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GENERIC

GUIDE SPECIFICATIONS

FOR

GEOTHERMAL

HEAT PUMP SYSTEM

INSTALLATION

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INTRODUCTION

The attached Geothermal (Ground-Source) Heat Pump (GHP) Guide Specifications have been developed by Oak Ridge National Laboratory (ORNL) with the intent to assist federal agency sites and engineers in the preparation of construction specifications for GHP projects. These specifications have been developed in the industry-standard Construction Specification Institute (CSI) format and cover several of the most popular members of the family of GHP systems. These guide specifications are applicable to projects whether the financing is with conventional appropriations, arranged by GHP specialty ESCOs under the U.S. Department of Energy's Technology-Specific GHP Super ESPCs, arranged by utilities under Utility Energy Service Contracts (UESCs) or arranged by generalist ESCOs under the various regional ESPCs.

These specifications can provide several benefits to the end user that will help ensure successful GHP system installations. GHP guide specifications will help to streamline the specification development, review, and approval process because the architecture and engineering (AE) firm will be working from the familiar CSI format instead of developing the specifications from other sources. The guide specifications help to provide uniformity, standardization, and consistency in both the construction specifications and system installations across multiple federal sites. This standardization can provide future benefits to the federal sites in respect to both maintenance and operations. GHP guide specifications can help to ensure that the agency is getting its money's worth from the GHP system by preventing the use of marginal or inferior components and equipment. The agency and its AE do not have to start from scratch when developing specifications and can use the specification as a template and/or a checklist in developing both the design and the contract documents. The guide specifications can save project costs by reducing the engineering effort required during the design development phase.

Use of this guide specification for any project is strictly optional and at the discretion of the responsible party in charge. If used as a construction specification master template for GHP systems, this guide specification must, in all cases, be edited to apply to the specific project in question and to reflect the site-specific conditions relevant to the project. There is no guarantee of accuracy or applicability with respect to any portion of this specification and the user assumes all risk associated with the application of the information contained in this document.

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FOR

GEOTHERMAL HEAT PUMP SYSTEM INSTALLATION

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GENERIC

GUIDE SPECIFICATION

FOR

GEOTHERMAL HEAT PUMP SYSTEM INSTALLATION

PREPARED BY

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DIVISION 0

INTRODUCTION

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00050	APPLICABLE SECTIONS FOR GEOTHERMAL HEAT PUMP SYSTEMS	8

SECTION 00050

APPLICABLE SECTIONS FOR GEOTHERMAL HEAT PUMP SYSTEMS

PART 1 GENERAL

1.01 SUMMARY:

A. This section provides guidance for selecting applicable sections for editing this construction specification. The matrix format table can help user select typical specifications for each type of geothermal system.

1.02 SECTION INCLUDES:

A. Table 1: Applicable Specifications by Division. Table shows typical specifications, ordered by division.

1.03 RELATED SECTIONS

A. Division 0 - Introduction.

B. Division 1 – General Requirements (project specific).

C. Division 2 – Site Work.

D. Division 3 – Borehole Grout.

E. Division 15 - Mechanical.

F. Division 16 - Electrical.

PART 2 PRODUCTS

Not Used.

PART 3 EXECUTION

Not Used.

Table 1
Applicable Specifications by Division

Spec Number	Spec Title	Vertical Bore Ground Heat Exchanger	Horizontal Ground Heat Exchanger	Surface Water Heat Exchanger	Ground-water with Plate Heat Exchanger
Division 0 – Introduction					
00050	Applicable Sections for Geothermal Heat Pump Systems	x	x	x	x
Division 1 – General Requirements (project specific)					
01000	Site-Specific Specification	x	x	x	x
Division 2 –Site Work					
02050	Demolition	x	x	x	x
02110	Site Clearing	x	x	x	x
02200	Earthwork	x	x	x	x
02225	Trenching	x	x	x	x
02270	Erosion Control	x	x	x	x
02276	Geotextile Fabric	x	x	x	x
02300	Boring and Jacking	x	x	x	x
02505	Mineral Aggregate Base Course	x	x	x	x
02510	Asphalitic Concrete Paving	x	x	x	x

Spec Number	Spec Title	Vertical Bore Ground Heat Exchanger	Horizontal Ground Heat Exchanger	Surface Water Heat Exchanger	Ground-water with Plate Heat Exchanger
02520	Screen and/or Gravel Pack – Unconsolidated Aquifer				x
02525	Open Hole Completion – Consolidated Formation				x
02936	Seeding	x	x	x	x
02938	Sodding	x	x	x	x
Division 3 – Borehole Grout					
03600	Thermal-Enhanced Bentonite Grout	x			
Division 15 – Mechanical					
15050	Piping Systems	x	x	x	x
15052	Brazing	x	x	x	x
15071	Underground Protective Coating	x	x	x	x
15072	Cleaning	x	x	x	x
15073	Pressure/Leak Testing	x	x	x	x
15074	Identification and Labeling	x	x	x	x
15100	Valves	x	x	x	x
15101	Steam and Condensate (0-150 psig)	x	x	x	x

Spec Number	Spec Title	Vertical Bore Ground Heat Exchanger	Horizontal Ground Heat Exchanger	Surface Water Heat Exchanger	Ground-water with Plate Heat Exchanger
15106	Chilled Water, Cooling Water, Process Water, & Heat Pump Water	x	x	x	x
15110	Geothermal Heat Pump and Loop Piping Systems (High Density Polyethylene)	x	x	x	x
15112	Instrument Air	x	x	x	x
15125	Fluorinated Hydrocarbon Refrigerants	x	x	x	x
15135	Thermometers and Gauges	x	x	x	x
15260	Piping Insulation	x	x	x	x
15262	Fibrous Glass Insulation	x	x	x	x
15265	Elastomeric Rubber Insulation	x	x	x	x
15270	Aluminum Jacketing	x	x	x	x
15292	Thermal Insulation for Ductwork-Fibrous Glass Panels w/AL Facing	x	x	x	x
15293	Thermal Insulation for Ductwork-Fibrous Glass Blanket w/AL Facing	x	x	x	x

Spec Number	Spec Title	Vertical Bore Ground Heat Exchanger	Horizontal Ground Heat Exchanger	Surface Water Heat Exchanger	Ground-water with Plate Heat Exchanger
15501	Heating, Ventilating, and Air Conditioning Systems – Installation and Equipment	x	x	x	x
15515	Exterior Ground Loop Heat Exchangers	x	x		
15540	Water Circulating Pumps for HVAC	x	x	x	x
15545	Submersible Well Pump				x
15550	Open Lineshaft, Water Lubricated Turbine Pump				x
15555	Oil Lubricated, Enclosed Lineshaft Turbine Pump				x
15786	Water Source Heat Pumps	x	x	x	x
15891	Ductwork-Galvanized Steel, Low Velocity and Low Pressure	x	x	x	x
15902	Ductwork – Insulated and Noninsulated Flexible	x	x	x	x
15950	Testing, Adjusting and Balancing	x	x	x	x
15951	Control Systems	x	x	x	x
15952	Copper Control Tubing w/ Compression Fittings	x	x	x	x

Spec Number	Spec Title	Vertical Bore Ground Heat Exchanger	Horizontal Ground Heat Exchanger	Surface Water Heat Exchanger	Ground-water with Plate Heat Exchanger
15954	Plastic Control Tubing – Pneumatic Controls	x	x	x	x
15955	Direct Digital Controls	x	x	x	x
15956	Control Panels	x	x	x	x
15970	Plate Heat Exchangers			x	x
15972	Package Cooling Towers	x	x	x	x
15975	Field Erected Cooling Towers	x	x	x	x
15980	Closed Circuit Coolers	x	x	x	x
15995	Mechanical System Commissioning	x	x	x	x
Division 16 - Electrical					
16050	Basic Materials and Methods	x	x	x	x
16060	Electrical Demolition	x	x	x	x
16111	Conduit and Fittings	x	x	x	x
16120	Building Wire and Cable - 600 volts and Below	x	x	x	x
16127	Splices and Terminations – 600 volts and Below	x	x	x	x
16131	Boxes	x	x	x	x

Spec Number	Spec Title	Vertical Bore Ground Heat Exchanger	Horizontal Ground Heat Exchanger	Surface Water Heat Exchanger	Ground-water with Plate Heat Exchanger
16141	Wiring Devices	x	x	x	x
16160	Equipment Cabinets and Enclosures	x	x	x	x
16191	Supporting Devices	x	x	x	x
16196	Electrical Identification	x	x	x	x
16441	Disconnect Switches	x	x	x	x
16451	Secondary Grounding	x	x	x	x
16471	Panelboards	x	x	x	x
16476	Enclosed Circuit Breakers	x	x	x	x
16481	Motor Control Centers	x	x	x	x
16482	Motor-Operated Equipment	x	x	x	x
16483	Motor Control	x	x	x	x
16484	Adjustable Frequency Drive For A-C Induction Motors	x	x	x	x
16485	Contactors	x	x	x	x
16942	Field Components Installation	x	x	x	x
16943	Consoles, Panels, Cabinets and Racks Installation	x	x	x	x
16960	Electrical Testing	x	x	x	x

END OF SECTION

DIVISION 1

GENERAL REQUIREMENTS

Number	Title	Pages
01000	SITE-SPECIFIC SPECIFICATION	1

SECTION 01000

SITE SPECIFIC SPECIFICATION

PART 1 GENERAL

1.01 SECTION INCLUDES: Details for site specific requirements. The site will develop this section as necessary to convey site-specific requirements.

1.02 RELATED SECTIONS

1.03 REFERENCES

1.04 DEFINITIONS

1.05 SUBMITTALS

PART 2 PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

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END OF SECTION

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02525	OPEN HOLE COMPLETION- CONSOLIDATED FORMATION	25
02936	SEEDING	4
02938	SODDING	3

SECTION 02050

DEMOLITION

PART 1 GENERAL

1.01 SECTION INCLUDES: Demolition, salvage, and relocation of buildings, utilities, and other structures.

1.02 SUBMITTALS

A. Submit procedures proposed for salvage, relocation, and demolition work for approval. Procedures shall provide for safe conduct of the work, careful removal and disposal of materials to be salvaged and relocated, protection of property that is to remain undisturbed, coordination with other work in progress, and timely disconnection of utility services. Include detailed description of methods and equipment to be used for each operation and sequence of operations.

1.03 SEQUENCING/SCHEDULING

A. Schedule work with Construction Manager (CM). CM is the Owner or Owner's representative responsible for managing the construction work and verifying conformance with the specification requirements. Notify CM in writing a minimum of 3 days before demolition work is to begin.

PART 2 PRODUCTS

Not used.

PART 3 EXECUTION

3.01 PROTECTION

A. Protect existing work from damage during demolition. Damage to structures, utilities, and equipment to remain shall be repaired by the Contractor at his expense, in accordance with the CM's instructions.

3.02 INSTALLATION/APPLICATION/ERECTION

A. General

[**Designer Note:** Use of explosives or burning during demolition activities shall be authorized by the responsible site manager.]

1. Execute demolition work in an orderly, careful manner. Provide barricades, fences, lights, and other protection to protect adjacent access.

2. Obtain advance approval from CM for any work performed in roadways or walkways adjacent to site and for any detouring of traffic. Provide all safety measures and devices required by CM and applicable regulatory agencies.

3. Control rubbish, debris, dust, and water runoff. Use of water is not permitted when it will result in or create hazardous or objectionable conditions such as flooding and pollution.

4. Remove and dispose of material resulting from demolition operations as soon as practical. Prevent spillage on streets or adjacent areas. Dispose of material as directed by the CM. Burying debris is prohibited.

5. Control the spread of dust. Comply with local, state, and federal noise, dust, and erosion control regulations.

B. Buildings

1. Completely remove buildings indicated for removal including foundations. Break up and remove slabs-on-grade together with stone ballast supporting them.

2. Fill resulting depressions and compact with suitable material specified in Section 02200, Earthwork. Do not use debris from demolition.

C. Utilities

1. Existing utility lines shown are approximate locations only. Field verify all existing utility lines prior to demolition or grading. Report deviations for the locations shown in writing to the CM prior to beginning demolition or grading.

2. Coordinate disconnection of piping and utilities with CM. Do not commence work until disconnections are approved in writing.

3. Plug dead ends of disconnected gravity pipelines by plugging with concrete or standard pipe plugs. Cap or plug dead ends of disconnected pressure pipelines with standard pressure pipe fittings, and anchor with concrete thrust blocks. Provide capped and plugged joints that are watertight.

4. Remove utilities and related equipment, pipelines, valves, conduits, overhead services, and underground utility structures where specified. When utility lines are encountered that are not indicated on the drawings, notify CM. Do not disturb without CM approval.

5. Preserve active utilities traversing project site, including, but not limited to, mains, lines, duct banks, manholes, catch basins, valve boxes, poles, guys, and other appurtenances in operating condition. Repair damage to any active utility in accordance with the CM's instructions.

D. Other Structures

1. Remove concrete and asphaltic concrete paving, concrete slabs, including aggregate base, sidewalk, curb, and gutter as indicated.

2. Where portions of concrete or asphalt work are to be retained, saw concrete along straight lines to a depth of not less than 2 inches. Cuts shall be made perpendicular to face and in alignment with cut in opposite face. Break out remainder of asphalt or concrete, provided that broken area is concealed in finished work and that remaining is sound. Where broken face cannot be concealed, ground smooth or the saw-cut shall penetrate entirely through the material.

END OF SECTION

SECTION 02110

SITE CLEARING

PART 1 GENERAL

1.01 SECTION INCLUDES: clearing site of plant life including removal of trees and shrubs and their root systems.

1.02 PROJECT CONDITIONS

A. Burning of debris on-site is not permitted.

PART 2 PRODUCTS

A. Not used.

PART 3 EXECUTION

3.01 INSPECTION

A. Tag or otherwise identify existing plant life, utilities, and features designated to remain after site clearing.

3.02 PROTECTION

A. Protect utilities that are to remain in service from damage.

B. Protect trees, plant growth, and features designated to remain as final landscaping. As a minimum, protection shall consist of physical barriers to prevent damage to trees, plant growth, and associated root systems.

C. Protect benchmarks, survey control points, and existing structures from damage or displacement.

D. Protect, from damage, living trees located more than 5 feet outside the construction lines of the project. Treat cut or scarred surfaces of trees or shrubs with paint prepared especially for tree surgery.

E. Maintain designated site access for vehicular and pedestrian traffic.

3.03 INSTALLATION/APPLICATION/ERECTION

A. Clear areas required for access to site and execution of work.

B Remove trees and shrubs within marked areas or as indicated on drawings. Remove stumps, main root ball, root system to a depth of 12 inches, surface rock, and other objectionable material.

C. Clear undergrowth and deadwood without disturbing subsoil.

D. Remove low hanging, unsound, or unsightly branches on trees or shrubs designated by the Owner or Owner's representative to remain after site clearing.

E. Remove debris, rock, and extracted plant life from site and transport to the disposal area(s) as directed by the Owner or Owner's representative.

END OF SECTION

SECTION 02200

EARTHWORK

PART 1 GENERAL

1.01 SECTION INCLUDES: Removal and stockpiling of top soil, excavation, compaction of fill and backfill to subgrade for piping systems associated with the installation of ground heat exchangers.

1.02 DEFINITION OF TERMS

A. Earth Excavation: Removal of material to lines, elevations, and dimensions shown on drawings and disposition of materials encountered in grading and excavation work except that classified as rock.

B. Rock Excavation: Removal of materials classified as rock and disposal of excavated material as specified herein and in conformity with lines, grades, and dimensions shown on drawings. To be classified as rock, material must be boulders of 9 ft^3 or more in volume, solid or ledge rock, or other hard material in place that cannot be excavated by heavy construction equipment, such as a Caterpillar 215C power excavator equipped with a short-tip radius rock bucket or a Caterpillar D9 bulldozer equipped with a single tooth hydraulic ripper. In addition, the material must exceed a value of 3 on Mohs' hardness scale. Material classified as rock shall be removed by drilling and feathering, bull point wedging, or other suitable means. Use of explosives is not allowed.

C. Unauthorized Excavation: Excavation not required by specifications or drawings or not authorized in writing by Construction Manager (CM). CM is the Owner or Owner’s representative that is responsible for managing the construction work and verifying conformance with the specification requirements.

D. Fill: Earth or other material, as specified, used to bring an existing grade to a specified grade.

E. Backfill: Earth or other material, as specified, used to replace material excavated during construction.

F. Subgrade: Compacted fill, backfill or undisturbed soil that supports a structure or pavement system.

G. Undercutting: Removal of soft or undesirable materials determined by CM encountered in undisturbed subgrade below grades specified for excavation.

H. Spot Subgrade Reinforcement: Placing approved fill or backfill in areas where authorized undercutting has been performed.

I. Shoring: A structure such as a metal hydraulic, mechanical, or timber shoring system that supports sides of an excavation and which is designed to prevent cave-ins.

J. Topsoil: Natural, friable, fertile, natural loam. It shall be of uniform composition, free of stones, lumps, live plants and their roots, sticks and other extraneous matter. It shall be capable of sustaining vigorous plant growth.

1.03 REFERENCES

A. ASTM D698-91, Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lb/ft (600 kN-m/m))

B. ASTM D2216-92, Standard Test Method for Laboratory Determination of Water (Moisture) Content of Soil and Rock.

C. ASTM D2487-93, Standard Classification of Soils for Engineering Purposes (Unified Soil Classification System).

D. ASTM D2922-91, Standard Test Methods for Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth).

E. ASTM D3017-93, Standard Test Method for Water Content of Soil and Rock In-Place by Nuclear Methods (Shallow Depth).

F. OSHA Code of Federal Regulations 29 CFR 1926, Subpart P - Excavations, latest edition.

1.04 SUBMITTALS

A. Submit test results for approval as described in Article 3.03

PART 2 PRODUCTS

2.01 MATERIALS

A. Fill and Backfill Materials

1. Earth Fill: Approved type of soil classified, in accordance with ASTM D2487, as GW, GP, GM, GC, SW, SP, SM, SC, ML or CL, and free of foreign substances, obtained from excavation on this project, or other approved source, and having a plasticity index between 7.5 and 17. Maximum rock diameter shall be 6 inches.

2. Granular Fill: Granular fill shall include clean, natural or prepared gravels, gravel-sand mixtures, sands or gravelly sands with little or no fines. A minimum of 95% shall be retained on a No. 200 sieve.

3. Top Soil: Natural, fertile, friable natural loam. It shall be of uniform composition, free of stones, lumps, live plants and their roots, sticks and other extraneous matter. It shall have a pH of 5.0 to 7.0 and contain not less than 3% organic matter. It shall be capable of sustaining vigorous plant growth. Topsoil that is suitable for use on site may be stockpiled at the site. Provide new topsoil that is similar in characteristics to that found at the project site where required.

2.02 EQUIPMENT

A. Maintain compaction equipment in satisfactory operating condition. Use compaction equipment capable of achieving the degree of compaction specified.

B. Power tampers for use in restricted areas shall be of a type and size suitable to perform required compaction.

PART 3 EXECUTION

3.01 PREPARATION

A. Verify that subgrade is not soft, spongy, or composed of otherwise unstable materials. If unstable materials are encountered, stop work and notify CM.

B. Verify that areas to be backfilled are free of debris, snow, ice, or water and that surfaces are not frozen.

C. Verify that stockpiled fill to be reused is acceptable.

3.02 INSTALLATION/APPLICATION/ERECTION

A. Stripping and Stockpiling Topsoil

1. Erosion control measures: install prior to stripping.

2. Stripping: Strip all vegetative matter, topsoil, sod, and rubbish from within portions of the job site to be excavated. Topsoil shall be segregated and stockpiled on site. Vegetative matter and rubbish shall be disposed of as directed by the CM.

3. Stockpiling: It is the Contractor's responsibility to locate and construct the stockpiles so not to disturb the drainage in the area. As a minimum, all stockpiled topsoil shall be covered with a single layer of 6-mil polyethylene sheeting anchored to prevent lifting from wind. Silt fence shall be installed around the stockpiles per Section 02270, Erosion Control.

B. Excavation

1. Carry excavation through whatever materials are encountered to depths shown on drawings. Remove all existing fill and other unsatisfactory materials within limits of excavation as indicated on drawings.

2. Remove excavated material not required or not suitable for backfill from site. Dispose of as directed by the CM.

3. Backfill unauthorized excavation with compacted earth or granular fill, as directed by CM.

4. The excavated materials shall be segregated into suitable and unsuitable materials and stockpiled on site. The stockpiled materials shall not obstruct proper drainage of the area. It is the Contractor's responsibility to construct the stockpiles in such a manner to minimize damage from weather.

C. Structural Excavation

1. Excavate subsoil required for construction operations and other work. Excavation to be in accordance with OSHA Safety Regulation 29 CFR 1926 Subpart P - Excavations, latest edition. Maintain a minimum of 2-ft working space around structure.

2. Do not excavate in vicinity of existing buildings and structures below existing foundations until underpinning and shoring have been installed. Protect or replace existing structures, piping, or foundations that are to be incorporated into final work.

3. Protect excavation by shoring, bracing, sheet piling, underpinning, or other methods required to prevent cave-ins or loose soil from falling into excavation. Protection to be in accordance with OSHA Safety Regulation 29 CFR 1926 Subpart P - Excavations, latest edition.

D. Backfill and Compaction

1. All areas receiving fill shall be cleared, scarified to a depth of 6 inches, brought to within 4% of optimum moisture content, and compacted to density requirements.

2. Spread material to be compacted in layers not to exceed 6 inches before compaction.

3. After placement of loose material in fill, adjust moisture content to bring material within required moisture content limits.

4. Fill or backfill material of unacceptable moisture content shall be either conditioned to adjust the moisture content to within the range needed to achieve the required density or removed. Any material having an unacceptable moisture content shall be conditioned or removed at the expense of the Contractor.

5. Compact fill and backfill under roads or other structures to a minimum of 95% of maximum dry density at not less than 4% below nor more than 4% above the optimum moisture content as determined by ASTM D698.

6. Compact fill not accessible to self-propelled or towed compactors by hand-operated power tampers or other approved means to the specified density.

7. Do not place fill material when weather conditions, condition of the subgrade, or condition of the fill material precludes obtaining the specified compaction. Do not use frozen material for fill, and do not place fill material on or against frozen surfaces.

E. Finish Grading

1. Prior to finish grading of the area, complete all backfill operations. Correct any washouts or other similar irregularities.

2. Grade all exposed earth surfaces to smooth contours and in such a manner to promote positive drainage. The finish for grading shall be that degree ordinarily obtainable for either blade-grade or scraper operations or that obtainable by hand shovel operations.

3. Scarify subsoil of area to receive topsoil to a depth of 3 inches.

4. Spread a uniform layer of topsoil 4 inches thick. Topsoil to be from stockpiled material or approved borrow source. Bond to subsoil by rolling with a light roller or by tamping. Hand rake surface.

5. No topsoil to be placed until seeding or sodding can immediately follow the topsoil placement. Seeding season and seeding requirements to conform to Section 02936, Seeding. Sodding to be in accordance with Section 02938, Sodding.

6. Topsoil to be placed to lines and grades shown on drawings and 2 inches thick layer of straw to be placed on the topsoil until seeding or sodding can begin. Seeding season and seeding requirements to conform to Section 02936, Seeding. Sodding to be in accordance with Section 02938, Sodding.

F. General

1. Maintain excavations free from standing water, and dispose of excess water by methods approved by CM. Report spring or seepage water encountered in excavation to CM.

2. Maintain newly graded areas by Contractor until final acceptance by CM. Restore areas showing settlement or washes to specified grades at no additional cost to CM prior to final acceptance.

3. Provide temporary shoring and bracing as necessary to safely support excavation. Remove shoring and bracing from excavation as backfill operations progress. Shoring, in accordance with OSHA 29 CFR 1926, Subpart P - Excavations, latest revision, Safety Regulations.

4. Provide erosion and sediment control to minimize erosion and transport of sediment beyond limits of Contractor's work area. Methods of control shall conform to Section 02270, Erosion Control.

5. Bind thin layers of added materials to material in place by scarifying and recompacting.

3.03 FIELD QUALITY CONTROL

A. Testing

1. Compaction of fill and backfill to the specified moisture-density relationship of soils shall be verified by in-place density tests using ASTM D2922 or other ASTM in-place density tests approved by the CM. Maximum density determination and in-place tests shall be performed by a certified independent testing laboratory.

2. Testing for moisture content of soils shall be in accordance with ASTM D2216 or D3017. Testing will be performed by a certified independent testing laboratory.

3. In-place density testing shall be conducted after each layer is placed at a frequency of one test per 5000 ft^2 of surface area of a compacted layer, with a minimum of two tests performed on each layer. The location of the density tests shall be selected randomly by the soils technician or as directed by the CM.

4. Laboratory tests shall be completed for each type of soil to be used for fill. A sample shall be obtained each time a change in appearance of the material is noted.

B. Top of subgrade shall be a uniformly smooth grade surface without high or low points and shall not be more than 0.10 ft above or below specified grades.

3.04 PROTECTION

A. Protect existing utility lines and structures in work area and existing roadway structures, seeded areas, and other features adjacent to work area during construction activities. Provide adequate shoring and bracing as required to protect and maintain the stability of previously constructed structures and facilities.

END OF SECTION

SECTION 02225

TRENCHING

PART 1 GENERAL

1.01 SECTION INCLUDES: Excavation of trenches for pipes, compaction of bedding and backfill over pipes to subgrade elevation, and compaction and backfill requirements for piping systems associated with the installation of ground heat exchangers.

1.02 REFERENCES

A. ASTM D698-91, Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lb/ft (600 kN-m/m)).

B. ASTM D2216-92, Standard Test Method for Laboratory Determination of Water (Moisture) Content of Soil and Rock.

C. ASTM D2922-91, Standard Test Methods for Density of Soil and Soil-Aggregate In-Place by Nuclear Methods (Shallow Depth).

D. ASTM D3017-93, Standard Test Method for Water Content of Soil and Rock In-Place by Nuclear Methods (Shallow Depth).

E. OSHA Code of Federal Regulations 29 CFR 1926 Subpart P, Excavation, latest revision.

1.03 RELATED SECTIONS

A. Division 15.

1.04 SUBMITTALS

A. Submit test results for approval as described in Article 3.03.

PART 2 PRODUCTS

2.01 MATERIALS

A. Backfill: Earth or other material, as specified, used to replace material excavated during construction. Broken concrete shall not be used as backfill material.

B. Bedding Materials for Pipes: Granular fill that includes clean sands with little or no fines. A minimum of 95% shall be retained on a No. 200 sieve.

C. Pea Gravel: Pea gravel shall consist of clean, hard, round particles of crushed stone, crushed or uncrushed gravel with the following gradation:

Sieve Size	Percent Passing
3/8”	85-95
No. 4	5-15
No. 8	0-2

D. Topsoil: in accordance with Section 02200, Earthwork.

PART 3 EXECUTION

3.01 PREPARATION

A. Verify fill materials to be reused are acceptable. Do not use frozen material.

B. Verify areas to be backfilled are free of debris, snow, ice, or water and exposed surfaces are not frozen.

C. Identify required lines, levels, contours, and datum.

3.02 INSTALLATION/APPLICATION/ERECTION

A. Excavation

1. Stockpile excavated materials in areas designated on-site and remove excess materials not being used from site.

2. Excavate trenches to a width necessary for proper installation of pipe to be accommodated. Excavation to be in accordance with OSHA Safety Regulation, 29 CFR 1926.650 and 1926.651. Clearance between pipe and trench walls, except where otherwise specified or indicated on the drawings, shall be not less than 6 inches nor more than 8 inches below and on either side of the pipe. [**Designer Note**: Trench clearances shall allow for maximum feasible separation of supply and return lines.]

3. Grade excavation top perimeter to prevent surface water runoff into excavation. Keep trench bottom free of standing water. Provide side drainage ditches along the trench bottom or dewatering pumps as required. Direct discharge of water collected in trench to surface drainage channels approved by Construction Manager (CM). CM is the Owner or Owner’s representative that is responsible for managing the construction work and verifying conformance with the specification requirements.

4. Grade bottom of trench to provide uniform bearing and support for pipe either on undisturbed soil or properly compacted backfill throughout the length of the pipe.

5. Remove soft, spongy, or otherwise unstable materials encountered at elevation of pipe that will not provide a firm foundation for the pipe. Provide satisfactory material in accordance with Section 02200, Earthwork.

6. Backfill unauthorized excavation at the Contractor's expense with compacted earth or other material, as directed by CM.

B. Bedding/Backfill

1. Do not backfill until all required inspections are made and tests are performed.

2. Backfill trenches with the excavated materials specified for backfilling.

3. Deposit bedding material in layers 6 inches in depth and carefully ram or tamp until bedding material is a minimum of 6 inches above the pipe crown. No sharp objects or rocks shall be in contact with the pipe. Extreme care shall be exercised to assure no bridging of and no air pockets in the bedding material. The remainder of the backfill shall be placed in horizontal layers 6 inches in depth and compacted by hand-maneuvered power compaction tools to specified density.

4. Remove temporary blocking or cribbing material used to support the pipe before backfilling.

5. Compact backfill under roads or other structures to a minimum of 95% of maximum dry density at not less than 4% below nor more than 4% above the optimum moisture content as determined by ASTM D698.

6. Compact backfill under yards and grounds to a minimum of 90% of maximum dry density at not less than 4% below nor more than 4% above the optimum moisture content as determined by ASTM D698.

7. For subsurface drains, excavate trench in areas designated by CM. Thereafter, line trench with geotextile fabric; material shall conform to Section 02276, Geotextile Fabric. Backfill trench with pea gravel and cover with geotextile fabric. Join geotextile fabric by a minimum of 18-inch overlap. [**Designer Note**: This type of drain system may only be applicable to small open loop installations. Delete if not required.]

C. General

1. Notify CM of unexpected subsurface conditions, and discontinue work in affected area until notification to resume work.

2. Employ a placement method that does not disturb or damage utility, foundation perimeter drainage, or trench.

3. In areas where paving, top soiling, or sodding is to be done, stop fill or backfill the required distance below finish grade to permit installation of these items.

4. Support pipe during placement and compaction of bedding and backfill. [**Designer Note:** Supports for piping shall not adversely impact the maximum feasible spacing between the supply and return pipes.]

3.03 FIELD QUALITY CONTROL

A. Testing

1. Compaction of fill and backfill to the specified moisture-density relationship of soils will be verified by in-place density tests using ASTM D2922 or other ASTM in-place test method approved by the CM. Maximum density determination and in-place density test will be performed by a certified independent testing laboratory.

2. Testing for moisture content of soils and aggregate shall be in accordance with ASTM D2216 or D3017. Testing will be performed by the soils technician.

3. A minimum of one in-place density test shall be conducted per 250 lin ft of trench. Layer to be tested shall be selected randomly by the soils technician or as directed by the CM.

4. Laboratory tests shall be completed for each type of soil to be used. A sample shall be obtained each time a change in appearance of material is noted.

B. Top of subgrade shall be a uniformly smooth grade surface without high or low points and shall not be more than 0.10 ft above or below specified grades. Bind thin layers of added materials to material in place by scarifying and recompacting.

3.04 PROTECTION

A. Protect excavation by shoring, bracing, sheet piling, underpinning, or other methods required to prevent cave-in of loose soil from falling into excavation. Protection shall be in accordance with OSHA 29 CFR 1926 Subpart P, Excavations, latest revision.

1. Trenches more than 5 ft in depth shall be shored or laid back to a stable slope or provided with some other equivalent means of protection.

2. Refer to OSHA 29 CFR 1926 Subpart P, Excavations, Appendices A and B, as a guide to minimum requirements for slopes that are laid back.

3. Refer to OSHA 29 CFR 1926 Subpart P, Excavations, Appendices C through E, as a guide to minimum requirements for shoring or bracing.

4. Trenches less than 5 ft in depth shall also be effectively protected when examination of ground indicates hazardous ground movement may be expected.

5. Trenches 4 ft deep or more shall have a means of exit requiring no more than 25 ft of lateral travel and shall be tested for suitable atmospheric conditions prior to entry of personnel.

END OF SECTION

SECTION 02270

EROSION CONTROL

PART 1 GENERAL

1.01 SECTION INCLUDES: Temporary control measures for slope protection and controls to reduce erosion, sedimentation, and water pollution through the use of erosion control devices.

1.02 REFERENCES

A. ASTM D4355-92, Standard Test Method for Deterioration of Geotextiles from Exposure to Ultraviolet Light and Water (Xenon-Arc Type Apparatus).

B. ASTM D4491-92, Standard Test Methods for Water Permeability of Geotextiles by Permittivity.

C. ASTM D4632-91, Standard Test Method for Grab Breaking Load and Elongation of Geotextiles.

D. ASTM D4751-93, Standard Test Method for Determining Opening Size of a Geotextile.

1.03 SUBMITTALS

A. Silt Fence: Submit manufacturer's data and installation instructions for information.

1.04 PROJECT/SITE CONDITIONS

A. Coordinate temporary pollution control provisions with permanent erosion control features to assure economical, effective, and continuous erosion control throughout construction and post-construction periods.

PART 2 PRODUCTS

2.01 MATERIALS

A. Silt Fences

1. Geotextile Filter Fabric: A nonwoven fabric consisting of pervious sheets of propylene, nylon, polyester, or ethylene yarn. Certify material by manufacturer to meet the following requirements.

Physical Requirements for Fabric Silt Fence

Property	Test Method	Requirement
Minimum Tensile Strength	ASTM D4632	90 lb
Maximum Elongation at 45 lb	ASTM D4632	50% max
Apparent Opening Size	ASTM D4751	AOS< 0.84 mm
Minimum Permittivity	ASTM D4491	1 X 10^{-2} SEC^{-1}
Ultraviolet Exposure Strength Retention	ASTM D4355	70% @ 500 h

2. Posts: Wood or steel and a minimum 5 ft long. Wood posts shall be at least 4 in. diam or nominal 2 X 2 in. Steel posts shall be round or "U," "T," or "C" shaped with a minimum weight of 1.33 lb/ft and projections for fastening wire to fence.

3. Wire Staples: 9 gage and minimum 1 in. long.

4. Preassembled silt fencing may be substituted if it meets the above requirements.

B. Straw Bale Barriers

1. Baled hay or straw containing 5 ft^3 or more of material. Securely bind bales with wire or nylon.

PART 3 EXECUTION

3.01 PREPARATION

A. Coordinate general preparation with requirements of Section 02110, Site Clearing.

B. Site Preparation: Prepare site in accordance with good engineering practices for installation of surface erosion control features. Compact surface and remove and replace pockets of soft soil with compacted earth material to provide a consistently uniform and stable surface in accordance with Section 02200, Earthwork.

3.02 INSTALLATION/APPLICATION/ERECTION

A. General

1. Control surface water runoff on-site and provide temporary soil stabilization measures as required to prevent removal of soil by action of either water or wind, more commonly known as erosion. Protect land areas adjacent to work site from sedimentation by installation of erosion and sediment control measures. Provide, as a first step in construction operation, sediment basins and traps, perimeter barriers, and other measures intended to deter erosion and transport of sediment associated with construction activities before upslope land disturbance takes place.

B. Silt Fences

1. Install silt fence to reduce the quantity of sediment and reduce sheet flows and low-to-moderate level channel velocities to downstream areas.

2. Space posts at a spacing of 6 feet maximum and securely install with at least 2 feet in ground. Excavate trench approximately 6 inches wide and 6 inches deep along line of posts and upslope from the barrier. Attach geotextile filter fabric directly to posts as required by wire, staples, or other means accepted by Construction Manager (CM). CM is the Owner or Owner’s representative that is responsible for managing the construction work and verifying compliance with the specification requirements. Install filter fabric in a manner such that fabric height above grade is 2 to 3 feet and that 12 to 18 inches of fabric is extended along the sides and bottom of the trench. Do not staple fabric to trees. Do not use fabric with defects, rips, holes, flaws, deterioration, or other damage. Backfill trench and compact soil over the fabric as installed.

3. Install preassembled silt fence in accordance with manufacturer specifications.

C. Straw Bale Barriers

1. Install straw bale barriers in a row of entrenched and anchored hay or straw bales around storm drain inlets and to reduce the quantity of sediment and flow velocities to downstream areas.

2. Wire bind or string tie bales. Install bales so that bindings are oriented around the sides rather than along tops and bottoms of bales in order to prevent deterioration of bindings. Excavate a trench the width of bale and a length of proposed barrier to a minimum depth of 4 inches. Place bales in the trench and fill the gaps with loose straw to prevent water from escaping between the bales. Anchor bales with at least two stakes or re-bars driven through bales to a depth of 1.5 to 2 feet in ground. Drive first stake in each bale toward previously laid bale to force the bales together. After bales are staked and chinked, backfill excavated soil against barrier. Backfill soil shall conform to ground level on downhill side and shall be built up to 4 inches against uphill side of the barrier.

   a. Channel Flow: Place bales at locations indicated, in a single row, lengthwise, oriented parallel to contour, with ends of adjacent bales tightly abutting one another. Extend barrier to such a length that bottoms of end bales are higher in elevation than top of lowest middle bale to assure that sediment-laden runoff will flow either through or over barrier but not around it.

b. Sheet Flow: Place bales at locations indicated, in a single row, lengthwise on the contour, with ends of adjacent bales tightly abutting one another.

3.03 MAINTENANCE

A. Silt Fences

1. All erosion and sediment control measures will be checked and repaired as necessary weekly during dry periods and within 24 hours after 0.5 inch or more of rainfall. During prolonged rainfall, checks and repairs will be made within a 24-hour period on all control devices. Should fabric decompose or become ineffective and still be necessary, replace fabric promptly. As a minimum, remove sediment when deposits reach approximately one-third the height of barrier. Dispose of sediment as directed by CM. Maintain fabric silt fence until upslope soils are permanently stabilized.

B. Straw Bale Barriers

1. All erosion and sediment control measures will be checked and repaired as necessary weekly during dry periods and within 24 hours after 0.5 inch or more of rainfall. During prolonged rainfall, checks and repairs will be made within a 24-hour period on all control devices. Repair damaged bales, end runs, and undercutting beneath bales. Accomplish necessary repairs to barriers or replacement of bales promptly. Remove sediment when level of deposition reaches approximately one-third the height of lowest point of barrier. Dispose of sediment as directed by CM. Maintain barrier until upslope soils are permanently stabilized.

END OF SECTION

SECTION 02276

GEOTEXTILE FABRIC

PART 1 GENERAL

1.01 SECTION INCLUDES: Use of geotextile fabric in subsurface drainage applications in which fabric serves as a filter/separator. Fabric shall provide a permeable barrier between pea gravel and clay soils allowing water to pass while retaining soil.

1.02 DEFINITION OF TERMS

A. Geotextile Separator: Fabric barrier placed between dissimilar materials so that the integrity of both materials can remain intact or be improved.

B. Geotextile Filter: Movement of liquid through fabric while retaining drainage material on the upstream side of the fabric.

C. Planar Flow (Transmissivity): Movement of liquid in plane of fabric.

D. Polymer: Plastic materials composed of numerous cross-linked molecules.

E. Polypropylene: Polymeric compound used to make some geotextile fabrics.

F. Polyester: Polymeric compound used to make some geotextile fabrics. Polyester fabrics are stronger and more stable than polypropylene fabrics of the same unit weight.

G. Nonwoven Fabric: Fabrics made by extruding and spraying fibers onto a moving conveyor belt to form a continuous web. Fabrics are then bonded by melt-bonding, resin-bonding, or needle punching. Nonwoven fabrics are nondirectional and have equal properties in all directions.

H. Woven Fabrics: Fabrics made by weaving polymeric threads on a loom. Properties of woven fabrics vary with direction.

I. UV: UV light, a component of sunlight, breaks down polymeric materials over time. Some polymers are stabilized against UV degradation.

1.03 QUALITY ASSURANCE

A. Manufacturer's Material Certification

1. Maintain a competent laboratory by producer of fabric at point of manufacture to ensure quality control in accordance with ASTM testing procedures. That laboratory shall maintain records of its quality control results and provide, prior to shipment, a manufacturer's certificate. The certificate shall include the name of manufacturer, chemical composition, product description, statement of compliance to specification requirements, and signature of authorized official attesting to the

information required.

1.04 REFERENCES

A. ASTM D3786-87, Standard Test Method for Hydraulic Bursting Strength of Knitted Goods and Nonwoven Fabrics - Diaphragm Bursting Strength Tester Method.

B. ASTM D3787-89, Standard Method for Bursting Strength of Knitted Goods - Constant-Rate-of-Traverse (CRT) Ball Burst Test.

C. ASTM D4355-92, Standard Test Method for Deterioration of Geotextiles From Exposure to Ultraviolet Light and Water (Xenon-Arc Type Apparatus).

D. ASTM D4491-92, Standard Test Methods for Water Permeability of Geotextiles by Permittivity.

E. ASTM D4533-91, Standard Test Method for Trapezoidal Tearing Strength of Geotextiles.

F. ASTM D4632-91, Standard Test Method for Grab Breaking Load and Elongation of Geotextiles.

G. ASTM D4751-87, Standard Test Method for Determining Apparent Opening Size of a Geotextile.

1.05 SUBMITTALS

A. Submit Manufacturer's Material Certification for approval as described in Article 1.03.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Provide geotechnical fabric in rolls wrapped with protective covering to protect fabric from mud, dirt, dust, and debris. Free fabric of defects or flaws that significantly affect its physical properties.

B. Number rolls of fabric in shipments with a number or symbol to identify that production run.

PART 2 PRODUCTS

2.01 MATERIALS

A. Fabric

1. Nonwoven fabric consisting of polypropylene filaments or fibers.

2. Fabric shall be inert to commonly encountered chemicals and hydrocarbons, mildew and rot resistant, insect and rodent resistant, and shall conform to the following properties:

Property	Physical properties	Test method Reference
Grab strength lb	120	ASTM D4632
Puncture strength	65	ASTM D3787
Burst strength	240	ASTM D3786
Trapezoidal tear	50	ASTM D4533
Permeability	k fabric > k soil	ASTM D4491
UV resistance	70% strength retained	ASTM D4355
Apparent opening size, US sieve	[AOS <0.6 mm (greater than No. 30 sieve] [AOS <0.927 mm (greater than No. 50 sieve]	ASTM D4751

[Soil with 50% or less passing a No. 200 sieve, AOS less than 0.6 mm (greater than No. 30 sieve).]
[Soil with more than 50% passing a No. 200 sieve, AOS less than 0.927 mm (greater than No. 50 sieve).]

3. Minimum average roll value for strength properties of individual rolls tested from manufacturing lot or lots of a particular shipment shall be in excess of minimum average roll value stipulated in this specification.

B. Securing Pins

1. 3/16-inch steel bars pointed on one end and fabricated with a head to retain a steel washer having an outside diameter of not less than 1.5 inches. Pin length shall be not less than 18 inches. U-shaped pins are acceptable.

PART 3 EXECUTION

3.01 PREPARATION

A. Verify that grades and elevations are correct.

B. Verify that subgrade does not contain unsuitable, unstable, or soft material. Free subgrade from mud or soft soil materials that would clog fabric openings. If unstable materials are encountered, notify Owner or Owner’s representative immediately.

3.02 INSTALLATION/APPLICATION/ERECTION

A. Install geotextile fabric to limits and grades indicated on plans.

B. Field join geotextile fabric by a minimum of 18-inch overlap.

C. Use sand bags or other weight for temporary anchoring.

D. Free backfill material placed directly on fabric from mud or soft soil material that would clog fabric openings. Place backfill soil on geotextile fabric carefully to avoid damage to fabric by heavy equipment blades, buckets, or tracks. Initial lift of soil upon fabric shall be a minimum of 6 inches uncompacted and shall be compacted with equipment that will not penetrate soil layer and damage fabric.

E. Exposure of geotextiles to elements between lay down and cover shall be a maximum of 14 days to minimize damage potential.

END OF SECTION

SECTION 02300

BORING AND JACKING

PART 1 GENERAL

1.01 SECTION INCLUDES: materials and construction required for installation of pipeline using boring and jacking underneath roadway.

1.02 DEFINITION OF TERMS

A. Rock excavation: the removal of materials classified as rock and the disposal of the excavated material in conformity with the lines, grades, and dimensions shown on the drawings. Under this section only, rock is classified as hard material in place that cannot be excavated by pneumatic, hydraulic, or hand tools. Material classified as rock shall be removed by other suitable means. Use of explosives is prohibited.

B. Unauthorized Excavation: excavation not required by the specifications or drawings or not authorized in writing by Construction Manager (CM). CM is the Owner or Owner's representative that is responsible for managing the construction work and verifying conformance with the specification requirements.

C. Backfill: excavated material or other earth materials required to fill excavated pits. Backfill shall be placed and compacted to the same density as the surrounding soil. Backfilling of pits shall be brought to the lines and grade existing before excavation.

D. Carrier Pipes: [**Designer Note:** Pipe size and material requirements are subject to approval by the CM.]

E. Shoring: a structure, such as a metal hydraulic, mechanical, or timber shoring system, which supports the sides of an excavation and that is designed to prevent cave-ins.

1.03 RELATED SECTIONS

A. Division 15.

1.04 REFERENCES

A. ASTM A139-90, Standard Specification for Electric-Fusion (Arc)-Welded Steel Pipe (NPS 4 and Over).

B. AWWA/ANSI C203-91, AWWA Standard for Coal-Tar Protective Coatings and Linings for Steel Water Pipelines - Enamel and Tape - Hot-Applied.

C. OSHA Code of Federal Regulations 29 CFR 1926 Subpart P, Excavations, latest edition.

1.05 SUBMITTALS

A. Submit a written notice of intent to begin boring and jacking operations to the CM a minimum of 7 days before beginning work.

1.06 PROJECT/SITE CONDITIONS

A. Be aware that utilities may exist which are not shown on the drawings. Verify location of all utilities before construction.

B. Restrict all construction activities to the smallest area practicable and in no case shall construction activities extend beyond the state right-of-way. Verify the exact location of right-of-way before construction.

1.07 SEQUENCING/SCHEDULING

A. Notify CM in accordance with Article 1.05.

B. Coordinate and schedule all work within the state right-of-way with the state department of transportation.

C. Coordinate and schedule boring and jacking operations concurrently with installation of the pipelines.

PART 2 PRODUCTS

2.01 MATERIALS

A. Boring and Jacking

1. Steel casing pipe: [**Designer Note:** Pipe size and material requirements are subject to approval by the CM.]

2. Steel casing: coated on the outside with Type II, Coal-Tar Enamel in accordance with AWWA/ANSI C203.

PART 3 EXECUTION

3.01 INSTALLATION/APPLICATION/ERECTION

A. Before excavation begins, provide erosion and sediment control to minimize erosion and the transport of sediment beyond the limits of the Contractor's work area. Methods of control shall conform to Section 02270, Erosion Control.

B. Excavate boring and receiving pits to the width, length, and depth necessary for boring and jacking operations.

C. Locate pits a minimum of 2 feet beyond toe-of-slopes and a minimum of 3 feet beyond the far bank of ditches or swales. In no instance shall pits be closer than 10 feet from edge of roadway shoulder.

D. Stockpile materials excavated from pits in areas designated by the CM and in accordance with OSHA 29 CFR 1926 Subpart P, Excavations. Excavated materials or equipment shall not be placed on pavement or shoulders of roadway.

E. Begin boring and jacking operations immediately after excavation of the pits have been completed.

F. Bored installations shall be a bored-hole diameter essentially the same as the outside diameter of the casing pipe to be installed.

G. Jack casing pipe into boring as soon as possible after boring is made. Use lengths of casing pipe as long as practical. Weld joints between sections of casing pipe as recommended for joining the particular type of pipe.

H. Care shall be taken to ensure that casing pipe installed by boring and jacking is at the proper alignment and grade.

I. Accomplish boring, jacking, or driving casing pipe under existing roadway without jetting, sluicing, or wet boring. [**Designer Note:** Consideration may given to the use of rotary horizontal drilling equipment.]

J. After casing pipe is installed, install the carrier pipe in such a manner as to protect coating, lining, and joint integrity. Place each carrier pipe in proper horizontal and vertical alignment using wooden blocking/wedges or prefabricated pipe collars spaced radially around pipe and secured firmly in place.

K. Promptly backfill excavated pits as directed by the CM. Place backfill materials in 6-inch layers and tamp. Backfilling of pits shall be brought to the lines and grade existing before excavation in accordance with Section 02200, Earthwork.

L. Dispose of excavated material not used as backfill for pits in areas designated by the CM.

M. Seed disturbed areas in accordance with Section 02936, Seeding.

3.02 PROTECTION

A. Protect excavation by shoring, bracing, sheet piling, underpinning, or other methods required to prevent cave-in of loose soil into excavation. Protection shall be in accordance with OSHA 29 CFR 1926 Subpart P, Excavations.

B. Excavations 5 feet or more in depth shall be shored, laid back to a stable slope, or provided with some other equivalent means of protection.

C. Refer to OSHA 29 CFR 1926 Subpart P, Excavations, Appendices A and B, as a guide to minimum requirements for slopes that are laid back.

D. Refer to OSHA 29 CFR 1926 Subpart P, Excavations, Appendices C through E, as a guide to minimum requirements for shoring or bracing.

E. Excavations less than 5 feet in depth shall also be effectively protected when examination of the ground indicates that hazardous ground movement may be expected.

F. Employees required to be in excavations 4 feet deep or more shall have an adequate means of exit, so as to require no more than 25 feet of lateral travel and shall be tested for appropriate atmospheric conditions prior to personnel entry.

END OF SECTION

SECTION 02505

MINERAL AGGREGATE BASE COURSE

[**Designer Note:** This specification will vary according to the individual state's requirements. The following is an example of the Tennessee Department of Transportation guidelines and shall be modified according to the individual state's department of transportation standards.]

PART 1 GENERAL

1.01 SECTION INCLUDES: Compaction and installation requirements of mineral aggregate base course for roads, driveways, and parking areas as a wearing surface and as a subbase for asphaltic concrete paving.

1.02 DEFINITION OF TERMS

A. Mineral Aggregate Base Course: Premixed base materials of crushed stone mixed with binder material and water and is compacted in layers on previously prepared subgrade to a finished thickness and in areas specified on drawings.

B. Stabilized Aggregate Base: Same as Mineral Aggregate Base Course.

C. Crusher Run: Same as Mineral Aggregate Base Course.

D. Crushed Stone: Aggregate mixture conforming to AASHTO Standard Specification M-147, latest revision, Gradation C.

E. No. 57 Stone: Clean, uniformly graded stone. Not a substitute for mineral aggregate base course.

1.03 REFERENCES

A. ASTM D698-91, Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lb/ft (600 kN-m/m)).

B. ASTM D1241-94, Standard Specification for Materials for Soil-Aggregate Subbase, Base, and Surface Courses.

C. ASTM D2216-92, Standard Test Method for Laboratory Determination of Water (Moisture) Content of Soil and Rock.

D. ASTM D2922-91, Standard Test Methods for Density of Soil and Soil-Aggregate In-Place by Nuclear Methods (Shallow Depth).

E. ASTM D-3017-93, Standard Test Method for Water Content of Soil and Rock In-Place by Nuclear Methods (Shallow Depth).

F. TDOT, Bureau of Highways "Standard Specifications for Road and Bridge Construction," March 1, 1995.

1.04 SUBMITTALS

A. Submit test results for approval as described in Article 3.03.

PART 2 PRODUCTS

2.01 MATERIALS

A. Mineral Aggregate Base Course: TDOT, Subsection 903.05, Class A aggregate, Grading D, and in accordance with ASTM D1241-68.

PART 3 EXECUTION

3.01 PREPARATION

A. Verify that grades and elevations are correct.

B. Verify that subgrade is not soft, spongy, or composed of otherwise unstable materials. If unstable materials are encountered, notify Construction Manager (CM) immediately. CM is the Owner or Owner's representative that is responsible for managing the construction work and verifying conformance with the specification requirements.

3.02 INSTALLATION/APPLICATION/ERECTION

A. Prepare subgrade according to Section 02200, Earthwork.

B. Compact mineral aggregate base course to a minimum of 100% of maximum dry density at not less than 4% below nor more than 4% above the optimum moisture content as determined by ASTM D1557.

C. When additional base material is to be added to existing mineral aggregate base, scarify existing base to a depth of 3 inches. Add new mineral aggregate base material and thoroughly mix with old material by blading and compaction continued as for new aggregate base.

D. Do not install material on subgrade that is frozen or contains frost.

E. Base material shall be transported to the job site while it contains the proper moisture content and spread to the required thickness and cross-section by means of an approved mechanical spreader.

F. The depth of each layer shall not exceed 6 inches before compaction. If required depth exceeds 6 inches, construct base in two or more layers of equal thickness.

G. Immediately following spreading, the base material shall be shaped to the required degree of uniformity and smoothness and compacted to the required density prior to any appreciable evaporation of surface moisture.

H. Maintain finished base course in a condition satisfactory to CM until installation of asphaltic concrete surfacing or final acceptance by CM. Repair or restore areas showing washes or looseness to specified condition at no expense to CM.

3.03 FIELD QUALITY CONTROL

A. Testing

1. Compaction of mineral aggregate base to the specified moisture-density relationship of soils shall be verified by in-place density tests using ASTM D2922 or other ASTM in-place density tests approved by the CM. Maximum density determination and in-place density tests shall be performed by a soils technician.

2. Testing for moisture content of mineral aggregate base shall be in accordance with ASTM D2216 or D3017. Testing will be performed by a soils technician.

3. In-place density/moisture testing shall be conducted after each layer is placed at a frequency of one test per 5000 ft^2 of surface area of a compacted layer, with a minimum of two tests performed on each layer. The location of the density/moisture tests shall be selected randomly by the soils technician or as directed by the CM.

B. The top of the aggregate surface shall be a uniformly smooth grade surface without high or low points and shall not be more than 0.10 ft above or below specified grades. Bind thin layers of added materials to the material in place by scarifying and recompacting.

END OF SECTION

SECTION 02510

ASPHALTIC CONCRETE PAVING

PART 1 GENERAL

1.01 SECTION INCLUDES: construction of hot-mixed, hot-laid bituminous pavement on prepared base or existing pavement course.

1.02 REFERENCES

A. TDOT, Bureau of Highways "Standard Specifications for Road and Bridge Construction," March 1, 1995.

1.03 SUBMITTALS

A. Submit a schedule of elements of work giving completion dates, areas to be completed, and expected quantities of material to be placed.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Trucks shall have tight, clean, smooth metal beds which have been coated to prevent mixture from adhering to the beds. Cover trucks to protect mixture from weather.

B. Deliver mixture to site at the specified temperature.

PART 2 PRODUCTS

2.01 MATERIALS

A. Bituminous Hot Mixed Base: TDOT Subsection 307.02 and 302.03, mix Grading [B] [C].

B. Prime Coat: TDOT Subsection 402.02, cut-back asphalt Grade RC-70 or RC-250, emulsified asphalt Grade AE-P.

C. Tack Coat: TDOT Subsection 403.02 for cut-back asphalt Grade RC-70 or RC-250.

D. Asphaltic Concrete Surfacing: TDOT Subsection 411.02 and 411.03, Aggregate Grading [D] [E].

E. Traffic Marking Paint: TDOT Subsection 910.02.

2.02 EQUIPMENT

A. Mixing Plant: TDOT Subsection 407.04.

B. Pavers: TDOT Subsection 407.06.

C. Rollers: TDOT Subsection 407.07.

PART 3 EXECUTION

3.01 PREPARATION

A. Verify that subgrade is in accordance with Specification Section 02505, Mineral Aggregate Base Course.

B. Erect adequate barricades, signs, flagmen, warning lights, and other devices to protect others from ongoing work, paving equipment, and stored materials.

