices, and makes no other warranty either expressed or implied as to the professional advice provided in the report.

UNANTICIPATED SOIL CONDITIONS

The analysis and recommendations submitted in this report are based upon the data obtained from soil borings performed at the locations indicated on the Boring Location Plan. This report does not reflect any variations which may occur between these borings.

The nature and extent of variations between borings may not become known until excavation begins. If variations appear, we may have to re-evaluate our recommendations after performing on-site observations and noting the characteristics of any variations.

CHANGED CONDITIONS

We recommend that the specifications for the project require that the contractor immediately notify Universal Engineering Sciences, as well as the owner, when subsurface conditions are encountered that are different from those present in this report.

No claim by the contractor for any conditions differing from those anticipated in the plans, specifications, and those found in this report, should be allowed unless the contractor notifies the owner and Universal Engineering Sciences of such changed conditions. Further, we recommend that all foundation work and site improvements be observed by a representative of Universal Engineering Sciences to monitor field conditions and changes, to verify design assumptions and to evaluate and recommend any appropriate modifications to this report.

MISINTERPRETATION OF SOIL ENGINEERING REPORT

Universal Engineering Sciences is responsible for the conclusions and opinions contained within this report based upon the data relating only to the specific project and location discussed herein. If the conclusions or recommendations based upon the data presented are made by others, those conclusions or recommendations are not the responsibility of Universal Engineering Sciences.

CHANGED STRUCTURE OR LOCATION

This report was prepared in order to aid in the evaluation of this project and to assist the architect or engineer in the design of this project. If any changes in the design or location of the structure as outlined in this report are planned, or if any structures are included or added that are not discussed in the report, the conclusions and recommendations contained in this report shall not be considered valid unless the changes are reviewed and the conclusions modified or approved by Universal Engineering Sciences.

USE OF REPORT BY BIDDERS

Bidders who are examining the report prior to submission of a bid are cautioned that this report was prepared as an aid to the designers of the project and it may affect actual construction operations.

Bidders are urged to make their own soil borings, test pits, test caissons or other investigations to determine those conditions that may affect construction operations. Universal Engineering Sciences cannot be responsible for any interpretations made from this report or the attached boring logs with regard to their adequacy in reflecting subsurface conditions which will affect construction operations.

STRATA CHANGES

Strata changes are indicated by a definite line on the boring logs which accompany this report. However, the actual change in the ground may be more gradual. Where changes occur between soil samples, the location of the change must necessarily be estimated using all available information and may not be shown at the exact depth.

OBSERVATIONS DURING DRILLING

Attempts are made to detect and/or identify occurrences during drilling and sampling, such as: water level, boulders, zones of lost circulation, relative ease or resistance to drilling progress, unusual sample recovery, variation of driving resistance, obstructions, etc.; however, lack of mention does not preclude their presence.

WATER LEVELS

Water level readings have been made in the drill holes during drilling and they indicate normally occurring conditions. Water levels may not have been stabilized at the last reading. This data has been reviewed and interpretations made in this report. However, it must be noted that fluctuations in the level of the groundwater may occur due to variations in rainfall, temperature, tides, and other factors not evident at the time measurements were made and reported. Since the probability of such variations is anticipated, design drawings and specifications should accommodate such possibilities and construction planning should be based upon such assumptions of variations.

LOCATION OF BURIED OBJECTS

All users of this report are cautioned that there was no requirement for Universal Engineering Sciences to attempt to locate any man-made buried objects during the course of this exploration and that no attempt was made by Universal Engineering Sciences to locate any such buried objects. Universal Engineering Sciences cannot be responsible for any buried man-made objects which are subsequently encountered during construction that are not discussed within the text of this report.

TIME

This report reflects the soil conditions at the time of exploration. If the report is not used in a reasonable amount of time, significant changes to the site may occur and additional reviews may be required.

UES

UES
GENERAL CONDITIONS

SECTION 1: RESPONSIBILITIES **1.1** *UES*, and its subsidiaries and affiliated companies ("UES"), is responsible for providing the services described under the Scope of Services. The term "UES" as used herein includes all of UES's agents, employees, professional staff, and subcontractors. **1.2** The Client or a duly authorized representative is responsible for providing UES with a clear understanding of the project nature and scope. The Client shall supply UES with sufficient and adequate information, including, but not limited to, maps, site plans, reports, surveys, plans and specifications, and designs, to allow UES to properly complete the specified services. The Client shall also communicate changes in the nature and scope of the project as soon as possible during performance of the work so that the changes can be incorporated into the work product. **1.3** The Client acknowledges that UES's responsibilities in providing the services described under the Scope of Services section is limited to those services described therein, and the Client hereby assumes any collateral or affiliated duties necessitated by or for those services. Such duties may include, but are not limited to, reporting requirements imposed by any third party such as federal, state, or local entities, the provision of any required notices to any third party, or the securing of necessary permits or permissions from any third parties required for UES's provision of the services so described, unless otherwise agreed upon by both parties in writing.