3.02 INSTALLATION/APPLICATION/ERECTION

A. Prime Coat

1. Apply prime coat to stabilized aggregate base at a rate of 0.20 gal/yd^2.

2. Apply by means of a pressure distributor at a uniform, continuous spread to the whole width of the area to be primed.

3. Application temperature shall be within the ranges set below:

Asphalt	Temperature range (degrees F)
RC 250	100-175
RC 70	80-150
AE-P	60-140

4. Correct any areas containing an excess or deficiency of material.

B. Tack Coat

1. Use tack coat on existing bituminous and Portland cement bases or where traffic or other conditions have injured bonding qualities of base course.

2. Apply by means of a pressure distributor at a rate not to exceed 0.05 gal/yd^2.

3. Application temperature shall be within the ranges set below:

Asphalt	Temperature range (degrees F)
RC 250	100-175
RC 70	80-150

4. Allow tacked surface to dry until it is in a proper condition to receive the next course.

5. Apply tack coat only so far in advance of the paving operations as is necessary to obtain the proper condition of tackiness.

6. Protect tack coat from damage until the next course is placed.

C. Bituminous Plant Mix Base (Hot Mix)

1. Install Bituminous Hot-Mix Base 2 in. thick after compaction on prepared base.

2. Subbase and surface shall be free of excess moisture and cleaned of loose particles.

3. Air temperature or surface temperature, whichever is less, shall be equal to or greater than (a) 40 degrees F for compacted asphaltic concrete thickness of 1 1/2 in. or more and (b) 50 degrees F for compacted asphaltic concrete thickness less than 1 1/2 in. before paving can begin. In either case, the temperature shall have the rising trend.

4. Compact base to an average of 90% of maximum theoretical density. No individual test shall be less than 87% of maximum theoretical density.

D. Asphaltic Concrete Surface (Hot Mix)

1. Install surface course on prepared roadway base, hot mix base, or previously surface roadway in areas specified on drawings.

2. Asphaltic concrete surface course shall be 1 1/2 in. thick after compaction.

3. Compact base to an average of 90% of maximum theoretical density. No individual test shall be less than 87% of maximum theoretical density.

4. After final rolling, do not permit vehicular traffic of any kind on pavement for 24 h.

5. Air or surface temperature, whichever is less, shall be equal to or greater than (a) 40 degrees F for compacted asphaltic concrete thickness of 1 1/2 in. or more and (b) 50 degrees F for compacted asphaltic concrete thickness of less than 1 1/2 in. before paving can begin. In either case, the temperature shall have the rising trend.

E. Traffic Marking

1. Install traffic markings such as center lines, parking lane lines, and traffic symbols as specified on drawings.

2. Traffic lines shall be 4 in. wide.

3.03 PROTECTION

A. Protect existing surfaces of roads, parking lots, and seeded areas adjacent to job site and repair all damaged areas at no additional expense to company.

END OF SECTION

SECTION 02520

SCREEN AND/OR GRAVEL PACK - UNCONSOLIDATED AQUIFER

PART 1 GENERAL

1.01 SCOPE OF WORK

A. The work includes the furnishing of all labor, material, transportation, tools, supplies, plant, equipment and appurtenances, unless specifically excepted, necessary to the complete and satisfactory construction, and testing ready for service of the well(s) herein specified.

B. [**Designer Note:** Fill in the blanks for the site specific requirements.] Final design of the well will be contingent upon subsurface conditions. Preliminary design consists of drilling a _____inch borehole to a minimum depth of ______ft (or if impermeable strata are present between the ground surface and the target aquifer, to the depth at which a minimum penetration of 5 ft can be made into an impermeable stratum) and setting a temporary ______in nominal diameter surface casing. Drilling a ______in borehole to a depth of approximately ______ and installing a nominal ______in pump chamber casing from ground surface to a depth of _____and suitable screen from that point to total depth. An artificial filter shall be installed contingent upon the results of a laboratory analysis of drilling samples.

1.02 OWNER FURNISHED FACILITIES

[**Designer Note:** Fill in the blanks for the site specific requirements (Water for drilling, electricity, site access etc.).]

The Construction Manager (CM) shall furnish free of cost to the Contractor at the work site, the following:

____

____

1.03 DESCRIPTION OF WELL SITE

A. The Contractor shall drill the well(s) at the approximate location(s) shown on the drawings or if required, at a location in the same vicinity on land having similar terrain.

B. The CM shall provide land and rights-of-way for the work specified in this contract and make suitable provisions for access. The contractor shall not enter on or occupy with men, tools, equipment, or material, any ground outside the project boundaries without written consent of the CM. Other contractors, employees or representatives of the Owner may, for business purposes, enter the work site and premises used by the Contractor. The Contractor shall conduct his work so as not to impede unnecessarily any work being done by others on or adjacent to the site.

C. Excepting as otherwise stated herein, the Contractor shall protect all structures, walks, pipelines, trees, shrubbery, lawns, etc., during the progress of his work; and shall remove from the site all cuttings, debris, and unused materials. Upon completion of the work, the Contractor shall restore the site as nearly as possible to its original condition, including the replacement, at the Contractor's expense, of any facility or landscaping which has been damaged beyond restoration.

D. It shall be the Contractor's responsibility to obtain and maintain at his own expense an adequate supply of water for his construction and domestic consumption. This includes all necessary supply piping and components, but only at such locations and in a manner approved by the CM. All water shall be carefully conserved. Before final acceptance of the well, temporary connections and piping installed by the Contractor shall be removed in a manner satisfactory to the CM.

E. Disposal of drill fluid and water produced by test pumping or other operations will be by such methods and to such locations that damage to, or interference with structures, roads or utilities, or with other construction projects will not occur. Method and place of disposal shall be approved by the CM. All cost incurred in connection with the disposal of drill mud and water will be borne by the Contractor.

F. [**Designer Note:** Fill in the blanks for the site specific requirements. Bold type in parenthesis indicate possible required information.] Logs of wells in the immediate vicinity are shown on attached sheets. It is expected that drilling will be into (through) _______________formation(s) consisting of _____________ (lithologic description) _______________.[**Designer Note**: This information is available from completion reports on nearby wells. This information is intended to assist in evaluating the amount and character of the work that might be required. It is given, however, without the assumption of responsibility for its accuracy, or for any conclusions that the Contractor might draw therefrom.]

G. Contractor shall inform himself by personal investigation of all local conditions affecting his work. Neither use of information contained in this specification, nor from the Owner or his employees, shall act to relieve the Contractor from any responsibility hereunder, nor from fulfilling all the terms and requirements of the contract.

1.04 REQUIREMENT FOR NOISE CONTROL

[**Designer Note**: The following section is optional and should be edited to site specific requirements.]

A. The Contractor shall comply with applicable Federal, State, and local laws, orders, and regulations concerning the prevention, control, and abatement of excessive noise. In addition, the Contractor will be required to operate in such a manner that the sound intensity does not exceed the following levels at the locations specified:

B. A nighttime limitation (8:00 PM - 7:00 AM) of NPL = 75 dB measured outdoors at residences or other noise sensitive areas, A daytime limitation (7:00 AM - 8:00 PM) of NPL = 80 dB measured outdoors at residences or other noise sensitive areas.

NPL is the noise pollution level. It is defined in:

HUD Report No. TE/NA 172 "Noise Assessment Guidelines, Technical Background."

"Noise and Vibration Control", Beranek, McGraw-Hill, 1971.

"Community Noise", NT1D300.3, 1971, available from the Superintendent of Documents, U.S. Government Printing Office, Washington DC 20402.

"Noise from Construction Equipment", NT1D300.1, available from the Superintendent of Documents.

Operations producing high intensity impact noise, such as nighttime blasting, jackhammer use, or pile driving, may be performed only upon approval of the CM.

Noise will be monitored by the CM, and any data obtained will be made available to the Contractor.

Method of calculating NPL:

NPL will be calculated by the CM from the formula:

$NPL = L_{50} + d + d^2/60$

where :

d = $(L_{10} - L_{90})$, dB(A)
L_{10} = noise level exceeded 10% of the time during the observation period, dB(A).
L_{90} = noise level exceeded 90% of the time during the observation period, dB(A).
L_{50} = median noise level, dB(A)

C. The observation period shall be designated by the CM and shall be at least 10 minutes. Equipment and techniques will conform to standard ANSI or IEC Practice wherever applicable. Contractor shall be aware of the need for noise control and include the cost of compliance with this section in his bid.

1.05 ARCHAEOLOGICAL OR HISTORICAL RESOURCE

[**Designer Note:** The following section is optional and should be edited to site specific requirements.]

A. Should a potential archaeological or historical resource be discovered during the construction of the well(s), the contractor shall cease all excavation work until a qualified archaeologist provided by the CM has evaluated the situation. Work shall not resume until review by the State Control Board (or other appropriate agency) and approval by the CM.

1.06 CONTRACTOR QUALIFICATIONS

[**Designer Note:** Fill in the blanks for the site specific requirements. Bold type in parenthesis indicate possible required information.]

A. The bidder shall have been engaged in the business of constructing _________ (type of well, i.e., cable tool, gravel envelope, etc.) _________ wells of diameter, depth, and capacity similar to the proposed well(s) for a period of at least _______ years. The bidder shall submit a list of ______ or more owners for whom the bidder has drilled similar wells. The list shall show the owner's name and address, an individual who may be contacted for reference, casing diameter and depth, and the well's maximum production and specific capacity. The individuals offered as references will be contacted. Failure to submit this list, or unsatisfactory responses from the references shall, in the CM's sole judgement, be grounds for bid rejection.

B. The bidder shall employ competent workers on this project, and all work shall be performed under the direct supervision of an experienced drilling superintendent satisfactory to the CM.

C. Prior to submitting a bid, the bidder shall have been issued a Well Drilling License, by the State of __________ Department of____________ a copy of which shall be submitted with the bid.

D. The bidder shall incorporate in his proposal a list of all subcontractors whose work is included in the bid, and a description of the work to be done by each subcontractor. Each bidder is required to perform a minimum of _____ % of the total dollar value of the contract with his own equipment and workers. The CM may require references from each subcontractor similar to those required from the bidder, and unsatisfactory subcontractor submittals may be basis for bid rejection.

1.07 PERMITS AND LICENSES

A. The Contractor shall, at his own expense, procure all permits, certificates and licenses required by law for the execution of his work. The Contractor shall comply with all federal, state, and local laws, ordinances, rules, and regulations relating to the performance of the work.

1.08 DRILLER'S LOGS AND REPORTS

A. Stratigraphic Log. The stratigraphic log shall be prepared by a qualified geologist to accompany the set of drilling samples, noting depth, strata thickness, lithology, including size, range and shape of constituent particles, smoothness, rock type, rate of penetration, and such special notes as might be helpful.

B. Driller’s Log. During the drilling of the test hole the Contractor shall prepare a complete log setting forth the following:

1. The reference point for all depth measurements.

2. The depth at which each change of formation occurs.

3. The depth at which the first water was encountered.

4. The depth at which each stratum was encountered.

5. The thickness of each stratum.

6. The identification of the material of which each stratum is composed, such as:

   a) Clay

   b) Sand or Silt

   c) Sand and Gravel-Indicate whether gravel is loose, tight, angular or smooth; color.

   d) Cemented formation-Indicate whether grains have natural cementing material between them; e.g., silica, calcite, etc.

   e) Hard rock-Indicate whether sedimentary bedrock or igneous (granite-like, basalt-like, etc.)

7. The depth at which each sample was taken.

8. The depth at which hole diameters (bit sizes) change.

9. The depth to the static water level (SWL) and changes in SWL with well depth.

C. Daily Driller's Report. During the drilling of the test hole or its conversion into a test well, a daily, detailed driller's report shall be maintained and delivered upon request to the CM at the well site. The report shall give a complete description of all formations encountered, number of feet (meters) drilled, number of hours on the job, shutdown due to breakdown, the water level in the well at the beginning and end of each shift, the water level at each change of formation if readily measurable with the drilling method used, feet of casing set, and such other pertinent data as requested by the CM. In rotary drilling, the fluid level in the hole should be measured daily prior to starting pumps.

D. Penetration Rate Log. During the drilling of the hole, a time log shall be kept showing the actual penetration time required to drill each foot of hole. The types of bits used in each portion of the hole shall be noted in this log-drag, roller, button or percussion type and whether designed for soft, medium or hard formations, together with approximate weight on the bits during the drilling of the various types of formations in the various sections of the hole.

E. Geophysical/Mechanical Logs. When called for under the provisions of the contract the Contractor shall perform or have performed the following logs:

1. Spontaneous-Potential Logging
2. Resistance Logging
3. Resistivity Logging
4. Natural-Gamma Logging
5. Acoustic Logging
6. Caliper Logging
7. Temperature Logging
8. Fluid-Movement Logging
9. Photographic Logging

[**Designer Note:** With the exception of temperature, logs are rarely run in the shallow, low cost wells used in geothermal direct use and ground source heat pump applications. Logs A, B and C can only be run in uncased holes and are used to identify the borders between strata. Log D is used for the same purpose in cased holes. Log F is used to measure the diameter of the hole.]

PART 2 PRODUCTS

2.01 WELL CASING SELECTION

A. Material Casing and liner shall be in new or like new condition, free of pits or breaks and shall meet minimum American Society of Testing Materials (ASTM) A-120 specifications. Minimum wall thickness for casing shall be as set forth in the following table:

Minimum Casing Wall Thickness (in)

Depth (ft.)	Nominal Diameter (in.)				
	6	8	10	12	14
< 100	0.250	0.250	0.250	0.250	0.250
100 – 200	0.250	0.250	0.250	0.250	0.250
200 – 300	0.250	0.250	0.250	0.250	0.250
300 – 400	0.250	0.250	0.250	0.250	0.250
400 – 600	0.250	0.250	0.250	0.250	0.250
600 - 800	0.250	0.250	0.250	0.250	0.313
800 - 1000	0.250	0.250	0.250	0.250	0.313
1000 – 1500	0.250	0.250	0.313	0.313	0.313

B. Temporary Surface Casing. Temporary surface casing shall have a minimum wall thickness of 0.250 in. And shall be a minimum of 4 inches larger in diameter than the nominal diameter of the pump chamber casing.

C. Pump Chamber Casing Diameter. [**Designer Note**: Specify material, wall thickness and inside diameter of pump casing.] The pump chamber casing shall be nominal __in material with a wall thickness of ______in and an inside diameter of ______in.(from table above)

2.02 GROUT MATERIALS

A. A mixture of Portland cement (ASTM C150) and not more than six (6) gallons of clean water per bag (one cubic foot or 94 pounds) of cement, shall be used. The use of special cements, bentonite to reduce shrinkage or other admixtures (ASTM C494) to reduce permeability, increase fluidity, and/or control time of set, and the composition of the resultant slurry must be approved by the CM

2.03 SCREEN-TYPE SELECTION

A. Louvered Pipe. The screen shall consist of a pipe that has punched openings in it where material has not been removed. The openings formed shall be between the corner of the outside of the pipe and the punched-out area, and the corner of the inside of the punched portion and its side. The openings shall be uniform and their total area shall be such that the entrance velocity at the design condition shall not exceed 6 feet per minute (0.1 foot per second).

B. Continuous Slot Wire Wound Screen. The screen shall be constructed of wound wire, reinforced with longitudinal bars, the bars having a cross section that will form an opening between each adjacent coil of wire that is shaped in such a manner as to increase in size inward. The wire shall be firmly attached to the bars which will, in turn, be attached to a coupling adapter. The total open area shall be such that the entrance velocity at the design condition shall not exceed 6 feet per minute (0.1 foot per second).

2.04 ENTRANCE VELOCITY

A. [**Designer Note**: In no case shall the entrance velocity through the screen exceed 0.1 ft/sec for production wells and 0.05 ft/sec for injection wells.]

2.05 APERTURE SIZE SELECTION CRITERIA

A. [**Designer Note**: The screen aperture size shall be based on the following criteria.]

1. Where the uniformity coefficient of the aquifer is greater than 6 and the aquifer is overlain by an essentially non-caving formation, the aperture size shall be that which retains 30 percent of the aquifer sample.

2. Where the uniformity coefficient of the aquifer is greater than 6 and the aquifer is overlain by a readily caving formation, the aperture size shall be that which retains 50 percent of the aquifer sample.

3. Where the uniformity coefficient of the aquifer is 3 or lower and the aquifer is overlain by an essentially non-caving formation, the aperture size shall be that which retains 40 percent of the aquifer sample.

4. Where the uniformity coefficient of the aquifer is 3 or lower and the aquifer is overlain by a caving formation, the aperture size shall be that which retains 60 percent of the aquifer sample.

5. For conditions between the extremes listed, the Contractor shall interpolate to obtain the proper screen aperture size.

6. Where an artificial filter is to be used the aperture size selection criteria shall be in accordance with Section 2.07.

[**Designer Note**: Where a formation to be screened has layers of differing grain sizes and gradations, use the following rule: If the 50 percent size of the coarsest layer is less than 4 times the 50 percent size of the finest layer, the aperture size shall be selected on the basis of the finest layer, or for each specific layer is indicated in 6.4.1, 6.4.2, 6.4.3, 6.4.4, 6.4.5. If the water is corrosive or the accuracy of the chemical analysis is in doubt, select an aperture size that will retain 10 percent more than is indicated in the above paragraphs. Where fine sand overlies coarse sand, use the fine sand size aperture for the top two feet of the underlying coarse sand. The coarse size aperture shall not be larger than twice the fine sand size.]

2.06 SCREEN LENGTH

A. The length of the screen for an artesian aquifer shall be such that at least 80 percent of the aquifer is screened. The screen shall be centered in the aquifer. The length of the screen for a water table aquifer shall be between 1/3 and 1/2 of the aquifer thickness. The screen should be positioned in the lower 1/3 or 1/2 of the aquifer. In no instance shall the well screen entrance velocity exceed 0.1 foot per second. For any specified discharge screen of sufficient length shall be installed to obtain an entrance velocity not exceeding 6 feet per minute (0.1 foot per second).

[**Designer Note**: Aquifer thickness as used here is the total thickness of the sand formation to be screened or, where geophysical logs indicate a specific water-bearing zone, the term refers to the total thickness of the sand formation as indicated by the geophysical log.]

2.07 REQUIREMENT FOR ARTIFICIAL FILTER

A. [**Designer Note**: If the formation is non-homogeneous, has a uniformity coefficient greater than 3.0, and has an effective grain greater than 0.01 inches, an artificial filter shall not be required.]

2.08 SELECTION OF FILTER GRAIN SIZE AND SCREEN APERTURE SIZE

A. The filter grain size shall be determined by multiplying the 70 percent retained grain size of the finest formation by a value not less than 4 and not greater than 6. The resulting value is the 70 percent retained grain size of the filter material to be used. The uniformity coefficient (the size of sieve that retains 40 percent of the sample divided by the size that retains 90 percent) of the filter material shall not be greater than 2.5. The gradation of the filter material shall form a smooth and gradual size distribution curve when plotted. The screen aperture openings shall be of such size as to retain a minimum of 85 percent of the filter material. The thickness of the filter shall range from a minimum of 3 inches to approximately 8 inches.

2.09 LENGTH OF ARTIFICIAL FILTER

A. The filter material shall extend from a point equal in distance to 2 1/2 times the largest diameter of the well below the lowest screen to the same distance above the highest screen.

Sand, cement, or additional filter material shall be placed between the filter material and the lower limit of the sanitary seal, according to state and local regulations. The size of the sand shall be such that it will not infiltrate into the filter material.

B. The filter material shall extend from a point equal in distance to 2 1/2 times the largest diameter of the well below the lowest screen to a point 50 feet above the lower end of the outer, or surface, casing where well depth permits.

C. The filter shall extend from a point equal in distance 2 1/2 times the largest diameter of the well below the lowest screen to the land surface. Suitable accompanying well design features will include (1) filter zone in the upper section of the well will be surrounded with casing and (2) cemented into place via the provisions applicable in Sections 3.0 and 4.0 to insure a sanitary seal.

2.10 DISINFECTANTS

A. Chlorine or other compounds approved by state or local regulatory agencies shall be used as disinfectants. The disinfectant shall be delivered to the site of the work in original closed containers bearing the original label indicating the percentage of available chlorine. The disinfectant shall be recently purchased. Chlorine compounds in dry form shall not be stored for more than one year and storage of liquid compounds shall not exceed 60 days. During storage, disinfectants shall not be exposed to the atmosphere or to direct sunlight. Unless superseded by governmental regulation, the quantity of chlorine compounds used for disinfection shall be sufficient to produce a minimum of 100 ppm (parts per million) available chlorine in solution when mixed with the total volume of water in the well.

PART 3 EXECUTION

3.01 METHODS OF CONSTRUCTION

A. The Contractor shall choose the construction method(s) to be used. Acceptable methods for this project include:

1. Conventional Fluid Rotary Drilling

2. Reverse Circulation Rotary Drilling

3. Air Rotary Drilling

4. Down-the-hole Drilling

5. Cable Tool

3.02 FORMATION SAMPLING

[**Designer Note**: Select the desired or appropriate option.]

A. Acceptable Methods

1. Return Flow Method (Continuous). A return flow sample shall be taken by removing from the circulating drilling fluid a representative sample of the formation by either collecting same in a cutting sample box, a "shale shaker", a baffle in a ditch, or catching it in a bucket and allowing the sample-to settle out. Provision shall also be made to obtain a record of circulation time and probable depth of the formation from which the cuttings are derived. Drill cutting samples collected at specified depth intervals shall be placed in approved containers and identified as specified in Section 2.3.3. The samples shall be stored in a safe place by the Contractor.

2. Return Flow Method (Circulated). A return flow sample shall be taken by removing from the discharge fluid a representative sample of the formation by either collecting same in a cutting sample box, a "shale shaker", a baffle in a ditch, or catching it in a bucket and allowing the sample to settle out. The penetration of the bit shall stop when the bottom of the sampling interval is reached for such time as is required for all the cuttings to move from the last drilled section of the hole and settle at the sampling point. The return ditch and sample catching device shall be cleaned of all cuttings after each sample is taken. A cutting sample shall be carefully collected from the sampling point. Drill cutting samples collected at specified depth intervals shall be taken by the Contractor. The total sample obtained from each interval shall be mixed and quartered until sufficient sample remains to furnish the required size of representative samples. [**Designer Note**: Specify sample size.] Drill cuttings shall be placed in approved containers and identified as specified in Section 2.3.3. The samples shall be stored in a safe place by the Contractor.

3. Auger Method. Formation samples obtained using the auger method are to be representative of the formation being penetrated. The samples will be collected, placed in approved containers, and stored in a safe place by the Contractor.

4. Bailer Method. In clay and consolidated formations the sample shall be taken by bailing the hole clean then advancing the drill bit and collecting cuttings. In sand and gravel the sample shall be taken by driving casing ahead of the drill bit then bailing with a flat bottom or suction bailer. In stable unconsolidated formations, samples shall be taken by drilling [**Designer Note**: Specify depth.]__________(5) feet and bailing before and after driving the casing to the bottom of the drilled interval.

5. Core Barrel Method. A core barrel shall be advanced, by being rotated or driven, its full length into the undisturbed formation. Once the core barrel has penetrated the desired interval, it shall be withdrawn and the core recovered and stored in a suitable core container. A core recovery of less than [**Designer Note**: Specify acceptable percentage.]__________ percent will not be acceptable.

6. Piston Tube Method. A piston tube sampler shall be driven into the undisturbed material at the bottom of the drilled hole to take formation core samples. This method is used to prevent the material in the core from expanding and to assure that the full core be held securely as the sampler is removed from the test hole. The cores are to be minimum of [**Designer Note**: Specify diameter.]__________ inches in diameter and [**Designer Note**: Specify length.] __________ inches in length. Upon removal to the surface the sample is to be capped and sealed in its tube, placed in a sample box and stored in a safe place by the Contractor.

7. Split Spoon Method. A steel cylinder shall be driven vertically into the undisturbed formation at the bottom of the drilled hole. The cylinder will be returned to the surface and transferred to a suitable core container. No sample recovery of less than 50 percent will be accepted.

8. Side-Hole Core Method. Formation samples will be taken using a [**Designer Note**: Specify diameter.]__________ inch diameter side-hole core sampler. This unit must be set at depths as directed in such a way as to assure penetration of the hole wall to a sufficient depth to provide a recovery of a [**Designer Note**: Specify length.] _____________ inch-long core. Side-hole cores will be taken after geophysical logs have been made, at depths specified by the CM. The samples shall be placed in a suitable container and identified as specified in Section 2.3.3, and stored by the Contractor.

B. Sampling Interval. Formation samples shall be collected each [**Designer Note**: Specify length.] __________ (10)foot, starting at [**Designer Note**: Specify length.]__________(20)ft, and at any pronounced change of formation. Special care shall be used for collecting samples from zones that are expected to be producing zones, wherein samples shall be collected at [**Designer Note**: Specify length.]__________ (5) foot interval.

C. Size of Sample, Containers, Identification, Storage and Transfer.

[**Designer Note**: Specify sample size.] __________ (2) __________ (1 quart ea) representative samples shall be obtained from each sampling interval. In most instances more cuttings will be recovered than required. The total volume of cuttings shall be thoroughly mixed and quartered until the number of volume of samples required are obtained as a residual.

1. Immediately after retrieval, formation samples shall be placed in approved containers, securely closed to avoid spillage and contamination, and clearly labeled with the following information:

a) Location of the well
b) Name or number of the well
c) Depth interval represented by the sample
d) Date taken
e) Time taken

2. Formation samples, immediately after being placed in container, shall be labeled clearly, either directly on the container or on a tag attached thereto, using ink, indelible pencil, or other medium that is resistant to moisture and sunlight. The label shall not be readily removable from the container. The Contractor shall be responsible for the safe storage of formation samples until such times as they are accepted by the CM. Time, place, and mode of delivery shall be as directed by the CM.

3. For wells which may or will utilize screens, the Contractor shall obtain additional samples as required in water-bearing formations for analysis by a laboratory or screen manufacturer. Duplicate samples shall be retained in a safe place until the results of the analysis are received.

3.03 DRILLING FLUID CONTROL PROGRAM

A. Production Zone Protection. Material used by Contractor to prepare the drilling fluid shall be composed of fresh, non-polluted water and sodium bentonite type drilling clay commercially processed to meet or surpass the viscosity specification in the American Petroleum Institute "Std. 13-A for Drilling Fluid Materials". All other drilling fluid additives used will comply with recognized industry standards and practices, and they will be applied and used as prescribed by the manufacturer. It is expressly understood that toxic and/or dangerous substances will not be added to the drilling fluid.

[**Designer Note**: The drilling fluids program should be agreed to by the Contractor and the CM. Selection and use of the drilling fluid materials shall be a part of this agreement.]

B. The Contractor shall be responsible for maintaining the quality of the drilling fluid to assure 1) protection of water bearing and potential water bearing formations exposed in the bore hole, and 2) good representative samples of the formation materials.[**Designer Note**: The drilling fluid properties required will depend on: 1) the type and size of drilling equipment to be used, and 2) down hole conditions anticipated or encountered.]

C. Properties of the drilling fluid are to be measured in accordance with the procedures of the American Petroleum Institute R.P. 13-B-"Procedures for Testing Drilling Fluids". Samples tested are those caught at the rig pump suction with care taken to assure a true and representative sample. Tests shall be conducted: 1) every 50 feet of depth or 2) every four circulating hours or 3) whenever conditions appear to have changed or problems arise.

a) Mud density: should be in the range of 9 pounds per gallon.

b) Mud viscosity: should be maintained in the range of 32 to 38 seconds per quart and at all times as thin as practical and still retain formation stability and adequate hole cleaning.

c) Sand content: should not exceed 2 percent of volume.

d) Filter cake 3/32" maximum.

D. The Contractor shall maintain current records on the site at all times to show: 1) time, depth and results of all mud tests, 2) all materials added to the system-kind, amount, time and depth, and 3) variances or modifications from agreed to mud program-time, depth, reason and authorization.

E. The Contractor is responsible for the removal of the drilling mud from the hole and the development of the well, as per Section 8.0 and related specifications on well development.

3.04 METHODS OF CASING INSTALLATION

[**Designer Note**: Select the desired or appropriate option.]

A. Lowering. The lowering method is used to install a jointed casing string in a pre-drilled hole. The casing shall be lowered with the drilling machine, utilizing clamps, elevators or other mechanical devices.

B. Floating. Where the casing load is extremely large it may be desirable to "float" the casing into place. A float collar shall be installed on the casing at the appropriate place in the casing string or a float plug shall be installed in the casing string near the bottom. Where a float collar or float shoe is to be used a casing-size dummy (40 ft. minimum length) shall be run into the hole first to insure that the hole is straight and free from obstruction which could result in a stuck casing.

3.05 METHOD OF JOINING CASING

[**Designer Note**: Select the desired or appropriate option.]

A. Contractor's Choice. Casing lengths shall be joined watertight by a method appropriate to the material used, as selected by the Contractor and approved by the CM, so that the resulting joint shall have the same structural integrity as the casing itself.

B. Welding shall conform to AWS B 3.0 and D 1.1. Cut off casing shall become the property of the Contractor and shall be removed from the site.

C. If threaded and coupled joints are used, couplings shall be API or equivalent, made up so that when tight all threads will be buried in the lip of the coupling.

3.06 CASING SEATING

A. Consolidated Formations. In consolidated formations the casing should extend at least five feet into the formation to assure a proper seat and bottom seal. It shall be the responsibility of the Contractor to effect a proper seal. Where the casing is to be driven it shall be fitted with a drive shoe and shall be driven to refusal. Where the casing is to be placed (rather than driven), cement grout shall be placed in the bottom of the hole in accordance with Section 4.0.

B. <u>Pressure Testing of Seating</u>. Where casing has been driven, pressure testing shall be employed immediately following installation to determine whether an air-tight seating has been accomplished. An appropriate temporary airtight cap is to be installed and a pressure of 7 to 10 pounds per square inch is to be maintained within the well, without the addition of more air, for a period of not less than one hour. Any loss of air shall be construed as indicating a defective seal. To correct such a defect, the CM shall require the Contractor to make the necessary repairs by either cementing the seating zone or by other means acceptable to both the CM and Contractor.

3.07 INSTALLATION OF GROUT-ACCEPTABLE METHODS

[**Designer Note**: Specify the appropriate method.]

A. <u>Positive Placement-Interior Method-Two Plug</u>. Grout shall be placed by the two-plug cementing method (after water or other drilling fluid has been circulated in the annular space sufficient to clear obstructions). The first spacer plug, which shall be a drillable plug such as a plaster-type material, shall then be inserted and the casing capped. A measured volume of grout shall be pumped in which shall be of sufficient quantity to grout the casing in place. The casing shall then be uncapped, the second plug shall be inserted, and the casing recapped. A measured volume of water slightly less than the volume of the casing shall then be pumped into the casing until the second plug is pushed to the bottom of the casing, expelling the grout from the casing up and into the annular space. The water in the casing shall be maintained constant to prevent back flow until the grout has set. Pressure shall be maintained for a minimum of 24 hours or until such time as a sample of the grout indicates a satisfactory set. Cement grout shall be used for this procedure with a minimum annular space thickness of l 1/2 inches completely surrounding the casing. Curing time before construction may be resumed: Portland Cement Type I-minimum 72 hours; Type III-minimum 36 hours. Concrete grout cannot be used with this method.

B. <u>Positive Placement-Interior Method-Upper Plug</u>. Grout shall be placed by the upper plug casing method (after water or other drilling fluid has been circulated in the annular space sufficient to clear obstructions). A measured quantity of grout, sufficient to grout the casing in place, shall be pumped into the capped casing. The casing shall be uncapped, and a drillable plug, constructed of plastic or other suitable material shall be inserted on top of the grout and the casing recapped. A measured volume of water, equal to the volume of the casing, shall be pumped into the casing, forcing the plug to the bottom of the casing and expelling the grout into the annular space surrounding the casing. The water in the casing shall be maintained under pressure to prevent back flow until the grout has set. Pressure shall be maintained for a minimum of 24 hours or until such time as a sample of the grout indicates a satisfactory set. Neat cement or sand-cement grout shall be used for this procedure, with a minimum annular space opening of l 1/2 inches completely surrounding the casing. Curing time before construction may be resumed: Portland Cement Type I-minimum 72 hours; Type III-minimum 36 hours. Concrete grout cannot be used with this method.

C. <u>Positive Placement-Interior Method-Capped Casing.</u> Grout shall be placed by pumping or air pressure injection through the grout pipe installed inside the casing from the casing head to a point 5 feet above the bottom of the casing (after water or other drilling fluid has been circulated in the annular space sufficient to clear obstructions). The grout pipe shall extend airtight, through a sealed cap on the casing head of the well casing. The casing head shall be equipped with a relief valve and the drop pipe shall be equipped at the top with a valve permitting injection. The lower end of the drop pipe and the casing shall be open. Clean water shall be injected down the grout pipe until it returns through the casing head relief valve. The relief valve is then closed and injection of water is continued until it flows from the bore hole outside of the casing to be grouted in place. This circulation of water is intended to clean the hole and condition it to better take the grout. Without significant interruption, grout shall be substituted for water and, in a continuous manner, injected down the grout pipe until it returns to the surface outside of the casing. A small amount of water, not to exceed seventeen gallons per hundred lineal feet of 2 inch drop pipe may be used to flush the grout pipe, but pressure shall be maintained constant on the inside of the grout pipe and the inside of the casing until the grout has set. Pressure shall be maintained for at least 24 hours, or until such time as a sample of the grout indicates a satisfactory set. Neat cement or sand-cement grout shall be used for this procedure with a minimum annular space of 1 1/2 inches completely surrounding the casing. Curing time before construction may be resumed: Portland Cement Type I-minimum 72 hours; Type III-minimum 36 hours. Concrete grout cannot be used with this method.

D. Continuous Injection Method. Grout shall be placed by the float shoe continuous injection method, (after water or other drilling fluid has been circulated in the annular space sufficient to clear obstructions). The bottom of the casing shall be fitted with a suitable drillable float shoe equipped with a back pressure valve. Tubing or pipe shall be run to the float shoe to which it shall be connected by a bayonet fitting, left hand thread coupling, or similar release mechanism. Water or other drilling fluid shall be circulated through the tubing and up through the annular space outside the casing. When the annular space is clean and open, grout shall be pumped down the pipe or tubing and forced by continual pumping out into the annular space surrounding the casing. Pumping shall continue until the entire zone to be grouted is filled. The grout pipe shall then be detached from the float shoe and raised to the surface for flushing. After the grout has set the float shoe, back pressure valve, and any concrete plug remaining in the bottom of the casing shall be drilled out. A neat cement or sand-cement grout shall be used for this procedure with a minimum annular space of 1.5 inches completely surrounding the casing. Curing time required before construction may be resumed shall be 72 hours for Type I Portland Cement and 36 hours for Type III. Concrete grout cannot be used with this method.

E. Grout Displacement Method. The hole shall be filled with the estimated volume of grout required for the purpose intended. The casing fitted at the bottom with a drillable back pressure valve, metal plate, or similar seal shall be lowered through the grout to the bottom of the hole. If necessary to maintain the bottom of the casing at the bottom of the hole, the casing shall be filled with water, or drilling fluid, and in some cases by applying a load on the bottom with drill pipe. The load shall be maintained until the grout has set, after which the bottom plug is drilled out and the well deepened. Use of this method is limited to wells not more than 100 feet in depth.

3.08 LOCATION OF GROUT

[**Designer Note**: The following specification should be considered a minimum.]

A. Surface Formation Seal. The annular space to be grouted, and surrounding the permanent well casing at the upper terminus of the well, shall be not less than a nominal 2 inches. The length of the grout seal shall be whatever is necessary to prevent the entrance of surface water or undesirable subsurface water into the well. In any circumstance, the length of seal shall not be less than the minimum specified in the state or locally applicable construction code.

B. The entire space to be grouted must be open and available to receive the grout at the time the grouting operation is performed. If a section of larger pipe (conductor pipe) is installed to keep the entire space open (in caving materials), this larger pipe must be removed, as the grout is installed, from the zone where the seal is required.

C. The effective length of grout seal (for sanitary purposes) shall be that distance measured from the deepest limit of the seal up to the depth of frost penetration. If a pitless adapter or unit is to be installed, the upper limit of the seal shall be one foot below the field connection of the adapter.

3.09 CENTRALIZERS

A. Centralizers at Bottom of Hole and other Critical Points. Centralizers shall be attached to the bottom of the casing at other critical grouting points such as zones of unsuitable water quality.

3.10 PRESSURE TESTING OF GROUTING SEAL

A. Pressure testing of the grout seal shall be employed following the appropriate time for curing of the grout according to all appropriate provisions in this Article. A pressure of 7 to 10 pounds of air per square inch is to be maintained within the well, without the addition of more air, for a period of not less than one hour. Any loss of air shall be construed as indicating a defective seal. To correct such a defect, the CM shall require the Contractor to make the necessary repairs by re-cementing and pressure testing at 15 psi for one hour.

3.11 PLUMBNESS AND ALIGNMENT

[**Designer Note**: Select one. “A” would suffice for shallow (< 200 ft) wells where a submersible type pump will be used. “B” is appropriate for deeper wells where a submersible pump will be used. “C” should be selected where a lineshaft type pump will be used for production.)

A. The completed well shall be sufficiently plumb and straight so that there will be no interference with installation, alignment, operation or future removal of the permanent well pump.

B. All wells should be constructed and all casings and liners set round, plumb, and true to line as defined herein. To demonstrate the compliance of the work with the requirements, the Contractor shall furnish all labor, tools and equipment and perform the test or tests described herein. The test for plumbness and alignment shall be made following construction of the well, and before test pump equipment is installed.

C. Alignment shall be tested by lowering into the well to a depth of at least ____________ feet (lowest anticipated pump setting) a section of pipe 40 feet long or a dummy of the same length. The outer diameter of the pipe or dummy shall be not more than 1/2 inch smaller than the inside diameter of that part of the casing or hole being tested when the casing diameter is a nominal 10 inches or less. When the nominal diameter of the casing being tested is 12 inches or greater, the outer diameter of the test pipe or dummy shall not be more than 1 inch smaller than the inside diameter of that part of the casing or hole being tested. The dummy when lowered into the casing shall pass freely the entire depth of the well.

D. [**Designer Note:** Fill in blanks as appropriate to the specific job.] The Contractor shall guarantee that the well when completed shall be sufficiently straight and plumb for the free installation and operation of a turbine pump of ____ inch [**Designer Note**: Bowl diameter is a function of pump capacity.] nominal bowl diameter with bowls set ____ feet below ground surface. To demonstrate compliance with this requirement the Contractor shall furnish all labor, tools, and equipment, and make a caging test to the satisfaction of the CM. The test shall be performed after completion of the well construction and before its acceptance. The completed well shall be drilled in such vertical alignment that a line drawn from the center of the well casing at ground surface to the center of the well casing ____ feet below the ground surface shall not deviate from the vertical more than 6 inches in 100 feet of length.

3.12 SCREEN

A. Design Basis

1. All screen and artificial filter design shall be based upon the results of a sieve test of samples retrieved from the aquifer interval as per Section 3.02 during the drilling process.

2. For a non-homogeneous aquifer, having a uniformity coefficient (sieve size that will retain 40 percent of the aquifer material divided by the sieve size that will retain 90 percent of the aquifer material) less than 3.0 and an effective grain size (sieve size that will retain 90 percent of the aquifer material) less than 0.01 inches, an artificial filter shall be used as described in Section 2.07.

3. For non-homogeneous aquifers less than 5 feet thick and separated vertically by less than 5 feet, the artificial filter will be used as described in Section 2.07, providing that more than 5 feet of the screen is required, and regardless of the uniformity coefficient of the aquifer material.

4. In the event that an artificial filter is not required, selection of screen aperture size shall be based upon criteria of Section 2.03. In the event that an artificial filter is required, selection of screen aperture size shall be based upon criteria of Section 2.07

3.13 SCREEN INSTALLATION

A. Suspended From Surface Method. The screen, with closed bottom, shall be attached by an approved manner to the casing and lowered into the well with the casing. In no instance shall it be driven or forced. It shall remain suspended from the surface until the formation has collapsed against it or until a filter material or formation stabilizer has been added.

3.14 JOINING

A. Joining Screen to Screen. Screen sections for a single interval shall be joined by threaded and coupled joints, socket-type fittings and solvent welding, or electric arc or acetylene welding. Welding rods and methods recommended by the screen manufacturer shall be employed. Resulting joint(s) must be straight, sand tight and retain 100 percent of the screen strength.

B. Blank spacers for multiple interval screen shall be of the same material as the casing, unless otherwise specified. They shall be joined to the screen by the threaded and coupled joints, socket-type fittings and solvent welding, or electric arc or acetylene welding using materials and procedures specified in Section 3.3. The resulting joints must be straight, sand tight and retain 100 percent of the screen strength.

C. Joining Screen to Casing

1. Neoprene or Rubber Seal. A neoprene or rubber seal especially made for this purpose shall be attached to the top of the screen. It shall be designed to be self-sealing in the well casing.

2. Threaded, Coupled, Welded Joints. The casing and screen shall be joined by threaded and coupled joints, socket fitting and solvent welding, or electric arc or acetylene welding using materials and procedures approved by the CM. The resulting joints must be straight, sand tight and retain 100 percent of the screen strength.

3.15 METHODS OF SEALING BOTTOM

A. The bottom of the deepest screen shall have a plate of the same material as the screen welded to it to seal it.

3.16 INSTALLATION OF FILTER MATERIAL-ACCEPTABLE METHODS

[**Designer Note:** Select the appropriate method.]

A. <u>Tremie Placed with Fluid</u>. The filter shall be placed by the use of a tremie pipe lowered to the bottom of the space to be packed and slowly raised as the filter is placed. Water or thin drilling fluid shall be pumped from the inner casing and allowed to flow into or be pumped in with the filter material.

B. Tremie with Ell. A tremie pipe with an ell formed on its bottom to direct its discharge perpendicular to the long axis of the screen shall be lowered to the bottom of the space to be packed and the filter shall be placed by pumping water or drilling fluid through the tremie pipe with the filter material being added to the fluid being pumped. Pressure shall be maintained that will keep the filter material in suspension in the annulus. The tremie shall be gradually raised as the pack is injected.

C. Crossover Tool. The filter material shall be placed by pumping it to a point above the screen through a "cross-over" tool and then allowed to fall as the drilling fluid is circulated through the bottom of the screen via an inner removable pipe.

3.17 WELL DEVELOPMENT

A. Acceptable Methods [**Designer Note**: Specify the preferred method of accomplishment]

1. Surging and Bailing (Utilizing Surge Block). The development process shall be carried out by surging and bailing the well. The surging shall be done by a single or double solid (or valved) surge block. Surging shall start at the bottom of the lowest screen in the well and proceed upwards.

2. Surging and Pumping. The development process shall include surging and pumping the well. The surging shall be done by either a solid or valved surge block. The pumping shall be done through the surge block which incorporates a piece of the suction pipe in the fabrication of the block. Pumping shall be done simultaneously with the surging at rates up to 1/2 of the design capacity. Fines drawn into the well shall be pumped out periodically before such accumulation reaches 10 percent of the screen length. Upon completion of the development work the well shall be cleaned to the bottom.

3. Hydraulic Jetting. Hydraulic jetting shall only be used in conjunction with one of the other methods described in this section. Development shall be accomplished by simultaneous high-velocity, horizontal-jetting and pumping. The outside diameter of the jetting tool shall be one inch less in diameter than the screen inside diameter. The minimum exit velocity of the jetting fluid at the jet nozzle shall be 150 ft./sec. The tool shall be rotated at a speed less than one rpm. It shall be positioned at one level for not less than two minutes and then shall be moved to the next level which shall be no more than 6 inches vertically from the preceding jetting level. The jetting shall proceed from the bottom of the screen to the top. Pumping from the well shall be at a rate of 5 to 15 percent more than the rate at which water is introduced through the jetting tool. Water to be used for jetting must contain less than 1 ppm suspended solids.

3.18 DEVELOPMENT AIDS

A. Washing with Water. Clean, clear water shall be circulated to remove sediment from the well. A pump of sufficient size shall be utilized for the washing process which will agitate the formation for the purpose of preventing bridging of the sand particles and removing a large portion of the finer material. The use of any chemicals, must be approved by the CM.

B. Washing with Chemicals. Where applicable and required, mud dispersing agents (such as glassy phosphate), acids for washing limestone, and other chemicals applicable to standard procedures may be used in accordance with the approval or direction of the CM.

3.19 SAND CONTENT LIMITS

[**Designer Note**: Sand content limits are a function of the design of the system. For applications in which an injection well will be used, the well should be sand free (< 1.0 ppm). For systems using surface discharge, a sand limit of 5 ppm should be used]

A. Well development shall continue until sand production is less than [**Designer Note**: Fill in blanks with information appropriate to the specific project.] _____(5, 15)ppm within _____(10) minutes after commencement of pumping at a minimum rate of _____(peak system flow rate) gpm and is not more than an average of _____(0.9, 5.0) ppm after a pumping cycle of two hours. Sand production shall be measured with a centrifugal sand separating device as described in the Journal of American Water Works Association Vol 46 No 2, Feb 1954

B. Recording Measurements. A record shall be made showing time, type of operation, specific capacity during pumping, pumping rate and the sand content measured and recorded. These records shall be submitted to the CM along with a _____(2) lb. Sample of the sand collected.

3.20 WELL FLOW TESTING

[**Designer Note**: Select either (A) or (B). The constant rate test is simpler but without the monitoring of nearby well water levels, produces less information about the aquifer than the step draw down test. The step draw down test can be shortened by eliminating the constant rate test at the end assuming that the water level in the well stabilized sufficiently during the final stage of the step test.]

A. CONSTANT RATE METHOD

[**Designer Note:** Fill in the blanks in items 1 and 2 with information appropriate to the specific project.]

1. The Contractor shall furnish, install and remove the necessary measuring instruments and pumping equipment capable of pumping to the required point of discharge a minimum of __________ (peak system flow rate) gpm, with a pumping level of __________ feet (determined from nearby wells) and with satisfactory throttling devices, so that the discharge may be reduced to __________ gpm (25% of peak system flow rate). The pumping unit shall be complete with an ample power source, controls and appurtenances and shall be capable of being operated without interruption for a period of __________(72) hours.

2. The well shall be pumped at a discharge rate of _________ gpm (peak system flow rate) for a minimum of __________ (12) hours. The test pump shall have its intake at least 5 feet below the estimated lowest pumping level, and shall have sufficient power and capacity to achieve the designated discharge rate. Discharge shall be measured with an accurate totalizing meter and stopwatch, a circular orifice meter, or a Venturi meter, any of which are subject to approval by the CM. Discharge shall be maintained within plus or minus 5 percent of the designated rate by means of a gate valve or throttling device. Discharge shall be checked and adjusted, if necessary, every 10 minutes during the first hour of pumping and at 30-minute intervals thereafter. The discharge and time of measurement shall be recorded each time it is checked and a note made of any adjustments. The static or non-pumping water level trend shall be established prior to the start of the test. Draw down shall be measured according to the following schedule: 0 to 10 minutes-every minute; 10 to 45 minutes--every 5 minutes; 45 to 90 minutes-every 15 minutes; 90 to 180 minutes--each half hour; 180 minutes to the end of the test-each hour. Should the measurements not be made exactly at the times specified, the actual time of each measurement shall be recorded. On completion of pumping, recovery measurements shall be made according to the above draw down schedule.

B. STEP-CONTINUOUS COMPOSITE METHOD

[**Designer Note:** Fill in the blanks in items 1,2,3,4 with information appropriate to the specific project.]

1. The Contractor shall furnish, install and remove the necessary measuring instruments and pumping equipment capable of pumping to the required point of discharge a minimum of __________ gpm (peak system flow rate), with the pumping level of __________ feet (determined from nearby wells), and with satisfactory throttling devices, so that the discharge may be reduced to __________ gpm (25% of peak system flow rate). The pumping unit shall be complete with an ample power source, controls and appurtenances and shall be capable of being operated without interruption for a period of __________(16) hours.

2. Prior to starting the pump, water level measurements shall be made at least hourly, for a minimum of eight hours, in the production well and all observation wells, and these measurements shall be recorded on the same note sheets to be used during the pumping test. The well shall be "step" tested at rates of approximately 25%, 50%, 75%, and 100% of the design capacity of __________ gpm (peak system flow rate). The complete test is estimated to require a minimum of approximately __________(4) hours. The Contractor shall operate the pump and change the discharge as directed by the CM. Discharge of the pump shall be controlled by a gate valve, if electric driven, and both gate valve and engine throttle if engine driven. The discharge shall be controlled and maintained at approximately the desired discharge for each step with an accuracy of plus or minus 5 percent. Pump discharge shall be measured with a totalizing meter and stopwatch, circular orifice meter, or Venturi meter as approved by the CM. A 2-wire electric probe calibrated so as to permit water level measurement accuracy of +/- 0.05 ft shall be used to measure the static water level and drawdown in the well. The probe shall be furnished by the Contractor.

3. After recovery from the step test is complete, a constant rate test shall be conducted by pumping the well at the design rate or at maximum yield for a period of not less than _____(4) hours or until the pumping level remains constant for at least 4 hours, or until the CM terminates the test.

4. Measurements of pumping rate and water level shall be made every 1 minute for the first 10 minutes of the test, every 2 minutes for the next 10 minutes, every 5 minutes for the next 40 minutes, every 15 minutes for the next hour, every 30 minutes for the next 3 hours, and hourly for the remainder of the pumping period. Recovery water-level measurements shall be made with the same frequency until sufficient data have been collected to extrapolate the full recovery of the well or until the CM requires no further data.

3.21 ABORTED TEST

A. Whenever continuous pumping at a uniform rate has been specified, failure of pump operation for a period greater than one per cent of the elapsed pumping time shall require suspension of the test until the water level in the pumped well has recovered to its original level. For the purposes of this specification, recovery shall be considered "complete" after the well has been allowed to rest for a period at least equal to the elapsed pumping time of the aborted test- except that if any three successive water level measurements spaced at least 20 minutes apart show no further rise in the water level in the pumped well, the test may be resumed immediately. The CM shall be the sole judge as to whether this latter condition exists.

3.22 DISCHARGE WATER

A. Discharged water shall be conducted from the pump to the nearest surface-water body, storm sewer, or ditch, as approved by the CM or at least a distance of [**Designer Note:** Fill in the blank with information appropriate to the specific project.]__________ feet through approved piping or lined ditches to prevent recirculation of discharged water into the aquifer being tested. It is imperative to insure that no damage by flooding or erosion is caused to the chosen drainage structure or disposal site.

3.23 RECORDS

A. The Contractor shall keep accurate records of the pumping test and furnish copies of all records to the CM upon completion of the test. The records shall also be available to the CM for inspection at any time during the test. For each well used in the test, the records shall include physical data describing the construction features such as, but not limited to: well depth and diameter, complete screen description, length, and setting; a description of the measuring point and its measured height above land surface and/or mean sea level; the methods used in measuring water levels and pumping rates. An accurate description or sketch map of the well locations with identifying names or numbers and distances between wells or from bodies of water shall be provided on each set of records. Records of measurements shall include the date of the test, the clock time and elapsed pumping time of each measurement, the depth to water below the measuring point, the pumping rate at the time of measurement, and any pertinent comments on conditions that may affect the measurements. Frequency of water-level measurements before, during, and after pumping shall be as specified by the CM.

3.24 MEASUREMENT OF WATER LEVELS

A. Electric Sonde Method. A 2-wire electric probe calibrated so as to permit water level measurement accuracy of +/- 0.05 ft shall be used to measure the static water level and draw down in the well. The probe shall be furnished by the Contractor.

3.25 WATER SAMPLES AND ANALYSIS

A. Specific Constituent-Analysis. Analysis for the following specific constituents shall be made:

pH	Carbonate	Stability Index
Iron	Bicarbonate	Saturation Index
Calcium	Sulphate	Carbon Dioxide
Magnesium	Chloride	Hydrogen Sulphide
Sodium	Alkalinity	Oxygen
Potassium	Total Hardness	Total Dissolved Solids

B. Sample Collection. A [**Designer Note:** Fill in the blank with information appropriate to the specific project.] __________ (1/2) gallon sample of water shall be collected for chemical analysis. The water sample shall be collected in a chemically cleaned container supplied by the laboratory that will make the analysis. The sample shall be collected from the water discharged during development or flow test pumping of the well, no less than [**Designer Note:** Fill in the blank with information appropriate to the specific project.] _______(1) hours after pumping has commenced.

C. Wellhead Tests. The temperature and pH of the water shall be taken immediately upon collection of the water sample and recorded on the sample container and drillers log. Tests shall be conducted according to procedures prescribed by the manufacturer of the test equipment employed, local health or water agencies, or as set forth in standard publications dealing with this method of analysis. Test for the presence of dissolved shall be made immediately following the collection in accordance with procedures prescribed by the manufacturer of the test equipment.

D. Laboratory Requirements. Laboratory tests shall consist of those specified by the regulations of local or state government or as described herein for the proposed use of the water. In addition, such other tests prescribed by the CM will be made. All laboratory tests shall be performed by a laboratory approved by the CM. Analytical techniques and methods shall be as prescribed in Standard Methods for the Examination, of Water and Waste Water, a joint publication of the American Public Health Association, American Water Works Association, and Water Pollution Control Federation. All samples shall be appropriately identified as to geographic location, date, time, method of collection, point of collection, water bearing formation(s), depth and diameter of well, water level and yield, and shall include the name of the sample collector, Contractor, driller and CM.

3.26 WELL DISINFECTION

A. Scheduling Disinfection

1. The Contractor shall provide for disinfection as soon as construction of the well and cleaning procedures have been completed. The Contractor shall carry out cleaning procedures immediately preceding disinfection where evidence indicates that normal well construction and development work have not cleaned the well. All oil, grease, soil, and other materials, which could harbor and protect bacteria from disinfectants, shall be removed from the well. Unless prior approval is obtained for employing chemicals or unusual cleaning methods, the cleaning operation is to be carried out by pumping and swabbing only. Where test pumping equipment is to be utilized, such equipment shall be installed prior to or during disinfection and be thoroughly hosed, scrubbed or otherwise cleaned of foreign material.

B. Interim Disinfection

1. Should a delay of three days or more be anticipated between the completion of the well and the regularly scheduled well disinfection an interim disinfection shall be provided by the Contractor. The Contractor shall install an approved disinfecting agent in an amount equal to 10 percent of the amount required for final disinfection. For this purpose the disinfecting agent shall be furnished or prepared in liquid form and placed in the well through a hose or tremie of sufficient length to extend to the bottom of the well. The disinfecting agent shall be applied through the hose, which is to be raised and lowered, to achieve uniform distribution of the solution throughout the well.

C. Daily Operations Disinfection

1. Daily chlorinating of the well shall be carried out by the Contractor during drilling operations. The Contractor shall submit to the CM the amount of disinfecting agent to be used and its method of use in advance of initiating the work. Chlorine compound dosages and method of utilization shall be satisfactory to the CM in its entirety.

D. Disinfection Procedure

1. Unless otherwise modified-due to problems involved with the specific well or conflict with local, state or federal governmental regulatory, agency requirements-disinfection procedure shall include, but not be limited to the following:

   a) Provide reliable means for insuring that the disinfecting agent is uniformly applied throughout the entire water depth of the well without relying on subsequent mechanical or surging action for dispersing the disinfectant; the dispersion of the disinfectant shall be assisted by pouring into the well a volume of water equal to the volume of the screen, after the disinfectant has been placed. This will cause the disinfectant to flow out of the well into the area adjacent to the screen.

b) All accessible portions of the well above the water level shall be maintained in a damp condition with water containing the required concentration of disinfecting agent for a period of not less than 20 minutes. The disinfecting agent shall be left in the well for a period of at least 12 hours. After a 12 hour, or longer, contact period the well is to be pumped to clear it of the disinfecting agent. The disposal point for the purged water shall be as selected so as to minimize potential damage to aquatic life or vegetation.

E. Disinfection Of Water Table Wells - Acceptable Methods

[**Designer Note:** Select the appropriate method and fill in the blank with information applicable to the specific project.]

1. Dry Chlorine Compounds. A doubly capped, perforated pipe container filled with the appropriate amount of a granular chlorine compound for the well shall be moved up and down the entire well bore until the material has dissolved.

2. Stock Solution (I). A stock solution sufficient to produce __________(100) ppm of available chlorine shall be added to the well at different intervals from top to bottom and then agitated to distribute it evenly throughout the well.

3. Stock Solution (II). A stock chlorine solution of 15,000 ppm shall be added to a continuous flow of water into the well to produce a __________(100) ppm concentration of available chlorine throughout the well.

4. Prepared Solution. The chlorine solution of the appropriate concentration to disinfect the well shall be prepared on the surface in containers having an aggregate volume equal to at least twice the volume of water in the well and then rapidly discharged into the well so as to thoroughly flush that portion of the casing which is above the water level.

F. Disinfection Of Flowing Artesian Wells - Acceptable Methods

[**Designer Note:** Select the appropriate method.]

1. Dry Chlorine Compounds. A doubly capped, perforated pipe container filled with a granular chlorine compound shall be placed at a point on or below the top of the producing horizon. This process shall be repeated as often as necessary to achieve and maintain the standard 50 ppm concentration for a period of not less than one hour.

2. Controlled Flow Disinfection. Flow shall be controlled by either capping or by a suitable standpipe. In the event the well is capped a stock chlorine solution shall be injected, under pressure, by means of a drop pipe to the bottom of the well. The cap shall be equipped with a suitable one-inch valve. After the injection is complete air shall be injected for agitation while simultaneously opening the valve in the cap permitting the chlorine solution to be

dispersed to the surface. The valve shall then be closed and the flow stopped. The chlorine concentration shall be maintained at 100 ppm for six hours.

a) In the event flow can be controlled by a suitable standpipe the chlorine treatment can be conducted as though the well was non-flowing.

3. Stock Solution. A stock chlorine solution shall be applied for a period of not less than one hour at a point at or below the top of the producing zone. The rate of application will be such that the standard 100 ppm concentration is achieved and maintained during the application period.

3.27 WELL ABANDONMENT

A. Aquifer Sealing Criteria

1. Aquifers shall be filled with disinfected, dimensionally stable materials, compacted mechanically if necessary to avoid later settlement. (Cement, cement-and-sand, and concrete do not require disinfection.)

2. Disinfection of aquifer fill materials shall be accomplished by using chlorine compounds such as sodium hypochlorite or calcium hypochlorite. Aquifer fill materials shall be clean (relatively free of clays and organic materials) before placement in the well. Disinfection shall be accomplished by dissolving sufficient chlorine compound to produce a calculated concentration of at least 100 ppm available chlorine in double the volume of water in the well. The fill material shall be placed in the well after the water in the well has been so treated

B. Permanent Bridges

1. Permanent bridges may be used to avoid having to fill very deep holes below the deepest point at which a permanent seal is required. Permanent bridges shall be composed only of cement or cement-bearing minerals. The cement shall be allowed to harden for at least 24 hours, if Type I cement is used, or for at least 12 hours if Type III (high early strength) cement is used, before backfilling is continued. Temporary bridges used to provide a base for the permanent bridge shall consist only of inorganic materials--except that patented devices containing expandable neoprene, plastic, and other elastomers, and specifically designed for use in well construction are acceptable.

C. Placement Of Grout

1. Placement Operations. Concrete, sand-and-cement grout, or cement grout used as a sealing material in abandonment operations shall be introduced at the bottom of the well or interval to be sealed (or filled) and placed progressively upward to the top of the well. All such sealing materials shall be placed by the use of grout pipe, tremie, cement bucket or dump bailer, in such a way as to avoid segregation or dilution of the sealing materials. Dumping grout material from the top shall not be permitted.

2. Seals intended to prevent vertical movement of water in the well or bore hole shall be composed of cement, sand-and-cement, or concrete--except that where such seals must be placed within casing or liners, only neat cement grout may be used. The cement-water ratio shall be that specified in Section 2.02. Cement seals shall be placed by means of pumping through drop pipe or by use of a dump-bailer, with placement beginning at the bottom and continuing upward. The minimum cement seal length, wherever dimensions permit, shall be 10 feet.

3. Intermediate Seals. Intermediate seals of cement, sand-and-cement, or concrete shall be placed in impermeable strata between aquifers which are identifiable as, or are suspected of being, hydraulically separated under natural, undisturbed conditions. Once the required cement seal has been installed, the remainder of the impermeable zone or non-producing zone between aquifers shall be filled with sand, sand and gravel, or cement-bearing mineral material.

4. Seal at Uppermost Aquifer. A cement, sand-and cement, or concrete seal shall be installed in the least permeable zone immediately above the uppermost water-producing zone. Such seals shall be placed only in quiescent (non-flowing) water.

5. Seals Placed Within Casing, Liners, Filters, etc. Seal which must be placed in casing, liners, or filters require special attention. The material between the well and the face of the bore hole shall be thoroughly perforated, ripped, or otherwise disintegrated as the necessary first step. Neat cement only, or neat cement with a maximum of 5 percent by weight of commercially processed bentonite clay, shall be used as the seal. Either of two methods may be used.

    a) The calculated amount of grout required to fill the well interval plus the annular space outside the lining shall be placed within the space to be cemented, running the cement through a special cementing packer manufactured for this purpose and installed immediately above the perforated or ripped zone. The cement shall be injected at a pressure calculated to be at least 50 psi greater than the normal hydrostatic pressure within the well at the point of injection.

    b) The calculated amount of cement grout required to fill the casing interval plus the annular space outside the lining, plus sufficient cement grout to fill an additional 10 feet of the lining, shall be introduced at the bottom of the interval to be cemented.

3.28 PLACEMENT OF FILL

A. Non-producing zones above the aquifer shall be filled with stable materials such as sand, sand-and-gravel, cement, cement-and-sand, or concrete. Non-producing zones above the uppermost aquifer seal shall be filled with materials less permeable than the surrounding undisturbed formations. The uppermost 5 feet of the bore hole (at land surface) shall be filled with a material appropriate to the intended use of the land.

3.29 SPECIAL CONDITIONS

A. An abandoned well which has already been affected by salt water intrusion or any other contaminants shall be considered a special case, and the method of filling and sealing such wells shall be subject to individual review and written approval by the regulatory agency involved.

B. In the sealing of a double or multiple cased well, the Contractor shall submit a drawing thereof with a description of the proposed procedure and materials to be used, for prior approval by the regulatory agency involved.

C. Mineral exploration holes, solution or "in situ" mining wells, de-watering wells, temporary service wells, construction water wells, process wells, and/or other structures which affect the withdrawal or quality of ground water, or the elevation of the water table, regardless of location or intended length of life of the structure, shall be abandoned according to standards and minimums as described herein for water supply wells.

3.30 WELL ABANDONMENT RECORDS

A. Before equipment is removed from the site, the exact location of the abandoned well or hole shall be determined and recorded, "tying in" the location with permanent reference points, or as prescribed by the state or local regulatory agency. All information relative to the abandonment procedures and the location of the abandoned well shall be prepared and assembled as prescribed by the state or local regulatory agency, with copies supplied to the respective agency and the owner of the land.

END OF SECTION

SECTION 02525

OPEN HOLE COMPLETION - CONSOLIDATED FORMATION

PART 1 GENERAL

1.01 SCOPE OF WORK

[**Designer Note:** There are many sections throughout this specification where it is necessary to provide information to fill in areas left blank. The intent is to provide the designer the flexibility to tailor the specification to the job specific requirements. In cases where information has been omitted, fill in the blanks with information applicable to the specific project. Information in ( ) is offered as default values if no preference is expressed otherwise.]

A. The work includes the furnishing of all labor, material, transportation, tools, supplies, plant, equipment and appurtenances, unless specifically excepted, necessary to the complete and satisfactory construction, and testing ready for service of well(s) herein specified.

B. Final design of the well will be contingent upon subsurface conditions. Preliminary design consists of drilling a _____inch borehole to a minimum depth of ______ft (or if impermeable strata are present between the ground surface and the target aquifer, to a depth at which a minimum penetration of 5 ft into an impermeable strata can be made). If materials in this portion of the borehole are caving a ______in nominal diameter temporary surface casing will be set. Drilling a ______in borehole to a depth of approximately ______ ft and installing a ______in nominal diameter pump chamber casing to a depth of ______ ft.

1.02 OWNER FURNISHED FACILITIES

[**Designer Note:** Fill in the blanks for the site specific requirements (Water for drilling, electricity, site access etc.).]

A. The Construction Manager (CM) shall furnish free of cost to the Contractor at the work site, the following:

____

____

1.03 DESCRIPTION OF WELL SITE

A. The Contractor shall drill the well(s) at the approximate location(s) shown on the drawings or if required, at a location in the same vicinity on land having similar terrain.

B. The CM shall provide land and rights-of-way for the work specified in this contract and make suitable provisions for access. The Contractor shall not enter on or occupy with men, tools, equipment, or material, any ground outside the project boundaries without written consent of the CM. Other Contractors, employees or representatives of the Owner may, for business purposes, enter the work site and premises used by the Contractor. The Contractor shall conduct his work so as not to impede unnecessarily any work being done by others on or adjacent to the site.

C. Excepting as otherwise stated herein, the Contractor shall protect all structures, walks, pipelines, trees, shrubbery, lawns, etc., during the progress of his work; and shall remove from the site all cuttings, debris, and unused materials. Upon completion of the work, the Contractor shall restore the site as nearly as possible to its original condition, including the replacement, at the Contractor's expense, of any facility or landscaping which has been damaged beyond restoration.

D. It shall be the Contractor's responsibility to obtain and maintain at his own expense an adequate supply of water for his construction and domestic consumption. This includes all necessary supply piping and components, but only at such locations and in a manner approved by the CM. All water shall be carefully conserved. Before final acceptance of the well, temporary connections and piping installed by the Contractor shall be removed in a manner satisfactory to the CM.

E. Disposal of drill fluid and water produced by test pumping or other operations will be by such methods and to such locations that damage to, or interference with structures, roads or utilities, or with other construction projects will not occur. Method and place of disposal shall be approved by the CM. All cost incurred in connection with the disposal of drill mud and water will be borne by the Contractor.

F. [**Designer Note:** Fill in the blanks for the site specific requirements. Bold type in parenthesis indicate possible required information.] Logs of wells in the immediate vicinity are shown on attached sheets. It is expected that drilling will be into (through) _______________formation(s) consisting of _____________ (lithologic description) _______________.[**Designer Note**: This information is available from completion reports on nearby wells. This information is intended to assist in evaluating the amount and character of the work that might be required. It is given, however, without the assumption of responsibility for its accuracy, or for any conclusions that the Contractor might draw therefrom.]

G. Contractor shall inform himself by personal investigation of all local conditions affecting his work. Neither use of information contained in this specification, nor from the CM or his employees, shall act to relieve the Contractor from any responsibility hereunder, nor from fulfilling all the terms and requirements of the contract.

1.04 REQUIREMENT FOR NOISE CONTROL

[**Designer Note**: The following section is optional and should be edited to site specific requirements.]

A. The Contractor shall comply with applicable Federal, State, and local laws, orders, and regulations concerning the prevention, control, and abatement of excessive noise. In addition, the Contractor will be required to operate in such a manner that the sound intensity does not exceed the following levels at the locations specified:

B. A nighttime limitation (8:00 PM - 7:00 AM) of NPL = 75 dB measured outdoors at residences or other noise sensitive areas, A daytime limitation (7:00 AM - 8:00 PM) of NPL = 80 dB measured outdoors at residences or other noise sensitive areas.

C. NPL is the noise pollution level. It is defined in:

1. HUD Report No. TE/NA 172 "Noise Assessment Guidelines, Technical Background."

2. "Noise and Vibration Control", Beranek, McGraw-Hill, 1971.

3. "Community Noise", NT1D300.3, 1971, available from the Superintendent of Documents, U.S. Government Printing Office, Washington DC 20402.

4. "Noise from Construction Equipment", NT1D300.1, available from the Superintendent of Documents.

D. Operations producing high intensity impact noise, such as nighttime blasting, jackhammer use, or pile driving, may be performed only upon approval of the CM.

E. Noise will be monitored by the CM, and any data obtained will be made available to the Contractor.

F. Method of calculating NPL:

1. NPL will be calculated by the CM from the formula:

$$NPL = L_{50} + d + d^2/60$$

where :

d = $(L_{10} - L_{90})$, dB(A)
L_{10} = noise level exceeded 10% of the time during the observation period, dB(A).
L_{90} = noise level exceeded 90% of the time during the observation period, dB(A).
L_{50} = median noise level, dB(A)

2. The observation period shall be designated by the CM and shall be at least 10 minutes. Equipment and techniques will conform to standard ANSI or IEC Practice wherever applicable. Contractor shall be aware of the need for noise control and include the cost of compliance with this section in his bid.

1.05 ARCHAEOLOGICAL OR HISTORICAL RESOURCE

[**Designer Note:** The following section is optional and should be edited to site specific requirements.]

A. Should a potential archaeological or historical resource be discovered during the construction of the well(s), the Contractor shall cease all excavation work until a qualified archaeologist provided by the CM has evaluated the situation. Work shall not resume until review by the State Control Board (or other appropriate agency) and approval by the CM.

1.06 CONTRACTOR QUALIFICATIONS

[**Designer Note:** Fill in the blanks for the site specific requirements. Type in parenthesis indicate possible required information.]

A. The bidder shall have been engaged in the business of constructing _________ (type of well, i.e., cable tool, gravel envelope, etc.) _________ wells of diameter, depth, and capacity similar to the proposed well(s) for a period of at least _______ years. The bidder shall submit a list of ______ or more owners for whom the bidder has drilled similar wells. The list shall show the owner's name and address, an individual who may be contacted for reference, casing diameter and depth, and the well's maximum production and specific capacity. The individuals offered as references will be contacted. Failure to submit this list, or unsatisfactory responses from the references shall, in the CM's sole judgement, be grounds for bid rejection.

B. The bidder shall employ competent workers that have at least 2 years of experience in the type of work required for the project under consideration. All work shall be performed under the direct supervision of an experienced drilling superintendent that has at least 5 years of relevant well drilling experience. Worker credentials shall be submitted to the CM for approval prior to initiating work.

C. Prior to submitting a bid, the bidder shall have been issued a Well Drilling License, by the State of __________ Department of____________ a copy of which shall be submitted with the bid.

D. The bidder shall incorporate in his proposal a list of all subcontractors whose work is included in the bid, and a description of the work to be done by each subcontractor. Each bidder is required to perform a minimum of _____ % of the total dollar value of the contract with his own equipment and workers. The CM may require references from each subcontractor similar to those required from the bidder, and unsatisfactory subcontractor submittals may be basis for bid rejection.

1.07 PERMITS AND LICENSES

A. The Contractor shall, at his own expense, procure all permits, certificates and licenses required by law for the execution of his work. The Contractor shall comply with all federal, state, and local laws, ordinances, rules, and regulations relating to the performance of the work.

1.08 DRILLER'S LOGS AND REPORTS

A. Stratigraphic Log. The stratigraphic log shall be prepared by a qualified geologist to accompany the set of drilling samples, noting depth, strata thickness, lithology, including size, range and shape of constituent particles, smoothness, rock type, rate of penetration, and such special notes as might be helpful.

B. Driller's Log. During the drilling of the test hole the Contractor shall prepare a complete log setting forth the following:

1. The reference point for all depth measurements.
2. The depth at which each change of formation occurs.
3. The depth at which the first water was encountered.
4. The depth at which each stratum was encountered.
5. The thickness of each stratum.
6. The identification of the material of which each stratum is composed, such as:
   a) Clay
   b) Sand or Silt
   c) Sand and Gravel-Indicate whether gravel is loose, tight, angular or smooth; color.
   d) Cemented formation-Indicate whether grains have natural cementing material between them; e.g., silica, calcite, etc.
   e) Hard rock-Indicate whether sedimentary bedrock or igneous (granite-like, basalt-like, etc.)
7. The depth at which each sample was taken.
8. The depth at which hole diameters (bit sizes) change.
9. The depth to the static water level (SWL) and changes in SWL with well depth.

C. Daily Driller's Report. During the drilling of the test hole or its conversion into a test well, a daily, detailed driller's report shall be maintained and delivered upon request to the CM at the well site. The report shall give a complete description of all formations encountered, number of feet (meters) drilled, number of hours on the job, shutdown due to breakdown, the water level in the well at the beginning and end of each shift, the water level at each change of formation if readily measurable with the drilling method used, feet of casing set, and such other pertinent data as requested by the CM. In rotary drilling, the fluid level in the hole should be measured daily prior to starting pumps.

D. Penetration Rate Log. During the drilling of the hole, a time log shall be kept showing the actual penetration time required to drill each foot of hole. The types of bits used in each portion of the hole shall be noted in this log-drag, roller, button or percussion type and whether designed for soft, medium or hard formations, together with approximate weight on the bits during the drilling of the various types of formations in the various sections of the hole.

E. Geophysical/Mechanical Logs. When called for under the provisions of the contract the Contractor shall perform or have performed the following logs:

1. Spontaneous-Potential Logging

2. Resistance Logging

3. Resistivity Logging

4. Natural-Gamma Logging

5. Acoustic Logging

6. Caliper Logging

7. Temperature Logging

8. Fluid-Movement Logging

9. Photographic Logging

[**Designer Note:** With the exception of temperature, logs are rarely run in the shallow, low cost wells used in geothermal direct use and ground source heat pump applications. Logs A, B and C can only be run in uncased holes and are used to identify the borders between strata. Log D is used for the same purpose in cased holes. Log F is used to measure the diameter of the hole.]

1.09 RECORDS

A. The Contractor shall keep accurate records of the pumping test and furnish copies of all records to the CM upon completion of the test. The records shall also be available to the CM for inspection at any time during the test. For each well used in the test, the records shall include physical data describing the construction features such as, but not limited to: well depth and diameter, complete screen description, length, and setting; a description of the measuring point and its measured height above land surface and/or mean sea level; the methods used in measuring water levels and pumping rates. An accurate description or sketch map of the well locations with identifying names or numbers and distances between wells or from bodies of water shall be provided on each set of records. Records of measurements shall include the date of the test, the clock time and elapsed pumping time of each measurement, the depth to water below the measuring point, the pumping rate at the time of measurement, and any pertinent comments on conditions that may affect the measurements. Frequency of water-level measurements before, during, and after pumping shall be as specified by the CM.

1.10 WELL ABANDONMENT RECORDS

A. Before equipment is removed from the site, the exact location of the abandoned well or hole shall be determined and recorded, "tying in" the location with permanent reference points, or as prescribed by the state or local regulatory agency. All information relative to the abandonment procedures and the location of the abandoned well shall be prepared and assembled as prescribed by the state or local regulatory agency, with copies supplied to the respective agency and the CM.

PART 2 PRODUCTS

2.01 WELL CASING SELECTION

A. Material Casing and liner shall be in new or like new condition, free of pits or breaks and shall meet minimum American Society of Testing Materials (ASTM) A-120 specifications. Minimum wall thickness for casing shall be as set forth in the following table:

Minimum Casing Wall Thickness (in)

Depth (ft.)	Nominal Diameter (in.)				
	6	8	10	12	14
< 100	0.250	0.250	0.250	0.250	0.250
100 – 200	0.250	0.250	0.250	0.250	0.250
200 – 300	0.250	0.250	0.250	0.250	0.250
300 – 400	0.250	0.250	0.250	0.250	0.250
400 – 600	0.250	0.250	0.250	0.250	0.250
600 - 800	0.250	0.250	0.250	0.250	0.313
800 - 1000	0.250	0.250	0.250	0.250	0.313
1000 – 1500	0.250	0.250	0.313	0.313	0.313

B. Temporary Surface Casing. Temporary surface casing shall have a minimum wall thickness of 0.250 in. And shall be a minimum of 4 inches larger in diameter than the nominal diameter of the pump chamber casing.

C. Pump Chamber Casing Diameter. The pump chamber casing shall be nominal _____(for required pump chamber casing size see table in appendix) in material with a wall thickness of ______in.(from table above).

2.02 GROUTING MATERIALS

A. Neat Cement Grout**.** A mixture of Portland cement (ASTM C150) and not more than six (6) gallons of clean water per bag (one cubic foot or 94 pounds) of cement, shall be used. The use of special cements, bentonite to reduce shrinkage or other admixtures (ASTM C494) to reduce permeability, increase fluidity, and/or control time of set, and the composition of the resultant slurry must be approved by the CM.

2.03 DISINFECTANTS

A. Chlorine or other compounds approved by state or local regulatory agencies shall be used as disinfectants. The disinfectant shall be delivered to the site of the work in original closed containers bearing the original label indicating the percentage of available chlorine. The disinfectant shall be recently purchased. Chlorine compounds in dry form shall not be stored for more than one year and storage of liquid compounds shall not exceed 60 days. During storage, disinfectants shall not be exposed to the atmosphere or to direct sunlight. Unless superseded by governmental regulation, the quantity of chlorine compounds used for disinfection shall be sufficient to produce a minimum of 100 ppm (parts per million) available chlorine in solution when mixed with the total volume of water in the well.

PART 3 EXECUTION

3.01 METHODS OF CONSTRUCTION

A. The Contractor shall choose the construction method(s) to be used. Acceptable methods for this well include:

1. Cable Tool

2. Air Rotary

3. Air Hammer

3.02 WELL DEVELOPMENT - ACCEPTABLE METHODS

[**Designer Note:** Development may not be necessary for wells completed in hard rock (granite, basalt) sequences. Select the appropriate method.]

A. Surging and Bailing (Utilizing Bailer). The development process shall include surging and bailing the well. The surging shall be accomplished by utilizing the bailer as a surging device. If fines have been drawn into the well and have settled on the bottom and accumulated to a depth where they block 10 percent or more of the total screen length, the well shall be bailed or otherwise cleaned to the bottom before resumption of surging. On completion of development the well shall be cleaned to the bottom.

B. Surging and Bailing (Utilizing Surge Block). The development process shall be carried out by surging and bailing the well. The surging shall be done by a single or double solid (or valved) surge block. Surging shall start at the bottom of the lowest screen in the well and proceed upwards.

C. Surging and Pumping**.** The development process shall include surging and pumping the well. The surging shall be done by either a solid or valved surge block. The pumping shall be done through the surge block which incorporates a piece of the suction pipe in the fabrication of the block. Pumping shall be done simultaneously with the surging at rates up to 1/2 of the design capacity. Fines drawn into the well shall be pumped out periodically before such accumulation reaches 10 percent of the screen length. Upon completion of the development work the well shall be cleaned to the bottom.

D. Hydraulic Jetting. Hydralic jetting shall only be used in conjunction with one of the other approved development methods in this section. Development shall be accomplished by simultaneous high-velocity, horizontal-jetting and pumping. The outside diameter of the jetting tool shall be one inch less in diameter than the screen inside diameter. The minimum exit velocity of the jetting fluid at the jet nozzle shall be 150 ft./sec. The tool shall be rotated at a speed less than one rpm. It shall be positioned at one level for not less than two minutes and then shall be moved to the next level which shall be no more than 6 inches vertically from the preceding jetting level. The jetting shall proceed from the bottom of the screen to the top. Pumping from the well shall be at a rate of 5 to 15 percent more than the rate at which water is introduced through the jetting tool. Water to be used for jetting must contain less than 1 ppm suspended solids.

3.03 DEVELOPMENT AIDS

A. Washing with Water**.** Clean, clear water shall be circulated to remove sediment from the well. A pump of sufficient size shall be utilized for the washing process which will agitate the formation for the purpose of preventing bridging of the sand particles and removing a large portion of the finer material. The use of any chemicals, if pay is to be received, must be approved by the CM.

B. Washing with Chemicals. Where applicable and required, mud dispersing agents (such as glassy phosphate), acids for washing limestone, and other chemicals applicable to standard procedures may be used in accordance with the approval or direction of the CM.

3.04 FORMATION SAMPLING

A. Acceptable Methods

[**Designer Note:** Select the appropriate method.]

1. Bailer Method**.** In clay and consolidated formations the sample shall be taken by bailing the hole clean then advancing the drill bit and collecting cuttings. In sand and gravel the sample shall be taken by driving casing ahead of the drill bit then bailing with a flat bottom or suction bailer. In stable unconsolidated formations, samples shall be taken by drilling __________**(**5**)** feet and bailing before and after driving the casing to the bottom of the drilled interval.

2. Core Barrel Method. A core barrel shall be advanced, by being rotated or driven, its full length into the undisturbed formation. Once the core barrel has penetrated the desired interval, it shall be withdrawn and the core recovered and stored in a suitable core container. A core recovery of less than __________ percent will not be acceptable.

3. Piston Tube Method. A piston tube sampler shall be driven into the undisturbed material at the bottom of the drilled hole to take formation core samples. This method is used to prevent the material in the core from expanding and to assure that the full core be held securely as the sampler is removed from the test hole. The cores are to be minimum of __________ inches in diameter and __________ inches in length. Upon removal to the surface the sample is to be capped and sealed in its tube, placed in a sample box and stored in a safe place by the Contractor.

4. Split Spoon Method**.** A steel cylinder shall be driven vertically into the undisturbed formation at the bottom of the drilled hole. The cylinder will be returned to the surface and transferred to a suitable core container. No sample recovery of less than 50 percent will be accepted.

5. Side-Hole Core Method. Formation samples will be taken using a __________ inch diameter side-hole core sampler. This unit must be set at depths as directed in such a way as to assure penetration of the hole wall to a sufficient depth to provide a recovery of a _____________ inch-long core. Side-hole cores will be taken after geophysical logs have been made, at depths specified by the CM. The samples shall be placed in a suitable container and identified as specified by the CM and stored by the Contractor.

B. Sampling Interval**.** Formation samples shall be collected each __________ foot (10, ten), starting at __________, (20, twenty ft)and at any pronounced change of formation. Special care shall be used for collecting samples from zones that are expected to be producing zones, wherein samples shall be collected at __________ foot (5, five) intervals.

C. Size of Sample, Containers, Identification, Storage and Transfer.

1. __________ (2, two) of __________ (1 quart ea) representative samples shall be obtained from each sampling interval. In most instances more cuttings will be recovered than required. The total volume of cuttings shall be thoroughly mixed and quartered until the number of volume of samples required are obtained as a residual.

2. Immediately after retrieval, formation samples shall be placed in approved containers, securely closed to avoid spillage and contamination, and clearly labeled with the following information:

a) Location of the well
b) Name or number of the well
c) Depth interval represented by the sample
d) Date taken
e) Time taken

3. Formation samples, immediately after being placed in container, shall be labeled clearly, either directly on the container or on a tag attached thereto, using ink, indelible pencil, or other medium that is resistant to moisture and sunlight. The label shall not be readily removable from the container. The Contractor shall be responsible for the safe storage of formation samples until such times as they are accepted by the CM. Time, place, and mode of delivery shall be as directed by the CM.

4. For wells which may or will utilize screens, the Contractor shall obtain additional samples as required in water-bearing formations for analysis by a laboratory or screen manufacturer. Duplicate samples shall be retained in a safe place until the results of the analysis are received.

D. Temporary Capping**.** Any well that is to be temporarily removed from service, or which is completed for a period prior to being placed in service, or is left uncompleted due to a recess or delay in construction shall be capped with a water-tight welded or threaded cap or equipped with some other type of "vandal-proof" cover satisfying applicable state or local regulations or recommendations

3.05 METHODS OF WELL CASING INSTALLATION

[**Designer Note:** Select the appropriate method or allow the discretion of the well drilling Contractor.]

A. Lowering**.** The lowering method is used to install a jointed casing string in a pre-drilled hole. The casing shall be lowered with the drilling machine, utilizing clamps, elevators or other mechanical devices.

B. Floating**.** Where the casing load is extremely large it may be desirable to "float" the casing into place. A float collar shall be installed on the casing at the appropriate place in the casing string or a float plug shall be installed in the casing string near the bottom. Where a float collar or float shoe is to be used a casing-size dummy (40 ft. minimum length) shall be run into the hole first to insure that the hole is straight and free from obstruction which could result in a stuck casing.

3.06 JOINING WELL CASING

A. Joining**.** Casing lengths shall be joined watertight by a method appropriate to the material used, as selected by the Contractor and approved by the CM, so that the resulting joint shall have the same structural integrity as the casing itself. If metallic casing is welded, the standards of the American Welding Society (AWS) shall apply.

B. If threaded and coupled joints are used, couplings shall be American Petroleum Institute (API) or equivalent, made up so that when tight all threads will be buried in the lip of the coupling.

C. Welding shall conform to AWS B 3.0 and D 1.1. Cut off casing shall become the property of the Contractor and shall be removed from the site.

3.07 CASING SEATING

A. Consolidated Formations. In consolidated formations the casing should extend at least five feet into the formation to assure a proper seat and bottom seal. It shall be the responsibility of the Contractor to effect a proper seal. Where the casing is to be driven it shall be fitted with a drive shoe and shall be driven to refusal. Where the casing is to be placed (rather than driven), cement grout shall be placed in the bottom of the hole in accordance with Section 3.08.

3.08 INSTALLATION OF GROUT - ACCEPTABLE METHODS

[**Designer Note:** Select the appropriate method.]

A. Positive Placement-Interior Method-Two Plug**.** Grout shall be placed by the two-plug cementing method (after water or other drilling fluid has been circulated in the annular space sufficient to clear obstructions). The first spacer plug, which shall be a drillable plug such as a plaster-type material, shall then be inserted and the casing capped. A measured volume of grout shall be pumped in which shall be of sufficient quantity to grout the casing in place. The casing shall then be uncapped, the second plug shall be inserted, and the casing recapped. A measured volume of water slightly less than the volume of the casing shall then be pumped into the casing until the second plug is pushed to the bottom of the casing, expelling the grout from the casing up and into the annular space. The water in the casing shall be maintained constant to prevent back flow until the grout has set. Pressure shall be maintained for a minimum of 24 hours or until such time as a sample of the grout indicates a satisfactory set. Cement grout shall be used for this procedure with a minimum annular space thickness of l 1/2 inches completely surrounding the casing. Curing time before construction may be resumed: Portland Cement Type I-minimum 72 hours; Type III-minimum 36 hours. Concrete grout cannot be used with this method.

B. <u>Positive Placement-Interior Method-Upper Plug</u>**.** Grout shall be placed by the upper plug casing method (after water or other drilling fluid has been circulated in the annular space sufficient to clear obstructions). A measured quantity of grout, sufficient to grout the casing in place, shall be pumped into the capped casing. Because this grout is in direct contact with the drilling fluid there will be a narrow zone of weak grout between the drilling fluid and the good grout. The casing shall be uncapped, and a drillable plug, constructed of plastic or other suitable material shall be inserted on top of the grout and the casing recapped. A measured volume of water, equal to the volume of the casing, shall be pumped into the casing, forcing the plug to the bottom of the casing and expelling the grout into the annular space surrounding the casing. Utilizing this method the weak grout zone at the interface of grout and drilling fluid will not be located at the critical position at the bottom of the casing. The water in the casing shall be maintained under pressure to prevent back flow until the grout has set. Pressure shall be maintained for a minimum of 24 hours or until such time as a sample of the grout indicates a satisfactory set. Neat cement or sand-cement grout shall be used for this procedure, with a minimum annular space opening of l 1/2 inches completely surrounding the casing. Curing time before construction may be resumed: Portland Cement Type I-minimum 72 hours; Type III-minimum 36 hours. Concrete grout cannot be used with this method.

C. <u>Positive Placement-Interior Method-Capped Casing</u>**.** Grout shall be placed by pumping or air pressure injection through the grout pipe installed inside the casing from the casing head to a point 5 feet above the bottom of the casing (after water or other drilling fluid has been circulated in the annular space sufficient to clear obstructions). The grout pipe shall extend airtight, through a sealed cap on the casing head of the well casing. The casing head shall be equipped with a relief valve and the drop pipe shall be equipped at the top with a valve permitting injection. The lower end of the drop pipe and the casing shall be open. Clean water shall be injected down the grout pipe until it returns through the casing head relief valve. The relief valve is then closed and injection of water is continued until it flows from the bore hole outside of the casing to be grouted in place. This circulation of water is intended to clean the hole and condition it to better take the grout. Without significant interruption, grout shall be substituted for water and, in a continuous manner, injected down the grout pipe until it returns to the surface outside of the casing. A small amount of water, not to exceed seventeen gallons per hundred lineal feet of 2 inch drop pipe may be used to flush the grout pipe, but pressure shall be maintained constant on the inside of the grout pipe and the inside of the casing until the grout has set. Pressure shall be maintained for at least 24 hours, or until such time as a sample of the grout indicates a satisfactory set. Neat cement or sand-cement grout shall be used for this procedure with a minimum annular space of 1 1/2 inches completely surrounding the casing. Curing time before construction may be resumed: Portland Cement Type I-minimum 72 hours; Type III-minimum 36 hours. Concrete grout cannot be used with this method.

D. <u>Continuous Injection Method</u>**.** Grout shall be placed by the float shoe continuous injection method, (after water or other drilling fluid has been circulated in the annular space sufficient to clear obstructions). The bottom of the casing shall be fitted with a suitable drillable float shoe equipped with a back pressure valve. Tubing or pipe shall be run to the float shoe to which it shall be connected by a bayonet fitting, left hand thread coupling, or similar release mechanism. Water or other drilling fluid shall be circulated through the tubing and up through the annular space outside the casing. When the annular space is clean and open, grout shall be pumped down the pipe or tubing and forced by continual pumping out into the annular space surrounding the casing. Pumping shall continue until the entire zone to be grouted is filled. The grout pipe shall then be detached from the float shoe and raised to the surface for flushing. After the grout has set the float shoe, back pressure valve, and any concrete plug remaining in the bottom of the casing shall be drilled out. A neat cement or sand-cement grout shall be used for this procedure with a minimum annular space of 1 1/2 inches completely surrounding the casing. Curing time required before construction may be resumed shall be 72 hours for Type I Portland Cement and 36 hours for Type III. Concrete grout cannot be used with this method.

E. Grout Displacement Method**.** The hole shall be filled with the estimated volume of grout required for the purpose intended. The casing fitted at the bottom with a drillable back pressure valve, metal plate, or similar seal shall be lowered through the grout to the bottom of the hole. If necessary to maintain the bottom of the casing at the bottom of the hole, the casing shall be filled with water, or drilling fluid, and in some cases by applying a load on the bottom with drill pipe. The load shall be maintained until the grout has set, after which the bottom plug is drilled out and the well deepened. Use of this method is limited to wells not more than 100 feet in depth.

3.09 LOCATION OF GROUT

[**Designer Note**: The following specification should be considered a minimum.]

A. Surface Formation Seal**.** The annular space to be grouted, and surrounding the permanent well casing at the upper terminus of the well, shall be not less than a nominal 2 inches. The length of the grout seal shall be whatever is necessary to prevent the entrance of surface water or undesirable subsurface water into the well. In any circumstance, the length of seal shall not be less than the minimum specified in the state or locally applicable construction code.

B. The entire space to be grouted must be open and available to receive the grout at the time the grouting operation is performed. If a section of larger pipe (conductor pipe) is installed to keep the entire space open (in caving materials), this larger pipe must be removed, as the grout is installed, from the zone where the seal is required.

C. The effective length of grout seal (for sanitary purposes) shall be that distance measured from the deepest limit of the seal up to the depth of frost penetration. If a pitless adapter or unit is to be installed, the upper limit of the seal shall be one foot below the field connection of the adapter or unit.

3.10 CENTRALIZERS

A. Centralizers at Bottom of Hole and other Critical Points**.** Centralizers shall be attached to the bottom of the casing at other critical grouting points such as zones of unsuitable water quality.

3.11 PRESSURE TESTING OF GROUTING SEAL

A. Pressure testing of the grout seal shall be employed following the appropriate time for curing of the grout according to all appropriate provisions in this Article. A pressure of 7 to 10 pounds of air per square inch is to be maintained within the well, without the addition of more air, for a period of not less than one hour. Any loss of air shall be construed as indicating a defective seal. To correct such a defect, the CM shall require the Contractor to make the necessary repairs by re-cementing and pressure testing at 15 psi for one hour.

3.12 PLUMBNESS AND ALIGNMENT

[Designer Note: Select one - "A" would suffice in cases where the well is very shallow (and a submersible pump will be used). "B" is appropriate for a deeper well (300 ft)and where a submersible pump will be used. "C" should be selected where a line shaft type well pump will be used.]

A. The completed well shall be sufficiently plumb and straight so that there will be no interference with installation, alignment, operation or future removal of the permanent well pump.

B. All wells should be constructed and all casings and liners set round, plumb, and true to line as defined herein. To demonstrate the compliance of the work with the requirements, the Contractor shall furnish all labor, tools and equipment and perform the test or tests described herein. The test for plumbness and alignment shall be made following construction of the well, and before test pump equipment is installed.

C. Alignment shall be tested by lowering into the well to a depth of at least ____________ feet (lowest anticipated pump setting) a section of pipe 40 feet long or a dummy of the same length. The outer diameter of the pipe or dummy shall be not more than 1/2 inch smaller than the inside diameter of that part of the casing or hole being tested when the casing diameter is a nominal 10 inches or less. When the nominal diameter of the casing being tested is 12 inches or greater, the outer diameter of the test pipe or dummy shall not be more than 1 inch smaller than the inside diameter of that part of the casing or hole being tested. The dummy when lowered into the casing shall pass freely the entire depth of the well.

D. The Contractor shall guarantee that the well when completed shall be sufficiently straight and plumb for the free installation and operation of a turbine pump of ____ inch (pump bowl diameter is a function of pump capacity. See table in appendix) nominal bowl diameter with bowls set ____ feet below ground surface. To demonstrate compliance with this requirement the Contractor shall furnish all labor, tools, and equipment, and make a caging test to the satisfaction of the Engineer. The test shall be performed after completion of the well construction and before its acceptance. The completed well shall be drilled in such vertical alignment that a line drawn from the center of the well casing at ground surface to the center of the well casing ____ (pump bowl setting depth) feet below the ground surface shall not deviate from the vertical more than 6 inches in 100 feet of length.

3.13 SAND CONTENT LIMITS

[**Designer Note:** Sand content limits are a function of the design of the design of the system. For applications in which an injection well is used, the well should be sand free (< 1.0 ppm). For applications using surface disposal, the limit should be 5 ppm.]

A. Sample Well development shall continue until sand production is less than _____ (5, 15) ppm within _____(10) minutes after commencement of pumping at a minimum rate of _____ (peak system flow rate) gpm and is not more than an average of _____ (0.9, 5.0)ppm after a pumping cycle of two hours. Sand production shall be measured with a centrifugal sand separating device as described in the Journal of American Water works Association Vol 46 No 2, Feb 1954

B. Recording Measurements. A record shall be made showing time, type of operation, specific capacity during pumping, pumping rate and the sand content measured and recorded. These records shall be submitted to the CM along with a _____(2.0) lb sample of the sand collected.

3.14 WELL FLOW TESTING

[**Designer Note**: Select either A or B. The constant rate test is simpler but without the monitoring of nearby well water levels, produces less information about the aquifer than the step draw down test. The step draw down test can be shortened by eliminating the constant rate test at the end assuming that the water level in the well stabilized sufficiently during the final stage of the step test.]

A. CONSTANT RATE METHOD

1. The Contractor shall furnish, install and remove the necessary measuring instruments and pumping equipment capable of pumping to the required point of discharge a minimum of __________ gpm (peak system flow rate), with a pumping level of __________ feet (determined from nearby wells), and with satisfactory throttling devices, so that the discharge may be reduced to __________ gpm (25% of peak system flow rate). The pumping unit shall be complete with an ample power source, controls and appurtenances and shall be capable of being operated without interruption for a period of __________(72) hours.

2. The well shall be pumped at a discharge rate of _________ gpm (peak system flow rate) for a minimum of __________(12) hours. The test pump shall have its intake at least 5 feet below the estimated lowest pumping level, and shall have sufficient power and capacity to achieve the designated discharge rate. Discharge shall be measured with an accurate totalizing meter and stopwatch, a circular orifice meter, or a Venturi meter, any of which are subject to approval by the CM. Discharge shall be maintained within plus or minus 5 percent of the designated rate by means of a gate valve or throttling device. Discharge shall be checked and adjusted, if necessary, every 10 minutes during the first hour of pumping and at 30-minute intervals thereafter. The discharge and time of measurement shall be recorded each time it is checked and a note made of any adjustments. The static or non-

pumping water level trend shall be established prior to the start of the test. Draw down shall be measured according to the following schedule: 0 to 10 minutes-every minute; 10 to 45 minutes--every 5 minutes; 45 to 90 minutes-every 15 minutes; 90 to 180 minutes--each half hour; 180 minutes to the end of the test-each hour. Should the measurements not be made exactly at the times specified, the actual time of each measurement shall be recorded. On completion of pumping, recovery measurements shall be made according to the above draw down schedule.

B. STEP-CONTINUOUS COMPOSITE METHOD

1. The Contractor shall furnish, install and remove the necessary measuring instruments and pumping equipment capable of pumping to the required point of discharge a minimum of __________ gpm (peak system flow rate), with the pumping level of __________ feet (determined based on the performance of nearby wells), and with satisfactory throttling devices, so that the discharge may be reduced to __________ gpm (25% of peak system flow rate). The pumping unit shall be complete with an ample power source, controls and appurtenances and shall be capable of being operated without interruption for a period of __________ (16) hours.

2. Prior to starting the pump, water level measurements shall be made at least hourly, for a minimum of eight hours, in the production well and all observation wells, and these measurements shall be recorded on the same note sheets to be used during the pumping test. The well shall be "step" tested at rates of approximately 25%, 50%, 75% and 100% of the design capacity of __________ gpm (peak system flow rate). The complete test is estimated to require a minimum of approximately __________(4) hours. The Contractor shall operate the pump and change the discharge as directed by the CM. Discharge of the pump shall be controlled by a gate valve, if electric driven, and both gate valve and engine throttle if engine driven. The discharge shall be controlled and maintained at approximately the desired discharge for each step with an accuracy of plus or minus 5 percent. Pump discharge shall be measured with a totalizing meter and stopwatch, circular orifice meter, or Venturi meter as approved by the CM. A two-wire electric probe calibrated so as to permit water level measurement accuracy of +/- 0.05 ft shall be used to measure the static water level and drawdown in the well. A clearly marked convenient reference point shall be set at the top of the pipe. The probe shall be furnished by the Contractor.

3. After recovery from the step test is complete, a constant rate test shall be conducted by pumping the well at the design rate or at maximum yield for a period of not less than _____(4) hours or until the pumping level remains constant for at least 4 hours, or until the CM terminates the test.

4. Measurements of pumping rate and water level shall be made every 1 minute for the first 10 minutes of the test, every 2 minutes for the next 10 minutes, every 5 minutes for the next 40 minutes, every 15 minutes for the next hour, every 30 minutes for the next 3 hours, and hourly for the remainder of the pumping period. Recovery water-level measurements shall be made with the same frequency until sufficient data have been collected to extrapolate the full recovery of the well or until the CM requires no further data.

3.15 ABORTED TEST

A. Whenever continuous pumping at a uniform rate has been specified, failure of pump operation for a period greater than one per cent of the elapsed pumping time shall require suspension of the test until the water level in the pumped well has recovered to its original level. For the purposes of this Article, recovery shall be considered "complete" after the well has been allowed to rest for a period at least equal to the elapsed pumping time of the aborted test- except that if any three successive water level measurements spaced at least 20 minutes apart show no further rise in the water level in the pumped well, the test may be resumed immediately. The CM shall be the sole judge as to whether this latter condition exists.

3.16 DISCHARGE WATER

A. Discharged water shall be conducted from the pump to the nearest surface-water body, storm sewer, or ditch, as approved by the CM or at least a distance of __________ feet through approved piping or lined ditches to prevent recirculation of discharged water into the aquifer being tested. It is imperative to insure that no damage by flooding or erosion is caused to the chosen drainage structure or disposal site.

3.17 MEASUREMENT OF WATER LEVELS

A. <u>Electric Probe Method</u> . A two-wire electric probe calibrated so as to permit water level measurement accuracy of +/- 0.05 ft shall be used to measure the static water level and drawdown in the well.

3.18 WATER SAMPLES AND ANALYSIS

A. <u>Specific Constituent-Analysis</u>**.** Analysis for the following specific constituents shall be made:

pH	Carbonate	Stability Index
Iron	Bicarbonate	Saturation Index
Calcium	Sulphate	Carbon Dioxide
Magnesium	Chloride	Hydrogen Sulphide
Sodium	Alkalinity	Oxygen
Potassium	Total Hardness	Total Dissolved Solids

B. <u>Sample Collection</u>**.** A __________ (1/2) gallon sample of water shall be collected for chemical analysis. The water sample shall be collected in a chemically cleaned container supplied by the laboratory that will make the analysis. The sample shall be collected from the water discharged during development or flow test pumping of the well, no less than _______(**1**) hours after pumping has commenced.

C. <u>Wellhead Test</u>**<u>s</u>.** The temperature and pH of the water shall be taken immediately upon collection of the water sample and recorded on the sample container and drillers log. Tests shall be conducted according to procedures prescribed by the manufacturer of the test equipment employed, local health or water agencies, or as set forth in standard publications dealing with this method of analysis. Test for the presence of dissolved gasses identified in Section 9.7.1 shall be made immediately following the collection in accordance with procedures prescribed by the manufacturer of the test equipment.

D. Laboratory Requirements**.** Laboratory tests shall consist of those specified by the regulations of local or state government or as described herein for the proposed use of the water. In addition, such other tests prescribed by the CM will be made. All laboratory tests shall be performed by a laboratory approved by the CM. Analytical techniques and methods shall be as prescribed in Standard Methods for the Examination, of Water and Waste Water, a joint publication of the American Public Health Association, American Water Works Association, and Water Pollution Control Federation. All samples shall be appropriately identified as to geographic location, date, time, method of collection, point of collection, water bearing formation(s), depth and diameter of well, water level and yield, and shall include the name of the sample collector, Contractor, driller and CM.

3.19 WELL DISINFECTION

A. Scheduling Disinfection

1. The Contractor shall provide for disinfection as soon as construction of the well and cleaning procedures have been completed. The Contractor shall carry out adequate cleaning procedures immediately preceding disinfection where evidence indicates that normal well construction and development work have not adequately cleaned the well. All oil, grease, soil, and other materials, which could harbor and protect bacteria from disinfectants, shall be removed from the well. Unless prior approval is obtained for employing chemicals or unusual cleaning methods, the cleaning operation is to be carried out by pumping and swabbing only. Where test pumping equipment is to be utilized, such equipment shall be installed prior to or during disinfection and be thoroughly hosed, scrubbed or otherwise cleaned of foreign material.

B. Interim Disinfection

1. Should a delay of three days or more be anticipated between the completion of the well and the regularly scheduled well disinfection an interim disinfection shall be provided by the Contractor. The Contractor shall install an approved disinfecting agent in an amount equal to 10 percent of the amount required for final disinfection. For this purpose the disinfecting agent shall be furnished or prepared in liquid form and placed in the well through a hose or tremie of sufficient length to extend to the bottom of the well. The disinfecting agent shall be applied through the hose, which is to be raised and lowered, to achieve uniform distribution of the solution throughout the well.

C. Daily Operations Disinfection

1. Daily chlorination of the well shall be carried out by the Contractor during drilling operations. The Contractor shall discuss with the CM the amount of disinfecting agent to be

used and its method of use in advance of initiating the work. Chlorine compound dosages and method of utilization shall be satisfactory to the CM in its entirety.

D. Disinfection Procedure

1. Unless otherwise modified-due to problems involved with the specific well or conflict with local, state or federal governmental regulatory, agency requirements-disinfection procedure shall include, but not be limited to the following:

2. Provide reliable means for insuring that the disinfecting agent is uniformly applied throughout the entire water depth of the well without relying on subsequent mechanical or surging action for dispersing the disinfectant; the dispersion of the disinfectant shall be assisted by pouring into the well a volume of water equal to the volume of the screen, after the disinfectant has been emplaced. This will cause the disinfectant to flow out of the well into the area adjacent to the screen.

3. All accessible portions of the well above the water level shall be maintained in a damp condition with water containing the required concentration of disinfecting agent for a period of not less than 20 minutes. The disinfecting agent shall be left in the well for a period of at least 12 hours. After a 12 hour, or longer, contact period the well is to be pumped to clear it of the disinfecting agent. The disposal point for the purged water shall be as selected so as to minimize potential damage to aquatic life or vegetation.

E. Disinfection Of Water Table Wells - Acceptable Methods

1. Dry Chlorine Compounds**.** A doubly capped, perforated pipe container filled with the appropriate amount of a granular chlorine compound to produce an available chlorine concentration of ________(100) ppm in the well shall be moved up and down the entire well bore until the material has dissolved.

2. Stock Solution (I). A stock solution sufficient to produce __________(100) ppm of available chlorine shall be added to the well at different intervals from top to bottom and then agitated to distribute it evenly throughout the well.

3. Stock Solution (II). A stock chlorine solution of 15,000 ppm shall be added to a continuous flow of water into the well to produce a __________(100) ppm concentration of available chlorine throughout the well.

4. Prepared Solution**.** The chlorine solution of the appropriate concentration to disinfect the well shall be prepared on the surface in containers having an aggregate volume equal to at least twice the volume of water in the well and then rapidly discharged into the well so as to thoroughly flush that portion of the casing which is above the water level.

F. Disinfection Of Flowing Artesian Wells - Acceptable Methods

1. Dry Chlorine Compounds**.** A doubly capped, perforated pipe container filled with a granular chlorine compound shall be placed at a point on or below the top of the producing

horizon. This process shall be repeated as often as necessary to achieve and maintain the standard 50 ppm concentration for a period of not less than one hour.

2. Controlled Flow Disinfection**.** Flow shall be controlled by either capping or by a suitable standpipe. In the event the well is capped a stock chlorine solution shall be injected, under pressure, by means of a drop pipe to the bottom of the well. The cap shall be equipped with a suitable one-inch valve. After the injection is complete air shall be injected for agitation while simultaneously opening the valve in the cap permitting the chlorine solution to be dispersed to the surface. The valve shall then be closed and the flow stopped. The chlorine concentration shall be maintained at 100 ppm for six hours.

   a) In the event flow can be controlled by a suitable standpipe the chlorine treatment can be conducted as though the well was non-flowing.

3. Stock Solution**.** A stock chlorine solution shall be applied for a period of not less than one hour at a point at or below the top of the producing zone. The rate of application will be such that the standard 100 ppm concentration is achieved and maintained during the application period.

3.20 WELL ABANDONMENT

A. Aquifer Sealing Criteria

1. Aquifers shall be filled with disinfected, dimensionally stable materials, compacted mechanically if necessary to avoid later settlement. (Cement, cement-and-sand, and concrete do not require disinfection.)

2. Disinfection of aquifer fill materials shall be accomplished by using chlorine compounds such as sodium hypochlorite or calcium hypochlorite. Aquifer fill materials shall be clean (relatively free of clays and organic materials) before placement in the well. Disinfection shall be accomplished by dissolving sufficient chlorine compound to produce a calculated concentration of at least 100 ppm available chlorine in double the volume of water in the well. The fill material shall be placed in the well after the water in the well has been so treated

B. Permanent Bridges

1. Permanent bridges may be used to avoid having to fill very deep holes below the deepest point at which a permanent seal is required. Permanent bridges shall be composed only of cement or cement-bearing minerals. The cement shall be allowed to harden for at least 24 hours, if Type I cement is used, or for at least 12 hours if Type III (high early strength) cement is used, before backfilling is continued. Temporary bridges used to provide a base for the permanent bridge shall consist only of inorganic materials--except that patented devices containing expandable neoprene, plastic, and other elastomers, and specifically designed for use in well construction are acceptable.

C. Placement Of Grout

1. Placement Operations**.** Concrete, sand-and-cement grout, or cement grout used as a sealing material in abandonment operations shall be introduced at the bottom of the well or interval to be sealed (or filled) and placed progressively upward to the top of the well. All such sealing materials shall be placed by the use of grout pipe, tremie, cement bucket or dump bailer, in such a way as to avoid segregation or dilution of the sealing materials. Dumping grout material from the top shall not be permitted.

2. Seals intended to prevent vertical movement of water in the well or bore hole shall be composed of cement, sand-and-cement, or concrete--except that where such seals must be placed within casing or liners, only neat cement grout may be used. The cement-water ratio shall be that specified in Part 2 above. Cement seals shall be placed by means of pumping through drop pipe or by use of a dump-bailer, with placement beginning at the bottom and continuing upward. The minimum cement seal length, wherever dimensions permit, shall be 10 feet.

3. Intermediate Seals**.** Intermediate seals of cement, sand-and-cement, or concrete shall be placed in impermeable strata between aquifers which are identifiable as, or are suspected of being, hydraulically separated under natural, undisturbed conditions. Once the required cement seal has been installed, the remainder of the impermeable zone or non-producing zone between aquifers shall be filled with sand, sand and gravel, or cement-bearing mineral material.

4. Seal at Uppermost Aquifer**.** A cement, sand-and cement, or concrete seal shall be installed in the least permeable zone immediately above the uppermost water-producing zone. Such seals shall be placed only in quiescent (non-flowing) water.

5. Seals Placed Within Casing, Liners, Filters, etc. Seal which must be placed in casing, liners, or filters require special attention. The material between the well and the face of the bore hole shall be thoroughly perforated, ripped, or otherwise disintegrated as the necessary first step. Neat cement only, or neat cement with a maximum of 5 percent by weight of commercially processed bentonite clay, shall be used as the seal. Either of two methods may be used.

   a) The calculated amount of grout required to fill the well interval plus the annular space outside the lining shall be placed within the space to be cemented, running the cement through a special cementing packer manufactured for this purpose and installed immediately above the perforated or ripped zone. The cement shall be injected at a pressure calculated to be at least 50 psi greater than the normal hydrostatic pressure within the well at the point of injection.

   b) The calculated amount of cement grout required to fill the casing interval plus the annular space outside the lining, plus sufficient cement grout to fill an additional 10 feet of the lining, shall be introduced at the bottom of the interval to be cemented.

3.21 PLACEMENT OF FILL

A. Non-producing zones above the aquifer shall be filled with stable materials such as sand, sand-and-gravel, cement, cement-and-sand, or concrete. Non-producing zones above the uppermost aquifer seal shall be filled with materials less permeable than the surrounding undisturbed formations. The uppermost 5 feet of the bore hole (at land surface) shall be filled with a material appropriate to the intended use of the land.

3.22 SPECIAL CONDITIONS

A. An abandoned well which has already been affected by salt water intrusion or any other contaminants shall be considered a special case, and the method of filling and sealing such wells shall be subject to individual review and written approval by the regulatory agency involved.

B. In the sealing of a double or multiple cased well, the Contractor shall submit a drawing thereof with a description of the proposed procedure and materials to be used, for prior approval by the regulatory agency involved.

C. Mineral exploration holes, solution or "in situ" mining wells, de-watering wells, temporary service wells, construction water wells, process wells, and/or other structures which affect the withdrawal or quality of ground water, or the elevation of the water table, regardless of location or intended length of life of the structure, shall be abandoned according to standards and minimums as described herein for water supply wells.

3.23 MODIFICATIONS TO OPEN-HOLE COMPLETION - CONSOLIDATED SPECIFICATIONS

[Designer Note: The following design information and modifications pertain to the Open-Hole Completion - Consolidated Specifications and may be useful to consider at the discretion of the designer. All changes should always consider project specific and site specific conditions.]

A. Modifications for Air Rotary

Sampling - Substitute the following as necessary.