SECTION 2: STANDARD OF CARE **2.1** Services performed by UES under this Agreement will be conducted in a manner consistent with the level of care and skill ordinarily exercised by members of UES's profession practicing contemporaneously under similar conditions in the locality of the project. No other warranty, express or implied, is made. **2.2** Execution of this document by UES is not a representation that UES has visited the site, become generally familiar with local conditions under which the work is to be performed, or correlated personal observations with the requirements of the Scope of Services. It is the Client's responsibility to provide UES with all information necessary for UES to provide the services described under the Scope of Services, and the Client assumes all liability for information not provided to UES that may affect the quality or sufficiency of the services so described.

SECTION 3: SITE ACCESS AND SITE CONDITIONS **3.1** Client will grant or obtain free access to the site for all equipment and personnel necessary for UES to perform the work set forth in this Agreement. The Client will notify any possessors of the project site that Client has granted UES free access to the site. UES will take reasonable precautions to minimize damage to the site, but it is understood by Client that, in the normal course of work, some damage may occur, and the correction of such damage is not part of this Agreement unless so specified in the Scope of Services. **3.2** The Client is responsible for the accuracy of locations for all subterranean structures and utilities. UES will take reasonable precautions to avoid known subterranean structures, and the Client waives any claim against UES, and agrees to defend, indemnify, and hold UES harmless from any claim or liability for injury or loss, including costs of defense, arising from damage done to subterranean structures and utilities not identified or accurately located. In addition, Client agrees to compensate UES for any time spent or expenses incurred by UES in defense of any such claim with compensation to be based upon UES's prevailing fee schedule and expense reimbursement policy.

SECTION 4: BILLING AND PAYMENT **4.1** UES will submit invoices to Client monthly or upon completion of services. Invoices will show charges for different personnel and expense classifications. **4.2** Payment is due 30 days after presentation of invoice and is past due 31 days from invoice date. Client agrees to pay a finance charge of one and one-half percent (1 ½ %) per month, or the maximum rate allowed by law, on past due accounts. **4.3** If UES incurs any expenses to collect overdue billings on invoices, the sums paid by UES for reasonable attorneys' fees, court costs, UES's time, UES's expenses, and interest will be due and owing by the Client.

SECTION 5: OWNERSHIP AND USE OF DOCUMENTS **5.1** All reports, boring logs, field data, field notes, laboratory test data, calculations, estimates, and other documents prepared by UES, as instruments of service, shall remain the property of UES. Neither Client nor any other entity shall change or modify UES's instruments of service. **5.2** Client agrees that all reports and other work furnished to the Client or his agents, which are not paid for, will be returned upon demand and will not be used by the Client for any purpose. **5.3** UES will retain all pertinent records relating to the services performed for a period of five years following submission of the report or completion of the Scope of Services, during which period the records will be made available to the Client in a reasonable time and manner. **5.4** All reports, boring logs, field data, field notes, laboratory test data, calculations, estimates, and other documents prepared by UES, are prepared for the sole and exclusive use of Client, and may not be given to any other entity, or used or relied upon by any other entity, without the express written consent of UES. Client is the only entity to which UES owes any duty or duties, in contract or tort, pursuant to or under this Agreement.

SECTION 6: DISCOVERY OF UNANTICIPATED HAZARDOUS MATERIALS **6.1** Client represents that a reasonable effort has been made to inform UES of known or suspected hazardous materials on or near the project site. **6.2** Under this agreement, the term hazardous materials include hazardous materials, hazardous wastes, hazardous substances (40 CFR 261.31, 261.32, 261.33), petroleum products, polychlorinated biphenyls, asbestos, and any other material defined by the U.S. EPA as a hazardous material. **6.3** Hazardous materials may exist at a site where there is no reason to believe they are present. The discovery of unanticipated hazardous materials constitutes a changed condition mandating a renegotiation of the scope of work. The discovery of unanticipated hazardous materials may make it necessary for UES to take immediate measures to protect health and safety. Client agrees to compensate UES for any equipment decontamination or other costs incident to the discovery of unanticipated hazardous materials. **6.4** UES will notify Client when unanticipated hazardous materials or suspected hazardous materials are encountered. Client will make any disclosures required by law to the appropriate governing agencies. Client will hold UES harmless for all consequences of disclosures made by UES which are required by governing law. In the event the project site is not owned by Client, Client it is the Client's responsibility to inform the property owner of the discovery of unanticipated hazardous materials or suspected hazardous materials. **6.5** Notwithstanding any other provision of the Agreement, Client waives any claim against UES, and to the maximum extent permitted by law, agrees to defend, indemnify, and save UES harmless from any claim, liability, and/or defense costs for injury or loss arising from UES's discovery of unanticipated hazardous materials or suspected hazardous materials including any costs created by delay of the project and any cost associated with possible reduction of the property's value. Client will be responsible for ultimate disposal of any samples secured by UES which are found to be contaminated.