1. Contractor's Choice**.** The method of sampling will be left to the discretion of the Contractor; however, the Contractor must collect, identify and store representative samples in accordance with direction from the CM, collected with sufficient frequency and at sufficient increments of depth to permit a thorough evaluation of the water-bearing properties of the formations encountered in drilling the test hole.

2. Return Flow Method (Continuous**). A** return flow sample shall be taken by removing from the circulating drilling fluid a representative sample of the formation by either collecting same in a cutting sample box, a "shale shaker", a baffle in a ditch, or catching it in a bucket and allowing the sample-to settle out. Provision shall also be made to obtain a record of

circulation time and probable depth of the formation from which the cuttings are derived. Drill cutting samples collected at specified depth intervals shall be placed in approved containers and identified as specified by the CM . The samples shall be stored in a safe place by the Contractor.

3. Return Flow Method (Circulated). A return flow sample shall be taken by removing from the discharge fluid a representative sample of the formation by either collecting same in a cutting sample box, a "shale shaker", a baffle in a ditch, or catching it in a bucket and allowing the sample to settle out. The penetration of the bit shall stop when the bottom of the sampling interval is reached for such time as is required for all the cuttings to move from the last drilled section of the hole and settle at the sampling point. The return ditch and sample catching device shall be cleaned of all cuttings after each sample is taken. A cutting sample shall be carefully collected from the sampling point. Drill cutting samples collected at specified depth intervals shall be taken by the Contractor. The total sample obtained from each interval shall be mixed and quartered until sufficient sample remains to furnish __________ (number) ___________ (volume), representative samples. Drill cuttings shall be placed in approved containers and identified as specified by the CM . The samples shall be stored in a safe place by the Contractor.

4. Auger Method. Formation samples obtained using the auger method are to be representative of the formation being penetrated. The samples will be collected, placed in approved containers, and stored in a safe place by the Contractor.

B. For small low-temp geothermal and for ground source heat pump wells:

Substitute the following for grout installation ahead of the existing paragraphs and re-number as necessary:

1. Gravity Filling Without Tremie Method**.** Grout material shall be uniformly poured into the annular space without the aid of a tremie or grout pipe (after water or other drilling fluid has been circulated in the annular space sufficient to clear obstructions). This method shall be employed only where the interval to be grouted is clearly visible from the surface and is dry. Maximum allowable depth to bottom of grout interval shall be 30 feet.

2. Tremie Method**.** Grout material shall be placed by tremie pouring (after water or other drilling fluid has been circulated in the annular space sufficient to clear obstructions). The tremie method shall only be used where there is a minimum annular space of 3 inches between the outside surface of the inside casing and the inside surface of either the external casing or the borehole. The minimum size tremie pipe utilized shall be 2 inches inside diameter. Where concrete grout is used the minimum size tremie pipe used shall be three inches inside diameter. When making a tremie pour, the tremie pipe shall be lowered to the bottom of the zone being grouted, and raised slowly as the grout material is introduced. The tremie pipe shall be kept full continuously from start to finish of the grouting procedure, with the discharge end of the tremie pipe being continuously submerged in the grout until the zone to be grouted is completely filled. Curing time before construction may be resumed: Portland Cement Type I-minimum 72 hours; Type III-minimum 36 hours.

C. For injection wells:

1. Sealing of an injection well is more critical than for a production well particularly if the well is expected to operate with a positive injection pressure at the surface. Effective sealing of the well prevents the possibility of injection fluid moving vertically along the well bore to the surface. As an alternative, if continuous grouting is chosen, the following text from the National Water Well Association Water Well Specifications may be used.

2. Continuous Grouting**.** Grout shall be placed in the annular space surrounding the casing by the method specified. Grouting shall be continuous from the bottom of the permanent casing to the land surface; or, where a filter pack has been installed, from the top of the pack (following development) to the land surface; or, where a well screen only has been installed, from a point 5 feet above the screen to the land surface. When a pitless adapter or unit is to be installed, the grout shall extend from such depth to within one foot of the field connection of the adapter or unit.

3. Injection wells should always be equipped with an injection tube. This is a pipe through which the water flows into the well. The tube extends from the surface to well below the static water level in the well. The purpose of the injection tube is to reduce the tendency for "cascading of water from the surface to the static level. Cascading results in air entrainment in the injected water. Entrained air bubbles, if carried into the aquifer can result in plugging of the area immediately around the well in the same manner as entrained particulate matter.

END OF SECTION

SECTION 02936

SEEDING

[**Designer Note:** This specification will vary according to the individual state's requirements. The following is an example of the Tennessee Department of Transportation guidelines and shall be modified according to the individual state's department of transportation standards.]

PART 1 GENERAL

1.01 SECTION INCLUDES: Seeding, hydroseeding, mulching, fertilizing, and liming.

1.02 SUBMITTALS

A. Submit certified laboratory report from accredited commercial seed laboratory showing the analysis of the seed furnished.

1.03 QUALITY ASSURANCE

A. Provide seed mixture in containers showing percentage of seed mix, year of production, net weight, date of packaging, and location of packaging.

1.04 REFERENCES

A. TDOT, Bureau of Highways, Standard Specifications for Road and Bridge Construction, March 1, 1995.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Deliver grass seed mixture in sealed containers. Seed in damaged packaging is not acceptable.

B. Deliver fertilizer in waterproof bags showing weight, chemical analysis, and name of manufacturer.

PART 2 PRODUCTS

2.01 MATERIALS

A. Seed Mixture

1. Seed Mixture: In accordance with requirements of TDOT Subsection 918.14. Percentages forming group shall be as set out below.

Seed	Quantity % by Weight	Seeding Dates
Group A		
Kentucky 31 Fescue	80	Feb. 1-July 1
English Rye	5	
Korean Lespedeza	15	
Group B		
Kentucky 31 Fescue	55	June 1- Aug. 15
English Rye	20	
Korean Lespedeza	15	
German Millet	10	
Group C		
Kentucky 31 Fescue	70	Aug. 1-Dec. 1
English Rye	20	
White Clover	10	
Group C1		
Crown Vetch	25	Feb. 1-Dec. 1
Kentucky 31 Fescue	70	
English Rye	5	

B. Topsoil

1. Topsoil: In accordance with Section 02200, Earthwork.

C. Accessories

1. Mulching Material: Oat or wheat straw, free from weeds, foreign matter detrimental to plant life, and dry. Hay or chopped cornstalks are not acceptable. Straw shall be suitable for spreading with standard mulch blower equipment.

2. Fertilizer: Standard commercial fertilizer conforming to requirements of TDOT Specification, Subsection 918.15 with guarantee of analysis conforming to a 10-10-10 formula. Fertilizer shall be uniform in composition, free flowing, and suitable for application with approved equipment.

3. Agricultural Limestone: Agricultural Limestone shall contain not less than 85% of calcium carbonate and magnesium carbonate combined and be crushed so that at least 85% will pass No. 10 mesh sieve and 50% through a 40 mesh sieve.

4. Water: Clean, fresh, and free of substances or matter that could inhibit vigorous growth of grass.

5. Erosion Control Matting: Shall meet requirements of following TDOT subsections of Section 918 - Miscellaneous Materials:

Material	Subsection
Jute Mesh	918.28
Staples	918.19

PART 3 EXECUTION

3.01 PREPARATION

A. Verify that prepared soil base is ready to receive work of this section and that final dressing is within reasonably close conformity to lines, grades, and cross-sections.

3.02 INSTALLATION/APPLICATION/ERECTION

A. Fertilizing and Liming

1. Apply commercial Grade 10-10-10 fertilizer at a rate of not less than 20 lb/1000 ft^2 and agricultural limestone at a rate of not less than 75 lb/1000 ft^2.

2. Apply after smooth raking of topsoil and prior to roller compaction.

3. Do not apply fertilizer at same time or with same machine used to apply seed.

4. Uniformly incorporate into soil for a depth of approximately 1/2 inch.

5. Lightly water to aid the dissipation of fertilizer.

B. Seeding and Mulching

1. Apply seed at a rate of 3 lb/1000 ft^2 evenly in two intersecting directions. Rake in lightly. Do not seed area in excess of that which can be mulched on same day.

2. Refer to Subparagraph 2.01.A.1 for seed mixture based upon the seeding date. Seeding shall not occur from December 1 through February 1. Place temporary mulch material over all areas ready for seeding between December 1 and February 1.

3. Do not sow immediately following rain, when ground is too dry, or during windy periods.

4. Roll seeded area with an approved roller.

5. Immediately following seeding and rolling, apply mulch at a rate of 100 lb/1000 ft^2. Maintain clear of shrubs and trees.

6. Apply water with a fine spray immediately after each area has been mulched. Saturate to 2 in. of soil.

C. Hydroseeding

1. Apply seeded slurry at a rate of 3 lb/1000 ft^2 evenly in two intersecting directions with a hydraulic seeder. Do not hydroseed area in excess of that which can be mulched on same day.

2. Immediately following seeding, apply mulch at a rate of 100 lb/1000 ft^2. Maintain clear of shrubs and trees.

3. Apply water with a fine spray immediately after each area has been mulched. Saturate to 2 in. of soil.

4. Combined hydraulic application of seed fertilizer, mulch, and binder will be considered if site conditions are suitable and application is approved by the Construction Manager (CM). CM is the Owner or Owner's representative that is responsible for managing the construction work and verifying conformance with the specification requirements.

D. Seed Protection

1. Cover seeded slopes where grade is 3 horizontal to 1 vertical or greater or other areas at locations shown on plans with jute mesh.

2. Place and secure jute mesh on previously shaped and seeded channels, slopes, or other areas and locations shown on plans or as required by the CM in accordance with construction requirements of TDOT Sect. 805.05.

E. Maintenance

1. Maintain newly graded and topsoiled and seeded areas until final acceptance. Restore areas showing settlement of wash to specified grades. Newly seeded areas shall be watered as necessary or reseeded at the Contractor's expense until an acceptable stand of grass has been achieved. An acceptable stand of grass is defined as follows:

   a. No bare spots larger than 3 ft^2.

   b. No more than 10% of total area with bare spots larger than 1 ft^2.

   c. No more than 15% of total area with bare spots larger than 6 $in.^2$.

END OF SECTION

SECTION 02938

SODDING

[**Designer Note:** This specification will vary according to the individual state's requirements. The following is an example of the Tennessee Department of Transportation guidelines and shall be modified according to the individual state's department of transportation standards.]

PART 1 GENERAL

1.01 SECTION INCLUDES: Installation of sod and fertilization of subsoil.

1.02 QUALITY ASSURANCE

A. Sod Producer: Manufacturer specializing in sod production and harvesting with minimum 5 years' experience and certified by the state.

B. Sod: Minimum age of 18 months with root development that will support its own weight, without tearing, when suspended vertically by holding upper two corners.

1.03 REFERENCES

A. ASPA: Guideline Specifications to Sodding.

B. TDOT, Bureau of Highways "Standard Specifications for Road and Bridge Construction," March 1, 1995.

1.04 SUBMITTALS

A. Submit sod certification for grass species and manufacturer of sod for information.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Deliver sod on pallets. Protect exposed roots from dehydration.

B. Do not deliver more sod than can be laid within 24 hours.

PART 2 PRODUCTS

2.01 MATERIALS

A. Sod

1. Sod shall conform to requirements of TDOT Specification, Subsection 803.02, Sod.

2. Machine cut sod and load on pallets in accordance with ASPA guidelines.

3. Cleanly cut sod in strips having a reasonably uniform thickness of not less than 2 1/2 inches, reasonably uniform width of not less than 8 inches, and length of not less than 12 inches.

B. Topsoil

1. Topsoil in accordance with Section 02200, Earthwork.

C. Fertilizer

1. Fertilizer shall conform to requirements of TDOT Specification, Subsection 918.15, and shall be Grade 10-10-10 or 1-1-1 formula.

D. Water

1. Clean, fresh, and free of substances or matter that could inhibit vigorous growth of grass.

E. Accessories

1. Wood Pegs: Softwood; sufficient size and length to ensure anchorage of sod on slope.

2. Wire Mesh: Interwoven hexagonal metal wire mesh of 2 inches size.

3. Edging: Galvanized steel.

PART 3 EXECUTION

3.01 PREPARATION

A. Place topsoil in accordance with Section 02200, Earthwork.

B. Fertilizing

1. Apply fertilizer at a rate of 12 lb/1000 ft^2.

2. Apply after smooth raking of topsoil and prior to installation of sod.

3. Apply fertilizer no more than 48 hours before laying sod.

4. Mix thoroughly into upper 2 inches of topsoil.

5. Lightly water to aid dissipation of fertilizer.

3.02 INSTALLATION/APPLICATION/ERECTION

A. Moisten prepared surface immediately prior to laying sod.

B. Lay sod within 24 hours after delivering to site to prevent deterioration.

C. Lay sod tight with no open joints visible, and no overlapping; stagger end joints 12 inches minimum. Do not stretch or overlap sod pieces.

D. Lay smooth. Align with adjoining grass areas. Place top elevation of sod 1/2 inch below adjoining edging, paving, or curbs.

E. On slopes exceeding 2 horizontal to 1 vertical, lay sod perpendicular to slope and secure every row with wooden pegs at maximum 2 feet on center. Drive pegs flush with soil portion of sod.

F. Prior to placing sod, on slopes exceeding 1.5 horizontal to 1 vertical or where indicated, place wire mesh over topsoil. Securely anchor in place with wood pegs sunk firmly into ground.

G. Water sodded areas immediately after installation. Saturate sod to 3 inches of soil.

H. After sod and soil have dried, roll sodded areas to ensure good bond between sod and soil and to remove minor depressions and irregularities.

I. Maintenance

1. Water to prevent grass and soil from drying out.

2. Immediately replace sod to areas that show deterioration or bare spots.

END OF SECTION

DIVISION 3

BOREHOLE GROUT

Number	Title	Pages
03600	THERMAL-ENHANCED BENTONITE GROUT	4

SECTION 03600

THERMAL-ENHANCED BENTONITE GROUT

[**Designer Note:** The requirements for depth, materials, and placement of grout vary greatly with locality and local codes and regulations should always be consulted before specifying grout placement. Local codes may allow sand, drill cuttings, gravel or cement to be placed in the borehole in lieu of conventional grout materials. The required depth of grout placement can vary from full length to only a top cap and in some areas no grouting is required. The designer should be aware of the cost factors impacted by the grout specification. Excessive grout specification can negatively impact project costs with respect to materials and placement. Inadequate grout specifications can negatively impact system performance through reduced thermal conductivity. The following section specifically addresses thermally enhanced bentonite grout. It is provided as a guide for specifying a grout material and placement that generally represents the most stringent or conservative approach to GHP vertical borehole grouting.]

PART 1 GENERAL

1.01 SECTION INCLUDES: Requirements for furnishing, mixing, and placing thermally-enhanced bentonite grout to seal and backfill each vertical u-bend well bore of the closed-loop ground heat exchangers to insure proper thermal contact with the earth and to ensure the environmental integrity of each vertical bore column. No other backfill material shall be accepted.

1.02 REFERENCES

A. National Ground Water Association - geothermal heat pump manual- Guidelines for the Construction of Vertical Boreholes for Closed Loop Heat Pump Systems

B. Local codes

1.03 SUBMITTALS

A. Manufacturer’s published data sheets including thermal conductivity, permeability, percent solids, grout weight, linear shrinkage potential, maximum particle size and unit yield along with verification of the required listing.

1.04 QUALITY ASSURANCE

A. Grouting compound shall be certified and listed by National Sanitation Foundation International to ANSI/NSF Standard 60, “Drinking Water Treatment Chemicals - Health Effects”.

PART 2 PRODUCTS

2.01 MANUFACTURER/PRODUCT

[**Designer Note**: Two grout requirements are provided below for comparison purposes. One is more generic while the other is more proprietary or product specific. The designer can take either approach or a hybrid combination of the two. Other grout products are listed below for information.

Grout Products:
Aquagard
Aquagrout
Black Hills Grout
Enviroplug
Groutwell
Puregold
Quick Grout
Volclay Grout]

A. Grouting: Materials to be utilized by the Contractor shall be a minimum of 20% high sodium solids bentonite grout. The bentonite will be a slurry that will be tremie grouted from the bottom of the boring to the surface in accordance with the IGSHPA installation manual. The contractor will work quickly to assure that there are no air voids forming as a result of the bentonite placing.

B. Grouting material shall be Black Hills Bentonite's Thermal Grout Select as supplied by GeoPro, Inc. or equivalent which is pre-approved by the Owner or Owner's representative.

2.02 THERMAL CONDUCTIVITY

A. The thermal conductivity of the grouting compound must be 0.85 Btu/hr-ft-F or greater.

2.03 PERMEABILITY

A. The grout mixture shall also have a maximum permeability rate of less than 6.9×10^{-8} cm/s as determined by using the "Falling-Head Method" (defined in the United States Army Corps of Engineers' Civil Engineering Manual No. EM 1110-2-1906, "Laboratory Soils Testing" as recommended by the U.S. Environmental Protection Agency to insure proper sealing. Permeability shall be verified by an independent testing laboratory with a copy of the report being supplied upon request from the Owner or Owner's representative.

2.04 TOTAL SOLIDS AND ENHANCEMENT COMPOUND PERCENTAGE

A. The thermally-enhanced bentonite grout used shall have a minimum manufacturers recommended mixture of 63.5% solids. The thermal enhancement compound (high-grade silica compound) shall constitute a minimum of 50% by weight of the aqueous slurry.

2.05 PACKAGING

A. Grouting materials shall be pre-manufactured and packaged prior to delivery to the job site.

PART 3 EXECUTION

3.01 MIXING

A. Thermally-enhanced bentonite grouting material shall be mixed according to manufacturers' written instructions.

B. Contractor shall monitor the grouting operation to ensure grout is properly mixed and the viscosity is adequately maintained for pumping. [**Designer Note**: It may be more desirable to specify a grout flow rate which takes in to account the time required to fill the bore diameter in question and which accounts for differences in tremie pipe diameter and material, i.e. metal vs. plastic.]

C. Grout shall be mixed by a paddle type mixing device or by manufactured portable grouting unit specifically designed for the vertical ground heat exchanger industry. Jet mixing and re-circulation are not allowed for grout.

3.02 INSTALLATION

A. Grout material shall be pressure pumped through a 1 in., 1-1/4 in. or 1-1/2 in. inside diameter tremie pipe and placed in the bore column from the bottom to the top. Grouting process shall conform to the manufacturer's instructions. [**Designer Note:** "Geothermal Heat Pump Grouting Manual - Engineering Design and Field Procedures Manual", as published by the Electric Power Research Institute, 1997 (TR-109169) may also be consulted for additional information.] Completed grouted surface shall be placed at ground level to ensure complete fill of the bore column.

B. Contractor shall maintain a ready supply of spare grout pipes, hoses and fittings on the site.

C. A positive displacement pump shall be used for placing the grout in the borehole. Minimum pump suction and discharge lines shall be 3 inches and 1-1/2 inches respectively.

D. Drilling fluids shall be confined to the site and disposed of in accordance with prevailing local environmental regulations.

3.03 INSPECTION

A. Since some settling may occur after initial placement of the grout material, the Contractor shall monitor each borehole and continue adding grout as required for a period of no less than 30 minutes and no longer than 2 hours.

B. Grouting manufacturer shall provide testing of site mixed grouting material to verify thermal conductivity. Manufacturer shall provide a minimum of 3 sample analyses for each project. [**Designer Note:** Testing requirements are optional and would be contingent upon the availability of an independent testing laboratory capable of performing such tests.]

At a minimum, sampling shall be taken at the beginning of the project, at approximately one-third completion, and at approximately two-thirds completion. In the event that the analysis indicates a thermal conductivity value below the minimum specified value, corrective action shall be taken to increase thermal conductivity value back. [**Designer Note:** Testing requirements are optional and would be contingent upon the availability of an independent testing laboratory capable of performing such tests.]

END OF SECTION

DIVISION 15

MECHANICAL

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15050	PIPING SYSTEMS	10
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15071	UNDERGROUND PROTECTIVE COATING	3
15072	CLEANING	5
15073	PRESSURE/LEAK TESTING	10
15074	IDENTIFICATION AND LABELING	4
15100	VALVES	7
15101	STEAM AND CONDENSATE (0-150 PSIG)	6
15106	CHILLED WATER, COOLING WATER, PROCESS WATER AND HEAT PUMP WATER	5
15110	GEOTHERMAL HEAT PUMP AND LOOP PIPING SYSTEMS (HIGH DENSITY POLYETHYLENE)	7
15112	INSTRUMENT AIR	3
15125	FLUORINATED HYDROCARBON REFRIGERANTS	5
15135	THERMOMETERS AND GAUGES	5
15260	PIPING INSULATION	8
15262	FIBROUS GLASS INSULATION	4
15265	ELASTOMERIC RUBBER INSULATION	4
15270	ALUMINUM JACKETING	2
15292	THERMAL INSULATION FOR DUCTWORK – FIBROUS GLASS PANELS W/AL FACING	3
15293	THERMAL INSULATION FOR DUCTWORK – FIBROUS GLASS BLANKET W/AL FACING	3
15501	HEATING, VENTILATING AND AIR CONDITIONING SYSTEMS - INSTALLATION AND EQUIPMENT	5
15515	EXTERIOR GROUND LOOP HEAT EXCHANGERS	11

DIVISION 15 cont'd

MECHANICAL

Number	Title	Pages
15540	WATER CIRCULATING PUMPS FOR HVAC	6
15545	SUBMERSIBLE WELL PUMPS	3
15550	OPEN LINESHAFT, WATER LUBRICATED TURBINE PUMP	3
15555	OIL LUBRICATED, ENCLOSED LINESHAFT TURBINE PUMP	4
15786	WATER SOURCE HEAT PUMPS	12
15891	DUCTWORK - GALVANIZED STEEL, LOW VELOCITY AND LOW PRESSURE	5
15902	DUCTWORK - INSULATED AND NON-INSULATED FLEXIBLE	3
15950	TESTING, ADJUSTING AND BALANCING	8
15951	CONTROL SYSTEMS	4
15952	COPPER CONTROL TUBING W/ COMPRESSION FITTINGS	4
15954	PLASTIC CONTROL TUBING – PNEUMATIC CONTROLS	6
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15970	PLATE HEAT EXCHANGERS	2
15972	PACKAGE COOLING TOWERS	4
15975	FIELD ERECTED COOLING TOWERS	5
15980	CLOSED CIRCUIT COOLERS	3
15995	MECHANICAL SYSTEM COMMISSIONING	15

SECTION 15050

PIPING SYSTEMS

PART 1 GENERAL

1.01 SECTION INCLUDES: Fabrication and installation requirements for piping systems.

1.02 RELATED SECTIONS

A. Section 02225, Trenching.

B. Section 15052, Brazing.

C. Section 15071, Underground Protective Coating.

1.03 REFERENCES

A. ANSI B1.20.1-83, Pipe Threads, General Purpose (Inch) (R 1992)

B. ASME B31.3-95c, Chemical Plant and Petroleum Refinery Piping.

C. ASTM B32-94, Standard Specification for Solder Metal.

D. ASTM B828-92, Standard Practice for Making Capillary Joints by Soldering of Copper and Copper Alloy Tube Fittings.

E. CDA 404/0R, Copper Tube Handbook, Copper Development Association, Inc.

F. Underwriters Laboratories, Fire Resistance Directory, 2000 Edition.

[**Designer Note:** The design standards listed below may be replaced with site specific design standards as required.]

F. Engineering Standard ES-4.5-2, Pipe Hangers - General Notes.

G. Engineering Standard ES-4.5-3, Pipe Support Spacing.

H. Engineering Standard ES-4.5-5, Copper Tubing - Support Spacing.

1.04 DEFINITIONS

A. Pressure-Relief Valve: pressure-relieving device designed to re-close after normal conditions have been restored to prevent further flow of fluid.

B. Safety Valve: pressure-relief valve actuated by inlet static pressure and characterized by rapid-opening/pop-action.

C. Relief Valve: pressure-relief valve actuated by inlet static pressure and characterized by opening in proportion to increases in inlet static pressure.

D. Safety-Relief Valve: pressure-relief valve characterized by rapid-opening/pop-action or by opening in proportion to increases in inlet static pressure, depending on application.

E. Non-closing Pressure-Relief Device: pressure-relieving device designed to remain open after operation (e.g., rupture discs, fuse plugs, etc.).

1.05 PERFORMANCE REQUIREMENTS

A. Acceptance of piping systems and associated equipment is contingent upon proper execution of specified tests and acceptable test results.

B. Construction Manager will distribute copies of test reports to CM's Engineering Department, Maintenance, and responsible Operations department. Construction Manager will retain original test reports.

C. Acceptance of equipment is contingent upon equipment satisfactorily performing its specified function.

D. Construction Manager will prepare and issue acceptance reports for equipment and systems. Construction Manager will retain original acceptance reports.

1.06 SUBMITTALS FOR APPROVAL

A. Cold bending equipment, procedures, and methods. [**Designer Note:** If cold bending is not applicable to the GHP project under consideration, then delete requirements.]

B. Hot bending equipment, procedures, and methods.

1.07 SUBMITTALS FOR INFORMATION

A. Red-lined copies of design drawings that indicate changes made from routing shown on design drawings.

B. Test Reports for piping systems and associated equipment.

C. Acceptance Reports for equipment and systems (prepared by Construction Manager).

D. Hot Bending Procedure Qualification

1. Bend three consecutive samples.

2. Inspect samples to specification requirements.

3. Examine surface of samples for cracks and tears by liquid penetrant or magnetic particle method.

4. Measure wall thickness directly by sectioning bend or by ultrasonic methods. Bend pipe so that minimum wall thickness is not less than that allowed by code requirements of material before bending.

1.08 DELIVERY, STORAGE, AND HANDLING

A. Deliver piping and valves to site in clean and protected condition.

B. Maintain end seals and flange covers in place. Remove seals and covers only for cleaning, fabrication, erection, or inspection.

C. Exercise care in handling and storage of materials and pre-fabrications to ensure that contamination by foreign material does not occur.

D. Reinstall end seals or covers on partially erected systems to prevent contamination by foreign material.

PART 2 PRODUCT

2.01 FABRICATION

A. Code Requirements

1. Fabricate piping systems specified in Division 15 per Normal Fluid Service requirements of ASME B31.3 except where otherwise specified.

2. Fabricate piping systems specified in Section 15112 per Category D Fluid Service requirements of ASME B31.3.

3. Additional and alternate fabrication requirements are specified in individual system sections of these specifications.

B. Cutting

1. Cut pipe and tubing accurately with pipe or tube cutters.

2. Ream cuts to remove burrs.

3. Remove defects by machining, chipping, or grinding.

C. Cold Bending [**Designer Note:** If cold bending is not applicable to the GHP project under consideration, then delete requirements.]

1. Do not perform cold bending on piping without prior CM approval.

2. Make cold bends only in steel, aluminum, copper, or alloy pipe and tube. Cold bending is not permitted in lined pipe.

3. Re-qualify and approve change in process, equipment manufacturer, equipment model, pipe schedule, wall thickness, material specification type, specification grade, or a decrease in bend radius of cold bending.

4. Fabricate bends free from cracks, buckles, wrinkles, bulges, and grooves.

5. Locate weld seams as near as practical to neutral axis of bend. In compound bends, locate weld seam no closer than 30 degrees to inner or outer radius.

6. Bend pipe and tubing with 1/2-inch actual outside diameter and larger so that ovallity does not exceed 8% after bending. Calculate ovallity as follows:

[**Designer Note:** Insert preferred formula or methods for calculations of ovallity.]

D. Hot Bending

1. Do not perform hot bending on piping without prior CM approval.

2. Re-qualify and approve change in process, equipment manufacturer, equipment model, pipe schedule, wall thickness, material specification type, specification grade, or a decrease in bend radius of cold bending.

3. Fabricate bends free from cracks, buckles, wrinkles, bulges, and grooves.

4. Fill tube or pipe to be bent completely and compactly with dry, sulphur-free, high-temperature silica sand of a suitable grade and fineness. Plug or cap ends of pipe or tube to confine sand. Heat section to be bent uniformly, bend to desired configuration, allow to cool, and remove sand. Reject sections having wrinkles, flats, or humps. Clean pipe after hot bending.

E. Off-Site Fabrication: Perform off-site fabrication in compliance with on-site fabrication requirements. **[Designer Note:** Include this statement in contract documents for off-site fabrication and provide contractor with appropriate documents necessary to ensure compliance.]

2.02 SOURCE QUALITY CONTROL

A. Shop-Fabricated Piping Tolerance: ±1/8-inch maximum on overall dimensions.

PART 3 EXECUTION

3.01 INSTALLATION

A. General

1. Follow piping route shown on drawing. Record changes required to suit field conditions from routing or components shown on drawings.

2. When joining dissimilar materials, provide non-conducting dielectric connections.

3. Provide clearance for installation of insulation and access to valves, flanges, and unions.

4. Provide access where valves, flanges, and unions are not exposed.

5. Install piping to conserve building space and not interfere with use of space.

6. Group piping at common elevations.

7. Install piping to allow for expansion and contraction without stressing pipe, joints, or connected equipment.

8. Work pipe carefully into place. Do not force or spring pipe into place [unless cold springing is required].

9. Provide piping connections to equipment with flanges or unions.

10. Paint piping per site-specific requirements.

11. Install specialties per manufacturer's instructions.

B. Underground Piping

1. Follow route shown on drawings for underground lines. Verify that excavations are to required grade, dry, and not over-excavated.

2. Maintain a 1-foot clearance between pipe surfaces at points where lines being installed cross existing lines.

3. Encase in concrete potable water lines that cross under creeks and/or cross or pass within 10 feet of sanitary, chemical, radioactive liquid-waste lines, or other hazardous services.

4. Trenching: Section 02225.

5. Clean ditch of debris and other foreign matter immediately before pipe is lowered into ditch. Where ditch is in rock, gravel, or like material, pad by filling with a minimum of one foot of sand depth to form a cushion on bottom of ditch before pipe is lowered into ditch.

6. Allow coating to harden before lowering coated pipe into ditch. Lower pipe into ditch without placing strain on pipe. Center pipe in ditch.

7. Use only approved equipment to handle and lay pipe. Do not use chain or wire-rope slings.

8. Coating Application and Inspection: Section 15071.

9. Before back-filling, inspect line to ensure that it lies evenly on bottom of ditch, that no debris is present, and that joints are not covered until tests are completed.

10. Protect coated piping during back-filling by hand placing sand or selected earth free from rock and other injurious materials around pipe to a minimum depth of 12 inches above pipe top surface or by wrapping pipe with 1/4-inch minimum thickness coal tar-saturated fiber wrapping held in place with banding clamps.

11. Install plastic pipe per manufacturer's installation instructions.

12. Underground Piping Cathodic Protection [**Designer Note:** Omit cathodic protection requirements if site soil conditions indicate that it is not required.]

    a. Locate and install anodes, rectifiers, and connections to pipe as shown on drawings.

    b. Number, type, and depth to which anodes are to be installed on drawings.

C. Pipe Sleeves

1. Provide pipe sleeves that allow 1/4-inch annular clearance around pipe or insulation for piping passing through floors, walls, and ceilings.

2. Provide pipe sleeves that allow 1/2-inch annular clearance around pipe or insulation for underground piping passing through walls.

3. Install pipe sleeves flush with walls and ceilings.

4. Provide pipe sleeves extending 3 inches above floor surface [except where specified otherwise].

5. Pipe sleeves penetrating fire-zone floors and walls shall be rated for the appropriate fire barrier requirement. Install per manufacturer instructions.

D. Valves

1. Pack and make leak-proof valves for test pressure specified.

2. Disassemble, prior to heating, valves which are to be soldered, brazed, or welded. Allow valves to cool, clean if necessary, and reassemble. [**Designer Note:** Some solder joint valves are manufactured to be brazed without disassembly.]

3. Deliver safety valves, relief valves, safety-relief valves, pressure-control valves, pressure-reducing valves, and back flow prevention devices to CM for testing and/or pressure setting prior to installation.

4. Install globe valves with pressure under seat.

5. Blank off valved connections provided for future expansion as follows:

   a. Flanged Valve: Provide blind flange.

   b. Threaded or Socket-Weld Valve: Provide 4-inch nipple and threaded pipe cap.

   c. Solder-Type Valve: Provide copper-to-MPT adapter and threaded brass pipe cap.

6. Install valves with stems in upright or horizontal position.

7. Provide manual shutoff valves to isolate equipment, parts of systems, or vertical risers.

8. Provide manual control valves for throttling, bypass, or manual flow control.

9. Provide check valves on discharge of pumps.

10. In copper tube systems, provide brass male adapters on both sides of valves.

11. Provide shutoff valves with unions downstream at equipment and fixture connections.

12. Provide shutoff valves for branch headers as close as practical to main header. [**Designer Note**: Consider isolation of new piping for purposes of pressure/leak testing in design of modifications to existing systems.]

E. Hangers and Anchors

1. Locate and design pipe hangers as shown on drawings. In some cases for pipe 2-inch and smaller, hangers may not be shown and may be field installed. Provide suitable hangers selected from, or patterned after, those shown in Engineering Standard ES-4.5-2. [**Designer Note**: Attach Engineering Standard ES-4.5-2.]

2. Provide adjustable clevis hangers [except where specified otherwise].

3. Space hangers to hold piping or tubing in position without swaying, vibrating, or sagging. Do not exceed maximum spans given in Engineering Standard ES-4.5-3 and Engineering Standard ES-4.5-5. [**Designer Note:** Attach Engineering Standards ES-4.5-3 (for steel pipe) and/or Engineering Standard ES-4.5-5 (for copper tubing).]

4. Support horizontal runs of cast iron and high-silicone cast iron, hub-and-plain-end drain piping at maximum intervals of 5 feet or at each hub if hub intervals do not exceed 5 feet.

5. Use typical method of fastening hanger rods to building structure as shown on Engineering Standard ES-4.5-2. [**Designer Note**: Attach Engineering Standard ES-4.5-2.]

3.02 JOINING METHODS

A. Threaded Joints

1. Threads: ANSI B1.20.1.

2. Thread pipe after bending, forging, or heat-treating operations. Where threading must be performed first, protect threads during such operations.

3. When threading chemically cleaned pipe, use nontoxic cutting fluid containing no rust retardants or oils. After threading chemically cleaned pipe, immerse threaded end in solvent for minimum 1 minute.

4. Apply pipe joint compound to male threads only.

5. Do not apply thread tape to first two threads of pipe.

B. Flanged Joints

1. Provide flat-face flanges and full-face gaskets where steel flanges mate with cast-iron flanged fittings, valves, or equipment.

2. Provide full-face gaskets between cast-iron flanges.

3. Provide flat ring-type gaskets between steel flanges equipped with raised serrated faces [except where specified otherwise].

4. Prior to bolt-up, align flange faces to the design plane within 1/16-inch per foot (0.5%) measured across any diameter. Align flange bolt holes to within 1/8-inch maximum offset. Assemble mating flanges flush and true.

5. Center gaskets evenly between flange faces with ring gaskets engaging fully upon raised-face flanges.

6. Provide bolts that extend through nuts by minimum one full thread when made up. Provide bolts of uniform length on a single flange.

7. Coat bolt threads with high-temperature thread joint compound prior to installation.

8. Tighten bolts uniformly to draw flanges evenly and firmly upon gasket. Use standard industrial practice for bolt tightening. [**Designer Note:** For systems where flange sealing is critical, specify necessary bolt torque required to effect a seal based on gasket manufacturer's gasket stress requirements. Ensure that stresses on bolts do not exceed those design stress values specified in ASME B31.3, Paragraph 302.3.2 and Table A-2.]

C. Plastic Pipe Joints (not excluded by ASME B31.3, Paragraph 300.1.3) [**Designer Note:** Plastic pipe joints are included in Section 15110.]

1. Bonding: ASME B31.3, Paragraph A328.

2. Bonding Procedure Qualifications: ASME B31.3.

3. Bonder Performance Qualifications: ASME B31.3.

4. Inspector: ASME B31.3, Paragraphs A328.2.2 and A328.2.3.

5. Refer to Section 15110 for HDPE pipe thermal fusion joining methods.

D. Welded Joints [**Designer Note:** Welded joints are included in Sections 15101, 15106.]

1. Perform welding activities per site-specific requirements.

E. Brazed Joints [**Designer Note:** Brazed joints are included in Section 15125.]

1. Perform brazing activities per Section 15052.

F. Compression Joints [**Designer Note:** Compression joints are included in Section 15112.]

1. Clean internal surface of fitting and external surface of piping to be free of foreign materials.

2. When using cut pipe, remove sharp edges by preening or lightly filing edge.

3. Slide compression nut onto pipe so that broad shoulder of compression nut faces away from end of pipe.

4. Slip ferrules onto pipe.

5. Press threaded body of compression fitting onto end of pipe.

6. Screw compression nut onto fitting body.

7. Tighten with one wrench on compression nut and one wrench on fitting body per manufacturer's instructions.

8. Do not overstress in order to effect a seal.

G. Flared Joints [**Designer Note:** Flared joints are included in Section 15125.]

1. Clean internal surface of fitting and external surface of piping to be free of foreign materials.

2. When using cut pipe, remove sharp edges by preening or lightly filing edge.

3. Slide flare nut onto pipe so that tapered end of flared nut faces away from end of pipe.

4. Clamp end of pipe into manufacturer's recommended flaring tool and screw ram into end of pipe. Remove flaring tool from pipe.

5. Press tapered end of fitting body into flared end of pipe.

6. Screw flared nut onto fitting body.

7. Tighten with one wrench on flared nut and one wrench on fitting body per manufacturer's instructions.

8. Do not overstress in order to effect a seal.

END OF SECTION

SECTION 15052

BRAZING

PART 1 GENERAL

1.01 SECTION INCLUDES: requirements for brazing as a method for joining pipe and tubing. [**Designer Note:** Specified in Section 15125.]

1.02 REFERENCES

A. ASME B31.3-96, Process Piping.

B. ASME B31.5-92, Refrigeration Piping.

C. ASME Boiler and Pressure Vessel Code, Section IX-95, Qualification Standard for Welding and Brazing Procedures, Welders, Brazers, and Welding and Brazing Operators.

D. AWS A5.8-92, Specification for Brazing Filler Metal.

1.03 SUBMITTALS FOR APPROVAL

A. Brazing Procedure Specifications and PQRs prior to brazing.

B. Brazer Qualification Records prior to brazing.

PART 2 PRODUCTS

2.01 MATERIALS

A. Filler Material: Table 1 lists filler material for brazing applications.

Table 1

Section	Service	Filler Material
15125	Fluorinated Hydrocarbon Refrigerant	BCuP per AWS A5.8

PART 3 EXECUTION

3.01 QUALIFICATIONS

A. Qualify brazing procedures and operators per ASME Boiler and Pressure Vessel Code, Sect. IX.

3.02 APPLICATION

A. Perform brazing within limits of qualified and approved procedure.

B. Assemble brazed joints in a sequence that allows visual examination of maximum number of joints on both sides of joint after brazing.

C. After brazing, remove flux and flux residue from accessible surfaces.

D. Visually inspect accessible surfaces of brazed joints to ensure that brazing metal has penetrated entire length of joint.

3.03 REPAIR/RESTORATION

A. Repair and reinspect rejected joints.

3.04 FIELD QUALITY CONTROL

A. Inspection

1. Joints are subject to inspection by CM representative.

2. CM representative reserves right to reject joints which are (or are believed to be) in violation of these specifications.

B. Identification

1. Assign operators unique identification symbols.

2. Use operator identification symbols to identify work by operator.

C. Records

1. Maintain records of operator and procedure qualifications.

2. Make records available to CM representative upon request.

END OF SECTION

SECTION 15071

UNDERGROUND PROTECTIVE COATING

PART 1 GENERAL

1.01 SECTION INCLUDES: protective coating for exterior surfaces of underground steel piping and accessories.

1.02 REFERENCES

A. ASTM D227-89, Standard Specification for Coal-Tar-Saturated Organic Felt Used in Roofing and Waterproofing.

B. ASTM D450-91, Standard Specification for Coal-Tar-Pitch Used in Roofing, Dampproofing, and Waterproofing.

C. AWWA C203-91, Coal-Tar Protective Coatings and Linings for Steel Water Pipelines - Enamel and Tape - Hot Applied.

1.03 DELIVERY, STORAGE, AND HANDLING

A. Handle and store coated pipe to avoid damage to coating.

B. Use slings of reinforced rubber belting to handle pipe.

C. Do not use wire rope or chain slings.

D. Store pipe on padded supports or skids.

PART 2 PRODUCTS

2.01 MATERIALS

A. Metal Conditioner: Phospholene 7, Western Reserve Laboratories.

B. Tape: Tapecoat 20, Tapecoat Company, Inc.

C. Primer: TC Primecoat, Tapecoat Company, Inc.

D. Enamel: Koppers Company, Bitumastic Hi-Melt Enamel.

E. Mastic: Coal-tar, waterproofing, bitumen, ASTM D450, Type III, Koppers Company, Inc., Bitumastic 50.

F. Fiber Felt: Koppers Company, Inc., 15-lb, coal tar-saturated, organic fiber felt, ASTM D227.

2.02 EQUIPMENT

A. Holiday Detector: Portable, low amperage, adjustable voltage, pulse-type; Model E-P, Tinker & Rasor Co. (San Gabriel, CA), or Model 14/20, D.E. Stearns Company (Shreveport, LA).

PART 3 EXECUTION

3.01 APPLICATION

A. Yard or Shop Coating

1. Clean, prime, and coat exterior of pipe and fittings per AWWA C203 including Appendix A, Sect. A 1.5.

2. Apply pipeline enamel per manufacturer's recommendation.

3. Do not apply enamel to end of pipe and fittings for 9 in. to allow for welding.

B. Field Coating

1. Field coat pipe 12 in. and smaller if use of portable dope kettle is not justified.

2. Remove rust, slag, weld splatter, charred felt, enamel, and dirt by wire brushing. Using Manganese to remove oil. Ensure surfaces are clean and dry.

3. Warm surface with torch to remove moisture. (Use paint-burning type of torch with wide-mouth burner used in conjunction with bottled gas.) Apply primer to pipe surfaces at rate of 400 ft^2/gal. Allow to dry to tacky consistency.

4. Heat Tapecoat lightly with torch to obtain softening or bleeding of the pitch. Apply Tapecoat spirally with minimal lap of 1/2 in. Heat only amount of Tapecoat that will remain in liquified during application. Overlap adjacent coatings a minimum of 3 in. with Tapecoat.

C. Larger Pipe

1. For pipe and fittings 12 in. and larger and where sections of pipe with high numbers of weld joints, coat pipe weld areas and fittings to same specifications as yard coated pipe.

2. Remove kraft paper and outer felt wrapper to expose yard-coated enamel for 3 in.

3. Overlap yard coating with field joint coating by 3 in. to provide continuous coating system.

D. Valves, Fittings, Flanges, and Bolts

1. Field coat valves, fittings, flanges, tie rods, nuts, and bolts with thick coat of mastic.

2. Overlap adjacent coating with mastic by a minimum of 3 in.

3. Apply spiral wrap of fiber felt over mastic to protect coating from backfill.

3.02 REPAIR

A. Remove coating at holiday to bare pipe using draw knife.

B. Recoat holiday area to comply with original coating system.

C. Recheck for holidays.

3.03 FIELD QUALITY CONTROL

A. Use holiday detector to test coating. Set detector operating voltage within range of 6,000 to 14,000 V.

B. Test yard-coated pipe with holiday detector. Ensure that yard-coated pipe is free of holidays before shipment.

C. Inspect coatings (except on valves and flanges) for holidays just prior to lowering pipe in ditch.

END OF SECTION

SECTION 15072

CLEANING

PART 1 GENERAL

1.01 SECTION INCLUDES: Cleaning requirements for piping systems. [**Designer Note**: For piping systems of high density polyethylene, clean pipe in accordance with manufacturer's recommendation. See section 15125 for cleaning information specific to refrigeration system piping and section 15112 for information specific to instrument air piping systems.]

1.02 SEQUENCING

A. Perform Type I and Type II cleaning after completion of testing.

B. Perform Type III and Type IV cleaning before installation.

1.03 SUBMITTALS FOR APPROVAL

A. Written evidence of experience of commercial cleaning contractor.

[**Designer Note:** Include the above requirement when Type III and/or Type IV n cleaning are to be performed.]

B. Disposal Plans for Flushing Media.

[**Designer Note:** Include the above requirement when Type II cleaning is to be performed.]

1.04 QUALITY ASSURANCE

A. Obtain the services of a recognized commercial cleaning contractor for performance of Type III and Type IV pre-erection cleaning.

B. For piping systems requiring Type III pre-erection cleaning, pipe may be purchased in chemically cleaned condition provided requirements of Type III cleaning are satisfied.

[**Designer Note:** Include the above requirement when Type III and/or Type IV pre-erection cleaning is to be performed.]

PART 2 PRODUCTS

2.01 MATERIALS

A. Dry Oil-Free Compressed Air (DCA): compressed air, oil free, -40°F to -75°F dew point at atmospheric pressure.

B. Solvent: Solvent 140, Ashland Oil Co. or equivalent as approved by the CM.

PART 3 EXECUTION

3.01 EXAMINATION

A. Ensure pipe and components are free from physical defects.

3.02 PREPARATION

A. Remove loose scale, rust, dirt, and other foreign materials by wire brushing, scrubbing, flushing, or purging.

B. Remove dirt, rust, grease, oil, or other contaminants from exterior surface.

3.03 APPLICATION

A. Type I and Type II Cleaning

1. Isolate equipment, pumps, compressors, and other equipment that could be harmed by purging or flushing action. Block control valves in open position. Remove orifice plates, traps, strainers, instruments, or other equipment that could be adversely affected by flow or accumulation of particles cleaned by purge/flush procedure.

2. Introduce purging/flushing media at remote end of piping system. Where possible, flow from upstream side of globe or check valves. If not possible, remove globe or check valves and replace with spool pieces.

3. Open each branch or drop extremity of piping system to purge/flush entire system for specified minimum time period.

4. (For Type I Cleaning): Flow dry oil-free compressed air through piping systems at a minimum inlet pressure of 50 psig for a sufficient time to reach a -40°F dew point at outlet points. Hold for a minimum of 10 min. [**Designer Note:** Nitrogen may be substituted for dry oil-free compressed air as the purging medium. When nitrogen is used, maintain a 0°F dew point at outlet points for a minimum of 10 min.]

5. (For Type II Cleaning): Flow potable water through piping systems at minimum velocity of 2.5 ft/s for minimum of 5 min through each outlet point. Notify CM minimum 72 h before flushing operation. [**Designer Note:** A slower minimum flow velocity may be used for piping systems with a nominal diameter of 4 in. or greater.]

6. Reconnect isolated, removed, or bypassed items after completion of purge/flush.

B. Type III Cleaning [**Designer Note:** Use this procedure only when there is significant doubt about the origin of the pipe. Reputable pipe vendors perform sufficient cleaning operations at the manufacturing facility.]

1. Immerse pipe and fittings in a hot acid bath. Rinse pipe and fittings. Immerse pipe and fittings in a hot caustic bath followed by three rinse cycles. Use a final rinse with a chlorine content of less than 10 PPM.

2. Use cleaning chemicals that are compatible with materials being cleaned.

3. Apply an internal coating of nontoxic rust retardant after cleaning.

4. If ASTM markings are removed during cleaning, remark pipe and fittings to duplicate original ASTM markings. Ensure that material used to mark piping does not damage piping.

5. Cap pipe and fittings for shipment.

6. Maintain caps in place until removed for inspection, fabrication, or erection. If pipe lengths are cut, cap both ends.

7. CM will inspect shipments of chemically cleaned piping.

8. Field clean shipments of piping determined by CM to be contaminated.

9. Immerse threaded end of pipe threaded after commercial cleaning in solvent for a minimum of 1 min.

10. Re-clean accidentally contaminated pipe and fittings by purging with dry oil-free compressed air and field cleaning.

C. Type IV Cleaning [**Designer Note:** Use this procedure only when there is significant doubt about the origin of the pipe. Reputable pipe vendors perform sufficient cleaning operations at the manufacturing facility.]

1. Immerse pipe and fittings in a hot acid bath. Rinse pipe and fittings. Immerse pipe and fittings in a hot caustic bath followed by three rinse cycles. Use a final rinse with a chlorine content of less than 10 PPM.

2. Use cleaning chemicals that are compatible with materials being cleaned.

3. Do not apply rust retardant or oils after cleaning.

4. If ASTM markings are removed during cleaning, remark pipe and fittings to duplicate original ASTM markings. Ensure that material used to mark piping does not damage piping.

5. Cap pipe and fittings for shipment.

6. Maintain caps in place until removed for inspection, fabrication, or erection. If pipe lengths are cut, cap both ends.

7. CM will inspect shipments of chemically cleaned piping.

8. Field clean shipments of piping determined by CM to be contaminated.

9. Immerse threaded end of pipe threaded after commercial cleaning in solvent for a minimum of 1 min.

10. Re-clean accidentally contaminated pipe and fittings by purging with dry oil-free compressed air and field cleaning.

D. Alternative: In lieu of cleaning per this section, an in-situ cleaning procedure may be used if specifically allowed and described in project specifications. [**Designer Note:** Attach job specific in-situ cleaning requirements if specified and described in the project specifications.]

E. Field Cleaning: May be used in place of Type III or Type IV cleaning only when procurement of commercially cleaned piping is not practical and when approved by Facility Mechanical Systems Engineer.

1. Perform field cleaning outdoors or in a highly ventilated area. [**Designer Note:** Coordinate precautions for field cleaning with Fire Department and Industrial Hygiene Department.]

2. Manually remove loose scale and/or rust from pipe identification with a steel identification brush. Visually inspect pipe. If scale is visible, repeat Step 2.

3. Saturate a clean cloth with solvent. Pull cloth through pipe or fitting. (Fittings may be immersed in solvent, or pipe may be filled with solvent as an alternative.) Inspect cloth and piping. If grease, oil, scale, or other contaminants are visible, repeat Step 3.

4. Saturate a clean cloth with isopropyl alcohol. Pull cloth through pipe or fitting. Inspect cloth and piping. If grease, oil, scale, or other contaminants are visible, repeat Steps 3 and 4.

5. Pull a clean, dry cloth through pipe or fitting. Inspect cloth and piping. If grease, oil, scale, or other contaminants are visible, repeat Steps 3, 4, and 5.

6. Cap or plug pipe or fittings.

F. Disposal: Dispose of cleaning media per requirements of applicable state and federal regulations. [**Designer Note:** Include additional disposal requirements such as those listed in the Project Waste Management Plan.]

3.04 FIELD QUALITY CONTROL

A. CM will inspect shipments of chemically cleaned piping as follows:

1. Randomly select one piece of each 50 pieces received.

2. Visually inspect selected pieces.

3. Wipe piece with clean, white, solvent-dampened cloth.

4. Visually inspect piece and cloth for contamination. Bloom (flash) rust formed after cleaning is not considered a contaminant.

5. Accept shipments where no pieces are found contaminated. Rejected shipments will be re-cleaned.

Table 1

Section	Pre-erection	Post-erection	Remarks
15101		II	
15106		II	Cooling Water
15106	IV	I	Plant Air
		II	Water, Drain, and Vents
15110		II	Ground Loop
15112		I	
15125	III	I	

END OF SECTION

SECTION 15073

PRESSURE/LEAK TESTING

PART 1 GENERAL

1.01 SECTION INCLUDES: Pressure/leak testing of piping systems.

1.02 REFERENCES

A. ANSI B31.3-93, Chemical Plant and Petroleum Refinery Piping.

B. Standard Plumbing Code, Southern Building Code Congress International Incorporated (1994).

1.03 DEFINITIONS

A. Dry Oil-free Compressed Air (DCA): compressed air, oil free, with -40° to -75°F dew point at atmospheric pressure.

1.04 SUBMITTALS FOR APPROVAL

A. Test records for each piping system prepared during pressure/leak testing, indicating date of test, identification of piping system tested, test media, test pressure, and certification of results.

1.05 QUALITY ASSURANCE

A. Prepare test records for each system during pressure/leak testing, including date of test, identification of piping system tested, test media, test pressure, and certification of results. Individual test records need not be retained if certification that piping has satisfactorily passed pressure/leak testing is retained.

1.06 SEQUENCING

A. Perform testing after completion of installation.

[**Designer Note**: For HDPE pipe, the pressure test is done with the pipe on the spool before installation (if the pipe has not been shipped under air pressure), after placement of the U-bend in the ground, and after the header connections have been completed.]

B. Perform hydrostatic testing of potable water systems before cleaning and disinfection.

PART 2 PRODUCTS

2.01 TEST EQUIPMENT

A. Calibration Date: maximum 12 months prior to test.

B. Use test equipment with label indicating serial number, calibration date, name of firm or laboratory performing calibration.

C. CM representative will examine test equipment prior to test. CM representative may require that test equipment be submitted to CM for calibration check. Test equipment failing calibration check must be submitted to an approved testing laboratory for proper calibration prior to use.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine system installation for compliance with drawings and specifications.

B. Ensure pressure-relief valves have been inspected and set at required pressure by CM.

C. Ensure that rupture discs have been properly installed.

D. Examine system for leaks at valves, flanges, welds, connections, and joints.

E. Examine piping system for defective, broken, or cracked piping and fittings.

3.02 PREPARATION

A. Isolate or replace with spool pieces vessels, pumps, instruments, controls, safety valves, relief valves, and other equipment items rated for pressures below test pressure.

B. Provide temporary over pressurization protection devices between pressure source and test equipment.

1. For Class A - Pneumatic Test, set temporary over pressurization protection devices at test pressure plus lesser of 50 psi or 10% of test pressure.

2. For Class B - Hydrostatic Test, set temporary over pressurization protection devices at 130% of test pressure.

C. Disconnect or isolate by blinds or other means equipment that is not to be tested. Valves may be used provided valves are rated for test pressures.

D. Maintain joints, including welds and bonds, uninsulated and exposed for examination during testing. Joints previously tested may be insulated or covered.

E. Provide additional temporary supports as necessary to support test media [when weight of test media exceeds weight of design system fluid].

F. Clear test area of personnel not involved with pneumatic testing.

3.03 REPAIR/RESTORATION

A. Repair leaks and retest repaired joints until test requirements have been satisfied.

3.04 CLASS A - PNEUMATIC TEST

A. Test Pressure

1. For piping 6 in. and smaller, use test pressure that is 110% of design pressure or 50 psig, whichever is greater.

2. For piping 8 in. and larger with design pressures of 45 psig and less, use test pressure that is 110% of design pressure but in no case greater than 50 psig.

3. For piping 8 in. and larger with design pressures greater than 45 psig, hydrostatically test piping per Class B test procedures.

B. Preliminary Leak Test Procedure

[**Designer Note:** ANSI B31.3, para. 345.1(b) allows for the substitution of a combined hydrostatic-pneumatic test when the hazard of energy stored in compressed gas makes a pneumatic test impracticable. The Hydrostatic-Pneumatic Leak Test is described in ANSI B31.3, para. 345.6.]

1. Gradually pressurize piping system to 25 psig.

2. Maintain 25-psig pressure for a minimum of 10 min.

3. Visually examine valves, flanges, welds, joints, and connections for major leaks.

C. Final Leak Test Procedure (test pressures of 50 psig and less)

1. Gradually pressurize piping system to test pressure.

2. Maintain test pressure for a minimum of 10 min.

3. Soap test welds, joints, and connections while system is at test pressure.

4. Depressurize system.

D. Final Leak Test Procedure (test pressures exceeding 50 psig)

1. Gradually pressurize system to 50% of test pressure.

2. Increase pressure in steps of 10% of test pressure until test pressure is reached.

3. Maintain test pressure for a minimum of 30 min. [**Designer Note:** Direct sunlight and temperature will cause pressure to fluctuate during a pressure test. There can be some stretch in certain piping materials which will allow the pressure to drop. For these materials, it is best to pressure up to the desired test pressure, allow a 30 minute period for equalization to occur, bleed the pressure down, and pressure up again to the test pressure to start the 30 min test time.]