SECTION 7: RISK ALLOCATION **7.1** Client agrees that UES's liability for any damage on account of any breach of contract, error, omission, or professional negligence will be limited to a sum not to exceed \$50,000 or UES's fee, whichever is greater. If Client prefers to have higher limits on contractual or professional liability, UES agrees to increase the limits up to a maximum of \$1,000,000.00 upon Client's written request at the time of accepting UES's proposal provided that Client agrees to pay an additional consideration of four percent of the total fee, or \$400.00, whichever is greater. If Client prefers a \$2,000,000.00 limit on contractual or professional liability, UES agrees to increase the limits up to a maximum of \$2,000,000.00 upon Client's written request at the time of accepting UES's proposal provided that Client agrees to pay an additional consideration of four percent of the total fee, or \$800.00, whichever is greater. The additional charge for the higher liability limits is because of the greater risk assumed and is not strictly a charge for additional professional liability insurance. **7.2** Client shall not be liable to UES and UES shall not be liable to Client for any incidental, special, or consequential damages (including lost profits, loss of use, and lost savings) incurred by either party due to the fault of the other, regardless of the nature of the fault, or whether it was committed by Client or UES, their employees, agents, or subcontractors; or whether such liability arises in breach of contract or warranty, tort (including negligence), statutory, or any other cause of action. **7.3** As used in this Agreement, the terms "claim" or "claims" mean any claim in contract, tort, or statute alleging negligence, errors, omissions, strict liability, statutory liability, breach of contract, breach of warranty, negligent misrepresentation, or any other act giving rise to liability.

SECTION 8: INSURANCE **8.1** UES represents it and its agents, staff and consultants employed by UES, is and are protected by worker's compensation insurance and that UES has such coverage under public liability and property damage insurance policies which UES deems to be adequate. Certificates for all such policies of insurance shall be provided to Client upon request in writing. Within the limits and conditions of such insurance, UES agrees to indemnify and save Client harmless from and against loss, damage, or liability arising from negligent acts by UES, its agents, staff, and consultants employed by it. UES shall not be responsible for any loss, damage or liability beyond the amounts, limits, and conditions of such insurance or the limits described in Section 7, whichever is less. The Client agrees to defend, indemnify, and save UES harmless for loss, damage or liability arising from acts by Client, Client's agents, staff, and others employed by Client. **8.2** Under no circumstances will UES indemnify Client from or for Client's own actions, negligence, or breaches of contract. **8.3** To the extent damages are covered by property insurance, Client and UES waive all rights against each other and against the contractors, consultants, agents, and employees of the other for damages, except such rights as they may have to the proceeds of such insurance.

SECTION 9: DISPUTE RESOLUTION **9.1** All claims, disputes, and other matters in controversy between UES and Client arising out of or in any way related to this Agreement will be submitted to mediation or non-binding arbitration, before and as a condition precedent to other remedies provided by law. **9.2** If a dispute arises and that dispute is not resolved by mediation or non-binding arbitration, then: (a) the claim will be brought in the state or federal courts having jurisdiction where the UES office which provided the service is located; and (b) the prevailing party will be entitled to recovery of all reasonable costs incurred, including staff time, court costs, attorneys' fees, expert witness fees, and other claim related expenses.

SECTION 10: TERMINATION **10.1** This agreement may be terminated by either party upon seven (7) days written notice in the event of substantial failure by the other party to perform in accordance with the terms hereof, or in the case of a force majeure event such as terrorism, act of war, public health or other emergency. Such termination shall not be effective if such substantial failure or force majeure has been remedied before expiration of the period specified in the written notice. In the event of termination, UES shall be paid for services performed to the termination notice date plus reasonable termination expenses. **10.2** In the event of termination, or suspension for more than three (3) months, prior to completion of all reports contemplated by the Agreement, UES may complete such analyses and records as are necessary to complete its files and may also complete a report on the services performed to the date of notice of termination or suspension. The expense of termination or suspension shall include all direct costs of UES in completing such analyses, records, and reports.