4. Reduce pressure to design pressure.

5. Soap test welds, joints, and connections while system is at design pressure.

6. Depressurize system.

E. Reconnect instruments and equipment and retest connections at maximum operating pressure.

F. Acceptance Criteria: No continuous bubble formation is allowed.

[**Designer Note:** CM normally supplies dedicated and controlled equipment for testing potable water systems.]

3.05 CLASS B - HYDROSTATIC TEST

[**Designer Note**: Water is the preferred test medium for polyethylene pipe. After all air is removed from the test section, raise the pressure at a steady rate to the required pressure. The pipe should be covered at intervals, particularly at curves to hold it in place during pressure tests. Test pressure should not exceed 1.5 times the rated operating pressure of the pipe. The pipe should be raised to the test pressure and allowed to stand for a sufficient time to allow expansion of the pipe (2-3 hours). After equilibrium is established, the test section is pressurized to 1.5 times the operating pressure, and the final test held for the specified time (1, 2, or 3 hours). Polyethylene holds pressure by developing stress in its walls. This process continues though out the test period, and the pipe increases slightly in diameter. Pressure drop will occur due to continued expansion of the pipe. A drop in pressure is common and does not prove with certainty that a leak or failure is present. Polyethylene pipe is tested by measuring the “make up” water required to return the section to test pressure. Allowable amounts of make up water for expansion during the pressure test are shown in Table 16 from Plastic Pipe Institute (PPI) Technical Report 31. Also see the special test in 3.11 below.]

A. Special Requirements for Water Systems

1. Test systems conveying potable water with dedicated and controlled test equipment that is used only on systems conveying potable water.

2. Equipment includes pumps, pressure gages, hoses, pipes, caps, and other test equipment that contacts potable water.

B. Test Pressure: 150% of design pressure or 100 psig, whichever is greater.

[**Designer Note:** For systems with design temperatures greater than test temperatures, refer to ANSI B31.3, para. 345.4.2(b) for test pressure correction.]

C. Test Procedure

[**Designer Note:** ANSI B31.3, para. 345.2.1(c) allows for a preliminary pneumatic test using air at a maximum pressure of 25 psig prior to hydrostatic testing to locate major leaks.]

1. Pressurize system to test pressure.

2. Maintain test pressure for minimum 30 min. [**Designer Note:** Direct sunlight and temperature will cause pressure to fluctuate during a pressure test. There can be some stretch in certain piping materials which will allow the pressure to drop. For these materials, it is best to pressure up to the desired test pressure, allow a 30 minute period for equalization to occur, bleed the pressure down, and pressure up again to the test pressure to start the 30 min test time.]

3. Examine valves, flanges, welds, joints, and connections for leaks.

4. Drain test media from system.

5. Reconnect instruments and equipment.

6. Refill system with test media, pressurize to maximum operating pressure, and examine valves, flanges, welds, joints, and connections for leaks.

D. Acceptance Criteria: No leakage is permitted at welds, brazed joints, soldered joints, compression fittings, or threaded joints. No leakage is acceptable at valves and gaskets unless specified otherwise.

E. Test Media: Table 1 lists test media for Class B tests.

Table 1

Section	Service	Test Media
15101	Steam and Condensate 0-150 psig	Potable Water
15106	Chilled Water, Cooling Water, Process Water and Heat Pump Water	Potable Water

3.06 CLASS C - WATER TEST (DRAIN)

A. Building Drain and Vent Systems

1. Test per Standard Plumbing Code.

2. Perform either smoke or peppermint final test.

B. Building Sewer: Test per Standard Plumbing Code.

C. Test Media: Table 2 lists test media for Class C tests.

Table 2

Section	Service	Test Medium
x	Drains (as applicable)	Potable Water

3.07 CLASS D - VACUUM TEST

A. Class D tests will be performed by CM.

3.08 CLASS E - SPECIAL TESTS

A. Class E tests are special tests required by codes or as described in specifications or on drawings.

B. See section for test pressure, test media, and test procedure.

C. Systems Governed: Table 3 lists services subject to special tests.

Table 3

Section	Service
15125	Fluorinated Hydrocarbon Refrigerant

3.09 DEMONSTRATION

A. Perform tests in presence of CM representative.

B. Provide CM with the option of witnessing tests.

3.10 TEST PRESSURE TOLERANCE

A. Use test pressure tolerance of +5 psig and -0 psig.

[**Designer Note:** The following special test procedure can be applied to High Density Polyethylene Pipe (HDPE). It may be applied to the construction specifications or deleted and refer to manufacturer's test requirements.]

3.11 **HIGH DENSITY POLYETHYLENE PIPING TESTING**

A. Preliminary Work: Thoroughly clean pipe and tubing prior to installation. During installation, prevent foreign matter from entering systems. Prevent if possible or remove obstructions from piping and systems.

B. Flushing, Purging, Pressure and Flow Testing:

1. All fusion joints and loops lengths shall be checked to verify that no leaks have occurred in shipping or in fusion joining.

2. All loops will be pressure tested before installation, and all horizontal components of the ground heat exchanger will be pressure tested prior to back-filling.

3. Heat exchangers will be tested in accordance with the HDPE Quick Test II. Do not test until every joint has set and cooled at least 8 hours. Record trench temperature at start and finish of pressure test. Use test gage with one psi increment and readable to ½ psi.

4. Cleaning: Flush systems and apparatus, upon completion of pressure and miscellaneous tests. Completely open valves and flush each system with clean water, prior to chemical cleaning. Repeatedly flush at short intervals until twice the system water capacity has been flush through. Chemically clean systems immediately following flushing operations. Circulate a solution consisting of trisodium phosphate, in a proportion of one pound of chemical to every 50 gallons of water in the system. Completely fill system with cleaning solution; vent system and place in operation, with automatic controls operating and valves fully open. Allow system to reach design operating temperature. Circulate the solution through the system for a minimum of 4 consecutive hours. Keep strainers unplugged during cleaning operations. Remove and clean strainer screens prior to operational test. Refill system with clean water.

5. Flow rates and pressure drops will be compared to calculated values to assure that there is not blockage or kinking of any pipe.

6. A minimum velocity of 2 ft./sec in each piping section must be maintained for a minimum of 15 minutes to remove all air. A change of more than one inch in the level of fluid in the purge pump tank during pressurization indicates air still trapped in the system.

C. HDPE Quick Test II.

HDPE Quick test II

[**Designer Note:** This test method is a relatively quick test whereby the recoverable diametrical strain in the HDPE pipe is sustained by maintaining a constant test pressure for 45 minutes duration. The control valve is opened and the pressure decreased to a nominal psi value before re-closing the valve. The subsequent “recovery” of pressure in the pipeline indicates a sound pipeline. Slow loss of pressure at the reduced value is indicative of a possible leak. This simple “PASS/FAIL” test is very appropriate for short lengths of small diameter pipeline where there is NO residual air in the test section. The test pressure should nominally be 1.5 times the pipe’s 50 years Water Rated Working Pressure (i.e. 1.5 x WRWP) adjusted for the ambient temperature of the test section per Table 1.]

Table 1. Target Test Pressure

Temperature (°F)	**SDR - II Pipe Pressure Rating (psi)**	**1.5 X Design (psi)**	**20 ft. Down to Static Water Level**	**40 ft. Down to Static Water Level**	**50 ft Down to Static Water Level**	**100 ft Down to Static Water Level**
73.4	160	240	230	221	216	192
80	150	225	216	207	203	180
90	140	210	207	193	189	168
100	125	188	180	173	169	150

Step 1: The pipe line pressure is uniformly raised to the target test-pressure value obtained from Table 1 in a time frame of 5-10 minutes (as previously discussed). This hydrostatic pressure is maintained by intermittently pumping water into the test section. The target test pressure is then held for 45 minutes. During this time the pipeline and valves and components should be examined for obvious leaks.

Step 2: At time “zero”, the pipeline pressure is then lowered by rapidly bleeding water from the system to a nominal pressure of approximately 30 psi to 40 psi at the test gauge. Quickly close the control/bleed valve to again isolate the test section.

Step 3: Manually record and plot the pressure gauge reading at the following time intervals (or use a continuous pressure vs. time plotter/recorder):

No. of Readings	**Time Interval**	**Elapsed Time Sequence**
5 Readings	@ 2 minutes each	0-10 minutes
5 Readings	@ 4 minutes each	11-30 minutes
6 Readings	@ 10 minutes each	31-90 minutes

The pressure should rise from time “zero” due to the visco-elastic strain recovery of the HDPE and the absence of leaks.

Step 4: Compare the resulting graph, plot, or chart to the characteristic time-pressure profile shown below. The test result should be similar to this indicating a “pass” or “fail” pressure test. If a failure occurs, the problem should be rectified or corrected. Then, repeat the HDPE Quick Test II after a 24-hour recuperation period following the last pressure test. Repeat this test until at “passing” pressure test is achieved.

[**Designer Note:** The degree to which the diametral strain recovery in the material affects the pressure/time graph will be affected by:

- The length of test section
- The diameter of the test pipe
- The presence of entrapped air
- The ambient temperature
- The efficiency of the compacted embedment envelope

With a 1 ½ hour period, a good indication of pipeline integrity will be demonstrated by this test method. The total test time is (10 min. fill + 45 min. stretch + 90 min data) 145 minutes or about 2 ½ hours total. Upon proper completion of the test, the pressure should be reduced to zero or drained depending upon the pipeline usage, application, design, or project engineer’s discretion. All data should be logged on a worksheet that is similar to the sample shown in Figure 2.]

D. Balancing: Balance pipe loop flow to quantities indicated on drawings.

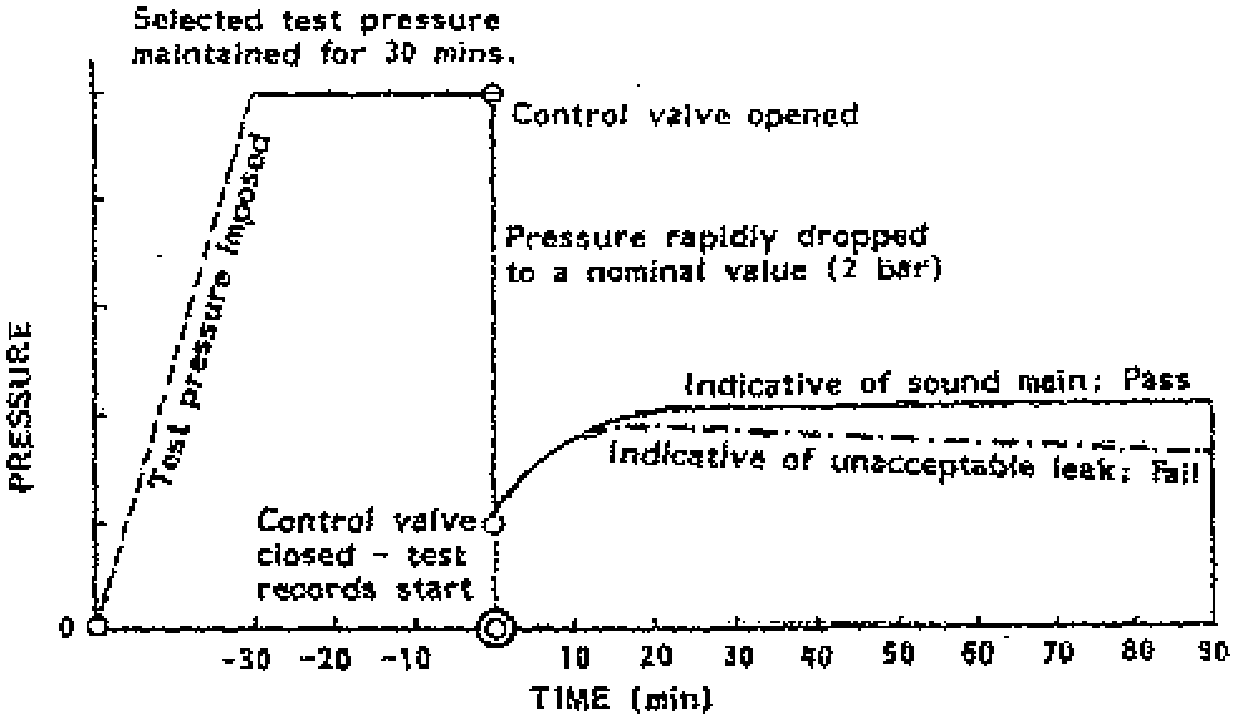


Figure 1. Typical HDPE Test Pressure vs. Time Plot

Job Title													
Contractor/Driller/Loop Installer										Test Performer: Initials:		Date	
Date:	HDPE Design Pressure Rating: _________psig x 1.5 – Hydrostatic Water Pressure _______psig = HDPE Test II Pressure _____psig HDPE Pipe Type: Working Pressure is________psig												
Header System:													
Header Description:													
		Date:		Date:		Date:		Date:		Date:		Date:	
Test Type		Time	Pressure	Time	Pressure	Time	Pressure	Time	Pressure	Time	Pressure	Time	Pressure
45 Minute	Start End												
Reduced Pressure													
2 Minute	Sample 1												
	Sample 2												
	Sample 3												
	Sample 4												
	Sample 5												
4 Minute	Sample 1												
	Sample 2												
	Sample 3												
	Sample 4												
	Sample 5												
10 Minute	Sample 1												
	Sample 2												
	Sample 3												
	Sample 4												
	Sample 5												

Figure 2. Sample HDPE Test II Worksheet

END OF SECTION

SECTION 15074

IDENTIFICATION AND LABELING

PART 1 GENERAL

1.01 SECTION INCLUDES: Identification and labeling of piping systems.

1.02 REFERENCES

A. ANSI A13.1-81, Scheme for Identification of Piping Systems (R 1985).

B. NEMA Z535.1-91, Safety Color Code.

1.03 DEFINITIONS

A. Exposed Piping: Piping which is normally visible or may be visible after removal of covers or panels designed to provide access for inspection or maintenance.

PART 2 PRODUCTS

2.01 MATERIALS

A. Labels and Banding Materials: Weather-resistant, service rating for outdoor service, -20°F (-28°C) to 220°F (104°C) service temperature range, compatible with specified operating environment, low-halide content (for stainless steel application only).

2.02 LABEL FABRICATION

A. Fabricate labels with label format per ANSI A13.1.

B. Fabricate labels with background and letter colors per NEMA Z535.1.

C. Fabricate labels of type compatible with operational and service conditions.

D. Fabricate adhesive film labels with one or more adhesive-backed layers.

E. Fabricate system labels for piping systems common to sites and some piping systems unique to specific sites using approved piping label attributes listed in Table 1. [**Designer Note:** For piping systems not included in Table 1, CM will coordinate piping label attributes include in Table 1.]

F. Fabricate labels with text letter heights per NEMA Z535.1 as follows:

Pipe or covering outside diameter (in.)	Letter height (in.)
Up to 1/2	1/2
1/2 to 2	3/4
2 1/2 to 6	1 1/4
8 to 10	2 1/2
10 and up	3 1/2

G. Fabricate flow direction labels of same background color as system labels.

H. Supplemental Labels

1. Fabricate supplemental pressure and temperature labels of same background color, letter color, and letter height as system labels.

2. Fabricate supplemental pressure labels to numerically indicate line operating pressure and end with letters PSIG.

3. Fabricate supplemental temperature labels numerically indicate normal operating temperature and end with symbol °F.

PART 3 EXECUTION

3.01 LABEL INSTALLATION

A. Provide labels on straight sections of pipelines inside buildings at maximum intervals of 40 ft.

B. Provide labels on straight sections of pipelines outside buildings at maximum intervals of 100 ft.

C. Provide labels on branch lines not more than 5 ft from main header.

D. Provide labels on lines that penetrate walls or floors on each side of penetration not more than 5 ft from penetration.

E. Provide labels on banks of piping in a row, side by side, for ease of reference.

F. Provide labels with label format per ANSI A13.1.

G. Provide labels with approved piping label attributes as shown in Table 1 or coordinated between Operating and Engineering Divisions.

H. Provide labels with background colors, letter colors, and letter heights per NEMA Z535.1.

I. Provide labels of type compatible with operational and service conditions.

1. On bare pipe, provide manufacturer's standard adhesive film labels or band-on labels. Stenciling may be used on services approved by Facilities Manager.

2. On insulated pipe, provide thin adhesive film labels, snap-on labels, or band-on labels.

J. Provide flow direction labels adjacent to system label to indicate the direction of flow.

K. Supplemental Labels

1. Provide supplemental pressure labels on gaseous service piping. Provide supplemental pressure labels on liquid service piping operating at 100 psig or greater.

2. Provide supplemental temperature labels on service piping operating at 120°F or greater.

L. If available, use portable labeling system with a single label displaying required information.

3.02 LABEL APPLICATION

A. Ensure that surface to be labeled is free of scale, dirt, dust, grease, and moisture. Ensure that mastic coatings on insulated lines are completely dry before applying labels.

B. Firmly press label in place. Rub thoroughly, particularly along edges, until adhesive bonds.

C. Apply banding tape or flow-arrow tape over abutting edges of adhesive labels when multiple labels are required for supplemental information.

D. For fire protection water piping, apply labels to piping in aboveground, concealed areas only.

Table 1. Label Attributes

System Name	Background Color	Letter Color	Section Number
Air			
Instrument Air	Blue	White	15112
Plant Air	Blue	White	15106
Chilled Water Supply	Green	White	15106
Chilled Water Return	Green	White	15106
Condensate			
Process Steam Condensate	Yellow	Black	15101
Steam Condensate	Yellow	Black	15101
Refrigerant			
Refrigerant R-22 Liquid	Yellow	Black	15125
Refrigerant R-22 Vapor	Yellow	Black	15125
Steam	Yellow	Black	15101
Water			
Process Cold Water	Green	White	15106
Process Hot Water	Green	White	15106

END OF SECTION

SECTION 15100

VALVES

PART 1 GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 1 Specification sections, apply to this and other Sections of Division 15.

1.02 SUMMARY

A. This Section includes general duty valves common to most mechanical piping systems.

1. Special purpose valves are specified in individual piping system specifications.

1.03 SUBMITTALS

A. General: Follow the procedures specified in Division 1 and Section 15050 – Piping Systems.

B. Product data, including body material, valve design, pressure and temperature classification, end connection details, seating materials, trim material and arrangement, dimensions and required clearances, and installation instructions.

1.04 QUALITY ASSURANCE

A. American Society of Mechanical Engineers (ASME) Compliance: Comply with ASME B31.9 for building services piping and ASME B31.1 for power piping.

B. Manufacturers Standardization Society of the Valve and Fittings Industry (MSS) Compliance: Comply with the various MSS Standard Practices referenced.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Preparation For Transport: Prepare valves for shipping as follows:

1. Ensure valves are dry and internally protected against rust and corrosion.

2. Protect valve ends against damage to threads, flange faces, and weld-end preps.

3. Set valves in best position for handling. Set globe and gate valves closed to prevent rattling; set ball and plug valves open to minimize exposure of functional surfaces; set butterfly valves closed or slightly open; and block swing check valves in either closed or open position.

B. Storage: Use the following precautions during storage:

1. Do not remove valve end protectors unless necessary for inspection; then reinstall for storage.

2. Protect valves from weather. Store valves indoors. Maintain valve temperature higher than the ambient dew point temperature. If outdoor storage is necessary, support valves off the ground or pavement in watertight enclosures.

C. Handling: Use a sling to handle valves whose size requires handling by crane or lift. Rig valves to avoid damage to exposed valve parts. Do not use handwheels and stems as lifting or rigging points.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Manufacturer: Subject to compliance with requirements, provide products from one of the following:

1. Grinnell

2. Powell

3. Stockham

4. Nibco

5. Apollo

2.02 VALVE FEATURES, GENERAL

A. Valve Design: Rising stem or rising outside screw and yoke stems.

B. Pressure and Temperature Ratings: As scheduled and required to suit system pressures and temperatures.

C. Sizes: Same size as upstream pipe, unless otherwise indicated.

D. Operators: Provide the following special operator features:

1. Handwheels, fastened to valve stem, for valves other than quarter turn.

2. Lever handles, on quarter-turn valves 6-inch and smaller, except for plug valves. Provide plug valves with square heads; provide one wrench for every 10 plug valves.

3. Chain-wheel operators, for valves 2-1/2-inch and larger, installed 96 inches or higher above finished floor elevation. Extend chains to an elevation of 5'-0" above finished floor elevation.

4. Gear drive operators, on quarter-turn valves 8-inch and larger.

E. Extended Stems: Where insulation is indicated or specified, provide extended stems arranged to receive insulation.

F. Bypass and Drain Connections: Comply with MSS SP-45 bypass and drain connections.

G. End Connections: As indicated in the valve specifications.

1. Threads: Comply with ANSI B1.20.1.

2. Flanges: Comply with ANSI B16.1 for cast iron, ANSI B16.5 for steel, and ANSI B16.24 for bronze valves.

3. Solder-Joint: Comply with ANSI B16.18.

a) Caution: Where soldered end connections are used, use solder having a melting point below 840°F for gate, globe, and check valves; below 421°F for ball valves.

2.03 GATE VALVES

A. Gate Valves, 2-Inch and Smaller: MSS SP-80; Class 150, body and union bonnet of ASTM B 62 cast bronze; with threaded ends or solder ends, solid disc, copper-silicon alloy stem, brass packing gland, "Teflon" impregnated packing, and malleable iron handwheel. Do not use solder end valves for hot water heating or steam piping applications.

B. Gate Valves, 2-Inch and Smaller (High Pressure Steam and Condensate Service): MSS SP-80; Class 300, body and union bonnet of ASTM B 61 cast bronze; with threaded ends, solid disc, copper-silicon alloy stem, brass packing gland, and malleable iron hand wheel.

C. Gate Valves, 2-1/2-Inch and Larger: MSS SP-70; Class 125 iron body, bronze mounted, with body and bonnet conforming to ASTM A 126 Class B; with flanged ends, "Teflon" impregnated packing, and two-piece backing gland assembly.

D. Gate Valves, 2-1/2-Inch and Larger (High Pressure Steam and Condensate Service): MSS SP-70; Class 300 cast steel body, bronze mounted, with body and bonnet conforming to ASTM A 126 Class B; with flanged ends.

2.04 BALL VALVES

A. Ball Valves, 1/2-Inch to 2-Inch: Rated for 150 psi saturated steam pressure, 400 psi WOG pressure; 3-piece construction; with bronze body conforming to ASTM B 62, full port, chrome-plated brass ball, replaceable "Teflon" or "TFE" seats and seals, blowout proof stem, and vinyl-covered steel handle. Provide solder ends for chilled water and domestic hot and cold water service; threaded ends for heating hot water.

2.05 GLOBE VALVES

A. Globe Valves, 2-Inch and Smaller: MSS SP-80; Class 125; body and screwed bonnet of ASTM B 62 cast bronze; with threaded or solder ends, brass or replaceable composition disc, copper-silicon alloy stem, brass packing gland, "Teflon" impregnated packing, and malleable iron hand wheel. Provide Class 150 valves meeting the above where system pressure requires.

B. Globe Valves, 2-Inch and Smaller (High Pressure Steam and Condensate Service): MSS SP-80; Class 300; body and screwed bonnet of ASTM B 61 cast bronze; with threaded ends, brass or replaceable composition disc, copper-silicon alloy stem, brass packing gland, and malleable iron hand wheel.

C. Globe Valves, 2-1/2-Inch and Larger: MSS SP-85; Class 125 iron body and bolted bonnet conforming to ASTM A 126, Class B; with outside screw and yoke, bronze mounted, flanged ends, and "Teflon" impregnated packing, and two-piece backing gland assembly.

2.06 BUTTERFLY VALVES

A. Butterfly Valves, 2-1/2-Inch and Larger: MSS SP-67; rated bubbletight at 200 psi; cast-iron body conforming to ASTM A 126, Class B. Provide valves with field replaceable EPT sleeve, aluminum bronze disc, stainless steel stem, and EPT stem seals. Provide lever operators with position indicator and lock for sizes 2½ through 6 inches and gear operators with position indicator for sizes 8 through 24 inches. Provide lug type body. Drill and tap valves on dead-end service or requiring additional body strength.

2.07 CHECK VALVES

A. Swing Check Valves, 2-Inch and Smaller: MSS SP-80; Class 125, cast-bronze body and cap conforming to ASTM B 62; with horizontal swing, Y-pattern, and bronze disc; and having threaded or solder ends. Provide valves capable of being reground while the valve remains in the line. Provide Class 150 valves meeting the above specifications, with threaded end connections, where system pressure requires or where Class 125 valves are not available.

B. Swing Check Valves, 2 Inch and Smaller (High Pressure Steam and Condensate Service): MSS SP-80; Class 300, cast-steel body and cap conforming to ASTM B 61; with horizontal swing, Y-pattern, and bronze disc; and having threaded ends.

C. Swing Check Valves, 2½ Inch and Larger: MSS SP-71; Class 125, cast iron body and bolted cap conforming to ASTM A 126, Class B; horizontal swing, and bronze disc or cast-iron disc with bronze disc ring; and flanged ends. Provide valves capable of being refitted while the valve remains in the line.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine valve interior through the end ports for cleanliness, freedom from foreign matter, and corrosion. Remove special packing materials, such as blocks used to prevent disc movement during shipping and handling.

B. Actuate valve through an open-close and close-open cycle. Examine functionally significant features, such as guides and seats made accessible by such actuation. Following examination, return the valve closure member to the shipping position.

C. Examine threads on both the valve and the mating pipe for form (i.e., out-of-round or local indentation) and cleanliness.

D. Examine mating flange faces for conditions that might cause leakage. Check bolting for proper size, length, and material. Check gasket material for proper size, material composition suitable for service, and freedom from defects and damage.

E. Prior to valve installation, examine the piping for cleanliness, freedom from foreign materials, and proper alignment.

F. Replace defective valves with new valves.

3.02 VALVE ENDS SELECTION

A. Select valves with the following ends or types of pipe/tube connections:

1. Copper Tube Size, 2-Inch and Smaller: Solder ends.

2. Steel Pipe Sizes, 2-Inch and Smaller: threaded end.

3. Steel Pipe Sizes 2-1/2 Inch and Larger: flanged.

3.03 VALVE INSTALLATIONS

A. Locate valves for easy access and provide separate support where necessary.

B. Install valves and unions for each fixture and item of equipment arranged to allow equipment removal without system shutdown. Unions are not required on flanged devices.

C. Install three-valve bypass around each pressure reducing valve using throttling-type valves.

D. Install valves in horizontal piping with stem at or above the center of the pipe.

E. Install valves in a position to allow full stem movement.

F. Installation of Check Valves: Install for proper direction of flow as follows:

1. Swing Check Valves: Horizontal position with hinge pin level.

2. Wafer Check Valves: Horizontal or vertical position, between flanges.

3.04 SOLDER CONNECTIONS

A. Cut tube square and to exact lengths.

B. Clean end of tube to depth of valve socket with steel wool, sand cloth, or a steel wire brush to a bright finish. Clean valve socket in same manner.

C. Apply proper soldering flux in an even coat to inside of valve socket and outside of tube.

D. Open gate and globe valves to full open position.

E. Remove the cap and disc holder of swing check valves having composition discs.

F. Insert tube into valve socket, making sure the end rests against the shoulder inside valve. Rotate tube or valve slightly to ensure even distribution of the flux.

3.05 THREADED CONNECTIONS

A. Note the internal length of threads in valve ends, and proximity of valve internal seat or wall, to determine how far pipe should be threaded into valve.

B. Align threads at point of assembly.

C. Apply appropriate tape or thread compound to the external pipe threads (except where dry seal threading is specified).

D. Assemble joint, wrench tight. Wrench on valve shall be on the valve end into which the pipe is being threaded.

3.06 FLANGED CONNECTIONS

A. Align flange surfaces parallel.

B. Assemble joints by sequencing bolt tightening to make initial contact of flanges and gaskets as flat and parallel as possible. Use suitable lubricants on bolt threads. Tighten bolts gradually and uniformly with a torque wrench.

C. For dead-end service, butterfly valves require flanges both upstream and downstream for proper shutoff and retention.

3.07 FIELD QUALITY CONTROL

A. Tests: After piping systems have been tested and put into service, but before final adjusting and balancing, inspect valves for leaks. Adjust or replace packing to stop leaks; replace valves if leak persists.

3.08 ADJUSTING AND CLEANING

A. Cleaning: Clean mill scale, grease, and protective coatings from exterior of valves and prepare valves to receive finish painting or insulation.

3.09 VALVE PRESSURE/TEMPERATURE CLASSIFICATION SCHEDULES

VALVES, 2-INCH AND SMALLER

SERVICE	GATE	GLOBE	BALL	CHECK
Chilled Water	125	125	150	125
Domestic Hot and Cold Water	125	125	150	125
Heating Hot Water	150	150	150	150
Low-Pressure Steam	50	150	150	150
High Pressure Steam	300	300	300	300

VALVES, 2-1/2-INCH AND LARGER

SERVICE	GATE	GLOBE	BUTTERFLY	CHECK
Chilled Water	125	125	200	125
Domestic Hot and Cold Water	125	125	200	125
Heating Hot Water	125	125	200	125
Low-Pressure Steam	125	125	N/A	125
High Pressure Steam	300	300	N/A	300

END OF SECTION

SECTION 15101

STEAM AND STEAM CONDENSATE
(0 to 150 PSIG)

PART 1 GENERAL

1.01 SECTION INCLUDES: Steel piping systems for steam and steam condensate service 480EF (249EC) maximum temperature and 0-psig to 150-psig pressure range.

1.02 RELATED SECTIONS

A. Section 15050, Piping Systems.

B. Section 15072, Cleaning.

C. Section 15073, Pressure/Leak Testing.

D. Section 15074, Identification and Labeling.

E. Section 15100, Valves.

F. Section 15260, Piping Insulation.

G. Section 15262, Fibrous Glass Insulation.

H. Section 15270, Aluminum Jacketing.

1.03 REFERENCES

A. ASME B16.5-96, Pipe Flanges and Flanged Fittings; Addenda B16.5A-92.

B. ASME B16.9-93, Factory-Made Wrought Steel Buttwelding Fittings.

C. ASME B16.11-96, Forged Fittings, Socket-Welding and Threaded.

D. ASME B16.14-91, Ferrous Pipe Plugs, Bushings, and Locknuts with Pipe Threads.

E. ASME B31.3-96, Process Piping.

F. ASME B36.10M-96, Welded and Seamless Wrought Steel Pipe.

G. ASTM A53-97, Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless.

H. ASTM A105-97, Standard Specification for Carbon Steel Forgings for Piping Components.

I. ASTM106-97, Standard Specification for Seamless Carbon Steel Pipe for High Temperature Service.

J. ASTM A181-94, Standard Specification for Carbon Steel Forgings for General Purpose Piping.

K. ASTM A193-97, Standard Specification for Alloy Steel and Stainless Bolting Materials for High Temperature Service.

L. ASTM A194-97, Standard Specification for Carbon and Alloy Steel Nuts for Bolts for High Pressure and High Temperature Service.

M. ASTM A216-97, Standard Specification for Carbon Steel Castings suitable for Fusion Welding, for High Temperature Service.

N. ASTM A234-97, Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service.

PART 2 PRODUCTS

2.01 MATERIALS: Use materials selected from list below [except where specified otherwise].

A. Pipe (to 10 in.): Steel, ASTM A106 Grade B, seamless, Schedule 40.

B. Pipe (12 in. to 24 in.): Steel, ASTM A53 Grade A or B, ERW or seamless, ASME B36.10, standard weight.

C. Fittings (to 1 ½ in.): Steel, ASTM A105 or A181 Class 70, threaded, ASME B16.11 Class 2000. (Use ASME B16.11 Class 300 couplings, half-couplings, caps, and reducers.)

D. Fittings (2 in. to 24 in.): Steel, ASTM A234 Grade WPB, butt weld, seamless, standard weight, ASME B16.9.

E. Unions (to 2 in.): Steel, ASTM A105 or ASTM A181 Class 70, threaded, integral steel seats, 3000 lb, manufacturer’s standard dimensions.

F. Flanges (½ in. and ¾ in.): Steel, ASTM A105 or ASTM A181 Class 60, socket-weld, ASME B16.5 Class 150.

G. Flanges (1 in. to 24 in.): Steel, ASTM A105 or ASTM A181 Class 60, slip-on or weld neck, ASME B16.5 Class 150.

H. Gaskets: Nonasbestos, spiral-wound, high-purity, flexible graphite filler; 1/8-in.-thick compression ring of AISI Type 304L stainless steel; dimensioned to fit ASME B16.5 raised-face flanges, class rating to match flanges installed. Flexitalic CG type with Flexicarb filler.

I. Studs: Alloy steel, ASTM A193 Grade B7.

J. Nuts: Alloy steel, heavy hex, ASTM A194 Grade 2 or 2H.

K. Joint Compound: ReactorSeal 100 Virgin thread compound or graphite and oil.

L. Plugs: Steel, ASTM A105 or ASTM A181 Class 70, solid, square head, threaded, ASME B16.11.

M. Strainers (to 2 in.): Cast steel, ASTM A-216 Grade WCB, Y type, threaded, 40 mesh monel screen, 600-lb steam rating at 800EF.

N. Strainers (to 2 ½ in. and larger): Steel, ASTM A216 Grade WCB, Y type, ASTM B16.5 Class 600 flanges, 40 mesh monel screen, 150-lb steam rating at 500EF.

O. Traps [**Designer Note:** Specify job specific requirements for traps.]

P. Valves: See Sect. 15100 for valve descriptions and requirements.

Service	Size (in.)	End Type
Shutoff		
Globe	¼ to 2	Screwed
Gate	½ to 2	Screwed
Gate	½ to 2	Socket Weld
Gate	½ to 2	Screwed
Gate	3/8 to 2	Socket Weld
Gate	½ to 3	Screwed
Gate	2 to 30	Flanged
Gate	2 to 30	Butt Weld
Control		
Globe	¼ to 2	Screwed
Globe	½ to 2	Socket Weld
Globe	2 to 14	Flanged
Globe	2 to 14	Butt Weld
Angle	¼ to 3	Screwed
Angle	2 to 12	Flanged
Check		
Swing	¼ to 20	Screwed
Swing	2 ½ to 16	Flanged
Swing	2 ½ to 16	Butt Weld
Piston	½ to 2	Socket Weld

[**Designer Note:** Use Gate Valves on steam condensate lines downstream of steam traps.]

Q. Valve Stem Packing (for repacking only): Graphite yarn, nonasbestos, Garlock Style No. G-100, Sepco ML-4444, or John Crane No. 1625GF.

R. Pressure-Reducing Valves: Dead-end service, manufactured by Fisher, Masoneilan, Leslie, or Kiely-Mueller. [**Designer Note:** Specify job specific requirements for pressure-reducing valves.]

S. Pressure-Relief Valves: ASME National Board stamped for steam service, level operator (packed for indoor service). [**Designer Note:** Specify job specific requirements for pressure-relief valves.]

PART 3 EXECUTION

3.01 INSTALLATION

A. Install steam and steam condensate piping system per Normal Fluid Service requirements of ASME B31.3 and Sect. 15050.

B. Pitch steam and steam condensate piping downward 0.025 in./ft in direction of flow [except where specified otherwise].

C. Cold spring pipe as specified.

D. Expansion Loops: Use butt weld fittings.

E. Steam Pressure-Reducing Stations

1. Provide pressure-reducing valves per site specific design standards for steam stations.

2. Provide pressure-reducing valves minimum one pipe size smaller than upstream steam main line.

3. Locate steam pressure-reducing stations for maintenance access.

4. If steam pressure-reducing station is subject to freezing, provide pressure-regulating valves that enclose spring, diaphragm, and piston in one housing. [**Designer Note:** Consider two-stage pressure reduction if required by valve size and/or velocity.]

F. Avoid locating steam trap below steam condensate return main. If steam trap must be located below steam condensate return main, determine lift using 2 ft maximum lift per pound of differential pressure across trap. Do not exceed maximum available lift.

G. Provide drip legs on steam distribution headers at low points.

H. Provide minimum size ¾-in. gate valve for drip leg drains.

I. For discharge of steam condensate not to be returned to generating plant, provide French drain.

J. Do not connect steam condensate piping to storm drain.

K. Do not connect steam condensate piping to fire protection sprinkler system drain.

L. Install gate and globe valves with handwheels in upright or horizontal position.

M. Install pressure-reducing and pressure-relief valves in upright position.

N. Insulate steam piping per Sects. 15260 and 15262 with insulation thickness specified.

O. Insulate steam condensate piping per Sects. 15260 and 15262 with insulation thickness specified.

P. Provide aluminum jacketing per Sect. 15270 over insulation on outside steam and steam condensate piping.

Q. Identification/Labeling: Sect. 15074.

3.02 FIELD QUALITY CONTROL

A. Pressure/Leak Test: Sect. 15073, Class B.

B. [Perform additional testing specified.]

3.03 CLEANING

A. Post-erection Cleaning: Sect. 15072, Type II.

END OF SECTION

SECTION 15106

CHILLED WATER, COOLING WATER, PROCESS WATER, AND HEAT PUMP WATER

PART 1 GENERAL

1.01 SECTION INCLUDES: [**Designer Note:** Refer to section 15110 for information specific to HDPE piping systems.]

A. Steel piping systems for chilled water service with 150^{o}F (66^{o}C) maximum temperature and 150-psig maximum pressure.

B. Steel piping systems for cooling tower water and recirculating cooling water service with 150^{o}F (66^{o}C) maximum temperature and 150-psig maximum pressure.

C. Steel piping systems for process water service with 150^{o}F (66^{o}C) maximum temperature and 150-psig maximum pressure.

D. Steel piping systems for heat pump service with 150^{o}F (66^{o}C) maximum temperature and 150-psig maximum pressure.

1.02 RELATED SECTIONS

A. Section 15050, Piping Systems.

B. Section 15072, Cleaning.

C. Section 15073, Pressure/Leak Testing.

D. Section 15074, Identification and Labeling.

E. Section 15100, Valves.

F. Section 15260, Piping Insulation.

G. Section 15262, Fibrous Glass Insulation.

1.03 REFERENCES

A. ANSI B16.1-85, Cast Iron Pipe Flanges and Flanged Fittings.

B. ANSI B16.3-92, Malleable Iron Threaded Fittings Classes 150 and 300 (1985).

C. ANSI B16.5-88, Pipe Flanges and Flanged Fittings; Addenda B16.5A-92.

D. ANSI B16.9-93, Factory-Made Wrought Steel Buttwelding Fittings.

E. ANSI B16.11-91, Forged Fittings, Socket-Welding and Threaded.

F. ANSI B16.21-92, Nonmetallic Flat Gaskets for Pipe Flanges.

G. ANSI B16.39-86, Malleable Iron Threaded Pipe Unions Classes 150, 250 and 300.

H. ANSI B31.3-93, Chemical Plant and Petroleum Refinery Piping.

I. ANSI B36.10-85, Welded and Seamless Wrought Steel Pipe.

J. ASTM A53-93a, Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless.

K. ASTM A105-94, Standard Specification for Forgings, Carbon Steel, for Piping Components.

L. ASTM A126-93, Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings.

M. ASTM A134-90, Standard Specification for Pipe, Steel, Electric-Fusion (Arc)-Welded (Sizes NPS 16 and over).

N. ASTM A181-94, Standard Specification for Forgings, Carbon Steel, for General Purpose Piping.

O. ASTM A197-87, Standard Specification for Cupola Malleable Iron (R 1992).

P. ASTM A/234-94, Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and Elevated Temperatures.

Q. ASTM A307-94, Standard Specification for Carbon Steel Bolts and Studs, 60,000 psi Tensile Strength.

R. ASTM A563-94, Standard Specification for Carbon and Alloy Steel Nuts.

S. ASTM D2000-90, Standard Classification System for Rubber Products in Automotive Applications (SAE Recommended Practive J200).

T. ASTM F104-93, Standard Classification System for Nonmetallic Gasket Materials.

U. AWWA C200-91, Steel Water Pipe - 6 in. (150 mm) and Larger.

V. AWWA C207-86, Standard for Steel Pipe Flanges for Waterworks Service - Sizes 4 in. Through 144 in.

W. AWWA C208-83, Dimensions for Fabricated Steel Water Pipe Fittings.

PART 2 PRODUCTS

2.01 MATERIALS: Use materials selected from list below [except where specified otherwise].

A. Pipe (to 10 in.): steel, ASTM A53, furnace welded, Schedule 40.

B. Pipe (2 in. to 10 in.): steel, ASTM A53 Grade A or B, ERW or seamless, ANSI B36.10, Schedule 40.

C. Pipe (12 in. to 24 in.): steel, ASTM A53 Grade A or B, ERW or seamless, ANSI B36.10, standard weight.

D. Pipe (30 in. to 36 in.): steel, ASTM A134, straight or spiral seam, welded, 0.3125-in. wall.

A. Fittings (to 1• in.): malleable iron, ASTM A197, threaded, ANSI B16.3 Class 150.

F. Fittings (2 in. to 24 in.): steel, ASTM A234 Grade WPB, butt weld, standard weight, ANSI B16.9.

G. Unions (to 2 in.): malleable iron, ASTM A197, threaded, brass-to-iron seats, ANSI B16.39 Class 150.

H. Flanges (to 24 in.): steel, ASTM A105 or ASTM A181 Class 60, slip-on or weld neck, ANSI B16.5 Class 150.

I. Flanges (to 26 in.): steel, ASTM A105 or ASTM A181 Class 60; manufactured: AWWA C207 Class E, hub type; drilling and outside diameter: ANSI B16.1 Class 125 dimensions for cast iron flanges.

J. Gaskets (water service): nonasbestos, red rubber sheet, ASTM D2000 M2AA 507 A13, 1/16 in. thick, flat ring or full face, ANSI B16.21; SEPCO Style 20.

K. Gaskets (air service): nonasbestos, 1/8 in. thick, flat ring or full face, ASTM F104; Garlock Incorporated Blue-Gard 3000 or Gylon 3500.

L. Bolts: steel, heavy hex head, ASTM A307 Grade B.

M. Nuts: steel, heavy hex, ASTM A563 Grade B.

N. Joint Compound: Rectorseal No. 5, Rectorseal Corporation; Key-Tite, Cooper Industries; Tyte Unyte, J.C. Whitlam Manufacturing Company; or PTFE thread seal tape, Sealing Equipment Products Company.

O. Plugs (to 3 in.): steel, ASTM A105 or ASTM A181 Class 70, solid, square head, threaded, ANSI B16.11.

P. Strainers (to 1-1/2 in.): cast iron body, ASTM A126 Class B, Y type, threaded, 125 lb ANSI, threaded cap, removable 20 mesh monel screen.

Q. Strainers (2 in. and larger): cast iron body, ASTM A126 Class B, Y type, ANSI B16.1 Class 125 flanges, 125 lb ANSI, bolted cap, removable 20 mesh monel screen.

R. Valve Boxes: 5-1/4 in. shaft diameter, James B. Clow & Sons Incorporated Figure F-2450; furnished complete with Figure F-2465 Base and Figure F-2490 Cover marked "Cooling Water."

S. Expansion Joints: steel, packed, sleeve type, Dresser Manufacturing Division Style 63, Type I.

T. Valves: See Sect. 15100 for valve descriptions.

Shutoff	Size	Number*	End type
Butterfly	1/2 to 2	V-6474	Screwed
Gate	1/4 to 2	V-1	Screwed
Gate	2 1/2 to 24	V-5	Flanged
Gate	2 to 48	V-4	Flanged
Butterfly	3 to 24	V-6199-1	Wafer-Flanged
Butterfly	3 to 24	V-6199-2	Wafer-Flanged

[**Designer Note:** Specify butterfly valves for use in water service piping only. * Valve numbers given as example or can use site specific unique identifiers.]

Control	Size	Number*	End type
Globe	1/4 to 2	V-6036	Screwed
Globe	2 1/2 to 10	V-102	Flanged
Angle	1/4 to 2	V-6089	Screwed
Angle	2 1/2 to 14	V-6050	Flanged

Check	Size	Number*	End type
Swing	1/4 to 2	V-201	Screwed
Swing	2 1/2 to 24	V-204	Flanged
Center Guide	2 1/2 to 24	V-1376	Wafer-Flanged

U. Valve Stem Packing (for repacking only): nonasbestos, John Crane Incorporated K-1730 or Garlock Incorporated Style No. 8922.

V. Pressure-Reducing Valves: dead-end service, manufactured by Fisher, Masoneilan, Leslie, or Kiely-Mueller. [**Designer Note:** Include job specific requirements for pressure-reducing valves.]

W. Pressure-Relief Valves (air service): ASME National Board stamped. [**Designer Note:** Include job specific requirements for pressure-relief valves.]

X. Air Vent Valves: ball-float type, 1-in. threaded connection, 10 cfm (free air) venting capacity at 150-psig effective seat pressure; similar to Crispin Pressure Air Release Valve Model PL10, Multiplex Manufacturing Company.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install system per Category D Fluid Service requirements of ANSI B31.3 and Sect.15050.

[**Designer Note:** Issue specific fabrication and construction specifications meeting site requirements for the installation of pipe 36 in. and larger.]

B. Perform welding activities per site-specific requirements and following:

1. Do not perform welding within 24 in. of installed butterfly valves.

C. [For aboveground chilled water and process water systems,] Insulate piping system per Sects. 15260 and 15262 with insulation thickness specified on drawing.

D. [For process cooling water and recirculating cooling water piping systems,] Insulate piping system per Sects. 15260 and 15262 with insulation thickness specified on drawing.

[**Designer Note:** Insulation is not normally required on raw water lines, or cooling tower water lines that maintain continuous flow.]

E. Identification/Labeling: Sect. 15074.

3.02 FIELD QUALITY CONTROL

A. Pressure/Leak Test (water service): Sect. 15073, Class B.

B. Weld Examination: per site-specific requirements.
[Perform additional testing as specified by site requirements.]

3.03 CLEANING

A. Post-erection Cleaning (water service): Sect. 15072, Type II.

END OF SECTION

SECTION 15110

GEOTHERMAL HEAT PUMP AND LOOP PIPING SYSTEMS (HIGH DENSITY POLYETHYLENE)

PART 1 GENERAL

1.01 SECTION INCLUDES: HDPE pipe used for geothermal heat pump water loop installations. [**Designer Note**: Polybutylene may also be used if available.]

1.02 RELATED SECTIONS

A. Section 15050, Piping Systems.

B. Section 15073, Pressure/Leak Testing.

C. Section 15074, Identification and Labeling.

1.03 REFERENCES

A. ASTM D1683-98, Standard Test Method for Environmental Stress-Cracking of Ethylene Plastics.

B. ASTM D2447-99, Standard Specification for Polyethylene (PE) Plastic Pipe, Schedules 40 and 80, Based on Outside Diameter.

C. ASTM D2513-99, Standard Specification for Thermoplastics Gas Pressure Pipe, Tubing and Fittings.

D. ASTM D2683-98, Standard Specification for Socket-Type Polyethylene Fittings for Outside Diameter-controlled Polyethylene Pipe and Tubing.

E. ASTM D2837-98a, Standard Test Method for Obtaining Hydrostatic Design Basis for Thermoplastic Pipe Materials.

F. ASTM D3261-97, Standard Specification for Butt Heat Fusion Polyethylene (PE) Plastic Fittings for Polyethylene (PE) Plastic Pipe and Tubing.

G. ASTM D3035-95, Standard Specification for Polyethylene (PE) Plastic Pipe (DR-PR) Based on Controlled Outside Diameter.

H. ASTM D3350-98a, Standard Specification for Polyethylene Plastics Pipe and Fitting Materials.

I. ASTM F714-97, Standard Specification for Polyethylene (PE) Plastic Pipe (SDR-PR) Based on Outside Diameter.

J. ASTM F1055-98, Standard Specification for Electrofusion Type Polyethylene Fitting for Outside Diameter Controlled Polyethylene Pipe and Tubing.

1.04 SUBMITTALS FOR APPROVAL

A. Submit manufacturer's technical product data and installation instructions for pipe and fittings.

B. Submit names and certificates of successful completion of manufacturer training for the application specified.

C. Submit manufacturer's technical data on fusion machine to be used in joining the pipe and fittings.

D. Copies of pipe and fitting warranties must be submitted.

PART 2 PRODUCTS

2.01 MATERIALS: Material Description- ASTM D3350- Type III, Grade PE34

A. Pipe: The pipe shall be virgin resin with an allowance for on-site manufacturer re-processed resin. No recycled resin shall be used. All pipe and heat-fused materials shall be manufactured from a virgin polyethylene extrusion compound material in accordance with ASTM D-2513, Sections 4.1 and 4.2. The material shall maintain a 1600 psi (110.316 Bar) Hydrostatic Design Basis at 73.4^{o} F (23.5 ^{o} C) per ASTM D-2837, and shall be listed in PPI TR4 as a PE3408 piping formulation. The material shall be a high density extrusion compound having a cell classification of PE345434, PE355434, or PE345534 with a UV stabilizer of C, D, or E as specified in ASTM D-3350 with the following exception: this material shall exhibit zero failures (F0) when tested for a minimum of 192 hours under ASTM D-1693, Condition C, as required in ASTM D-3350.

1. Pipe shall be manufactured to outside diameters, wall thickness, and respective tolerances as specified in ASTM D-3035 or D-2447. Molded fittings(White/Drisco) shall be manufactured to dimensional specifications and requirements of (White/Drisco) ASTM D-2683 for socket fittings, ASTM D-3261 for butt/sidewall fittings, ASTM D-2513, Section 6.10.1 for Mechanical Stab fittings, and ASTM F-1055 for electrofusion fittings.

a) Pipe with a diameter of 1.252 inches or less (3.175 cm) (nominal) shall be manufactured in accordance with ASTM D-3035 with a minimum[based on pressure rating]dimension ratio of 11.

b) Pipe manufactured with a diameter of 1.253 inches (3.175 cm) (nominal) and larger shall be manufactured in accordance with ASTM D-3035 and ASTM F714 with a minimum[based on pressure rating]dimension ratio of 15.5, or ASTM D-2447 Schedule 40. If the pipe is used in a vertical bore application, it shall be manufactured in accordance with ASTM D-3035 with a minimum[based on pressure rating]dimension ratio of 11.

2. Factory- shipped U-bend assemblies shall be sealed and under air pressure.

B. Fittings: The geothermal system pipe fittings which are molded shall be manufactured to the dimensional specifications and requirements of ASTM D-3261 for butt/sidewall fittings. The material used in the manufacturing of the fitting shall be the same approved extrusion material as the connecting pipe. For fabricated fittings, a minimum 'quick-burst' strength of the fittings shall not be less than that of the pipe, nor less than four times the long-term water-rated working pressure.

1. Purpose-designed U-bend fittings shall be used instead of L+Street for ease of insertion. Manufacturers include Phillips and Enlink.

C. Joints: The approved joints are heat fusion, flanging, transition fittings and proof-tested, approved mechanical "couplers". Fusion joints shall be made by trained and qualified construction crew staff. The butt fusion machine used to make the joints shall encompass the following features:

1. Guide rods shall be in a plane that passes through the centerline of the pipe, thus canceling the bending forces in the machine caused by the fusion forces.

2. The pipe clamps shall have the strength to 'round-up' the pipe close to the fusion joint. They must be adjustable for removal of high/low mismatch of pipe walls and clamp each piece on continuing straight centerline.

3. The pipe facing device shall be capable of rapid facing of the pipe ends to a perfectly flat surface, so when the ends are brought together, there is 100 percent plastic contact.

4. The facer may be hand or electric powered for pipe sizes up to 2 inches (5.1 cm), and electrically powered for pipe sizes up to 8 inches (20.3 cm).

5. The facer shall have precisely machined stops to lock the facer squarely between the clamping jaws at the end of the face off.

6. The heater plate shall be electrically heated and thermostatically controlled. The surface shall be smooth with a high quality non-stick coating. The heater shall be capable of quick heat-up and maintaining a constant surface temperature in the desired temperature range even in inclement conditions. The heater plate shall be equipped with a thermometer to indicate temperature change. A surface pyrometer is used periodically to assure proper temperature. Use pipe manufacturer's recommended fusion temperature.

7. The socket fusion machine used to make the joints shall encompass the following features:

    a) An electric, thermostatically-controlled heater plate. The surface shall be smooth and free of foreign material. The heating tool shall be capable of heating socket faces to the appropriate fusion temperatures as per manufacturer's recommendations.

    b) A set of metal socket faces which are dimensionally accurate according to current industry practices. The surface of the socket face that will be in direct contact with the pipe or fitting shall be smooth and coated with a high quality non-stick coating.

    c) Temperature-indicating crayons or a surface pyrometer. One temperature crayon shall be for the proper 'low' end temperature indication and another crayon shall be for indicating the 'high' end temperature. Use pipe manufacturer's recommended fusion temperature range.

    d) A depth gauge that is sized according to pipe diameter and corresponding fusion fitting socket depth. The depth gauge shall be used to locate the cold ring the proper distance from the pipe end.

    e) A metal locking cold ring clamp which supplies support for the entire circumference of the piping material. Cold ring shall have the ability to keep the pipe end round. The cold ring shall be used to limit the pipe depth entry into the socket face and fusion fitting socket.

    f) A timing device that emits an audible tone and a timing light on one second intervals. Timer shall be used to determine proper heat cycle for the pipe and fitting. Use pipe manufacturer's recommended heating times.

    g) A number of clean, dry, 100 percent cotton rags used to clean the socket heater faces after each fusion application. Rags shall be free of any cleaning solvents, grease, or dirt.

8. Install piping in accordance with manufacturer's written instructions. The pipe and fittings must be joined using the butt, socket, electrofusion, or fusion process. No other method is acceptable. The vertical loop take-off tee fittings may be made using tees or the saddle fusion process on header piping 1.25 inch (3.18 cm) and above. Exercise extreme caution to completely remove the cutout on saddle tees. Bell reductions shall be used at all pipe reductions to eliminate trapped air.

9. Use reducing socket tees when fabricating socket type reducing headers. Consult with manufacturer for available fittings and fabricated headers.

10. Avoid sharp bends in piping. Consult pipe manufacturer for minimum bend radius. Install elbow fittings for bends which require tighter radii than manufacturer recommends. Use only continuous pipe in sharp bends.

D. Marking: Each pipe shall be permanently indent marked with the manufacturer's name, nominal size, pressure rating, relevant ASTM standards, cell classification number and date of manufacture.

1. Each fitting shall be identified with the manufacturer's name, nominal size, pressure rating, relevant ASTM standards and date of manufacturer.

2. Each pipe and factory-fitted "U-bend" vertical heat exchangers shall be permanently indent marked with distance in feet or meters from the U-bend tip, with marking every two feet or one meter.

E. Packaging, Handling, And Storage: The pipe and fittings shall be packaged, handled and stored in accordance with the approved manufacturer's general guidance and recommendations.

Table Of Water Pressure Ratings at 73.4^{o}F (23.5^{o}C) for DR-PR PE 3408 Plastic Pipe:

Dimension Ratio	Pressure Rating, psi	Pressure Rating, Bar
7	267	18.4
9	200	13.8
9.3	193	13.3
11	160	11.03
13.5	128	8.8
15.5	110	7.6
17	100	6.9

2.02 SOURCE QUALITY CONTROL

A. Obtain pipe and fittings from compatible manufacturers.

B. The pipe and fittings manufacturer shall have in place a functional quality assurance program. Such QC/QA programs shall deal with quality and workmanship, OA verification, OA rejection and have OA record retention systems in place.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install piping system per Sect. 15050.

B. Join pipe and fittings by approved methods described above.

C. Pipe Supports

1. Space pipe supports per following table or per applicable manufacturer's instructions, if available:

Size (in.)	Maximum spacing
1.25	2 ft 9 in.
2	3 ft 0 in.
3	3 ft 6 in.
4	3 ft 9 in.

2. Remove sharp edges and burrs of hanger parts which contact pipe.

3. Do not rigidly clamp or force pipe into position by means of hangers.

4. Support vertical pipe with riser clamps. Restrict side motion by means of oversize U-bolts.

D. Identification/Labeling: Sect. 15074.

3.02 REPAIR/RESTORATION

A. Repair leaks found when testing by cutting the damaged section and replacing it with an approved socket- or butt-fused piece (or approved mechanical connector). Large diameter polyethylene piping may be repaired by use of a torch.

3.03 FIELD QUALITY CONTROL

A. Pressure/Leak Test: Per manufacturer's instruction:

1. U-bend assembly before insertion.

2. U-bend assembly before circuit header installation.

3. Each circuit.

4. System at the vault or interior pump manifold .

3.04 CLEANING

A. Flush piping system with potable water at 2 fps and observe for free flow. [**Designer Note**: The contractor must ensure there is not partial kinking, or crimping, either in the header or in the U-bend.]

B. Remove material or obstructions that interfere with full flow.

C. Adjust piping to remove kinks or crimping in piping, U-bends, and header system.

END OF SECTION

SECTION 15112

INSTRUMENT AIR

PART 1 GENERAL

1.01 SECTION INCLUDES: copper tubing systems for instrument air service with 150°F (65°C) maximum temperature and 100-psig maximum pressure.

1.02 RELATED SECTIONS

A. Section 15050, Piping Systems.

B. Section 15052, Brazing.

C. Section 15072, Cleaning.

D. Section 15073, Pressure/Leak Testing.

E. Section 15074, Identification and Labeling.

F. Section 15100, Valves.

1.03 REFERENCES

A. ANSI B16.22-89, Wrought Copper and Copper Alloy Solder Joint Pressure Fittings.

B. ANSI B31.3-93, Chemical Plant and Petroleum Refinery Piping.

C. ASTM B16-92, Standard Specification for Free-Cutting Brass Rod, Bar, and Shapes for Use in Screw Machines.

D. ASTM B75-93, Standard Specification for Seamless Copper Tube.

E. ASTM B88-93a, Standard Specification for Seamless Copper Water Tube.

F. ASTM B124-89, Standard Specification for Copper and Copper-Alloy Forging Rod, Bar, and Shapes.

PART 2 PRODUCTS

2.01 MATERIALS: Use materials selected from list below [except where specified otherwise].

[**Designer Note:** Specify type of tubing and fittings (solder type or compression type) to be used.]

A. Tubing (1/4-in. OD X 0.030-in. wall and 3/8-in. OD X 0.032-in. wall): copper, UNS C12200, ASTM B88, Type K, Temper H, seamless, water tube, furnished straight.

B. Tubing (1/4-in. OD X 0.025-in. wall and 3/8-in. OD X 0.032-in. wall): copper, UNS C12200, ASTM B75, Temper H80, seamless, furnished straight.

C. Solder Fittings (1/4-in. OD and 3/8-in. OD): copper, UNS C12200, solder joint, ANSI B16.22.

D. Compression Fittings (1/4-in. OD and 3/8-in. OD): brass, ASTM B16 Type CA360 or ASTM B124 Type CA377, compression type, 1500-psig pressure rating; Intru-Lok, Parker Hannifan Corporation.

E. Valves: See Sect. 15100 for valve descriptions.

Service Shutoff	Size (in.)	Number	End type
Globe	1/4 to 3/8 OD	V-6193	Compression

F. Pressure-Reducing Valves:

[**Designer Note:** Specify job-specific requirements for pressure- reducing valves.]

G. Pressure-Relief Valves: ASME National Board Stamped for air service.

[**Designer Note:** Specify job-specific requirements for pressure- relief valves.]

H. [**Designer Note:** In applications with the direct use of ground water or in areas where freeze protection may be required:
Ground water heat exchangers shall be of copper-nickel or equivalent alloy and shall be capable of being frozen without danger of rupture.]

PART 3 EXECUTION

3.01 INSTALLATION

A. Install piping system per Category D Fluid Service requirements of ANSI B31.3 and Sect. 15050.

B. When solder fittings are specified, use compression-type fittings to make connections to threaded valves and instruments.

C. Use bends to minimize use of fittings. Group fittings required for racked tubing to simplify system leak testing.

D. Run exposed and concealed tubing in horizontal and vertical planes. Run horizontal lines parallel to building walls and partitions.

E. In areas with suspended ceilings, conceal horizontal tubing runs above ceilings.

F. Do not embed tubing directly in concrete. Provide a sleeve made from conduit or pipe for tubing penetrations through concrete floors and walls.

G. Identification/Labeling: Sect. 15074.

3.02 FIELD QUALITY CONTROL

A. Pressure/Leak Test: Sect. 15073, Class A.

3.03 CLEANING

A. Posterection Cleaning: Sect. 15072, Type I.

END OF SECTION

SECTION 15125

FLUORINATED HYDROCARBON REFRIGERANTS

PART 1 GENERAL

1.01 SECTION INCLUDES: copper tubing systems for refrigerant service with –80^{o}F (-62^{o}C) to 150^{o}F (66^{o}C) temperature range and 0-psig to 300-psig pressure range.

1.02 RELATED SECTIONS

A. Section 15050, Piping Systems.

B. Section 15052, Brazing.

C. Section 15072, Cleaning.

D. Section 15074, Identification and Labeling.

E. Section 15260, Piping Insulation.

F. Section 15265, Elastomeric Rubber Insulation.

G. Section 15270, Aluminum Jacketing.

1.03 REFERENCES

A. ANSI B16.18-84, Cast Copper Alloy Solder Joint Pressure Fittings.

B. ANSI B16.22-89, Wrought Copper and Copper Alloy Solder Joint Pressure Fittings.

C. ANSI B16.26-88, Cast Copper Alloy Fittings for Flared Copper Tubes.

D. ANSI B31.5-92, Refrigeration Piping.

E. ASTM A193-94b, Standard Specification for Alloy-Steel and Stainless Steel Bolting Materials for High Temperature Service.

F. ASTM A194-94a, Standard Specification for Carbon and Alloy-Steel Nuts and Bolts for High Pressure and High Temperature Service.

G. ASTM B62-93, Standard Specification for Composition Bronze or Ounce Metal Castings.

H. ASTM B280-93a, Standard Specification for Seamless Copper Tube for Air Conditioning and Refrigeration Field Service.

I. Engineering Standard Y-ES-4.5-2, Pipe Hangers - General Notes.

PART 2 PRODUCTS

2.01 MATERIALS: Use materials selected from list below [except where specified otherwise].

A. Tubing (3/8-in. OD to 4 1/8-in. OD): copper, UNS C12200, ASTM B280, seamless tube, drawn temper straight lengths, including Supplemental Requirement S2 (Quality Assurance).

B. Brazed Fittings (3/8-in. OD to 4 1/8-in. OD): copper, UNS C12200, solder joint, ANSI B16.22. (Use long radius elbows for 90• elbows).

C. Brazed Fittings (3/8-in. OD to 4 1/8-in. OD): brass, UNS C83600, ASTM B62, solder joint, ANSI B16.18.

D. Flared Fittings (3/8-in. OD to 7/8-in. OD): brass, UNS C83600, ASTM B62, ANSI B16.26.

E. Flanged Fittings: companion flanges, provided with valves or equipment, suitable for silver brazing.

F. Gaskets: nonasbestos, 1/8 in. thick, Garlock Style No. 3300.

G. Studs: alloy steel, heavy hex head, ASTM A193 Grade B7.

H. Nuts: alloy steel, heavy hex, ASTM A194 Grade 2 or 2H.

I. Valves: [**Designer Note:** Specify job-specific requirements for valves.]

J. Accessories: [**Designer Note**: Specify job-specific requirements for accessories.]

PART 3 EXECUTION

3.01 INSTALLATION

A. Install piping system per ANSI B31.5 and Sect. 15050.

B. Install refrigerant tubing complete with tube fittings, valves, supports, and specialties.

C. Use tubing that is uniformly round and free from blisters, flats, or dents. Ream ends to full inside diameter before erection.

D. Install tubing to be capable of relieving strain caused by expansion and contraction.

E. Use fittings to make connections only where necessary. Make connections neat and inconspicuous.

F. Use tube cutter or hack saw and miter box to accurately cut refrigerant tubing to proper length with square ends.

G. Brazing

1. Perform brazing activities per Sect. 15052.

2. Disassemble valves to be sweat-fitted prior to brazing. Remove packing. After brazing, allow valves to cool before reassembling.

3. Thoroughly clean brazed joints to remove residual flux.

H. Locate components requiring service or repair during normal operation to be accessible.

I. Use flared fittings only to mate with valves or equipment.

J. Provide companion flanges for valves or equipment that require flanged connections. Size flanges for full connection to refrigerant lines.

K. Insulate piping system per Sects. 15260 and 15265 with insulation thickness specified on drawings.

L. Provide aluminum jacketing per Sect. 15270 over insulation.

M. Hangers

1. Support tubing by hangers patterned after those shown in Engineering Standard Y-ES-4.5-2. [**Designer Note:** Attach Engineering Standard Y-ES-4.5-2 or site specific standards as appropriate.]

2. Secure supports to structural members or walls to provide rigidity with spans that do not exceed the following:

Tube Size (in.)	Maximum Span
≤1	6 ft 0 in.
1 1/4 to 4	10 ft 0 in.
5 to 612 ft 0 in.	

3. Isolate noninsulated tubing from supports by securely fastening two complete wraps of 1/8-in.-thick neoprene to tubing.

4. Where tube lines are insulated, provide tube cradles similar to those shown in Engineering Standard Y-ES-4.5-2. Install cradles to center on supports. [**Designer Note:** Attach Engineering Standard Y-ES-4.5-2 or site specific standards as appropriate.]

5. Install flexible refrigerant tube connections as closely as possible to equipment being isolated. Securely anchor to building structure the end of flexible connection farthest from equipment.

N. Identification/Labeling: Sect. 15074.

3.02 FIELD QUALITY CONTROL

A. Refrigerant Leak Detector: Mars H10G or H10D or approved equal.

B. Prior to installation of insulation, test system by charging to approximately 10 psig with Refrigerant 22 and then adding nitrogen or helium to increase system pressure to 300 psig. Maintain pressure for 12 h without loss. Use refrigerant leak detector to check entire system for leaks at 300-psig pressure. Make repairs. Retest affected sections of system after repairs. Evacuate system to within 4 mm of absolute vacuum measured with standard manometer. When system does not lose more than 4 mm of vacuum in 5 min, the vacuum may be broken with required refrigerant charge.

C. When refrigeration system is in operation and prior to refrigerant tubing insulation installation, perform a final test for refrigerant leaks with refrigerant leak detector.

3.03 CLEANING

A. Take precautions to prevent entrance of foreign matter into system before, during, and after erection.

B. Pre-erection Cleaning: Sect. 15072, Type III. [**Designer Note:** Type III pre-erection cleaning is not required for tubing that has been maintained clean as received with sealed ends in place per ASTM B280. Specify that contractor perform cleanness test per Sect. 12 of ASTM B280 if contamination of tubing is suspected.]

C. Post-erection Cleaning: Sect. 15072, Type I.

END OF SECTION

SECTION 15135

THERMOMETERS AND GAUGES

PART 1 GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including the General and Supplementary Conditions and Division 1 Specification Sections, apply to this and the other Sections of Division 15.

1.02 SUMMARY

A. This Section includes thermometers and gauges used in mechanical systems.

1.03 SUBMITTALS

A. General: Submit the following according to the Conditions of the Contract and Division 1 Specification Sections.

B. Product data for each type of thermometer, gauge, and fitting specified. Include scale range, ratings, and calibrated performance curves, certified where indicated. Submit a schedule showing manufacturer's figure number, scale range, location, and accessories for each thermometer and gauge.

C. Product certificates signed by manufacturers of meters and gauges certifying accuracy's under specified operating conditions and compliance with specified requirements.

1.04 QUALITY ASSURANCE

A. Comply with applicable portions of American Society of Mechanical Engineers (ASME) and Instrument Society of America (ISA) standards pertaining to construction and installation of thermometers and gauges.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Liquid-in-Glass Thermometers:

    a. Marsh Instrument Co.

    b. H.O. Trerice Co.

c. Weiss Instruments, Inc.

2. Pressure Gauges:

a. AMETEK, U.S. Gauge Div.

b. Ashcroft by Dresser Industries, Instrument Div.

c. Marsh Instrument Co.

d. H.O. Trerice Co.

e. Weiss Instruments, Inc.

2.02 THERMOMETERS, GENERAL

A. Scale Range: Temperature ranges for services listed as follows:

1. Domestic Hot Water: 30 to 240°F, with 2-degree scale divisions (0 to 115°C, with 1-degree scale divisions).

2. Domestic Cold Water: 0 to 100°F, with 2-degree scale divisions (minus 18 to 38°C, with 1-degree scale divisions).

3. Hot Water: 30 to 300°F, with 2-degree scale divisions (0 to 150°C, with 1-degree scale divisions).

4. Chilled Water: 0 to 100°F, with 2-degree scale divisions (minus 18 to 38°C, with 1-degree scale divisions).

5. Steam and Condensate: 50 to 400°F, with 2-degree scale divisions (10 to 205°C, with 1-degree scale divisions).

6. Comfort Cooling Air: 0 to 100°F, with 2-degree scale divisions (minus 18 to 38°C, with 1-degree scale divisions).

B. Accuracy: Plus or minus 1 percent of range span or plus or minus one scale division to maximum of 1.5 percent of range span.

2.03 LIQUID-IN-GLASS THERMOMETERS

A. Description: ASTM E 1, liquid-in-glass thermometer.

B. Case: Die-cast and aluminum-finished in baked-epoxy enamel, glass front, spring secured, 9 inches (230 mm) long.

C. Adjustable Joint: Finished to match case, 180-degree (3.1rad) adjustment in vertical plane, 360-degree (6.3rad) adjustment in horizontal plane, with locking device.

D. Tube: Red-reading mercury-filled with magnifying lens.

E. Scale: Satin-faced non-reflective aluminum with permanently etched markings.

F. Stem: Copper-plated, steel, aluminum, or brass for a separable socket of length to suit installation.

2.04 THERMOMETER WELLS

A. Description: Brass or stainless-steel thermometer well.

B. Pressure Rating: Not less than piping system design pressure.

C. Stem Length: To extend to center of pipe.

D. Extension for Insulated Piping: 2 inches (50 mm) nominal, but not less than thickness of insulation.

E. Threaded Cap Nut: With chain permanently fastened to well and cap.

2.05 PRESSURE GAUGES

A. Description: ASME B40.1, Grade A phosphor-bronze Bourdon-tube pressure gauge, with bottom connection.

B. Case: Drawn steel, brass, or aluminum with 4-1/2-inch (115mm) -diameter glass lens.

C. Connector: Brass, 1/4-inch (8mm) NPS.

D. Scale: White-coated aluminum, with permanently etched markings.

E. Accuracy: Plus or minus 1 percent of range span.

F. Range: Conform to the following:

1. Vacuum: 30 inches Hg of vacuum to 15 psig of pressure.

2. Vacuum: 100 kPa of vacuum to 100 kPa of pressure.

3. Fluids Under Pressure: 2 times operating pressure.

2.06 PRESSURE-GAUGE ACCESSORIES

A. Siphons: 1/4-inch (8mm) straight coil of brass tubing with threads on each end.

B. Snubbers: 1/4-inch (8mm) brass bushing with corrosion-resistant porous-metal disc of material suitable for system fluid and working pressure.

PART 3 EXECUTION

3.01 THERMOMETER AND GAUGE APPLICATIONS

A. General: Where indicated, install thermometers and gauges of types, sizes, capacities, and with features indicated.

3.02 THERMOMETER AND GAUGE INSTALLATION, GENERAL

A. Install thermometers, gauges, and accessories according to manufacturers' written instructions for applications where used.

3.03 THERMOMETER INSTALLATION

A. Install thermometers and adjust vertical and tilted positions.

B. Install in the following locations (as a minimum) and elsewhere as indicated:

1. At inlet and outlet of each hydronic chiller.

2. At inlet and outlet of each hydronic coil in air-handling units and built-up central systems.

3. At inlet and outlet of each hydronic heat exchanger except VAV terminal reheat coils.

4. On discharge duct off each air handling unit.

C. Thermometer Wells: Install in vertical position in piping tees where thermometers are indicated.

1. Install wells with stem extending to center of pipe.

2. Fill wells with oil or graphite and secure caps.

3.04 PRESSURE GAUGE INSTALLATION

A. Install pressure gauges in piping tee with pressure gage valve located on pipe at most readable position.

B. Install in the following locations (as a minimum) and elsewhere as indicated:

1. At suction and discharge of each pump (use common manifold with one gage).

2. At discharge of each pressure-reducing valve.

3. At building water service entrance.

4. At chilled water inlets and outlets of chillers.

5. At hot water inlets and outlets of steam-to-water heat exchanger.

6. At steam PRV stations, upstream and downstream of PRV.

C. Pressure Gage Needle Valves: Install in piping tee with snubber. Install siphon instead of snubber for steam pressure gauges.

3.05 CONNECTIONS

A. Piping installation requirements are specified in other Division 15 Sections. The Drawings indicate the general arrangement of piping, fittings, and specialties.

B. Install thermometers and gauges adjacent to machines and equipment to allow servicing and maintenance.

3.06 ADJUSTING AND CLEANING

A. Adjusting: Adjust faces of thermometers and gauges to proper angle for best visibility.

B. Cleaning: Clean windows of thermometers and gauges and factory-finished surfaces. Replace cracked and broken windows and repair scratched and marred surfaces with manufacturer's touchup paint.

END OF SECTION

SECTION 15260

PIPING INSULATION

PART 1 GENERAL

1.01 SECTION INCLUDES: Insulation installation details for piping and equipment.

1.02 RELATED SECTIONS

A. Section 15262, Fibrous Glass Insulation.

B. Section 15265, Elastomeric Rubber Insulation.

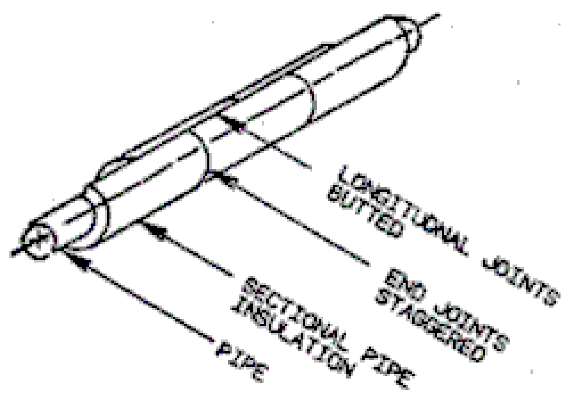
PART 2 PRODUCTS - NOT USED.

PART 3 EXECUTION

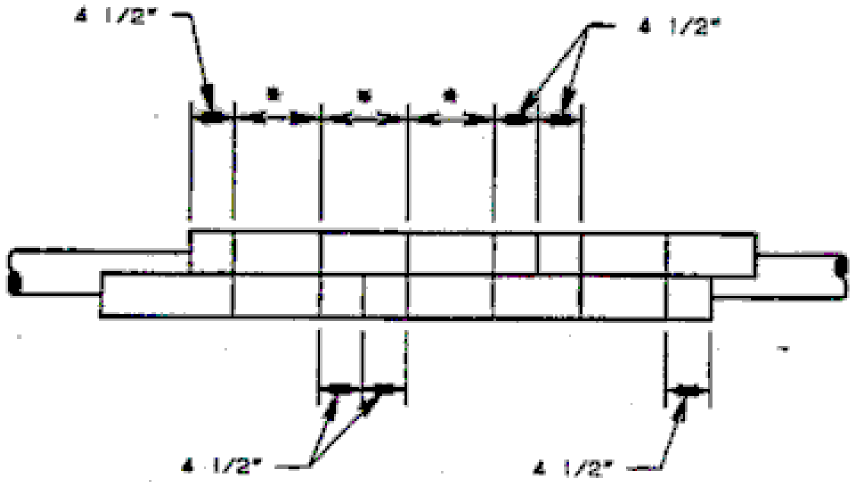
3.01 INSTALLATION

A. Install piping insulation per Figs. 15260-A through 15260-G.

END OF SECTION



LOCATION OF JOINTS

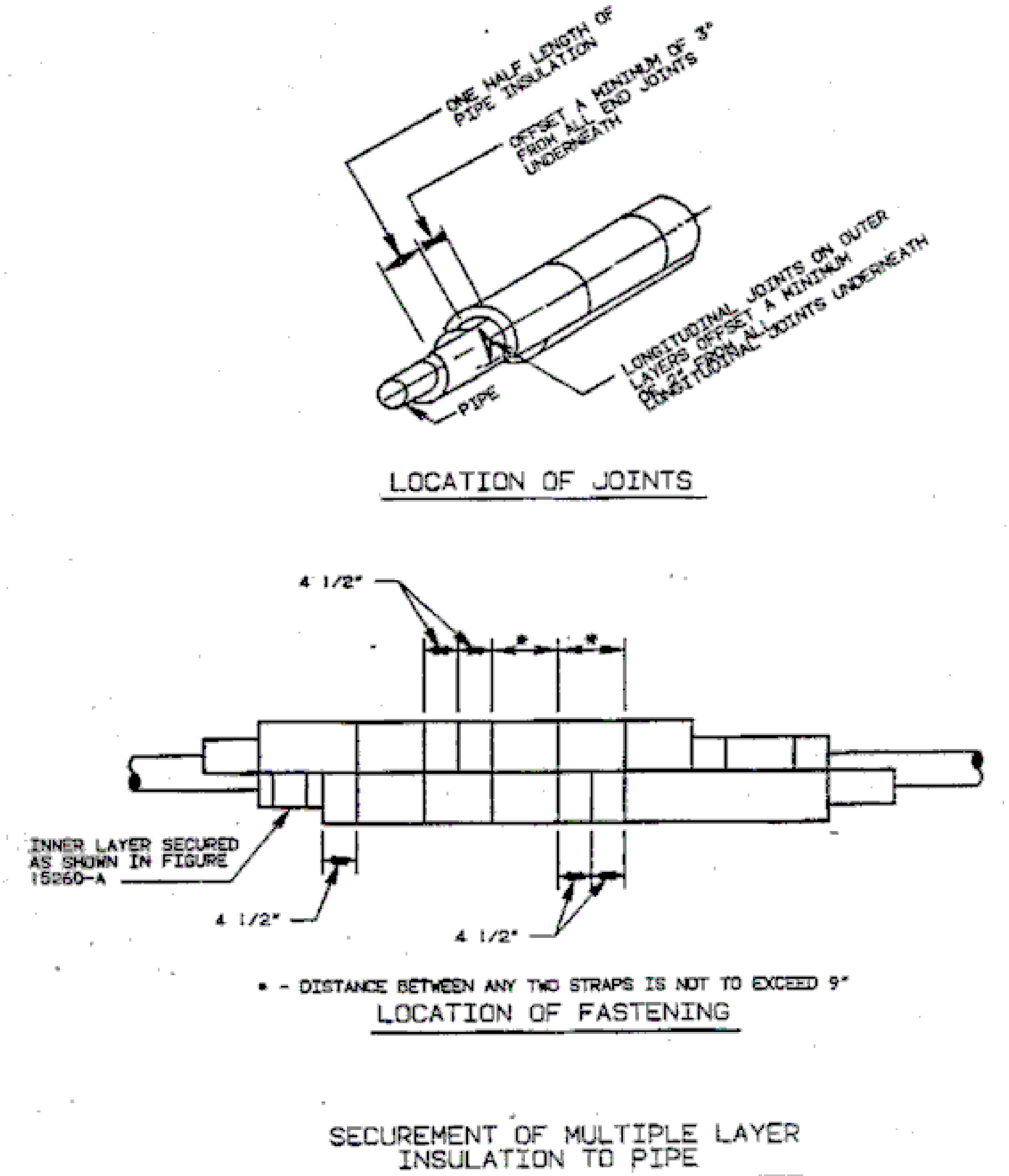


* - DISTANCE BETWEEN ANY TWO STRAPS IS NOT TO EXCEED 9"

LOCATION OF FASTENING

SECUREMENT OF SINGLE LAYER INSULATION TO PIPE

Fig. 15260-A



ONE HALF LENGTH OF PIPE INSULATION
OFFSET A MINIMUM OF 3" FROM ALL END JOINTS UNDERNEATH
LONGITUDINAL JOINTS ON OUTER LAYERS OFFSET A MINIMUM OF 2" FROM ALL LONGITUDINAL JOINTS UNDERNEATH
PIPE
LOCATION OF JOINTS
4 1/2"
INNER LAYER SECURED AS SHOWN IN FIGURE 15260-A
4 1/2"
4 1/2"
* - DISTANCE BETWEEN ANY TWO STRAPS IS NOT TO EXCEED 9"
LOCATION OF FASTENING
SECUREMENT OF MULTIPLE LAYER INSULATION TO PIPE

Fig. 15260-B

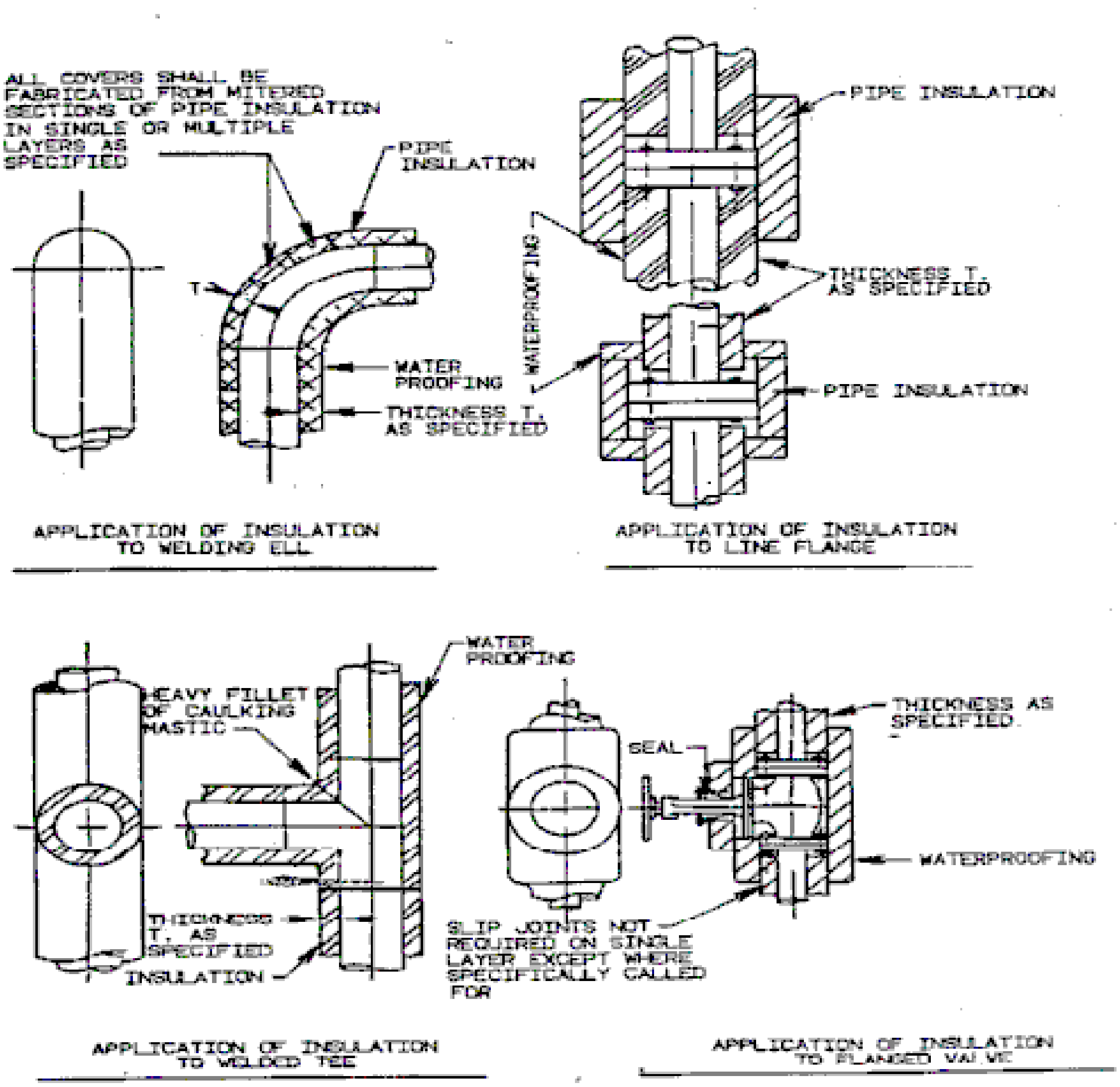
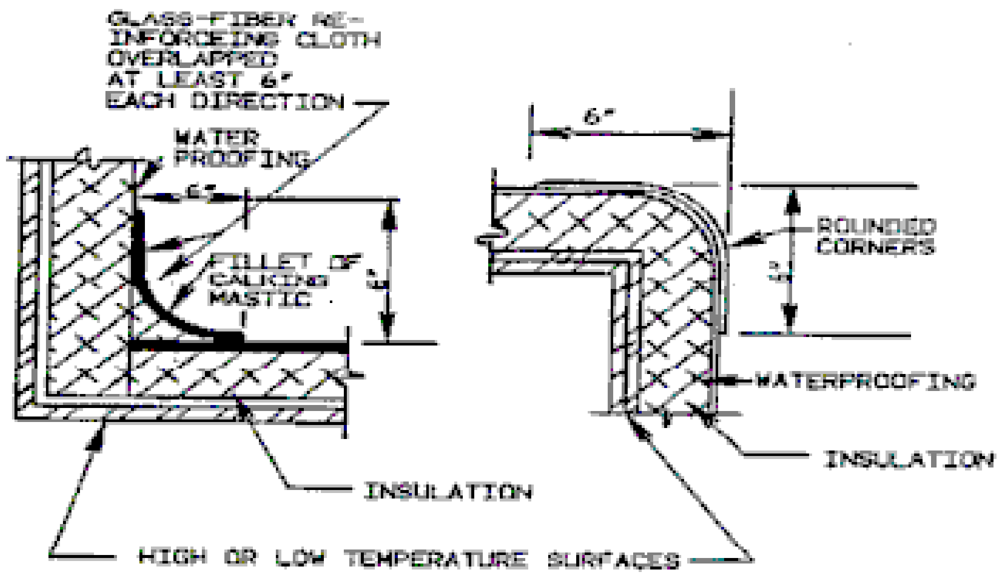
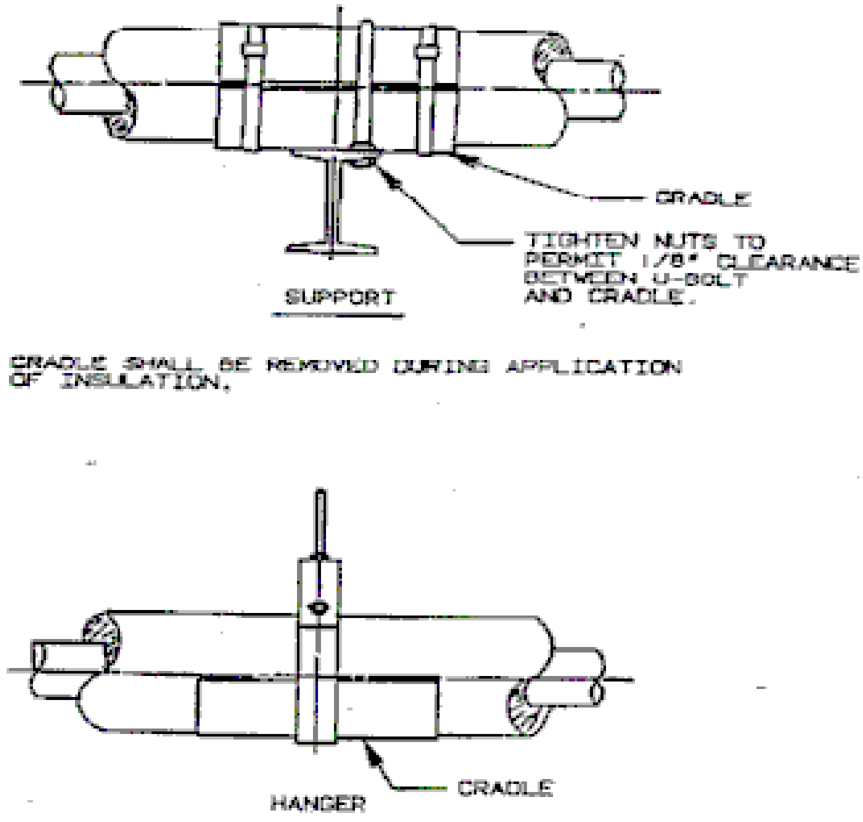

ALL COVERS SHALL BE FABRICATED FROM MITERED SECTIONS OF PIPE INSULATION IN SINGLE OR MULTIPLE LAYERS AS SPECIFIED
PIPE INSULATION
T
WATER PROOFING
THICKNESS T. AS SPECIFIED
APPLICATION OF INSULATION TO WELDING ELL
PIPE INSULATION
WATERPROOFING
THICKNESS T. AS SPECIFIED
PIPE INSULATION
APPLICATION OF INSULATION TO LINE FLANGE
HEAVY FILLET OF CAULKING MASTIC
WATER PROOFING
THICKNESS T. AS SPECIFIED
INSULATION
APPLICATION OF INSULATION TO WELDED TEE
THICKNESS AS SPECIFIED
SEAL
WATERPROOFING
SLIP JOINTS NOT REQUIRED ON SINGLE LAYER EXCEPT WHERE SPECIFICALLY CALLED FOR
APPLICATION OF INSULATION TO FLANGED VALVE

Fig. 15260-C



APPLICATION OF WATERPROOFING
COATING AT CORNERS

Fig. 15260-D



APPLICATION OF CALCIUM SILICATE INSULATION AT HANGERS AND SUPPORTS

Fig. 15260-E

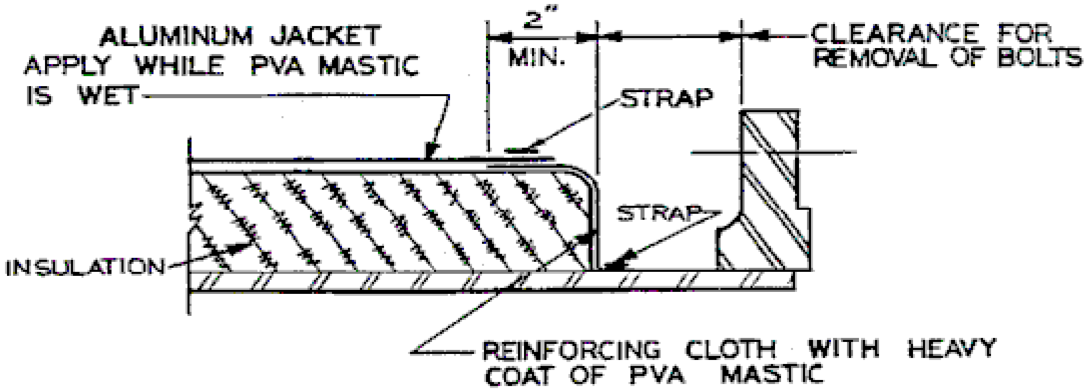


Figure 1-1. TERMINATION OF INSULATION AT UNINSULATED FLANGED JOINT.

Fig. 15260-F

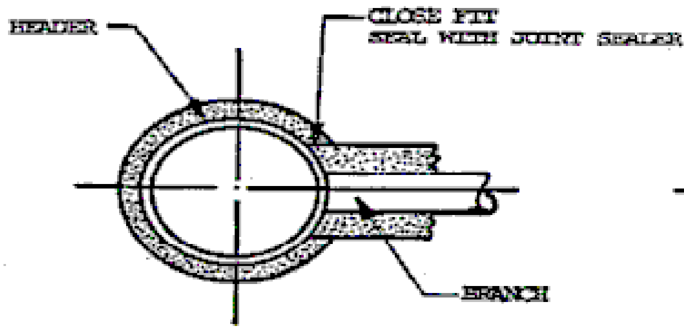


Figure 3-1. APPROVED

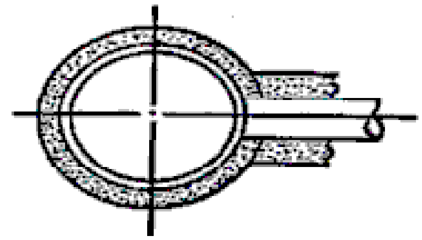


Figure 3-2. NOT PERMITTED

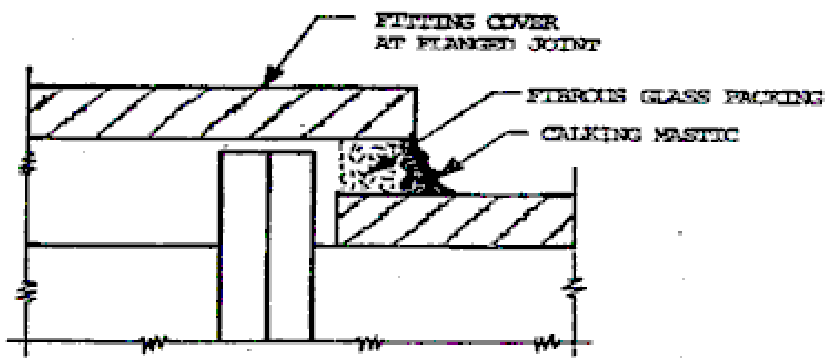


Figure 3-3. NOT PERMITED

Fig. 15260-G

SECTION 15262

FIBROUS GLASS INSULATION

PART 1 GENERAL

1.01 SECTION INCLUDES: Fibrous glass insulation for piping and equipment for services operating at temperatures between 20°F (-6.7°C) and 350°F (176°C).

1.02 REFERENCES

A. ASTM C177-85, Standard Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded - Hot-Plate Apparatus (R 1993).

B. ASTM C335-89, Standard Test Method for Steady-State Heat Transfer Properties of Horizontal Pipe Insulation.

C. FED-STD-595B-89, Colors Used in Government Procurement.

1.03 DELIVERY, STORAGE, AND HANDLING

A. Deliver materials to job site in original containers labeled with manufacturer's name and material contained.

B. Store materials protected from moisture.

PART 2 PRODUCTS

2.01 MATERIALS

A. Fibrous Glass Pipe Insulation: Owens-Corning Fiberglass Corporation heavy-density sectional-pipe insulation; fibrous glass wool with rosin binder; semicylindrical formed sections, flame-retardant self-sealing lap jacket of laminated aluminum foil, special embossed white kraft paper, flame-retardant snuffer-type adhesive, fiber glass reinforced, 6-lb/ft^3 density; Thermal Conductivity (Btu/h/ft^2/°F/in. thick): 0.24 max for 50°F mean temperature, 0.27 max for 100°F mean temperature, 0.33 max for 200°F mean temperature, ASTM C335.

B. Fibrous Glass Equipment Insulation: Owens-Corning Fiberglass Corporation Type 703 rigid equipment insulation; fibrous glass wool with rosin binder; 24-in. X 48-in. semirigid boards for equipment insulation, 4.2-lb/ft^3 density; Thermal Conductivity (Btu/h/ft^2/°F/in. thick): 0.24 max for 50°F mean temperature, 0.27 max for 100°F mean temperature, 0.33 max for 200°F mean temperature, ASTM C177.

2.02 ACCESSORIES

A. Caulking Mastic: Fomo 5-10 Silicate Sealant, 100°F (37°C) flash point.

B. Lagging Adhesive: Foster Products Corp. 81-42W Lag-Fas, red stripe or Marathon Industries MI-102, color white.

C. Mechanical Fasteners: Erico Fasteners.

D. PVA Mastic: Vimasco WC-1 or Marathon Industries MI-551, color gray to match Chip No. 36440, Federal Standard 595B.

E. Reinforcing Cloth: White open-weave glass cloth, 10 X 10 weave-set mesh with nonasphaltic binder, CCX Fiberglass Products.

F. Seals: Stainless steel, AISI Type 304, 3/8-in., double pronged, A. J. Gerrard.

G. Straps: Aluminum, 3/8 in. X 0.020 in.

H. Straps: Stainless steel, AISI Type 304, 3/8 in. X 0.020 in. and 3/4 in. X 0.020 in.

I. Wire: Stainless steel, AISI Type 304, 18 gage (0.0475 in.), cold-drawn, bright annealed.

J. Wire Netting: Stainless steel, AISI Type 304, 22 gage (0.028 in.), 1-in. hexagonal mesh.

K. Fabricating Adhesive: Foster Products Corp. 85-20, flash point - none.

L. Insulating Cement: Hydraulic setting, Delta-Maid One Shot, asbestos-free.

M. Joint Sealing Strips: 3-in.-wide, self-sealing, matching insulation jacket.

N. Tape: Nashua Corp. 402, 1 in. wide, acetate-back, fiber glass reinforced.

O. Vapor Barrier Mastic: Marathon Industries MI-570, color white.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine surfaces to receive insulation to ensure they are dry and clean.

3.02 PREPARATION

A. Provide adequate ventilation to eliminate fire hazards when flash points of insulation materials are equal to or less than temperature of surrounding atmosphere.

3.03 PIPE INSULATION APPLICATION

A. Follow manufacturer's recommendations for installation of insulating materials.

B. Apply insulation in single layers to maximum thickness practical. When additional thickness is required, apply multiple layers. Apply multiple layer with staggered joints.

C. Protect insulation from moisture when circumstances prevent immediate application of PVA mastic or aluminum jacketing.

D. Insulate fittings, flanges, and valves with covers fabricated from same material and thickness as adjacent pipe.

E. Apply insulation to pipe with joints tightly butted. Seal longitudinal lap of jacket and cover circumferential joints with sealing strips.

F. On cold water piping, seal joints with heavy coating of vapor barrier mastic. Apply to butt edges and inside surface of insulation 2 in. on either side of joint. Press in place while vapor barrier is wet.

G. Insulation: Vaporproof throughout.

H. No additional coating or finish is required on surface of factory-applied flame-retardant jacket [except where aluminum jacketing is specified].

I. Fabricate covers for fittings, flanges, and valves or use factory-molded covers. Valves and fittings 2 in. and smaller may be insulated with insulating cement. Adhere two halves of cover with fabricating adhesive and secure in place with tape or wire. Coat exterior surfaces of fitting covers with 1/8-in.-thick wet film of vapor barrier mastic. When vapor barrier mastic dries, cover joints between cover and adjacent pipe insulation with sealing strips.

J. Allow insulating cement to thoroughly dry before applying vapor barrier mastic.

K. Reinsulate cracks formed due to shrinkage of cement.

L. On outdoor piping, apply waterproof aluminum jacketing over flame-retardant jacket using vapor barrier mastic in place of PVA mastic.

3.04 EQUIPMENT INSULATION APPLICATION

A. Follow manufacturer's recommendations for installation of insulating materials.

B. Apply block or curved segments miter cut to fit neatly on surface with joints tightly butted. Apply segments staggered with linear dimensions of block parallel with axis of equipment. On flat surfaces, apply blocks staggered with joints tightly butted.

C. Support equipment insulation to prevent separation from equipment surface. Support insulation on vertical equipment more than 2 ft in diam or 10 ft in height near bottom. Provide additional supports at approximate 12-ft intervals.

D. Secure insulation on curved surfaces up to 30 in. in diam with 3/8-in. X 0.020-in. stainless steel straps spaced on approximately 9-in. centers. Secure insulation on curved surfaces greater than 30 in. in diam with 3/4-in. X 0.020-in. stainless steel straps.

E. Secure insulation on flat and irregular surfaces with mechanical fasteners spaced approximately $1/ft^2$. Depress clips 1/8 in. below surfaces and point up with insulation cement. Do not allow ends of pins to extend through waterproofing.

F. Stretch wire netting tightly over insulation and trowel a smooth 1/2-in. coat of insulating cement. When insulating cement has dried, coat surface with PVA mastic.

3.05 MASTIC COATING APPLICATION

A. Apply PVA and other mastic coatings by palming, troweling, or spraying. Install glass-fiber cloth embedded in mastic to conceal dry weave of cloth.

B. Lap cloth joints a minimum of 2 in. and apply with a smooth unbroken surface with a minimum finished dried thickness of 1/16 in.

C. When applying mastic coatings by spraying, protect adjacent surfaces that are not to be coated. Obtain approval from CM prior to performing inside spraying.

D. Before applying mastic coating, apply a heavy fillet of caulking mastic to inside corners of insulation and junctions of insulation and metal.

E. Apply double layer of reinforcing cloth in mastic to outside corners of insulation. Round outside corners of insulation.

END OF SECTION

SECTION 15265

ELASTOMERIC RUBBER INSULATION

PART 1 GENERAL

1.01 SECTION INCLUDES: elastomeric rubber insulation for piping and equipment for services operating at temperatures between -40°F (-40°C) and 220°F (104°C) and for low-wattage electric heat-trace applications for freeze protection. [**Designer Note:** Do not use elastomeric rubber insulation on stainless steel piping systems.]

1.02 REFERENCES

A. ASTM C177-85, Standard Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded - Hot-Plate Apparatus (R 1993).

B. ASTM C534-94, Standard Specification for Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form.

C. ASTM E84-94, Standard Test Method for Surface Burning Characteristics of Building Materials.

D. FED-STD-595B-89, Colors Used in Government Procurement.

1.03 DELIVERY, STORAGE, AND HANDLING

A. Deliver materials to job site in original containers labeled with manufacturer's name and material contained.

B. Store materials protected from moisture.

PART 2 PRODUCTS

2.01 MATERIALS

A. Elastomeric Rubber Piping Insulation: Rubatex R-180-FS; ASTM C534, Type I preformed tubes; flame rating: less than 25; smoke density rating: less than 50 for 1/2 in. thickness, ASTM E84, certified by independent testing laboratory; UL listed; temperature rating test (for continuous service -40° to 220°F); ASTM C177; Density: 6 lb/ft^3 max.

B. Elastomeric Rubber Equipment Insulation: Rubatex R-1800-FS; ASTM C534 Type II sheet; flame rating: less than 25; smoke density rating: less than 50 for 1/2 in. thickness, ASTM E84, certified by independent testing laboratory; UL listed; temperature rating test (for continuous service -40° to 220°F); ASTM C177; density: 6 lb/ft^3 max.

2.02 ACCESSORIES

A. Caulking Mastic: Fomo 5-10 Silicate Sealant, 100°F (37°C) flash point.

B. Lagging Adhesive: Foster Products Corp. 81-42W Lag-Fas, red stripe or Marathon Industries MI-102, color white.

C. Mechanical Fasteners: Erico Fasteners.

D. PVA Mastic: Vimasco WC-1 or Marathon Industries MI-551, color gray to match Chip No. 36440, FED-STD-595.

E. Reinforcing Cloth: White open weave glass cloth, 10 X 10 weave-set mesh with nonasphaltic binder, CCX Fiberglass Products.

F. Seals: Stainless steel, AISI Type 304, 3/8 in., double pronged, A. J. Gerrard.

G. Straps: Aluminum, 3/8 in. X 0.020 in.

H. Straps: Stainless steel, AISI Type 304, 3/8 in. X 0.020 in. and 3/4 in. X 0.020 in.

I. Wire: Stainless steel, AISI Type 304, 18 gage (0.0475 in.), cold-drawn, bright annealed.

J. Wire Netting: Stainless steel, AISI Type 304, 22 gage (0.028 in.), 1-in. hexagonal mesh.

K. Contact Adhesive: Rubatex R-373, air drying, compatible with elastomeric rubber insulation, approved by insulation manufacturer.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine surfaces to receive insulation to ensure they are dry and clean.

3.02 PREPARATION

A. Provide adequate ventilation to eliminate fire hazards when flash points of insulation materials are equal to or less than temperature of surrounding atmosphere.

3.03 PIPE INSULATION APPLICATION

A. Follow manufacturer's recommendations for installation of insulating materials.

B. Apply insulation in single layers to maximum thickness practical. When additional thickness is required, apply multiple layers. Apply multiple layers with staggered joints.

C. Protect insulation from moisture when circumstances prevent immediate application of PVA mastic or aluminum jacketing.

D. Insulate fittings, flanges, and valves with covers fabricated from same material and thickness as adjacent pipe.

E. Install elastomeric rubber insulation per manufacturer's recommendations using standard commercial practices.

F. Install piping insulation for thicknesses specified in single layers only [except where specified otherwise]. Provide aluminum jacket for elastomeric rubber insulated pipe.

G. Support pipe insulation with aluminum jacketing.

H. Field cut and form insulation to fit valves, fittings, and equipment. Cover valve, flange, and fitting insulation with preformed or field fabricated, aluminum jacketing.

3.04 EQUIPMENT INSULATION APPLICATION

A. Follow manufacturer's recommendations for installation of insulating materials.

B. Apply block or curved segments miter cut to fit neatly on surface with joints tightly butted. Apply segments staggered with linear dimensions of block parallel with axis of equipment. On flat surfaces, apply blocks staggered with joints tightly butted.

C. Support equipment insulation to prevent separation from equipment surface. Support insulation on vertical equipment more than 2 ft in diam or 10 ft in height near bottom. Provide additional supports at approximate 12-ft intervals.

D. Secure insulation on curved surfaces up to 30 in. in diam with 3/8-in. X 0.020-in. stainless steel straps spaced on approximately 9-in. centers. Secure insulation on curved surfaces greater than 30 in. in diam with 3/4-in. X 0.020-in. stainless steel straps.

E. Secure insulation on flat and irregular surfaces with mechanical fasteners spaced not less than $1/ft^2$. Depress clips 1/8 in. below surfaces and point up with insulation cement. Do not allow ends of pins to extend through waterproofing.

F. Install elastomeric rubber insulation per manufacturer's recommendations using standard commercial practices.

G. Install equipment insulation for thicknesses specified in single layers only [except where specified otherwise].

H. Support equipment insulation per manufacturer's specifications.

3.05 MASTIC COATING APPLICATION

A. Apply PVA and other mastic coatings by palming, troweling, or spraying. Install glass fiber cloth embedded in mastic to conceal dry weave of cloth.

B. Lap cloth joints a minimum of 2 in. and apply with a smooth unbroken surface with a minimum finished dried thickness of 1/16 in.

C. When applying mastic coatings by spraying, protect adjacent surfaces that are not to be coated. Obtain approval from CM prior to performing inside spraying.

D. Before applying mastic coating, apply a heavy fillet of caulking mastic to inside corners of insulation and junctions of insulation and metal.

E. Apply double layer of reinforcing cloth in mastic to outside corners of insulation. Round outside corners of insulation.

3.06 TRACED LINE INSULATION APPLICATION

[**Designer Note:** Include the following requirements for heat-trace applications.]

A. Insulate traced lines with material, size, and thickness specified on drawings.

B. Use insulation with inside diameter to cover heated line and tracer line with minimum clearance.

C. Insulate tracer line from heated line where specified.

D. Apply insulating cement on either side of tracer line at 3-ft intervals to fill voids and prevent sideways movement of insulation.

END OF SECTION

SECTION 15270

ALUMINUM JACKETING

PART 1 GENERAL

1.01 SECTION INCLUDES: aluminum jacketing for insulated pipe and equipment.

1.02 DELIVERY, STORAGE, AND HANDLING

A. Deliver materials to job site in original containers labeled with manufacturer's name and material contained.

B. Store materials protected from moisture.

PART 2 PRODUCTS

2.01 MATERIALS

A. Aluminum Jacketing: 0.016 in. thick, 3003 alloy aluminum sheet, stucco embossed, factory-attached moisture barrier on underside, supplied in 3-ft-wide rolls.

2.02 ACCESSORIES

A. Caulking Mastic: Marathon Industries MI-405, 100°F flash point.

B. Mechanical Fasteners: Erico Fasteners.

C. PVA Mastic: Vimasco WC-1 or Marathon Industries MI-551, color gray to match Chip No. 36440, Federal Standard 595.

D. Seals: Stainless steel, AISI Type 304, 3/8 in., double pronged, A. J. Gerrard.

E. Straps: Aluminum, 3/8 in. X 0.020 in.

F. Straps: Stainless steel, AISI Type 304, 3/8 in. X 0.020 in. and 3/4 in. X 0.020 in.

G. Wire: Stainless steel, AISI Type 304, 18 gage (0.0475 in.), cold-drawn, bright annealed.

H. Wire Netting: Stainless steel, AISI Type 304, 22 gage (0.028 in.), 1-in. hexagonal mesh.

I. Aluminum Paint: Pittsburgh Plate Glass Company, high heat-resistant aluminum paint, No. 6-221.

J. Screws: No. 8 X 1/2-in.-long stainless steel or cadium-plated sheet-metal screws.

PART 3 EXECUTION

3.01 PIPE INSULATION APPLICATION

A. Install insulating materials per manufacturer's recommendations.

B. Install aluminum jacketing per manufacturer's recommendations.

C. Apply aluminum jacketing by lapping, sealing with caulking mastic, and strapping tightly. When necessary, use screws in addition to straps to achieve a tight fit.

D. Use screws on vertical lines at circumferential joints. Space screws a maximum of 6 in. apart with a minimum of two screws per joint.

E. Stiffen exposed longitudinal edge of aluminum jacketing by bending a 1-in. hem on one edge.

F. Lap joints against weather so that water will run off lower edge.

G. Use caulking mastic to seal circumferential laps on horizontal lines, longitudinal laps on vertical lines, and lap formed where aluminum jacketing meets PVA mastic.

H. Prevent corrosion-causing galvanic action by ensuring that aluminum jacketing does not come in direct contact with other metals.

I. Waterproof valve, flange, and fitting covers and irregular shapes with PVA mastic.

J. Paint PVA mastic with one coat of aluminum paint. Paint exposed metal parts (i.e., uninsulated valves, flanges, and fittings) with one coat of aluminum paint.

END OF SECTION

SECTION 15292

THERMAL INSULATION FOR DUCTWORK
FIBROUS GLASS PANELS WITH ALUMINUM FACING

PART 1 GENERAL

1.01 SECTION INCLUDES: Materials and application of fibrous glass insulation with aluminum facing for ductwork systems.

1.02 REFERENCES

A. NFPA 90A-99, Standard for the Installation of Air Conditioning and Ventilating Systems.

PART 2 PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS:

A. Owens-Corning Fiberglas Corporation: Vapor seal duct insulation, Type 705 with FRK facing, Underwriters' Laboratories, Inc. labeled.

B. Johns-Manville: No. 817 with FSK 25 aluminum facing.

2.02 MATERIALS

A. Insulation Materials

1. Insulation materials: Tested in accordance with NFPA 90A and having a flame spread not to exceed 25 nor smoke density of 50.

2. Insulation: Composed of inorganic fibrous glass 1 1/2 in. thick with a resin binder preformed into semirigid panels and covered on one side with an aluminum foil, scrim, and flame-retardant kraft paper facing. [**Designer Note:** If thicker insulation required, edit to indicate desired thickness.]

3. Insulation density: 6 lb/ft^3.

4. Thermal conductivity not to exceed the following:

Mean Temp - EF	Btu/h/ft^2/EF/in. thick
50	0.22
75	0.23
100	0.24

B. Joint tape: 4-in.-wide aluminum foil, scrim, and flame-resistant kraft paper lamination. Paper face to have a pressure-sensitive adhesive with a peel-off protective cover.

C. Insulation pins for attachment to metal surfaces: 12-gage X (length of 1/2 in. longer than insulation thickness) coppered steel weld type with opposite end having a nail-point finish for washer impalement.

D. Insulation anchors for attachment to nonmetallic surfaces: 12-gage X (length of 1/2 in. longer than insulation thickness) coppered steel with pin mechanically connected perpendicular to a 2-in. square perforated light-gage galvanized-steel plate. Opposite end of pin to have a nail-point finish for washer impalement.