SECTION 11: REVIEWS, INSPECTIONS, TESTING, AND OBSERVATIONS **11.1** Plan review, private provider inspections, and building inspections are performed for the purpose of observing compliance with applicable building codes. Threshold inspections are performed for the purpose of observing compliance with an approved threshold inspection plan. Construction materials testing ("CMT") is performed to document compliance of certain materials or components with applicable testing standards. UES's performance of plan reviews, private provider inspections, building inspections, threshold inspections, or CMT, or UES's presence on the site of Client's project while performing any of the foregoing activities, is not a representation or warranty by UES that Client's project is free of errors in either design or construction. **11.2** If UES is retained to provide construction monitoring or observation, UES will report to Client any observed work which, in UES's opinion, does not conform to the plans and specifications provided to UES. UES shall have no authority to reject or terminate the work of any agent or contractor of Client. No action, statements, or communications of UES, or UES's site representative, can be construed as modifying any agreement between Client and others. UES's performance of construction monitoring or observation is not a representation or warranty by UES that Client's project is free of errors in either design or construction. **11.3** Neither the activities of UES pursuant to this Agreement, nor the presence of UES or its employees, representatives, or subcontractors on the project site, shall be construed to impose upon UES any responsibility for means or methods of work performance, superintendence, sequencing of construction, or safety conditions at the project site. Client acknowledges that Client or its contractor is solely responsible for project jobsite safety. **11.4** Client is responsible for scheduling all inspections and CMT activities of UES. All testing and inspection services will be performed on a will-call basis. UES will not be responsible for tests and inspections that are not performed due to Client's failure to schedule UES's services on the project, or for any claims or damages arising from tests and inspections that are not scheduled or performed.

SECTION 12: ENVIRONMENTAL ASSESSMENTS Client acknowledges that an Environmental Site Assessment ("ESA") is conducted solely to permit UES to render a professional opinion about the likelihood or extent of regulated contaminants being present on, in, or beneath the site in question at the time services were conducted. No matter how thorough an ESA study may be, findings derived from the study are limited and UES cannot know or state for a fact that a site is unaffected by reportable quantities of regulated contaminants as a result of conducting the ESA study. Even if UES states that reportable quantities of regulated contaminants are not present, Client still bears the risk that such contaminants may be present or may migrate to the site after the ESA study is complete.

SECTION 13: SUBSURFACE EXPLORATIONS **13.1** Client acknowledges that subsurface conditions may vary from those observed at locations where borings, surveys, samples, or other explorations are made, and that site conditions may change with time. Data, interpretations, and recommendations by UES will be based solely on information available to UES at the time of service. UES is responsible for those data, interpretations, and recommendations, but will not be responsible for other parties' interpretations or use of the information developed or provided by UES. **13.2** Subsurface explorations may result in unavoidable cross-contamination of certain subsurface areas, as when a probe or boring device moves through a contaminated zone and links it to an aquifer, underground stream, or other hydrous body not previously contaminated. UES is unable to eliminate totally cross-contamination risk despite use of due care. Since subsurface explorations may be an essential element of UES's services indicated herein, Client shall, to the fullest extent permitted by law, waive any claim against UES, and indemnify, defend, and hold UES harmless from any claim or liability for injury or loss arising from cross-contamination allegedly caused by UES's subsurface explorations. In addition, Client agrees to compensate UES for any time spent or expenses incurred by UES in defense of any such claim with compensation to be based upon UES's prevailing fee schedule and expense reimbursement policy.

SECTION 14: SOLICITATION OF EMPLOYEES Client agrees not to hire UES's employees except through UES. In the event Client hires a UES employee within one year following any project through which Client had contact with said employee, Client shall pay UES an amount equal to one-half of the employee's annualized salary, as liquidated damages, without UES waiving other remedies it may have.

SECTION 15: ASSIGNS Neither Client nor UES may delegate, assign, sublet, or transfer its duties or interest in this Agreement without the written consent of the other party.

SECTION 16: GOVERNING LAW AND SURVIVAL **16.1** This Agreement shall be governed by and construed in accordance with the laws of the jurisdiction in which the UES office performing the services hereunder is located. **16.2** In any of the provisions of this Agreement are held illegal, invalid, or unenforceable, the enforceability of the remaining provisions will not be impaired and will survive. Limitations of liability and indemnities will survive termination of this agreement for any cause.

SECTION 17: INTEGRATION CLAUSE **17.1** This Agreement represents and contains the entire and only agreement and understanding among the parties with respect to the subject matter of this Agreement, and supersedes any and all prior and contemporaneous oral and written agreements, understandings, representations, inducements, promises, warranties, and conditions among the parties. No agreement, understanding, representation, inducement, promise, warranty, or condition of any kind with respect to the subject matter of this Agreement shall be relied upon by the parties unless expressly incorporated herein. **17.2** This Agreement may not be amended or modified except by an agreement in writing signed by the party against whom the enforcement of any modification or amendment is sought.

SECTION 18: WAIVER OF JURY TRIAL Both Client and UES waive trial by jury in any action arising out of or related to this Agreement.

SECTION 19: INDIVIDUAL LIABILTY PURSUANT TO FLORIDA STAT. 558.0035, AN INDIVIDUAL EMPLOYEE OR AGENT OF UES MAY NOT BE HELD INDIVIDUALLY LIABLE FOR NEGLIGENCE.

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