E. Washers: Steel with punched and slotted center for fastening to pins.

F. Adhesive for fastening insulation anchors: Type M Black Magic by Miracle Adhesive Corporation.

PART 3 EXECUTION

3.01 INSTALLATION/APPLICATION/ERECTION

A. Clean and dry surfaces to which insulation is applied.

B. Install weld-type insulation pins to metallic surfaces or insulation anchors to nonmetallic surfaces with adhesive. Use sufficient fasteners to hold the insulation firmly against the surface being insulated. A minimum of $1/ft^2$ is required. On surfaces less than 12 in. wide, 1/lin ft is required. Sagging not permitted.

C. Apply insulation with joints tightly butted and fitted to eliminate voids. Do not fill voids with insulating cement, but eliminate by refitting or replacing insulation. Before application, true rounded corners on insulation surfaces to be butted.

D. Cut insulation on top and bottom of horizontal and sloping surfaces to overlap the side insulation allowing top pieces to be supported by side pieces.

E. Impale insulation on fastener pins, and depress clips. Cut fastener pins flush with insulation surface. Cover pins with joint tape.

F. Supporting angles and brackets need not be insulated beyond the thickness of the duct insulation.

G. Cut and bevel insulation to duct surface around Pitot openings, nameplates, and damper locking quadrants. Allow a minimum of 1 in. of metal surface around the opening. Butt insulation directly up to external-type Pitot ports and locking quadrants which extend beyond the insulation thickness.

H. Cover and securely seal joints and exposed edges of insulation and insulation washers with joint tape. Seal insulation facing to form a continuous vapor barrier surface throughout.

END OF SECTION

SECTION 15293

THERMAL INSULATION FOR DUCTWORK
FIBROUS GLASS BLANKET WITH ALUMINUM FACING

PART 1 GENERAL

1.01 SECTION INCLUDES: Application and materials of thermal insulation for ductwork using fibrous glass blanket with aluminum facing.

1.02 REFERENCES

A. NFPA 90A-99, Standard for the Installation of Air Conditioning and Ventilating Systems.

PART 2 PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. Owens-Corning Fiberglas Corporation: All service duct wrap with FRK facing.

B. Johns-Manville: No. R-6 with FSK facing.

2.02 MATERIALS

A. Insulation Material

1. Insulation materials: Tested in accordance with NFPA 90A and having a flame spread not to exceed 25 or smoke density of 50.

2. Insulation: Composed of inorganic fibrous glass 1-1/2 in. thick with a resin binder preformed into a blanket obtainable in rolls. Insulation to be covered on one side with an aluminum foil, scrim, and flame-retardant kraft paper facing. [**Designer Note:** If thicker insulation required, edit to indicate desired thickness.]

3. Insulation density: 3/4 lb/ft^3.

4. Thermal conductivity not to exceed 0.28 $Btu/h/ft^2/°F/in.$ thickness at a mean temperature of 75°F.

B. Joint tape: 4-in.-wide aluminum foil, scrim, and flame-resistant kraft paper lamination. Paper face to have a pressure-sensitive adhesive with a peel-off protective cover. MACTAC as manufactured by Morgan Adhesive Company; Stow, Ohio.

C. Insulation pins for attachment to metal surfaces: 12-gage X (length of 1/2 in. longer than insulation thickness) coppered steel weld type with opposite end having a nail-point finish for washer impalement.

D. Insulation anchors for attachment to nonmetallic surfaces: 12-gage X (length of 1/2 in. longer than insulation thickness) pin mechanically connected perpendicular to a 2-in. square, perforated, light-gage, galvanized-steel plate. Opposite end of pin to have a nail-point finish for washer impalement.

E. Washers: Steel with punched and slotted center for fastening to pins.

F. Adhesive for fastening insulation anchors: HT4620 Anchor Adhesive by Miracle Adhesive Co.

G. Staples: Outward clinch, 9/15-in. leg steel STCR 5019 by Bostitch Division of Textron, Inc.

PART 3 EXECUTION

3.01 INSTALLATION/APPLICATION/ERECTION

A. Clean and dry surfaces to which insulation is applied.

B. Install insulation pins and/or insulation anchors on vertical ductwork 24 in. and larger. On horizontal ductwork 24 in. and larger, use pins or anchors across bottom and sides on approximately 12-in. centers. Sagging not permitted.

C. Apply insulation with joints tightly butted and fitted to eliminate voids. Cut insulation 2 in. longer than needed to encircle duct. Remove 2 in. of insulation to form a facing lap for the longitudinal joint.

D. Impale insulation on fastener pins, and depress washers. Cut fastener pins flush with insulation surface. Cover washers with joint tape.

E. Cut insulation on top and bottom of horizontal and sloping surfaces to overlap the side insulation allowing top pieces to be supported by side pieces.

F. Supporting angles and brackets need not be insulated beyond the thickness of the duct insulation.

G. Cut and bevel insulation to duct surface around Pitot openings, nameplates, and damper locking quadrants. Allow a minimum of 1 in. of metal surface around the opening. Butt insulation directly up to external-type Pitot ports and locking quadrants which extend beyond the insulation thickness.

H. Cover and securely seal joints and exposed edges of insulation with joint tape. Seal insulation facing to form a vapor barrier surface throughout.

I. Staple circumferential and longitudinal joints.

END OF SECTION

SECTION 15501

HEATING, VENTILATING, AND AIR CONDITIONING SYSTEMS
INSTALLATION AND EQUIPMENT

PART 1 GENERAL

1.01 SECTION INCLUDES: The general requirements and related construction specifications and standards required for installation of the heating, ventilating, and air conditioning (HVAC) system(s).

1.02 RELATED SECTIONS

[**Designer Note:** Delete sections that do not apply.]

A. Section 15050, Piping Systems.

B. Section 15902, Ductwork--Insulated and Noninsulated Flexible.

C. Section 15293, Thermal Insulation for Ductwork--Fibrous Glass Blanket with Aluminum Facing.

D. Section 15515, Exterior Ground Loop Heat Exchangers.

E. Section 15540, Water Circulating Pumps for HVAC.

F. Section 15786, Water Source Heat Pumps.

G. Section 15891, Ductwork--Galvanized Steel--Low Velocity and Low Pressure.

H. Section 15950, Testing Adjusting and Balancing.

I. Section 15951, Control System.

J. Section 15952, Copper Control Tubing with Compression Fittings.

K. Section 15954, Plastic Control Tubing.

L. Section 15955, Direct Digital Controls.

M. Section 15956, Control Panels and Instruments.

1.03 REFERENCES

[**Designer Note:** Delete design standards that do not apply. Use site specific design standards if applicable.]

A. ES-5.11-1, Instrument Test Ports, Rectangular Duct With or Without External Insulation.

B. ES-5.11-5, Instrument Test Ports, Round Duct With or Without External Insulation.

C. ES-5.12-1, Fire Damper--Fire Partition, Frame Mounted.

D. ES-5.12-2, Fire Damper--Fire Partition, Duct Mounted.

E. ES-5.12-3, Fire Damper--Fire Partition, Duct Mounted.

F. ES-5.12-4, Fire Damper--Fire Partition, Duct Mounted.

G. ES-5.12-5, Fire Damper--Fire Wall, Opening Mounted.

H. ES-5.12-6, Fire Damper--Fire Wall, Frame Mounted.

I. ES-5.12-7, Fire Damper--Floor Barrier, Frame Mounted.

J. ES-5.12-8, Fire Damper--Floor Barrier, Duct Mounted.

K. ES-5.12-9, Fire Damper--Floor Barrier, Duct Mounted.

L. ES-5.12-10, Fire Damper--Floor Barrier, Duct Mounted.

1.04 SUBMITTALS

A. Submit the following for approval:

1. Manufacturer's data as required by [individual equipment data sheets] [equipment schedules on drawings].

B. Submit the following for information:

1. Manufacturer's certified data as required by [individual equipment data sheets] [equipment schedules on drawings].

1.05 SEQUENCING

A. Refer to Section 15891 for special sequencing requirements of ductwork installation.

PART 2 PRODUCTS

2.01 EQUIPMENT

A. Provide equipment in accordance with the following data sheets.

[**Designer Note:** Data sheets are to have I.D. numbers assigned per the CM standard procedures. The UNC numbers listed below are for illustrative purposes only. Equipment may be specified on design drawing schedules in lieu of data sheets.]

Equipment Description	Data Sheet No.
Air Diffusers	UCN-10533A
Air Louver	UCN-2641W
Automatic Air Damper	UCN-2641EE
Axial Flow Fan	UCN-2641A
Balancing Damper	UCN-2641P
Baseboard Heaters	UCN-2641BH
Brine Cooling Coil	UCN-2641J
Centrifugal Fan	UCN-2641
Control Valve	UCN-2641N
Data Sheet (Plain)	UCN-2641T
Data Sheet Continuation	UCN-2641T2
Electric Duct Heating Coil	UCN-2641M
Electric Unit Heater	UCN-2641Y
Exhaust or Return Grilles/Registers	UCN-10533B
Fan-Coil Air Conditioning Unit	UCN-2641F
Fire Dampers	UCN-2641R
Heating and Ventilating Unit	UCN-2641E
Hot Water Heating Coils	UCN-2641L
Hot Water Unit Heater	UCN-2641V
Manometers	UCN-2641BB
Motor	UCN-2641S
Propeller Fans	UCN-2641C
Roof and Wall Ventilator	UCN-2641D
Steam Unit Heater	UCN-2641X
Supply Grilles/Registers	UCN-10533C
V-Belt Drive	UCN-2641Q

B. Install the following equipment supplied by the CM.

[**Designer Note:** List the equipment that the CM is purchasing or is existing and being relocated, which the Contractor needs to install.]

2.02 FABRICATION

[**Designer Note:** Add special fabrication requirements for specific equipment or systems as required by the site specific requirements.]

PART 3 EXECUTION

3.01 INSTALLATION/APPLICATION/ERECTION

A. Maintain a minimum headroom of 6 ft 8 in. above finished floor. [**Designer Note:** Meets requirements of 29 CFR 1910.37.i. If a different dimension for minimum headroom is required, edit to indicate desired dimension.]

B. Install parts of the system requiring maintenance in an accessible location and position. Carefully coordinate the location of field routed pipes, conduit, and other obstructions to reserve space for equipment removal and maintenance.

C. Follow the published recommendations of the equipment manufacturer while assembling and installing equipment and accessory items. If a conflict should exist between the drawings and the manufacturer's instructions, notify the Construction Manager (CM). The CM will determine the required arrangement.

D. Equipment foundations and anchor bolt locations shown on the drawings are based on catalog data of the equipment specified. Determine the exact locations from certified dimensional drawings furnished by the equipment manufacturer, prior to installation of foundations and anchors.

E. Install vibration isolators in strict accordance with the design and the manufacturer's instructions. Give particular attention to isolator spring adjustment, anchor bolt adjustment, and correct installation of rubber noise pads to minimize the transmission of vibration and noise into the building structures. Equipment mounted on vibration isolators to be free to oscillate and not be restrained by piping, conduit, etc.

F. Provide safety guards to enclose the exposed sides of moving parts on equipment such as couplings, sheaves, and belts. Provide tachometer openings with removable covers for measuring driver and driven shaft speeds without removing guard. [**Designer Note:** Meets requirements of 29 CFR 1910.212.]

G. Provide pipe extensions and fittings for lubricating equipment without shutdown, disassembly, or removal of safety guards.

H. Install flexible connections in ductwork, piping, tubing, and conduit systems as close as possible to the equipment being isolated. Do not install hard connected service piping or electrical conduit in a manner that would void the isolation. Securely support and anchor the end of the flexible connection farthest from the equipment to the building structure.

I. Take care when installing horizontal tube steam coils to ensure proper condensate drainage. Some coils have tubes pitched within the casing while others have tubes parallel to the casing. Closely observe the manufacturer's instructions when setting a specific type of steam coil to ensure complete drainage of condensate.

J. Take precautions when installing cooling coils to obtain rated heat transfer capacities. The location of the coil connections with respect to the direction of airflow shall be carefully adhered to as follows:

1. Orient chilled water coils so that chilled water enters at the bottom of the coil on air-leaving side and that the chilled water return is at the top of the coil on the air-entering side.

2. Orient direct expansion coils so that liquid refrigerant enters on the air-leaving side of the coil and the suction header is on the air-entering side of the coil.

K. Provide stainless steel tags to identify equipment, with embossed or engraved equipment numbers in 1/4-in.-high (min) characters attached with stainless steel pop rivets, plated screws, or stainless steel wire. Tags for panel-mounted instruments, switches, etc., to be standard engraved bakelite with 1/4-in.-high (min) characters, attached by screws or epoxy adhesive.

L. Testing and balancing of HVAC systems to be performed by independent HVAC testing and balancing contractor (Section 15950).

3.02 PROTECTION

A. Take special care to prevent damage to the finned area of coils during handling and installation. Protect the exposed faces of cooling and heating coils within plenums or equipment enclosures using 1/4-in.-thick plywood temporary covers. Install the covers before the coils are rigged into place, and the covers are not be removed until just prior to startup. Covers are not required for the duct-mounted coils, but exercise care to prevent damage to the finned area while inserting the coil. Straighten damaged fins or replace the coil if judged necessary by the CM.

END OF SECTION

SECTION 15515

EXTERIOR GROUND LOOP HEAT EXCHANGERS

PART 1 – GENERAL

1.01 DESCRIPTION

This section shall include providing exterior underground heat pump heat exchangers. The extent of ground heat exchanger work is indicated on the drawings and schedules, and by the requirements of this section. The buried heat exchangers consist of polyethylene heat fusion-joined piping formed into vertical or horizontal loops. [**Designer Note:** If available, polybutylene may be used with approval of CM.] The loops are connected with prefabricated headers and prefabricated vertical heat exchanger U-bend assemblies.

1.02 RELATED WORK SPECIFIED ELSEWHERE

Refer to Division 1 for additional requirements applicable to the work. Also refer to sub-sections listed below.

A. Section 02200 – Earthwork.

B. Section 02225 – Trenching.

C. Section 03600 – Thermal-Enhanced Bentonite Grout.

D. Section 15050 – Piping Systems.

E. Section 15072 – Cleaning.

F. Section 15073 – Pressure/Leak Testing.

G. Section 15110 – Geothermal Heat Pump and Loop Piping Systems (High Density Polyethylene)

H. Section 15786 – Water Source Heat Pumps.

I. Section 15950 – Testing Adjusting and Balancing.

1.03 WARRANTIES

A. Provide manufacturer's standard material warranty for HDPE piping loop. Provide installer’s 1-year warranty on the piping installation.

1.04 SUBMITTALS

A. For Approval:

1. Shop Drawings and Product Data - Submit shop drawings and manufacturers' technical product data for all utility systems specified including all piping and appurtenances.

2. Include submittal for grout material and mix design.

3. Accurately record, on site plan, dimensioned "as built" drawing showing depth and location of horizontal piping and location of each bore, hole, measured from permanent fixture such as corner of building, fire hydrant, etc.

4. Certificates and Test Reports - Provide manufacturers' certificates of compliance (COC) and/or testing reports for pipes, tubing, U-bend heat exchangers, and appurtenances. Submit for review and approval prior to commencement of any pipe or loop installation. [**Designer Note**: The COC's may be omitted at the discretion of the Owner.]

5. Provide Installing Contractor's and Thermal Fusion Technician's records of qualification and related job experience.

6. Submit manufacturer's technical data on fusion machine to be used in fabricating the ground heat exchanger.

7. Copies of applicable pages from County SCS Survey. [**Designer Note**: GIS related information may also be requested .]

8. Loop pressure test procedures and results. Procedures shall be approved prior to commencement of pressure test activities. Provide a 2 working day notification to the CM prior to conducting pressure tests.

1.05 QUALITY ASSURANCE

A. Installing Contractor shall have a minimum of five (5) years experience in designing, installing, and commissioning vertical ground heat exchangers for ground-coupled heat pumps. Five references and contacts for previous jobs of a size and scope comparable to the project under consideration shall be provided. [**Designer Note**: It may be advisable to require that one or more individuals on the work crew have a minimum of three years experience in heat exchanger installation and or have IGSHPA certification.]

B. The Drilling Contractor shall be a State licensed well driller. [**Designer Note**: Verify the applicability of licensing for the state in which the job site is located.] As a minimum, state regulations and guidelines of the National Ground Water Association shall be followed for the backfilling vertical bore holes. Backfill shall be evenly distributed throughout the entire bore to provide maximum heat transfer without voids.

C. Thermal Fusion Technician shall be certified by recognized certification agency and shall have field experience in forming thermally fused joints. Must have completed a polyethylene heat fusion school in which each participant has performed a heat fusion procedure under direct supervision of an IGSHPA-accredited heat fusion technician, as part of an IGSHPA-approved manufacturing certification program, or under direct supervision of a DOT-certified heat fusion technician. Certified technicians must attend a retraining school annually.

D. Manufacturer's Qualifications: Must be regularly engaged in the manufacture of GHP ground heat exchanger materials or fusion equipment for not less than five (5) years. [**Designer Note:** These requirements may be relaxed at the discretion of the Owner in order to accommodate new technology or other suppliers deemed advantageous to the project.]

1.06 REFERENCE STANDARDS

A. ASHRAE 1995 Commercial/Institutional Ground Source Heat Pump Engineering Manual (ISBN 1-883413-21-4)

B. ASHRAE 1997 Ground Source Heat Pumps: Design of Geothermal Systems for Commerical and Institutional Buildings. (S.P. Kavanaugh and K. Rafferty) (ISBN 1-883413-52-4)

C. County Soil Conservation Service Soil Survey [**Designer Note**: Also may include GIS information.]

D. State Drilling Logs for local area [**Designer Note**: Also may include GIS information.]

E. IGSHPA 1997 Closed Loop/Geothermal Heat Pump Systems Design and Installation Standards

F. IGSHPA 1988 Closed Loop/Ground-Source Heat Pump Systems Installation Guide

G. IGSHPA 1989 Soil and Rock Classification for the Design of Ground-Coupled Heat Pump Systems – Field Manual

H. IGSHPA 1991Grouting Procedures for Geothermal Heat Pump Systems

I. IGSHPA 1994 Closed-Loop Geothermal Systems: Slinky Installation Guide

J. IGSHPA 1997 Geothermal Heat Pump System Design Training for Architects and Engineers – Appendices and Manual

K. EPRI 1994 Water-Loop Heat Pump Systems Vol. 1, Rev. 1

L. Cost Containment for GSHP Systems by Steve Kavanaugh & Christopher Gilbert

M. Grout Thermal Conductivity and Vertical Loop Design by C. P. Remund

N. National Ground Water Association's Guidelines for the Construction of Vertical Boreholes for Clossed Loop Heat Pump Systems.

PART 2 - PRODUCTS

2.01 MATERIALS AND MIXES

A. Grout: High-solids bentonite grout, bags labeled "Grout" ('GEL" label is not acceptable). Paddle mix grout with minimum shearing action and agitation of the slurry. See Section 03600.

B. Concrete: All concrete shall have 3000 psi 28 days compressive strength, air entrained and shall conform to ASTM C94 for ready mixed concrete.

2.02 FABRICATION AND MANUFACTURE

A. Heat Pump Water Piping and Fittings:

1. Materials: Virgin prime and comply with IGSHPA Standard I.C.3 for polyethylene with a minimum cell classification of PE345434C per ASTM D3350. See Section 15110.

B. Fittings shall be compatible with the pipe material or from the same material as the pipes.

C. Joints:

1. Thermally fused or mechanically joined per IGSHPA Standards. [**Designer Note**: No socket fusion (except electro-fusion) on pipe larger than 2".]

2. No joints in vertical tubing; maximum two joints at return U-bend. [**Designer Note:** May be useful to specify that the return U-bend be factory equipped with anti-buoyancy port, but limits to competition may also be a result of this requirement.]

D. Miscellaneous:

1. Markings: Pipe shall be marked with manufacturer's name and product name, nominal size, ASTM dimensional standard, PPI material classification, cell classification, sequential footage, and manufacturer's date code. Print line shall repeat every two feet.

E. GLYCOL SOLUTION

[**Designer Note**: Glycol may not be required on all systems, particularly larger commercial systems. The design engineer is responsible for determining by calculation the lowest loop temperature likely to be encountered and apply the appropriate percentage of glycol to prevent freezing. Glycol will also increase pumping costs for the system. Many systems may only require the introduction of inhibitors to prevent corrosion and scaling. The information presented below on glycol is to address such a possibility and is not mandatory for all systems.]

1. Heat pump water: Softened water and, 22% by volume, Dow-Frost (or approved equal) propylene glycol. Coordinate with General Contractor.

[**Designer Note**: The following antifreeze solutions could also be specified. All are currently EPA approved. The various weight by %, mean temperature, freeze point, density and volumetric heat capacity at various mixes should be specified -- Methanol/Water; Ethylene Glycol/Water; Sodium Chloride/Water; Calcium Chloride/Water.]

PART 3 - EXECUTION

3.01 GENERAL

A. Protection of Existing Utilities Structures. Protect the existing utilities shown on the drawings or the locations of which are known prior to excavation, from damage during excavation and backfilling of trenches and, if damaged, repair them at no expense to the Owner.

B. Any existing line or utility structure which is not shown on the drawings or the location of which is not made known in sufficient time to avoid damage, if inadvertently damaged, shall be repaired by the Contractor and an adjustment in payment will be made in accordance with "General Conditions".

C. Make repairs under the supervision of the utility concerned.

D. Contract for a thermal conductivity test for actual soil performance data. [**Designer Note**: The thermal conductivity test should be the first thing done for a potential GHP project. This test is used to aid in sizing the GHP bore field and piping systems.]

E. Ground field layout shall be capable of being purged of air and debris, balanced within 15 percent without flow regulators, and connected in a minimum number of trenches and/or pits.

F. Fill U-bend loops with water and insert the U-bend into the bore to the depth stated in the design documents.

G. Examine areas and conditions under which ground heat exchanger systems are to be installed. Verify that the loop layout is appropriate for site conditions. After approval from CM, correct site problems before proceeding.

3.02 PREPARATION - EXCAVATION

A. General: Perform all excavation of every description and of whatever substances encountered, to the depths required or indicated on the drawings, in accordance with OSHA.

1. During excavation, deposit material suitable for backfill in an orderly manner a sufficient distance from the excavation banks to avoid overloading and to prevent slides or cave-ins. Dispose of material unsuitable for backfill as directed by the CM.

2. Grade as necessary to prevent surface water from flowing into trenches or other excavations, and remove any water accumulating therein by pumping or by other acceptable method.

3. Unless otherwise specified, all excavation shall be by open cut. Fill any excess excavation below the levels indicated for structures or pipe with sand, gravel or concrete, as directed by the CM.

B. Trench Excavation: Excavate true to line to an elevation at least 2 feet above the top of pipe to provide a clear space on either side of the pipe to facilitate bedding. See Section 02225 for details.

1. Heat pump water piping shall be provided with a minimum cover of four (4) feet. [**Designer Note:** Five to six feet of minimum cover is recommended by some reference sources.]

2. Replace any material excavated beneath pipe entering and leaving manholes with sand or gravel fill and extend such fill to the center of pipe for a distance of at least 3 feet from face of manhole and terminate at a joint.

3. Subsurface Soil Data: [**Designer Note**: Add soil borings information as an attachment to this section, if available.]

4. Unsuitable Material: Where the bottom of the trench is found to be unstable or to include ashes, cinders, all types of refuse, vegetable or other organic material, or large pieces of fragments of inorganic material, which in the judgement of the CM should be removed, excavate and remove such unsuitable material to a minimum depth of 12 inches below the pipe.

5. Backfill the trench with selected bedding material and compact to provide uniform and continuous bearing for the pipe. Dispose of the unsuitable material as directed by the CM.

C. Borrow: When borrow areas are not indicated on the plans, it is the Contractor's responsibility to locate and obtain borrow material, subject to the acceptance by the CM.

D. Shoring Requirements: Perform all shoring and sheeting that is required to protect the excavation and to safeguard employees in accordance with OSHA. Widen excavation to provide for space occupied by shoring and sheeting.

E. Shoring shall meet the requirements of all applicable codes and regulations.

F. Cold Weather Protection. Protect excavation bottoms against freezing when atmospheric temperature is less than 35°F.

G. Dewatering: Do not allow water to accumulate in excavations. Prevent surface water and subsurface or ground water from flowing into excavations. See section 02225 for details.

H. Provide and maintain pumps, well points, sumps, suction and discharge lines, and other dewatering system components necessary to convey water away from excavations.

I. Do not use trench excavations as temporary drainage ditches. See section 02225 for details on diverting ditches.

3.03 INSTALLATION

A. Excavation and vertical drilling work shall be performed by qualified Contractors as defined in 1.05 above.

B. Pipe shall be installed in accordance with recommendations of ASHRAE and IGSHPA. Pipe joints shall be heat fusion type and shall be made as recommended by the pipe manufacturer.

C. Open ends of all pipe shall be sealed to prevent entry of contaminants until final connections are made.

D. Vertical loop piping shall be filled with water and pressure tested prior to insertion into the bore hole and tested again after manifolding. Refer to Section 15073 for test pressures and times. [**Designer Note**: When the manufacturer seals the assembly and ships under air pressure, the first pressure test may be omitted at the discretion of the CM.]

E. After connection to the vertical loop piping and prior to backfilling, each lateral shall be filled with water and pressure tested. Refer to Section 15073 for test pressures and times.

F. Results of all tests shall be recorded and supplied to the CM upon completion of the project.

G. All final tests shall be witnessed by and the report signed by the CM. Provide minimum of 2 working days advance notice to the CM prior to testing. [**Designer Note**: It may be advantageous to specify what part of the system is defined as the final test, i.e. lateral (=circuit header) + its boreholes, or of total loop field.]

H. Grouting: Vertical bore holes shall, as a minimum, be grouted in adherence with all state and local requirements and with the guidelines of NGWA. Since settling of the grouting material may occur after the initial grouting, Contractor shall monitor each bore hole and continue adding grout as required. Refer to Section 03600. [**Designer Note**: If complete bottom to top grouting of vertical bores is required or desired, the tremie pipe method, or equal approved by the CM, shall be used to assure sealing and good thermal conductivity between the earth and the pipe.]

I. Use temporary casings to support unstable soils. [**Designer Note**: In some instances the casings may be left intact provided the appropriate grouting and sealing is performed between the casing and the ground.]

3.04 BACKFILL

A. General: Do not backfill trenches until all required inspections are made and tests are performed.

B. Backfill horizontal trenches with the excavated materials specified for back filling and in accordance with section 02225. Broken concrete shall not be used as backfill material.

C. No backfilling shall take place in freezing weather, and no backfill shall be made with frozen material. [**Designer Note**: If unfrozen fill is available, it may be used a backfill material.]

D. Adjust the moisture content of the backfill material if required for proper compaction.

E. Reopen any trenches improperly backfilled, or where settlement occurs, to the depth required for proper compaction, refill and compact to specified density.

F. Compact all backfill for structures to the specified density.

G. Around Horizontal Pipe: Deposit backfill around the pipe in 6 inch layers and thoroughly compact. Refer to Section 02200. Be careful not to disturb the pipe. Perform back filling simultaneously on both sides of the pipe.

H. Remainder of Trench: Deposit suitable backfill material in layers not exceeding 6 inches in loose depth and thoroughly compact each layer.

I. Bedding: Crushed rock, sand, or gravel bedding, as defined in section 02200, shall be used where selected bedding material is required by the drawings, specifications or CM during construction to replace unsuitable foundation material.

J. Warning tape shall be of the type specifically manufactured for marking and locating underground utilities. The tape shall be installed directly above the pipe, at a depth of 18 inches below finished grade unless otherwise shown. The tape shall be acid- and alkali-resistant polyethylene film, 6 inches wide with minimum thickness of 0.004 inch and shall have a minimum strength of 1750 psi lengthwise and 1500 psi crosswise with an elongation factor of 350 percent. Tape color shall be yellow and shall bear a continuous printed inscription describing the service. Tape shall have integral wires, foil backing, or other means to enable detection by a metal detector when the tape is buried up to 3 feet deep. The metallic core shall be encased in a protective jacket or provided with other means to protect it from corrosion.

3.05 ADJUSTMENTS AND CLEANING

A. Pressure Testing

1. Utilizing the purging unit and the procedures recommended by IGSHPA, conduct a pressure and flow test on the ground heat exchanger to ensure the system is free of blockage. If the flow test indicates blockage, locate the blockage using the manufacturer's recommendation, remove the blockage, then purge and conduct the pressure and flow test again until all portions of the system are free-flowing**. [Designer Note:** This test may be required to be performed on each individual borehole and for individual circuits rather on a system wide basis only. It should be performed prior to backfilling the trenches.]

2. The flow test shall be observed and approved by the CM. Form 1, "Ground Heat Exchanger Inspection and Test Report," attached, shall be completed for each system by the CM before the systems can be backfilled.

B. Flushing and Purging:

1. Configure flushing/purging unit as recommended by IGSHPA and Section 15072.

2. Flush lines and appurtenances as required to remove all dirt and contaminants within the piping system with potable water until no dirty water appears at outlet.

3. Purge air from system, or sections of system, by maintaining minimum of 2 feet per second through all pipe. Purge until no air bubbles are observed leaving the system.

4. Notify CM minimum 2 days before flushing operation.

5. Utilize a portable temporary purging unit consisting of the following (see IGSHPA Closed Loop Ground Source Heat Pump Systems Installation Guide, Figures 7.7 & 7.8, pages 152-3):

   a) High volume, high head purge pump capable of maintaining the required purge velocity in all sections of the pipe.

   b) Open reservoir with inlet and outlet valves and pressure gauge

c) Filter assembly with bypass

d) Flow meter

e) Pressure gauge

f) Connecting piping

g) Connecting hoses

6. Using a purge pump and the procedures recommended by IGSHPA, flush and purge each ground heat exchanger system at 2 fps flow velocity until free of air, dirt, and debris. Perform the flushing and purging operation with the water source heat pumps isolated by shut-off valves from the ground heat exchanger system.

7. After the ground heat exchanger is completely flushed of air and debris, open the isolation valves and permit circulation through the heat pumps until the entire system is flushed and purged. Allow pump to run 15 minutes after the last air bubbles have been removed. [**Designer Note:** In some systems, it will be better to purge the interior loop and heat pumps before circulating through the ground loop.]

8. After purging has been completed, add the required amount of antifreeze to the system. Test the solution with a hydrometer to determine the actual freezing point.

3.06 REPORTS

A. The following reports shall be submitted to the CM for information.

1. SCS Soil Survey for site.

2. Drillers logs to depth in local area.

3. Meeting notes with utility supervisor on surface-to-15-ft. (4.6 m) soils previously encountered in area (as applicable).

4. Site layout of loop, header, warning tape, installation locations and lengths.

5. In situ loop thermal test report.

6. Purge pump specifications.

END OF SECTION

Ground Heat Exchanger (GHX) Inspection And Test Report (Form 1)

Note: Use a separate form for each system.

Building: Inspection Date:

Ground Heat Exchanger No. or Description:

List the WSHP Unit Nos. served by this GHX:

Ground Heat Exchanger Design Water Flow: gal/min

Calculated purging flow and press to achieve 2 ft/sec:

Purging: Flow: gal/min Head: psi Duration: min.

Did the system pass the pressure test? ☐ yes ☐ no

How much did -inch diameter reservoir level reservoir level change with ΔP? inches

Is antifreeze required in system? ☐ yes ☐ no If yes, was antifreeze measured? ☐ yes ☐ no

Has a dimensioned drawing been prepared, completely and accurately showing the layout of the GHX?
☐ yes ☐ no

Does the layout differ substantially from the contract documents? ☐ yes ☐ no
If so, is the deviation approved? ☐ yes ☐ no

Depth of installed vertical loops is ft. (Design is ft.)

Depth of horizontal piping is ft. (Design is ft.)

Are the trenches clear of sharp bends, rocks, or other sharp objects that could restrict the flow?
☐ yes ☐ no

Are all the joints heat fused (butt-, socket-, or saddle-fusion)? ☐ yes ☐ no
Do all the joints have the proper amount of roll-out? ☐ yes ☐ no

Has the piping material been cut out and properly removed from all saddle-fusion tees? ☐ yes ☐ no

Was the system backfilled properly with good, clean backfill materials? ☐ yes ☐ no

Comments:

Inspected and approved this ______________________(date)

By: Title:

SECTION 15540

WATER CIRCULATING PUMPS FOR HVAC

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this and other Sections of Division 15.

B. Section 16484, Adjustable Frequency Drive for A-C Induction Motors.

1.02 SUMMARY

A. This Section includes the following categories of HVAC pumps for hydronic systems:

1. End-suction pumps.

1.03 PERFORMANCE REQUIREMENTS

A. Pump Pressure Ratings: At least equal to system's maximum operating pressure at point where installed, but not less than specified.

B. Pumps greater than 2 horsepower shall be certified for use with Variable Speed Drives (VSD) by the manufacturer.

1.04 SUBMITTALS

A. General: Follow the procedures specified in Division 1 and Section 15050 – Piping Systems.

B. Product data including certified performance curves and rated capacities of selected models, weights, furnished specialties, and accessories. Indicate pump's operating point on curves.

C. Wiring diagrams detailing wiring for power, signal, and control systems and differentiating between manufacturer-installed wiring and field-installed wiring.

D. Maintenance data for pumps to include in the operation and maintenance manual specified in Division 1. Include startup instructions.

1.05 QUALITY ASSURANCE

A. Regulatory Requirements: Comply with provisions of the following:

1. ASME B31.9 "Building Services Piping" for piping materials and installation.

2. Hydraulic Institute's "Standards for Centrifugal, Rotary & Reciprocating Pumps" for pump design, manufacture, testing, and installation.

3. UL 778 "Standard for Motor Operated Water Pumps" for construction requirements. Include UL listing and labeling.

4. NEMA MG 1 "Standard for Motors and Generators" for electric motors. Include NEMA listing and labeling.

5. NFPA 70 "National Electrical Code" for electrical components and installation.

B. Single-Source Responsibility: Obtain each category of pumps from 1 source and by a single manufacturer.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Store pumps in dry location.

B. Retain shipping flange protective covers and protective coatings during storage.

C. Protect bearings and couplings against damage from sand, grit, and other foreign matter.

D. Extended Storage Longer than 5 Days: Dry internal parts with hot air or vacuum-producing device. Coat internal parts with light oil, kerosene, or antifreeze after drying. Dismantle bearings and couplings; dry; coat with acid-free, heavy oil; tag; and store in dry location.

E. Comply with pump manufacturer's rigging instructions.

PART 2 PRODUCTS

2.01 PUMPS, GENERAL

A. General: Factory assembled and tested.

B. Base-Mounted Pumps: Include pump casings that allow removal and replacement of impellers without disconnecting piping.

C. Types, Sizes, Capacities, and Characteristics: As indicated on drawings.

D. Motors (Less than 5 HP): NEMA MG 1, general purpose, continuous duty, Design B, except Design C where required for high starting torque. Furnish single-, multiple-, or variable-speed motors, with type of enclosures and electrical characteristics indicated. Include built-in thermal-overload protection and grease-lubricated ball bearings. Select each motor to be non-overloading over full range of pump performance curve.

E. Motors Above 5 HP Shall Be Energy Efficient: Minimum efficiency as indicated according to IEEE 112, Test Method B. Include motors with higher efficiency than "average standard industry motors" according to IEEE 112, Test Method B, if efficiency is not indicated. Select each motor to be non-overloading over full range of pump performance curve.

F. Motors greater than 2 HP shall be certified for use with variable speed drives by the manufacturer.

F. Factory Finish: Manufacturer's standard paint applied to factory-assembled and -tested units before shipping.

G. Manufacturer's Preparation for Shipping: Clean flanges and exposed machined metal surfaces and treat with anticorrosion compound after assembly and testing. Protect flanges, pipe openings, and nozzles with wooden flange covers or with screwed-in plugs.

2.02 SEPARATELY COUPLED, END-SUCTION PUMPS

[**Designer Note:** The following is typical wording for an end suction type water circulating pump. Other types of pumps may also be applicable to GHP water circulation service such as in-line pumps and horizontally split case pumps. Examples of these two types of pumps are as follows: in-line -- B&G series 60, 80, 90, &100; horizontally split case – B&G series HSC. Pump selection for the specific application is the designer's responsibility.]

A. Description: Supported-volute, centrifugal, separately coupled, end-suction, single-stage, bronze-fitted, radially split case design; rated for a minimum 175-psig (1200-kPa) working pressure and a continuous water temperature of 225°F (107°C). Include back-pull-out design, except where other design is indicated, and the following:

1. Casing: Cast iron, with flanged piping connections, drain plug in bottom of volute, and threaded gage tappings at inlet and outlet flange connections. Include integral feet or other means on volute to support weight of casing and attached piping.

2. Impeller: ASTM B 584, cast bronze, statically and dynamically balanced, closed, overhung, single suction, keyed to shaft, and secured by locking cap screw.

3. Wearing Rings: Replaceable, bronze casing ring.

4. Shaft and Sleeve: Steel shaft with bronze sleeve.

5. Seals: Mechanical type with flushing provision. Include carbon-steel rotating ring, stainless-steel spring, ceramic seat, and flexible bellows and gasket rated for 225°F minimum.

6. Coupling: Flexible, capable of absorbing torsional vibration and shaft misalignment.

7. Coupling Guard: Steel, removable, and attached to mounting frame.

8. Mounting Frame: Welded-steel frame and cross members, factory-fabricated from ASTM A 36 (ASTM A 36M) channels and angles. Fabricate for mounting pump casing, coupling guard, and motor. Grind welds smooth before application of factory finish. Field-drill motor-mounting holes for field-installed motors.

   a. Option: Frame may be cast iron instead of steel.

9. Motor: Secured to mounting frame, with adjustable alignment.

2.03 PUMP SPECIALTY FITTINGS

A. Include the following pump specialty fittings with end connections matching pump and piping, where indicated:

1. Suction Diffuser: Angle or straight pattern, 175-psig (1200-kPa) pressure rating, cast-iron body and end cap, pump-inlet fitting. Include bronze startup and bronze or stainless-steel permanent strainers; bronze or stainless-steel straightening vanes; drain plug; and factory- or field-fabricated support.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine areas, equipment foundations, and conditions, with Installer present, for compliance with requirements for installation and other conditions affecting performance of pumps.

B. Examine roughing-in for piping systems to verify actual locations of piping connections before pump installation.

C. Examine foundations for suitable conditions where pumps are to be installed.

D. Do not proceed until unsatisfactory conditions have been corrected.

3.02 CONCRETE

A. Install concrete bases of dimensions 6 inches greater on all sides than pump dimensions.

3.03 INSTALLATION

A. Install pumps according to manufacturer's written installation and alignment instructions.

B. Install pumps in locations indicated and arranged to provide access for periodic maintenance, including removal of motors, impellers, couplings, and accessories.

C. Support pumps and piping separately so that piping is not supported by pumps.

3.04 ALIGNMENT

A. Align pump and motor shafts and piping connections after setting them on foundations, after grout has been set and foundation bolts have been tightened, and after piping connections have been made.

B. Comply with pump and coupling manufacturers' written instructions.

C. Adjust alignment of pump and motor shafts for angular and parallel alignment.

D. After alignment is correct, tighten foundation bolts evenly but not too firmly. Fill base plate completely with nonshrink, nonmetallic grout, with metal blocks and shims or wedges in place. After grout has cured, fully tighten foundation bolts.

E. Alignment Tolerances: According to manufacturer's recommendations.

3.05 CONNECTIONS

A. General: Install shutoff valve and suction diffuser on pump suction and check valve, circuit setter and shutoff valve on pump discharge, except where other arrangement is indicated.

B. Connect piping to pumps as indicated. Install valves that are the same size as piping. Reductions to pump inlet and outlet connections shall be made at the connection to the equipment.

C. Install suction and discharge pipe sizes equal to or greater than the diameter of pump nozzles as indicated on the drawings.

D. Install flexible connectors on suction and discharge sides of base-mounted pumps and where indicated. Install between pump casing and valves, except where other arrangement is indicated.

E. Install thermometers where indicated.

F. Install temperature and pressure gage connector plugs in suction and discharge piping around each pump, and as detailed on the drawings.

G. Install electrical connections for power, controls, and devices.

H. Electrical power and control wiring and connections are specified in Division 16 Sections.

3.06 FIELD QUALITY CONTROL

A. Check suction piping connections for tightness to avoid drawing air into pumps.

B. Clean strainers.

C. Set pump controls.

3.07 COMMISSIONING

A. Final Checks Before Startup: Perform the following preventive maintenance operations and checks before startup:

1. Lubricate bearings.

2. Remove grease-lubricated bearing covers, flush bearings with kerosene, and clean thoroughly. Fill with new lubricant as per manufacturer's requirements.

3. Disconnect coupling and check motor for proper rotation that matches direction marked on pump casing.

4. Check that pumps are free to rotate by hand. Pumps for handling hot liquids shall be free to rotate with pump hot and cold. Do not operate pump if it is bound or even drags slightly until cause of trouble is determined and corrected.

5. Check that pump controls are correct for required application.

B. Starting procedure for pumps:

1. Prime pumps, opening suction valve, closing drains, and preparing pumps for operation.

2. Open circulating line valves if pumps should not be operated against dead shutoff.

3. Start motors.

4. Open discharge valves slowly.

5. Check general mechanical operation of pumps and motors.

C. Refer to Section 15950, "Testing, Adjusting, and Balancing", for detailed requirements for testing, adjusting, and balancing hydronic systems.

END OF SECTION

SECTION 15545

SUBMERSIBLE WELL PUMP

PART 1 GENERAL

1.01 SECTION INCLUDES: The contractor shall provide and install a complete submersible type well pump including intake strainer, pump bowl assembly, column, surface pedestal and submersible electric motor.

1.02 REFERENCES

A. National Electrical Manufacturers Association (NEMA)

B. ANSI B16.5-88, Pipe Flanges and Flanged Fittings; Addenda B16.5A-92.

PART 2 PRODUCTS

2.01 OPERATING CONDITIONS

[**Designer Note:** These values must be input for the site specific design conditions.]

1.) Pump housing casing diameter _______ inches
2.) Well total depth _______ ft
3.) Static water level (below casing top) _______ ft
4.) Pumping level (at design flow) _______ ft
5.) Total pump head (exclusive of column) _______ ft
6.) Required pump capacity _______ ft
7.) Well water temperature _______ F
8.) Expected operating flow range _______ to ______gpm
9.) Distance from wellhead to starter _______ ft
10.) Operating voltage _______ volts

2.02 MATERIALS

A. Motor

1. The submersible electric motor shall conform to the latest National Electrical Manufacturers Association (NEMA) specifications for submersible motors. The motor thrust bearing shall be sized to carry the weight of all rotating parts plus the hydraulic thrust of the motor regardless of the direction of rotation.

2. The motor shall be of squirrel cage induction type, suitable for across the line starting (and variable speed operation in conjunction with an adjustable frequency drive) and continuous operation in _____ F [**Designer Note:** Input the expected well water temperature.] water. The output shaft shall be 416 stainless steel. All fasteners exposed to the well water shall be of stainless steel.

B. Pump/Motor Coupling

1. The coupling shall be of 416 stainless steel and shall be capable of transmitting the total torque of the unit, regardless of the direction of rotation.

C. Inter-connector

1. The inter-connector shall be constructed of close-grained cast iron and shall connect the motor and bowl unit. It shall incorporate a bronze bearing with a length to shaft ration of at least 3:1. This bearing shall be protected from sand by a labyrinth type sand slinger. The inter-connector shall include a suction screen which has a net open area of at least 4 times the eye of the impeller. The screen shall be made of corrosion resistant material.

D. Pump

1. The pump supplied under this specification shall be of the multi stage turbine type. It shall be fitted with a stainless steel (410 or 416) shaft. Impellers shall be of SAE 40 bronze or enamel lined cast iron. Bowls (impeller housings) shall be of close grained cast iron with allowances for replacement of the wear rings. Bowls shall include sufficient clearance for impeller movement resulting from the combination of thermal expansion, dead weight and hydraulic thrust.

2. Impellers shall be securely fastened to the shaft using stainless steel split bushings. Impellers shall be adjustable vertically by an external means.

3. Pump shaft bearings shall be of SAE 660 bronze and shall be located above and below each impeller. The length of the top and bottom bearings shall be a minimum of 3 times the shaft diameter.

4. The pump shall be designed for continuous operation in ______ F [**Designer Note:** Input the expected well water temperature.] water of the chemical character described in the attached analysis results. Pump shall be selected for a minimum efficiency at the design flow rate of _____ %. [**Designer Note:** Input the desired pump efficiency.]

E. Surface Plate

1. The base plate shall be constructed of carbon steel plate of a minimum 1" thickness and shall rigidly support the weight of the motor, column pipe, pump, cable bowl assembly and column of water. It shall be equipped with a nominal ______ inch, [**Designer Note:** Input the desired flange size.] ANSI B16.5, 150 lb flanged connection for the production flow connection to the system.

F. Column

1. The column pipe shall be standard weight carbon steel pipe sized for a velocity at peak flow of not greater than ______ (5) ft/sec.

G. Submersible Cable

1. The cable shall be sized to limit the voltage drop to less than 2% at the motor terminals. Three separate conductors shall be furnished. The conductor insulation shall be water and oil resistant and suitable for continuous immersion.

2. The length of the cable to be furnished shall be the sum of the pump setting depth, including the bowl assembly, plus one foot for each 50 feet of setting, plus ______ [**Designer Note:** Input the desired distance to the pump panel.] feet to extend from the well head to the pump panel or junction box. The cable will be suitably supported from the pump column.

PART 3 EXECUTION

NOT USED

END OF SECTION

SECTION 15550

OPEN LINESHAFT, WATER LUBRICATED TURBINE PUMP

PART 1 GENERAL

1.01 SECTION INCLUDES: The contractor shall provide and install a complete water lubricated, open lineshaft turbine type well pump including intake strainer, pump bowl assembly, open type column with shaft and bearings, surface pedestal and vertical hollow shaft electric motor.

1.02 RELATED SECTIONS

A. Section 16484, Adjustable Frequency Drive for A-C Induction Motors.

1.03 REFERENCES

B. National Electrical Manufacturers Association (NEMA)

C. ASTM C1045-97, Standard Practice for Calculating Thermal Transmission Properties Under Steady-State Conditions

D. ANSI B 16.5-88, Pipe Flanges and Flanged Fittings; Addenda B16.5A-92.

PART 2 PRODUCTS

2.01 OPERATING CONDITIONS

[**Designer Note:** These values must be input for the site specific design conditions.]
Operating Conditions:

1.)	Pump housing casing diameter	_______ inches
2.)	Well total depth	_______ ft
3.)	Static water level (below casing top)	_______ ft
4.)	Pumping level (at design flow)	_______ ft
5.)	Total pump head (exclusive of column)	_______ ft
6.)	Required pump capacity	_______ ft
7.)	Well water temperature	_______ F
8.)	Expected operating flow range	______ to ______gpm

2.02 MATERIALS

A. Column, Shaft and Bearings

1. The lineshaft shall be of carbon steel turned and ground. It shall be furnished in interchangeable sections not more than _____ [**Designer Note:** Input for the site specific design conditions or desired length.] ft in length. The butting faces shall be machined square with the axis of the shaft. The diameter of the shaft shall be not less than that determined by ASA Specifications B58, Section 4.5, Table 5.6. Material shall be ________________ [**Designer Note:** Input desired grade of ASTM C1045.] steel and shall be of sufficient diameter that the elongation due to the combination of hydraulic thrust and dead weight loads shall not exceed the axial clearance available to the impellers in the bowls.

2. Shaft sections shall be joined by steel couplings of a design which incorporates a safety factor of 1.5 times the shaft safety factor. Coupling threads shall be left hand. A flame sprayed stainless steel or chrome plated section shall be provided on the shaft surface at each bearing.

3. The lineshaft bearings shall be constructed of ________________[**Designer Note:** Input for the site specific design conditions or desired material (neoprene)] and spaced not more than _____ [**Designer Note:** Input for the site specific design conditions or desired length (10).] ft apart. The bearing shall contain spiral grooves to accommodate water flow.

4. The column shall be of butt welded steel pipe in interchangeable sections not more than _____ [**Designer Note:** Input for the site specific design conditions or desired length (20).] ft in length. The ends of the section shall be faced parallel and machined to permit the ends to butt and insuring alignment when connected to standard mill couplings.

5. No coatings shall be applied to the wetted surfaces of the column assembly without approval of the Engineer.

B. Pump

1. The pump supplied under this specification shall be of the multi-stage turbine type. It shall be fitted with a stainless steel (410 or 416) shaft. Impellers shall be of SAE 40 bronze or enamel lined cast iron. Bowls (impeller housings) shall be of close grained cast iron with allowances for replacement of the wear rings. Bowls shall include sufficient clearance for impeller movement resulting from the combination of thermal expansion, dead weight and hydraulic thrust.

2. Impellers shall be securely fastened to the shaft using stainless steel split bushings. Impellers shall be adjustable vertically by an external means.

3. Pump shaft bearings shall be of SAE 660 bronze and shall be located above and below each impeller. The length of the top and bottom bearings shall be a minimum of 3 times the shaft diameter.

4. The pump shall be designed for continuous operation in ______ F [**Designer Note:** Input for the site specific well water temperature)] water of the chemical character described in the attached analysis results. Pump shall be selected for a minimum efficiency at the design flow rate of _____ %.

5. A suction pipe of _____ [**Designer Note:** Input for the site specific design conditions or desired length (10).] ft in length and the same diameter as the column shall be attached to the pump intake. A strainer having a net open area of not less than 4 times the area of the suction pipe shall be attached to the suction pipe. Strainer openings shall be a minimum of 3/4" in diameter.

C. Discharge Head

1. A discharge head constructed of cast iron, fabricated steel) shall be provided to support the weight of the pump assembly and to provide a conduit for the production flow. A nominal _____ [**Designer Note:** Input for the site specific design conditions or desired size.] inch ANSI B 16.5, 150 lb flanged outlet shall be provided with a companion flange threaded for ______ [**Designer Note:** Input for the site specific design conditions or desired size.] inch pipe.

2. The head shaft shall be of type 416 stainless steel and not less than 10 ft in length. An adjusting method shall be provided at the top of the head shaft to allow impeller adjustment.

D. Motor

1. The motor shall be a vertical, hollow shaft, TEFC, induction type, premium efficiency with a guaranteed minimum efficiency of _____ % [**Designer Note:** Input for the site specific design conditions or desired efficiency.] at full load. It shall be design for operation at 440 VAC and equipped with Class F insulation suitable for operation with a variable frequency drive.

2. The motor shall contain sufficient thrust bearings to carry the weight of all the rotating parts plus the hydraulic thrust of the pump impellers at the point of maximum thrust. A non reversing ratchet mechanism shall be installed on top of the motor to prevent pump back spin on shut down. [**Designer Note:** A non reversing ratchet is recommended for pumps on wells with static water levels below 50 ft. Open lineshaft pumps should not be used without a bearing preflush arrangements in wells with static water levels below 30 ft. Preflush requires a source of water at a pressure sufficient to cause flow through the required surface piping and to the lineshaft bearings. If other pumps are included in the system, flow can be diverted around the well head check valve for preflush. For a system served by a single pump, a pressurized tank or an external source must be provided for the source.]

PART 3 EXECUTION

NOT USED

END OF SECTION

SECTION 15555

OIL LUBRICATED, ENCLOSED LINESHAFT TURBINE PUMP

PART 1 GENERAL

1.01 SECTION INCLUDES: The contractor shall provide and install a complete oil lubricated lineshaft turbine type well pump including intake strainer, pump bowl assembly, enclosed type column with shaft, bearings and enclosing tube, surface pedestal and vertical hollow shaft electric motor.

1.02 RELATED SECTIONS

A. Section 16484, Adjustable Frequency Drive for A-C Induction Motors.

1.03 REFERENCES

A. National Electrical Manufacturers Association (NEMA).

B. ASTM C1045-97, Standard Practice for Calculating Thermal Transmission Properties Under Steady-State Conditions.

C. ANSI B 16.5-88, Pipe Flanges and Flanged Fittings; Addenda B16.5A-92.

PART 2 PRODUCTS

2.01 OPERATING CONDITIONS

[**Designer Note:** These values must be input for the site specific design conditions.]

Operating Conditions:

1.) Pump housing casing diameter	_______ inches
2.) Well total depth	_______ ft
3.) Static water level (below casing top)	_______ ft
4.) Pumping level (at design flow)	_______ ft
5.) Total pump head (exclusive of column)	_______ ft
6.) Required pump capacity	_______ ft
7.) Well water temperature	_______ F
8.) Expected operating flow range	______ to ______gpm

2.02 MATERIALS

A. Column, Enclosing Tube and Shaft

1. The lineshaft shall be of carbon steel turned and ground. It shall be furnished in interchangeable sections not more than _____ [**Designer Note:** Input for the site specific design conditions or desired length (5).] ft in length. The butting faces shall be machined square with the axis of the shaft. The diameter of the shaft shall be not less than that determined by ASA Specifications B58, Section 4.5, Table 5.6. Material shall be AISI C 1045 carbon steel and shall be of sufficient diameter that the elongation due to the combination of hydraulic thrust and dead weight loads shall not exceed the axial clearance available to the impellers in the bowls.

2. Shaft sections shall be joined by steel couplings of a design which incorporates a safety factor of 1.5 times the shaft safety factor. Coupling threads shall be left hand. A flame sprayed stainless steel or chrome plated section shall be provided on the shaft surface at each bearing.

3. The shaft enclosing tube shall be schedule 80 carbon steel pipe in interchangeable sections not more than ______ [**Designer Note:** Input for the site specific design conditions or desired length (5).] ft in length. The ends of the tube sections shall be machined square with the axis of the tube. The tube shall stabilized by rubber (suitable for continuous operation in _____ [**Designer Note:** Input temperature of well water.] F water) spiders at no less than ______ [**Designer Note:** Input for the site specific design conditions or desired length (5O).] ft intervals.

4. The combination lineshaft bearings and shaft enclosing tube couplings shall be constructed of SAE 660 bronze and spaced not more than _____ [**Designer Note:** Input for the site specific design conditions or desired length (5).] ft apart. The bearing shall contain spiral grooves to accommodate oil flow to lower bearings.

5. The column shall be of butt welded steel pipe in interchangeable sections not more than _____ [**Designer Note:** Input for the site specific design conditions or desired length (20).]ft in length. The ends of the section shall be faced parallel and machined to permit the ends to butt and insuring alignment when connected to standard mill couplings.

6. No coatings shall be applied to the wetted surfaces of the column assembly without approval of the Engineer.

B. Pump

1. The pump supplied under this specification shall be of the multi-stage turbine type. It shall be fitted with a stainless steel (410 or 416) shaft. Impellers shall be of SAE 40 bronze or enamel lined cast iron. Bowls (impeller housings) shall be of close grained cast iron with allowances for replacement of the wear rings. Bowls shall include sufficient clearance for impeller movement resulting from the combination of thermal expansion, dead weight and hydraulic thrust.

2. Impellers shall be securely fastened to the shaft using stainless steel split bushings. Impellers shall be adjustable vertically by an external means.

3. Pump shaft bearings shall be of SAE 660 bronze and shall be located above and below each impeller. The length of the top and bottom bearings shall be a minimum of 3 times the shaft diameter.

4. The pump shall be designed for continuous operation in ______ F [**Designer Note:** Input well water temperature] water of the chemical character described in the attached analysis results. Pump shall be selected for a minimum efficiency at the design flow rate of _____ %.

5. A suction pipe of _____ [**Designer Note:** Input for the site specific design conditions or desired length (10).] ft in length and the same diameter as the column shall be attached to the pump intake. A strainer having a net open area of not less than 4 times the area of the suction pipe shall be attached to the suction pipe. Strainer openings shall be a minimum of 3/4" in diameter.

C. Discharge Head

1. A discharge head constructed of _____________ [**Designer Note:** Input for the site specific design conditions or desired material (cast iron, fabricated steel).] shall be provided to support the weight of the pump assembly and to provide a conduit for the production flow. A nominal _____ [**Designer Note:** Input for the site specific design conditions or desired size.]inch 125 lb flanged outlet shall be provided with a companion flange threaded for ______ [**Designer Note:** Input for the site specific design conditions or desired size] inch pipe.

2. The head shaft shall be of type 416 stainless steel and not less than 10 ft in length. An adjusting method shall be provided at the top of the head shaft to allow impeller adjustment.

D. Motor

1. The motor shall be a vertical, hollow shaft, TEFC, induction type, premium efficiency with a guaranteed minimum efficiency of _____ % [**Designer Note:** Input for the site specific design conditions or desired efficiency.] at full load. It shall be design for operation at 440 VAC and equipped with Class F insulation suitable for operation with a variable frequency drive.

2. The motor shall contain sufficient thrust bearings to carry the weight of all the rotating parts plus the hydraulic thrust of the pump impellers at the point of maximum thrust. A non reversing ratchet mechanism shall be installed on top of the motor to prevent pump back spin on shut down. [**Designer Note:** A non-reversing ratchet is recommended for pumps on wells with static water levels below 50 ft]

E. Lubrication

1. A _____ [**Designer Note:** Input for the site specific design conditions or desired capacity (20).] gal lubricating oil reservoir shall be installed at the well head and connected to the shaft seal with copper tubing in such a way as to permit gravity flow of the oil from the reservoir to the pump shaft . The oil line shall be nominal 3/8 " type l copper and shall be equipped with ball valves at the reservoir and shaft seal. A 50 gal drum of ____________ [**Designer Note:** Input for the site specific design conditions or desired manufacturer.] lubricating oil shall be provided by the contractor.

PART 3 EXECUTION

NOT USED

END OF SECTION

SECTION 15786

WATER SOURCE HEAT PUMPS

PART 1 GENERAL

1.01 DESCRIPTION

A. Extent of water-source heat pump work required by this section is indicated on drawings and schedules, and by requirements of this section. Install water-source heat pumps in accordance with manufacturer's installation instructions. Install units plumb and level, unless otherwise specified, and firmly anchored in locations indicated. Maintain manufacturer's clearances. Design and heat pump selection shall be in accordance with the Closed Loop Ground Source Heat Pump Systems Installation Guide (available from the International Ground Source Heat Pump Association (IGSHPA), Stillwater, OK) and American Society of Heating, Refrigeration and Air Conditioning Engineers' (ASHRAE) Commercial/Institutional Ground Source Heat Pump Engineering Manual (ISBN 1-883413-21-4). Heat pump sizing will be based on a Building Energy Program such as DOE-2, BLAST, or other program appropriate for the size and type of building.

1.02 RELATED SECTIONS

A. Section 15050 – Piping Systems.

B. Section 15106 – Chilled Water, Cooling Water, Process Water and Heat Pump Water.

C. Section 15110 – Geothermal Heat Pump and Loop Piping Systems (High Density Polyethylene).

D. Section 15135 - Thermometers and Gauges.

E. Section 15501 – Heating, Ventilating and Air Conditioning Installation and Equipment.

F. Section 15515 – Heat Pump Exterior Heat Exchangers.

G. Section 15951 – Control System.

1.03 REFERENCES

A. ASHRAE, 1997, Fundamentals Handbook.

B. ASHRAE, Commercial/Institutional Ground Source Heat Pump Engineering Manual (ISBN 1-883413-21-4).

C. ASHRAE, Ground-Source Heat Pumps-Design of Geothermal Systems for Commercial and Institutional Buildings (S.P. Kavanaugh and K. Rafferty) (ISBN 1-883413-52-4)

D. ASHRAE, Standard 15-1994, Safety Code for Mechanical Refrigeration.

E. ASHRAE Standard 52.1-1992 - Gravimetric and Dust-Spot Procedures for Testing Air-Cleaning Devices Used in General Ventilation for Removing Particulate Matter (ANSI approved)

F. ASHRAE, Standard 90.1-1999, Energy Standards for Buildings Except Low-Rise Residential Buildings

G. ASHRAE, 1998, Operating Experiences with Commercial Ground-Source Heat Pump System

H. ARI-330-98 – Ground Source Closed Loop Heat Pumps

I. ARI-870-99, Direct Geoexchange Heat Pumps

J. ARI/ISO 13256-1, Water-to-Air and Brine-to-Air Heat Pumps – Testing and Rating for Performance

K. EPRI 1994 Water Loop Heat Pump Systems Vol. 1, Rev. 1.

L. IGSHPA 1997, Closed Loop Ground Source Heat Pump Systems Design and Installation Standards.

M. IGSHPA 1988, Closed Loop Ground Source Heat Pump Systems Installation Guide.

N. NFPA 70, National Electrical Code

O. IGSHPA 1997, Geothermal Heat Pump System Design Training for Architects & Engineers – Appendices and Manuals

P. Building Energy Calculation Programs (DOE-2, BLAST, etc.)

1.04 QUALITY ASSURANCE

A. The heat pump must be ARI rated as follows:

1. For heat pumps operating with an entering liquid temperature range from 25° to 115° F (-3.9° to 46.1° C), a unit rated under ARI Condition 330 must be used. [**Designer Note:** Energy Star listed equipment may be specified for higher performance efficiencies.]

B. The heat pump selected must be compatible with the working fluid (corrosion inhibited water or antifreeze). The working fluid properties must be as follows:

1. low viscosity

2. conducive to heat transfer

3. non-corrosive to the heat exchanger

4. non- flammable properties [**Designer Note:** Site specific conditions or regulations may allow the use of alcohol based anti-freeze solutions.]

5. no particulate contaminants

6. chemically compatible with the corrosion inhibitors.

C. Field Quality Control

1. Upon completion and before final acceptance of work, test each system in service to demonstrate compliance with the contract requirements. Refer to section 15950 for Testing Adjusting and Balancing.

1.05 SUBMITTALS

A. For Approval

1. Shop Drawings indicating dimensions and weight loadings, showing layout, mountings and supports, spatial relationship to associated equipment and nearby barriers, and connection location for condensate, air supply and return, electrical and controls.

2. Manufacturer's Product Data including equipment capacities, materials of construction, operating weights, furnished specialties and accessories, installation rigging, and start-up instructions and all connection information.

3. Wiring Diagrams including manufacturer's drawings differentiating between manufacturer-installed and field-installed wiring. Indicate connection points for signal input and output.

4. Maintenance Data including parts lists for each water-source heat pump, control, and accessory, including "trouble-shooting" maintenance guide.

B. Certified

1. Include product data, shop drawings, and wiring diagrams in a maintenance manual to be furnished to the CM at job completion.

1.06 WARRANTY

A. Warranty on Motor/Compressor

1. Provide written warranty, signed by manufacturer, agreeing to replace/repair, motors/compressors with inadequate or defective materials and workmanship, including leakage, breakage, improper assembly, or failure to perform as required provided

manufacturer’s instructions for handling, installing, protecting, and maintaining units have been adhered to during warranty period.

2. Provide an additional four year manufacturer's warranty for refrigeration system including compressor.

B. Other Components

A one-year warranty shall be provided by the equipment manufacturer for furnishing parts and labor at job site for replacing any part of the conditioner which becomes effective in normal operation from the date of Notice of Substantial Completion.

1. Available Manufacturers

Subject to compliance with requirements, manufacturers offering water-source heat pumps which may be incorporated in the work include, but are not limited to, the following:

a) Trane

b) McQuay

c) Climate Master

d) Water Furnace

e) Mammoth

f) Florida Heat Pump

g) Command Aire

h) American Standard

2. Adjustments

Adjust controls and equipment to give satisfactory operation. Adjust entire water temperature control system and place in operation so that water quantities circulated are as indicated. Adjust and balance air duct systems so that air quantities at outlets are as indicated and so that distribution from supply outlets is free from drafts and has uniform velocity over the face of each outlet. See section 15990 for details on testing and balancing of GHP systems.

3. Instructing Operating Personnel

Upon completion of work and at time designated by contracting officer, provide services of water source heat pump manufacturer’s technical representative for period of not less than three 8-hour working days for instruction of eight government operating personnel in proper operation and maintenance of equipment. **[Designer Note:** The training period should be specified to meet the site requirements.]

PART 2 PRODUCTS

2.01 GENERAL

A. Equipment using refrigerants R-11, R-12, R-113, R-114, R-115, R-500, or refrigerants with ozone depletion factor (ODF) greater than 0.05 will not be permitted.

2.02 EQUIPMENT

A. Water-Source Water-to-Air Heat Pumps (WSHP)

[**Designer Note:** Units rated below 39,560 W 135,000 Btuh cooling shall have minimum cooling performance EER of 13.0 and minimum heating performance COP of 3.0. Use Energy Star equipment for higher performance efficiencies.]

Provide water-source water-to-air heat pump units and ground-coupled, closed-loop, water-to-air heat pump units factory assembled, designed, tested, and rated in accordance with ARI 330. [**Designer Note**: Additionally specify ARI/ISO 13-256-1 when the document is finalized.] Units shall be ARI certified, or listed in ARI directory.

Units shall include fans, refrigerant-to-air heat exchangers, filters, compressor, reversing valve, expansion valve, and refrigerant-to-water heat exchangers. [**Designer Note**: For specific cases, it may also be advantageous to specify desuperheaters, hose kits, and controls as part of the heat pump package.]

[**Designer Note**: Paragraphs 1 through 12 apply to all heat pump configurations listed in this section.]

1. Cabinet: Provide manufacturer's standard galvanized steel cabinet finished. [**Designer Note:** In situations with potential for atmospheric corrosion, it may be necessary to specify special finish treatments such as corrosion resistant epoxy coating or lacquer acrylic.] Provide access panels for inspection and access to internal parts. Insulate cabinet with minimum 1/2 inch multi-density, fiberglass insulation with exposed edges sealed or tucked under flanges to prevent introduction of fibers into the air stream. Female threaded pipe condensate drain connections, supply water connections, and return water connections shall be copper or brass threaded fittings mechanically fastened to the cabinet. Water piping shall be insulated. Construct cabinet with compartments and locate the compressor, reversing valve, and water coil out of the air stream. Insulate the divider between the compressor and fan sections. The control box shall be located within the unit.

2. Fans: Provide centrifugal type, direct drive fans with permanently lubricated motors. [**Designer Note:** Industry uses direct drive motor/blowers in units smaller than 7 tons.] Motors shall be [**Designer Note:** Select either multi-speed or variable speed.] Permanent Split

Capacitor (PSC) type with thermal overload protection. [**Designer Note**: Consider belt driven blowers as an option for larger tonnage equipment.] Wheel and housing shall be designed for quiet operation and efficient air delivery. The blower shall be mounted on permanently lubricated, maintenance-free ball bearings. The ball bearing motor with V-belt and variable pitch pulley shall be mounted on an adjustable motor base for easy belt adjustment and/or speed change. The drive packages shall be designed for external static pressures sufficient to overcome system resistances.

3. Refrigerant-to-Air Heat Exchanger: Provide coil constructed of rifled copper tubes with plate aluminum fins designed for refrigerant working pressure of 450 psi. The metal condensate drain pan shall be epoxy coated and insulated, or of non-corrosive injection molded plastic. Provide internal traps on vertical units. [**Designer Note:** It may be cheaper to allow field installed traps.] Provide drain pan with overflow protection.

4. Filter Section: Provide [**Designer Note:** Select the size and type of filter desired for the application under consideration - replaceable (throwaway) filter [one inch] [2 inch] thick UL listed fiberglass; permanent washable type filters with [standard dust-holding capacity] [a mean efficiency of [35] [65] percent when tested in accordance with ASHRAE 52.1]. Mount filters in filter frames and provide access panels or doors for removal and replacement of filters.

5. Compressor: Provide hermetically sealed type compressor, installed on vibration isolators enclosed in an acoustically treated enclosure. Provide high and low pressure switches, motor thermal overload protection, [**Designer Note**: Additional control features that could be considered for the specific application are low suction temperature cut-out/coil freeze stat, 5 minute anti-recycle timer, and start capacitor kit.] [**Designer Note**: It may also be desirable to specify the capability to reset compressor lockout circuit at the remote thermostat and at the disconnect.] Provide units with factory installed sound attenuation package. [**Designer Note: S**pecify NC level based on ARI 260D Standard.]

6. Reversing Valve: Provide solenoid activated refrigerant reversing valves energized only during the cooling mode and designed to fail in the heating position.

7. Refrigerant-to-Water Heat Exchangers: Provide refrigerant-to-water heat exchangers of coaxial type, with inner copper water tube and outer steel refrigerant tube. Heat exchanger shall be tested and rated for 450 psi refrigerant working pressure. A thermal expansion valve assembly shall provide refrigerant metering and be sized by the manufacturer for proper superheat settings. [**Designer Note:** In applications with the direct use of ground water or in areas where freeze protection may be required it may be advisable to specify that ground water heat exchangers shall be made of copper-nickel or equivalent alloy and shall be capable of being frozen without danger of rupture.]

[**Designer Note:** The following options should only be included for installations which require domestic hot water service. Select either factory installed or field installed.]

8. Factory-Installed Domestic Hot Water Desuperheater: Provide desuperheater of vented double-wall construction, circulation pump, safety controls and factory installed within indoor heat pump cabinet.

9. Field-Installed Domestic Hot Water Desuperheater: Provide units factory assembled, designed, tested, and rated. Units shall include double-wall vented refrigerant-to-water heat exchanger, water line thermostat, and secondary safety thermostat to prevent scalding, internal fuse. Units shall be UL listed. Units shall be provided by the ground source closed loop heat pump manufacturer. [**Designer Note:** It may be desirable to specify the following additional features - water pump, internally mounted disconnect switch, air bleed port, and refrigerant ports.]

10. [**Designer Note**: The application of supplemental heaters is site specific. Large commercial and institutional systems may not require supplemental heaters. Smaller residential and family housing systems may warrant consideration of supplemental heaters.] Provide UL listed, electric resistance heater with internal fusing integral with heat pump unit; fan shall run until heater cools. Locate downstream of indoor coil.

11. Hose Kits: [**Designer Note**: Hose kits can be specified as optional accessories. The heat pump manufacturer should be responsible for supplying hose kits and for warranting their performance.] Unless otherwise noted on the contract drawings, hose kits shall include two - 2 foot long metal braided stainless steel hoses with swivel connectors on one end, an automatic flow control valve with test ports [**Designer Note**: Can also use two shutoff ball valves with memory stops (one with test port)], blow down ball valve, and Y-strainer. Hoses shall be fire rated to meet UL 94. Hoses shall have a maximum working pressure of 300 psi.

12. Hanger Kits: Provide horizontal units with hanger kits consisting of galvanized steel brackets, bolts, washers, and vibration isolators. The hanger kit shall be designed to support the unit from below and suspend from threaded rods.

B. Water-Source Water-to-Water Heat Pumps (GSHP)

Provide water-source water-to-water heat pump units and ground-coupled closed-loop water-to-water heat pump units factory assembled, with performance ratings verified by tests at the factory prior to shipment. Units shall include compressor, reversing valve, expansion valve, refrigerant-to-water condensing coil, refrigerant-to-water evaporator coil.

[**Designer Note:** In applications with the direct use of ground water or in areas where freeze protection may be required ground water heat exchangers shall be of copper-nickel or equivalent alloy and shall be capable of being frozen without danger of rupture.]

PART 3 EXECUTION

3.01 INSPECTION

A. A factory-trained representative shall start and test all units and submit a report to the CM.

B. Start water-source heat pumps in accordance with manufacturer's start-up instructions. Test controls and demonstrate compliance with requirements. Replace damaged or malfunctioning controls and equipment.

C. Start unit and verify initial charge of refrigerant for each refrigeration system. If system charge is deficient, determine if system has developed leaks. Repair leaks, evacuate and recharge system as required. Put system into operation, and test equipment performance.

D. Manufacturer's Qualifications include firms regularly engaged in manufacture of water-source heat pumps, of types and capacities required, whose products have been in satisfactory use in similar service for not less than five years.

E. Furnish equipment field test plans developed by each equipment manufacturer detailing recommended field test procedures for each item of equipment. Field test plans developed by the installing contractor or the equipment sales agency furnishing the equipment will not be acceptable. The CM will review and approve the field test plan for each item of equipment prior to commencement of field testing of the equipment.

1. Indicate in each field test plan when work required by this section requires coordination with test work required by other specification sections. Furnish test procedures for the simultaneous or integrated testing of equipment controls which interlock and interface with controls factory pre-wired or external controls for the equipment provided under Section 15951, Control System.

2. Equipment for which performance testing is dependent upon the completion of the work covered by Section 15950, Testing, Adjusting and Balancing, must have that work completed as a prerequisite to testing work under this section. Indicate in each field test plan when such prerequisite work is required.

3. Indicate in each field test plan each equipment manufacturer's published installation, start-up and field acceptance procedure for testing all automatic controls provided by the manufacturer. Each test plan shall include the required test reporting forms to be completed by the contractor's testing representatives. Structure procedures to test the controls through all modes of control to confirm that the controls are performing with the intended sequence of control. Controllers shall be verified to be properly calibrated and have the proper set point to provide stable control of their respective equipment.

4. Each test plan shall list performance variables that are required to be measured or tested as part of the field test. Include in the listed variables performance requirements indicated on the equipment schedules on the design drawings. Furnish with each test procedure a description of acceptable results that have been verified. Identify the acceptable limits or tolerances within which each tested performance variable shall acceptably operate.

5. Each test plan shall be job specific and shall address the particular item of equipment and particular conditions which exist with this contract. Generic or general preprinted test procedures are not acceptable.

6. Each test plan shall include procedures for field testing and field adjusting specialized components such as control valves or pressure valves.

7. Conduct the manufacturer's recommended tests and the operational tests; record the required data using the approved reporting forms. Notifying the CM in writing at least fifteen (15) calendar days prior to the testing. Within thirty (30) calendar days after acceptable completion of testing, submit each test report for review and approval.

8. Completed test report forms for each item of equipment shall be reviewed, approved, and signed by the contractor's test director and the QC manager. The manufacturer's field test representative shall review, approve, and sign the report of the manufacturer's recommended test. Signatures shall be accompanied by the person's typed name.

9. Any deficiencies identified during the tests shall be corrected to comply with the manufacturer's recommendations, and corrections re-tested in order to verify compliance.

3.02 INSTALLATION

A. Delivery, Storage, and Handling

1. Handle water-source heat pumps and components carefully to prevent damage, breaking, denting, and scoring. Do not install damaged water-source heat pumps or components; replace with new.

2. Store water-source heat pumps and components in a clean dry place. Protect from weather, dirt, fumes, water, construction debris, and physical damage.

B. Comply with manufacturer's rigging and installation instructions for unloading water-source heat pumps and moving units to final location for installation.

C. All contractors are to be aware of all overhead power lines and shall be responsible for assuring that their equipment does not come in contact with these wires.

D. All existing utilities to building are to be cut off at the main or as required by the utility companies. Contractor shall verify location of existing utilities with utility companies, determine locations of all connections, and include all costs in bid. Contractor is responsible for locating utility lines and paying all connecting fees.

E. All underground piping shall be a minimum of 18 inches below grade and must be approved by CM before backfilling.

F. Examine areas and conditions under which water-source heat pumps are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to CM.

G. Install water-source heat pumps in accordance with manufacturer's installation instructions.

H. Connect heat pump drain pan to nearest indirect waste connection, or as indicated.

I. Air separators, if required, shall be independently supported from the structure. Each separator air vent shall have an isolation ball valve to service the air vent. Extend a full size drain from the air vent to the floor sink. The drain tapping shall be fitted with a ball valve with hose end connection.

J. Auto air ,if required, vents shall have full-size drains to floor sinks or other approved points of disposal. Manual vents, if required, shall have full-size 180° return bends.

K. Pump flex connectors shall be installed without pipe weight or any other stresses applied to the connector.

L. Expansion loops, if required, shall be applied to provide a minimum of 1-inch (2.54 cm) expansion for 100 LF (30.5 m) of pipe. Provide anchors and guides as required. Install horizontally where possible to avoid air vents or drains.

M. [**Designer Note**: If circuit setters are the preferred device for flow balancing, the specify as follows.] Circuit setters shall be located with a minimum of five pipe diameters upstream and three pipe diameters downstream from any pipe system fittings. Circuit sensors shall be installed in accordance with the setter requirements and with the addition of a butterfly valve. Velocities shall not exceed 8 FPS.

[**Designer Note:** The following items may not be desirable for residential and family housing applications.]

N. Thermometers shall be adjusted for the best reading angle from the floor.

O. Pressure gauges shall be installed with a ¼-inch (63 mm) ball valve.

P. Suction diffusers shall have strainers installed and maintenance clearance provided. Extend Support to floor and adjust to remove stress from pump.

Q. Pressure reducing valves shall be equipped with a pressure gauge. Adjust valve to the pressure indicated on the drawings.

R. Pressure relief valves shall have full-size drains extended to a safe point of disposal. Do not raise line to point of disposal and do not tie together with any other drains.

S. Charging tanks shall have inlet and outlet isolation ball valves and a bottom drain ball valve.

T. Backflow protection valves shall have factory-furnished drain receptor with full-sized drain to approved point of disposal.

U. Expansion tanks shall be equipped with a lock-shield valve, auto air vent, and drain valve. Support tanks from the structure. Vertical tanks shall be anchored to the wall or floor.

V. All equipment, valves, and devices shall be installed in strict conformance with the Manufacturer's printed instructions for proper and safe operation.

W. Complete structural, mechanical, and electrical connections in accordance with manufacturer's installation instructions and drawings. Do not fasten piping or conduit to any removable panel on a unit.

X. Provide unit vibration isolators. Adjust unit vibration isolators to provide proper condensate flow to drain connection.

Y. Install equipment and associated piping and other connections in a manner to prevent conduction of sound to the framing and structural elements of the building.

Z. [**Designer Note**: The following auxiliary drain pan may be desirable in certain critical applications.] Where units are installed directly above a finished floor, install an 18-gauge galvanized steel or plastic condensate drain pan with safety switch, and a drain line with trap.

AA. Connect wiring to isolated equipment with flexible hanging loop.

3.03 NOISE CONTROL

A. Horizontal Units – For horizontal units reduce noise by providing the following: [**Designer Note**: The following recommendations may be invoked if there is no conflict with the manufacturer's recommendations.]

1. Use canvas duct connectors, flexible conduit, wire connectors, and hangers with spring or neoprene isolators to reduce noise from vibration.

2. Separate units by at least eight feet (2.4 m) to avoid additive noise.

3. Mount the unit over an acoustical pad (with an area at least twice the footprint of the HP unit) to attenuate radiated noise. This is particularly important over noise-sensitive areas like conference rooms and enclosed private offices.

4. Avoid locating large units (over 3 tons) above offices or other noise-sensitive areas. Where possible, locate units above corridors, equipment rooms, and utility closets.

B. Vertical Units - For vertical floor-mounted units reduce noise by providing the following: [**Designer Note**: The following recommendations may be invoked if there is no conflict with the manufacturer's recommendations.

1. Mount the unit on a pad of high-density sound-absorbent material that extends beyond the footprint of the unit by at least three inches in each direction. Suitable materials include rubber or cork. As an alternative, 3/8- to 1/2-inch (.96 to 1.27 cm) rubber-backed carpet may be used.

2. Make the duct turn at the top of the unit in the direction of fan rotation.

3. Use a sound barrier or other design techniques to eliminate line-of-sight sound transmission to the unit return.

3.04 SERVICE ACCESS

A. It is essential that heat pumps be easily accessible for maintenance (filter replacement, bearing lubrication, and condensate pan cleaning) and repair (replacement of major components or removal of the entire unit).

B. Horizontal Units

1. Provide a hinged access door in concealed spline, drywall, or plaster ceilings of sufficient size to provide access to all integral components and to allow for unit removal. Removable tiles and Ts may be used for access in T-bar or lay-in ceilings.

2. Provide easy access with hanger brackets, water valves, and fittings and tool access to both side panels and all electrical connections.

3. To permit removal, do not run rigid piping under any part of the unit.

4. If a return duct is used, provide a duct slot for filter access

C. Vertical Units

1. Provide access for filter replacement and drain pan cleaning. Make sure piping does not block filter access.

2. Provide access for blower motor, compressor, and coil replacement. Alternatively, permit

3. Removal of the entire unit.

4. Provide access to all electrical connections.

END OF SECTION

SECTION 15891

DUCTWORK - GALVANIZED STEEL
LOW VELOCITY AND LOW PRESSURE

PART 1 GENERAL

1.01 SUMMARY

A. SECTION INCLUDES: General requirements for fabrication and installation of galvanized steel ductwork systems operating within the range of 2 in. w.g. positive or negative static pressure and velocities less than 2500 fpm.

1.02 REFERENCES

A. ASTM A36-94, Standard Specification for Structural Steel.

B. ASTM A123-89, E1, Rev. A, Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.

C. ASTM A527-90, Standard Specification for Sheet Steel, Zinc-Coated (Galvanized) by the Hot-Dip Process, Lock-Forming Quality.

D. ASTM D1056-91, Standard Specification for Flexible Cellular Materials - Sponge or Expanded Rubber.

[**Designer Note:** The following design standards may be replaced with site specific design standards.]

E. ES-5.11-1, Instrument Test Ports - Rectangular Duct With or Without External Insulation.

F. ES-5.11-5, Instrument Test Ports - Round Duct With or Without External Insulation.

G. NFPA 90A-99, Standard for the Installation of Air Conditioning and Ventilating Systems.

H. SMACNA, HVAC Duct Construction Standards - Metal and Flexible, 1985.

I. SMACNA, HVAC Air Duct Leakage Test Manual, 1985.

1.03 SUBMITTALS

A. Submit the following test and inspection reports for information:

1. Air Duct Leakage Summary Reports prior to concealment of ductwork.

B. Submit the following for information:

1. Leakage test procedures prior to leak testing. [**Designer Note:** Design personnel have the option to request approval on critical or complex systems. Design personnel also have the option to define the leakage test procedure in detail and/or to remove it as a submittal requirement.]

[**Designer Note:** It is not recommended to require submittal of inspection reports. If deemed necessary by the Designer, submit for information the item to be inspected, type of inspection, and paragraph reference.]

1.04 SCHEDULING

A. Notify Construction Manager (CM) prior to the actual fabrication start date. The CM will have the option to inspect prior to, during, and upon completion of fabrication and installation and witness tests and inspections.

[**Designer Note:** Add Sect. Article 1.05 titled "SEQUENCING" when appropriate to provide job specific information on removal or replacement sequence of ductwork system. Include whether work is to be performed on weekends only and if temporary routing of ductwork is required. (Such as for laboratories or process area not able to function without HVAC systems in operation.]

PART 2 PRODUCTS

2.01 MATERIALS

A. Carbon steel structural shapes: In accordance with ASTM A36.

B. Fasteners, such as bolts, nuts, sheet metal screws, etc.: Either zinc-coated or cadmium-plated steel.

C. Galvanized steel sheet: In accordance with ASTM A527.

D. Galvanized steel structural shapes: In accordance with ASTM A36 and ASTM A123.

E. Flexible connection material: Hypalon-coated glass fabric weighing no less than 24 oz./yd^2; UL listed and NFPA 90A approved as noncombustible fabric and fire-retardant coating; and resistant to air and water penetration, ozone, alkalis, acids, gasoline, grease, and abrasion.

[**Designer Note:** For noncorrosive environments, material to weigh no less than 24 oz./yd^2 and be Ventlon (chlorosulfurated polyethylene) by Ventfabrics, Inc., or Durolon by Duro Dyne Corp. For corrosive environments, material to weigh no less than 14 oz./yd^2 and be Ventel (fluorocarbon) by Ventfabrics or Durolon by Duro Dyne Corp.]

F. Gaskets for flanged duct joints: 1/4-in.-thick, full face, closed cell, expanded Neoprene sponge in accordance with ASTM D1056, Grade SCE-43.

G. Sealant: Duct Sealer by United Sheet Metal; Duct Sealant 601 by Hardcast, Inc.; PA-2084 Duct Sealant by Precision Adhesives.

H. Access doors: Insulated double-wall galvanized steel construction. Door to have mounting knock-over edges, gasket, 1/2-in. thick minimum 1-lb/ft^3 density insulation, hinges, and latches, in accordance with SMACNA, HVAC Duct Construction Standards - Metal and Flexible, Fig. 2-12.

2.02 FABRICATION

A. Fabricate rectangular ductwork and accessories in accordance with SMACNA HVAC Duct Construction Standards - Metal and Flexible and the SMACNA Air Duct Leakage Test Manual, Seal Class B, Leakage Class 12, and as follows:

1. Straight Ductwork: Use the appropriate tables of SMACNA Section I for the pressure classes shown on the drawings.

2. Standard radius elbows to be in accordance with Figs. 2-2, 2-5, and 2-6 with a minimum inside turning radius equal to the duct dimension in the direction of turn unless otherwise noted. Use galvanized steel splitters, where required, firmly secured to the duct via pop rivets or sheet metal screws.

3. Unequal, square elbows shall not be used, unless otherwise detailed on the drawings. Where indicated on the drawings, fabricate 90 degree equal square elbows with turning vanes. Provide single thickness turning vanes without trailing edges in accordance with Type 2, Fig. 2-3. Fabricate vanes and runners of the same material and gage as the ductwork. Securely fasten vanes to runners and runners to duct to prevent vibration or fluttering. Install vanes within the elbow to project tangents to the airflow.

4. Install transitions and streamliner sections in accordance with Figs. 2-9 and 2-10, respectively.

5. Install branch-from-main connections in accordance with Figs. 2-7 and 2-8.

6. Install intake/exhaust storm covers in accordance with Figs. 5-6 and 5-7.

7. Install manual volume dampers in accordance with Fig. 2-14.

B. Fabricate round ductwork and accessories in accordance with design drawing details, Engineering Standards and the SMACNA HVAC Duct Construction Standards - Metal and Flexible, Seal Class B, Leakage Class 12, and as follows:

1. Install straight ductwork in accordance with Section III, Table 3-2, and Figs. 3-1 and 3-2.

2. Install radius elbows to be standard radius type fabricated in accordance with Fig. 3-3.

3. Install volume dampers in accordance with Fig. 2-14.

4. Install branch-from-main connections in accordance with Figs. 3-4 and 3-5.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify that openings for the installation of the duct system are of the size and in the location shown on the drawings, that openings are clear of obstructions which might interfere with the installation of the ductwork or accessories, and no other interferences exist in the routing of ductwork. Notify the CM of conflicts. The CM will determine a resolution.

3.02 INSTALLATION/APPLICATION/ERECTION

A. Install and support ductwork in accordance with the SMACNA HVAC Duct Construction Standards - Metal and Flexible.

B. Install access doors at fire dampers (for servicing spring latches and fusible links), at both the air-entering and the air-leaving sides of cooling and heating coils, at air-entering side of multiblade balancing dampers, and at locations indicated on the drawings. Install and seal access doors to the ductwork in accordance with the manufacturer's instructions. Brace the door openings to prevent vibration and distortion during system operation.

C. Cut and assemble field joints in accordance with the SMACNA HVAC Duct Construction Standards details.

D. Install flexible connections as close as possible to the equipment being isolated in accordance with SMACNA HVAC Duct Construction Standards - Metal and Flexible, Fig. 2-19.

E. Install rectangular and/or round ductwork instrument test ports in the general locations shown on the drawings either on the top, bottom, or sides of the duct to permit insertion of a Pitot tube across the entire duct section without interference. Install ports in accordance with ES-5.11-1 for rectangular ductwork and ES-5.11-5 for round ductwork. Clear opening through the duct wall to be equal to the port inside dimension.

F. Apply sealant to joints and seams in accordance with manufacturer's recommendations. Clean and dry joints, seams, and openings of oil, grease, and dirt before application of sealant.

3.03 FIELD QUALITY CONTROL

A. Duct Leakage Tests

1. Prepare leakage test procedures following the outlines and classifications in the SMACNA HVAC Air Duct Leakage Test Manual.

2. Leak test ductwork at the 2-in. w.g. pressure class or at design pressure, if less than 2 in. w.g. Duct system to be SMACNA Seal Class B and Leakage Class 12.

3. The leakage amount is not to exceed the calculated amount for the pressure class or the allocated amount for that portion of the system, whichever is applicable.

4. If a portion of the system fails to pass the leakage test, modify to bring it into compliance and retest it until acceptable leakage is demonstrated.

5. Complete tests and necessary repairs. Verify in writing and submit completed test reports to the CM.

6. Notify CM for inspection by the CM prior to concealment of ductwork.

B. After the ductwork is installed, verify by inspection and document that:

1. dampers are installed in the proper configuration and location shown on drawings;

2. instrument test ports are installed, in the correct positions, and the opening through duct wall is full inside port dimension, in accordance with ES-5.11-1 and ES-5.11-5;

3. duct interiors are free of debris;

4. ductwork joints and seams are sealed; and

5. leakage test report completed.

[**Designer Note:** According to SMACNA, Air Duct Leakage Manual, it is not recommended that duct systems constructed to 3-in. w.g. class or lower be tested since it is generally recognized as not being cost effective. SMACNA also states that if testing is required, the Designer must clearly designate in the contract documents the portions of the system(s) to be tested. Also, Designer should have good justification for <u>any</u> ductwork leak testing. If no leak testing is to be required, delete each reference to it from this section including submittal items.]

END OF SECTION

SECTION 15902

DUCTWORK - INSULATED AND NONINSULATED FLEXIBLE

PART 1 GENERAL

1.01 SECTION INCLUDES: Installation of insulated and noninsulated flexible ductwork used primarily in low pressure applications such as supply system branch take-offs between supply headers and individual diffusers. The maximum ductwork design conditions are 4000-fpm duct velocity, 4-in. w.g. positive pressure, and 250°F conveying air temperature.

1.02 REFERENCES

A. ASTM E96-94, Standard Test Methods for Water Vapor Transmission of Materials.

B. NFPA Bulletin 90A-93, Standard for the Installation of Air Conditioning and Ventilating Systems.

C. SMACNA HVAC Duct Construction Standards - Metal and Flexible, 1985.

D. UL Standard 181, UL Standard for Safety Factory-made Air Ducts and Air Connectors, Seventh Edition, 1990.

E. UL Standard 723, UL Standard for Safety Test for Surface Burning Characteristics of Building Materials, Seventh Edition, 1993, (R 1994).

1.03 SUBMITTALS

[**Designer Note:** It is not recommended to require submittal of inspection reports. If deemed necessary by the Designer, submit for information the item to be inspected, type of inspection, and paragraph reference.]

PART 2 PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. Noninsulated flexible ductwork.

1. Flexmaster U.S.A., Inc., Type 3.

2. Wiremold Co., Model WC.

3. Flexible Technologies Automation Industries, Inc., Thermaflex, Type S-TL.

B. Insulated flexible ductwork.

1. Flexmaster U.S.A., Inc., Type 5M.

2. Wiremold Co., Model WCK.

3. Flexible Technologies Automation Industries, Inc., Thermaflex, MKC.

2.02 MATERIALS

A. Flexible Duct

1. Constructed of a supporting helix of coated spring steel or formed aluminum; bonded or mechanically locked to a core liner of impregnated/coated fiberglass fabric or laminated fiberglass-reinforced and aluminized polyester film. Insulated flexible ductwork to have a minimum of 1-in. fiberglass yielding an overall C-factor no greater than 0.23 Btu/h/ft^2/°F at 75°F rated mean temperature. Outer jacket/vapor barrier to be as a minimum, fiberglass-reinforced, aluminized polyester film, with a maximum ASTM E96 permeance rating of 0.1 perm (grain/h/ft^2/in. Hg). Duct to have a positive pressure rating of 10 in. w.g.

2. UL listed as a Class 1 air-duct connector in accordance with Standard 181.

3. Flame spread index of not over 25 without evidence of continued combustion and smoke developed index of not over 50 in accordance with NFPA 90A and UL Standard 723.

B. Flexible duct to main duct collar connections to be factory fabricated, spin-in type fittings. Fittings to include butterfly dampers with locking devices as manufactured by Flexmaster U.S.A., Inc., Rainaire Products Inc., or R&J Manufacturing Co.

C. Fasteners such as bolts, nuts, sheet metal screws, etc.: Zinc-coated or cadmium-plated steel.

D. Clamps: Worm drive, stainless steel type with screw driver slot by Automation Industries, Inc., or AERO-Seal by Breeze Corporation.

E. Tape material: As recommended by the duct manufacturer and in accordance with UL 181 for Class 1 air duct.

PART 3 EXECUTION

3.01 INSTALLATION/APPLICATION/ERECTION

A. Install and support flexible ductwork in accordance with Sect. III of the SMACNA HVAC Duct Construction Standards - Metal and Flexible.

B. Install flexible ductwork with radius elbows and offsets having a minimum 1 1/2 times duct diameter centerline radius.

C. Use minimum length duct runs. Duct runs to be straight as possible, stretched in accordance with manufacturer's instructions. Do not compress ducts.

3.02 FIELD QUALITY CONTROL

A. After the ductwork has been installed, verify by inspection and document that:

1. duct interiors are free of debris,

2. potential air leak sites have been sealed,

3. supports installed in accordance with SMACNA, and

4. elbows have 1 1/2 times duct diameter centerline radius.

END OF SECTION

SECTION 15950

TESTING, ADJUSTING, AND BALANCING

PART 1 GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 1 Specification sections, apply to work of this section.

1.02 SUMMARY

A. This Section specifies the requirements and procedures for total mechanical systems testing, adjusting, and balancing. Requirements include measurement and establishment of the fluid quantities of the mechanical systems as required to meet design specifications, and recording and reporting the results.

B. Test, adjust, and balance the following mechanical systems:

1. Supply air systems
2. Return air systems
3. Exhaust air systems
4. Hydronic systems
5. Verify temperature control system operation.

1.03 DEFINITIONS

A. Systems testing, adjusting, and balancing is the process of checking and adjusting all the building environmental systems to produce the design objectives. It includes:

1. The balance of air and water distribution
2. Adjustment of total system to provide design quantities
3. Electrical measurement
4. Verification of performance of all equipment and automatic controls.

B. Test: To determine quantitative performance of equipment.

C. Adjust: To regulate the specified fluid flow rate and air patterns at the terminal equipment (e.g., reduce fan speed, throttling).

D. Balance: To proportion flows within the distribution system (submains, branches, and terminals) according to specified design quantities.

E. Procedure: Standardized approach and execution of sequence of work operations to yield reproducible results.

F. Report forms: Test data sheets arranged for collecting test data in logical order for submission and review. These data should also form the permanent record to be used as the basis for required future testing, adjusting, and balancing.

G. Terminal: The point where the controlled fluid enters or leaves the distribution system. These are supply inlets on water terminals, supply outlets on air terminals, return outlets on water terminals, and exhaust or return inlets on air terminals such as registers, grilles, diffusers, louvers, and hoods.

H. Main: Duct or pipe containing the system's major or entire fluid flow.

I. Submain: Duct or pipe containing part of the systems' capacity and serving two or more branch mains.

J. Branch main: Duct or pipe serving two or more terminals.

K. Branch: Duct or pipe serving a single terminal.

1.04 SUBMITTALS

A. Agency Data:

1. Submit proof that the proposed testing, adjusting, and balancing agency meets the qualifications specified below.

B. Engineer and Technicians Data:

1. Submit proof that the Test and Balance Engineer assigned to supervise the procedures, and the technicians proposed to perform the procedures meet the qualifications specified below.

C. Procedures and Agenda: Submit a synopsis of the testing, adjusting, and balancing procedures and agenda proposed to be used for this project.

D. Sample Forms: Submit sample forms, if other than those standard forms prepared by the Associated Air Balance Council (AABC) or National Environmental Balancing Bureau (NEBB) are proposed.

E. Certified Reports: Submit testing, adjusting, and balancing reports bearing the seal and signature of the Test and Balance Engineer. The reports shall be certified proof that the systems have been tested, adjusted, and balanced in accordance with the referenced standards; are an accurate representation of how the systems have been installed; are a true representation of how the systems are operating at the completion of the testing, adjusting, and balancing procedures; and are an accurate record of all final quantities measured, to establish normal operating values of the systems. Follow the procedures and format specified below:

1. Draft reports: Upon completion of testing, adjusting, and balancing procedures, prepare draft reports on the approved forms. Draft reports may be hand written, but must be complete, factual, accurate, and legible. Organize and format draft reports in the same manner specified for the final reports. Submit 2 complete sets of draft reports. Only 1 complete set of draft reports will be returned.

2. Final Report: Upon verification and approval of draft reports, prepare final reports, type written, and organized and formatted as specified below. Submit 2 complete sets of final reports.

3. Report Format: Report forms shall be those standard forms prepared by the referenced standard for each respective item and system to be tested, adjusted, and balanced. Bind report forms complete with schematic systems diagrams and other data in reinforced, vinyl, three-ring binders. Provide binding edge labels with the project identification and a title descriptive of the contents. Divide the contents of the binder into the below listed divisions, separated by divider tabs:

   a. General Information and Summary

   b. Air Systems

   c. Hydronic Systems

   d. Temperature Control Systems

   e. Special Systems.

4. Report Contents: Provide the following minimum information, forms and data:

   a. General Information and Summary: Inside cover sheet to identify testing, adjusting, and balancing agency, the Company, Engineer, and Project. Include addresses, and contact names and telephone numbers. Also include a certification sheet containing the seal and name address, telephone number, and signature of the Certified Test and Balance Engineer. Include in this division a listing of the instrumentations used for the procedures along with the proof of calibration.

b. The remainder of the report shall contain the appropriate forms containing as a minimum, the information indicated on the standard report forms prepared by the AABC or NEBB, for each respective item and system. Prepare a schematic diagram for each item of equipment and system to accompany each respective report form.

c. Calibration Reports: Submit proof that all required instrumentation has been calibrated to tolerances specified in the referenced standards, within a period of six months prior to starting the project.

1.05 QUALITY ASSURANCE

A. Test and Balance Engineer's Qualifications: A Professional Engineer registered in the State in which the services are to be performed, and having at least 3-years of successful testing, adjusting, and balancing experience on projects with testing and balancing requirements similar to those required for this project.

B. Agency Qualifications:

1. Employ the services of an independent testing, adjusting, and balancing agency meeting the qualifications specified below, to be the single source of responsibility to test, adjust, and balance the building mechanical systems identified above, to produce the design objectives. Services shall include checking installations for conformity to design, measurement and establishment of the fluid quantities of the mechanical systems as required to meet design specifications, and recording and reporting the results.

2. The independent testing, adjusting, and balancing agency certified by National Environmental Balancing Bureau (NEBB) or by the Associated Air Balance Council (AABC) in those testing and balancing disciplines required for this project, and having at least one Professional Engineer registered in the State in which the services are to be performed, certified by NEBB or AABC as a Test and Balance Engineer.

C. Codes and Standards

1. NEBB: "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems."

2. AABC: "National Standards For Total System Balance".

3. American Society of Heating, Refrigeration, and Air-Conditioning Engineers (ASHRAE): ASHRAE Handbook, 1999 HVAC Applications Volume, Chapter 36, Testing, Adjusting, and Balancing.

D. Pre-Balancing Conference: Prior to beginning of the testing, adjusting, and balancing procedures, schedule and conduct a conference with the Engineer and representatives of installers of the mechanical systems. The objective of the conference is final coordination and verification of system operation and readiness for testing, adjusting, and balancing.

1.06 PROJECT CONDITIONS

A. Systems Operation: Systems shall be fully operational prior to beginning procedures.

1.07 SEQUENCING AND SCHEDULING

A. Test, adjust, and balance the air systems before hydronic, steam, and refrigerant systems.

B. Test, adjust and balance air conditioning systems during summer season and heating systems during winter season, including at least a period of operation at outside conditions within 5°F wet bulb temperature of maximum summer design condition, and within 10° F dry bulb temperature of minimum winter design condition. Take final temperature readings during seasonal operation.

PART 2 PRODUCTS

Not Used.

PART 3 EXECUTION

3.01 PRELIMINARY PROCEDURES FOR AIR SYSTEM BALANCING

A. Before operating the system, perform these steps:

1. Obtain design drawings and specifications and become thoroughly acquainted with the design intent.

2. Obtain copies of approved shop drawings of all air handling equipment, outlets (supply, return, and exhaust) and temperature control diagrams.

3. Compare design to installed equipment and field installations.

4. Walk the system from the system air handling equipment to terminal units to determine variations of installation from design.

5. Check filters for cleanliness.

6. Check dampers for correct and locked position, and temperature control for completeness of installation before starting fans.

7. Prepare report test sheets for both fans and outlets. Obtain manufacturer's outlet factors and recommended procedures for testing. Prepare a summation of required outlet volumes to permit a crosscheck with required fan volumes.

8. Determine best locations in main and branch ductwork for most accurate duct traverses.

9. Place outlet dampers in the full open position.

10. Prepare schematic diagrams of system "as-built" ductwork and piping layouts to facilitate reporting.

11. Lubricate all motors and bearings.

12. Check fan belt tension.

13. Check fan rotation.

3.02 PRELIMINARY PROCEDURES FOR HYDRONIC SYSTEM BALANCING

A. Before operating the system perform these steps:

1. Open valves to full open position. Close coil bypass valves.

2. Remove and clean and replace all strainers.

3. Examine hydronic systems and determine if water has been treated and cleaned.

4. Check pump rotation.

5. Clean and set automatic fill valves for required system pressure.

6. Check expansion tanks to determine that they are not air bound and that the system is completely full of water.

7. Check air vents at high points of systems and determine if all are installed and operating freely (automatic type) or to bleed air completely (manual type).

8. Set temperature controls so all coils are calling for full flow.

9. Check operation of automatic bypass valves.

10. Check and set operating temperatures of chillers to design requirements.

11. Lubricate all motors and bearings.

3.03 MEASUREMENTS

A. Provide all required instrumentation to obtain proper measurements, calibrated to the tolerances specified in the referenced standards. Instruments shall be properly maintained and protected against damage.

B. Provide instruments meeting the specifications of the referenced standards.

C. Use only those instruments which have the maximum field measuring accuracy and are best suited to the function being measured.

D. Apply instrument as recommended by the manufacturer.

E. Use instruments with minimum scale and maximum subdivisions and with scale ranges proper for the value being measured.

F. When averaging values, take a sufficient quantity of readings which will result in a repeatability error of less than 5 percent. When measuring a single point, repeat readings until 2 consecutive identical values are obtained.

G. Take all reading with the eye at the level of the indicated value to prevent parallax.

H. Use pulsation dampeners where necessary to eliminate error involved in estimating average of rapidly fluctuation readings.

I. Take measurements in the system where best suited to the task.

3.04 PERFORMING TESTING, ADJUSTING, AND BALANCING

A. Perform testing and balancing procedures on each system identified, in accordance with the detailed procedures outlined in the referenced standards.

B. Cut insulation, ductwork, and piping for installation of test probes to the minimum extent necessary to allow adequate performance of procedures.

C. Patch insulation, ductwork, and housings, using materials identical to those removed.

D. Seal ducts and piping, and test for and repair leaks.

E. Seal insulation to re-establish integrity of the vapor barrier.

F. Mark equipment settings, including damper control positions, valve indicators, fan speed control levers, and similar controls and devices, to show final settings. Mark with paint or other suitable, permanent identification materials.

G. Retest, adjust, and balance systems subsequent to significant system modifications, and resubmit test results.

3.05 RECORD AND REPORT DATA

A. Record all data obtained during testing, adjusting, and balancing in accordance with, and on the forms recommended by the referenced standards, and as approved on the sample report forms.

B. Prepare report of recommendations for correcting unsatisfactory mechanical performances when system cannot be successfully balanced.

END OF SECTION

SECTION 15951

CONTROL SYSTEM

PART 1 GENERAL

1.01 SECTION INCLUDES: Installation of controls and instrumentation.

1.02 RELATED SECTIONS

A. Section 15956, Control Panels and Instruments.

1.03 SUBMITTALS

A. Submit the following for approval.

[**Designer Note:** Provisions for lockout/tagout of equipment and system components to be coordinated with other disciplines and incorporated into the design in accordance with 29 CFR 1910.147, "The Control of Hazardous Energy," and 29 CFR 1910.333, "Selection and Use of Work Practices."]

1. Shop drawings on each control panel and subpanel prior to fabrication. Include dimensions of the overall panel, overall instrument size, panel cutouts for recessed instruments, spacing between instruments, schematic layout and interrelationship of each control item including model numbers, flow rates, capacities, operating ranges, set points, throttling ranges, spring ranges, calibration instructions, and other pertinent data for describing the system operation.

2. Control system brochures containing equipment manufacturer's drawings and descriptive literature for each piece of equipment.

3. Manufacturer's data as required by [individual equipment data sheets] [equipment drawing schedules].

B. Submit the following for information.

1. Manufacturer's certified record brochures containing "as built" copies of the above drawings and data, plus manufacturer's parts list and maintenance instructions for each specific type and model of equipment installed.

2. Test and Inspection Reports.

3. As-built drawings.

4. Manufacturer's certified data as required by [individual equipment data sheets] [equipment drawing schedules].

PART 2 PRODUCTS

2.01 MATERIALS

A. Provide the controls and instruments in accordance with the following data sheets. [**Designer Note**: Include additional equipment as required for the specific job. Equipment Data Sheets are to have unique ID numbers assigned through site specific Document Control Depts. The UNC numbers are shown below for illustrative purposes only.]

Equipment Description	Data Sheet No.
Control Valve	UCN-2641N
Manometer	UCN-2641BB

PART 3 EXECUTION

3.01 INSTALLATION/APPLICATION/ERECTION

A. The complete control system to be installed in accordance with appropriate design and/or vendor drawings.

B. Install controls and accessories having a neat appearance and equal to the surrounding decor.

C. Mount room-type temperature controllers with centerline 5 ft above the finished floor.

D. Mount remote sensing elements of control devices in the medium with proper element exposure and supported to prevent mechanical failure due to vibration.

E. Install parts of the control system requiring maintenance in an accessible location and position. Carefully coordinate the location of pipes, conduit, and other obstructions to reserve space for instrument removal and maintenance.

F. Sufficiently isolate control panels to be free of vibration yet still provide accessibility to controls for operation and removal.

G. Identify controls with stainless steel tags embossed or engraved with equipment number in 1/4-in.-high (min) characters attached with stainless steel pop rivets, plated screws, or stainless steel wire. Tags for panel-mounted instruments, switches, etc., to be standard engraved bakelite with 1/4-in.-high (min) characters attached by screws or epoxy adhesive.

H. Install permanent reproductions of "as built" control diagrams and system operating procedures in each control cabinet.

I. Install electrical conduit and wiring in accordance with the drawings and specifications for the electrical work.

J. Install the tubing system as noted on the drawings.

K. Code markings to correspond to the identifications assigned on approved "as built" diagrammatic functional drawings.

3.02 FIELD QUALITY CONTROL

A. After the systems are installed, verify by inspection and document in writing that:

1. a continuity check has been performed on each of the interconnecting runs to insure that lines are terminated correctly and components are connected in accordance with the drawing and

2. system components have been spaced for instrument removal and maintenance.

B. After visual inspections and repairs are made prior to testing, revise "as built" drawings.

C. System Testing

1. Verify in writing that the following has been performed:

a. Check instruments and associated components for leaks and proper functioning. Leak test tubing as specified. Test all instruments in accordance with the recommendations of the manufacturer. [**Designer Note:** Specify appropriate sub-section for leak testing.]

b. Repair leaks and malfunctions and retest the repaired joints prior to start-up and calibration.

D. Provide a report on tests and inspections.

3.03 ADJUSTING AND CLEANING

A. Calibrate the control system including installed individual components.

B. Thermometers used for instrument calibration to be precision plain mercury in glass conforming to American Society for Testing and Materials standards. Thermometers to be at least 12 in. long with 60°F maximum ranges and 0.2°F scale graduations.

C. The operating ranges, action, and correct operation of each component in the control system to be individually verified and selected to match the controlled device to make certain that the equipment will perform the intended function specified or shown on the drawings.

D. Interlocks with other equipment and controllers to be individually demonstrated to accomplish their specific functions.

E. Lockout devices to be individually tested to demonstrate proper operation.

F. Calibrate the instruments to the set points and throttling ranges shown on the drawings. When throttling ranges are not specified, make several trial adjustments to obtain the best operating point for the particular system.

G. When verifying the actual operating ranges of pneumatic pilot positioners, disconnect the pilot line from the positioner to permit introducing a stable test pressure. Test pressure to be supplied by an independent air supply line and pressure regulating valve or by the use of a hand-operated pump assembly. Demonstrate the performance of the pilot positioner and associated control equipment by varying the test pressure in small increments throughout its operating range. After testing is complete, reconnect the normal pilot line.

H. Repair or replace defective instruments found during the calibration period.

3.04 PROTECTION

A. Deliver instruments to the Construction Manager 100% functional and undamaged.

END OF SECTION

SECTION 15952

COPPER CONTROL TUBING WITH COMPRESSION FITTINGS

PART 1 GENERAL

1.01 SECTION INCLUDES: Installation of copper control tubing with compression fittings.

1.02 RELATED SECTIONS

A. Section 15100, Valves.

1.03 REFERENCES

A. ASTM B280-93, Rev. A, Standard Specification for Seamless Copper Tube for Air Conditioning and Refrigeration Field Service.

PART 2 PRODUCTS

2.01 MATERIALS

A. Copper tubing: Standard refrigeration grade seamless soft annealed coils, cleaned and sealed in accordance with ASTM B280. Sizes: 1/4-in. O.D. X 0.030-in. wall and 3/8-in. O.D. X 0.032-in. wall.

B. Use brass tubing compression fittings for 1/4-in. and 3/8-in. O.D. tubing consisting of a body with one or more joints made with a female threaded brass nut and one or more brass ferrules.

C. Use globe-type shutoff valves with brass body, Buna N or Teflon trim, compression fitting ends in accordance with Valve No. V-6193 per Sect. 15100. Valves sizes: 1/4-in. and/or 3/8-in.

D. Solution for soap testing: Soapless lather, leak detector solution as manufactured by Industrial Colloids and Chemical, Inc. or approved equal.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify instrument locations for tubing terminals.

B. Verify clearances for routing tubing and supports.

3.02 INSTALLATION/APPLICATION/ERECTION

A. Provide instrument tubing in accordance with appropriate design and/or vendor drawings.

B. Cut tubing to have square ends with tube cutters or other methods approved by the CM. Ream cuts to remove burrs.

C. Use bends where practical instead of fittings. Make bends using tools which leave tubing free from wrinkles, flats, or humps.

D. When fittings are required for racked tubing, group them together to simplify system leak testing.

E. Conceal tubing runs within new partitions and walls. Those involving existing partitions and walls may be exposed. Splices in tubing are not to be placed inside walls or other inaccessible areas.

F. Maintain a minimum head room of 6 ft 8 in. above finished floor in areas. [**Designer Note:** Meets requirements of 29 CFR 1910.37.i. Designer to indicate specific dimension if other than what's listed.]

G. In areas provided with suspended ceilings, conceal horizontal tubing runs above the ceilings.

H. Provide a sleeve made from conduit or pipe for tubing penetrations through concrete floors and walls. Do not embed tubing directly in concrete.

I. Run exposed and concealed tubing in horizontal and vertical planes. Horizontal lines to be parallel to the building walls and partitions.

J. Protect tubing in areas where the possibility of abuse exists.

K. Support, fasten, and route tubing parallel with building structure or other services such as pipe or conduit. Support and protect tubing by a member having better structural value than itself. Place tubing supports at a maximum of 3 ft apart where the tubing is not otherwise supported by some other structure or surface.

3.03 FIELD QUALITY CONTROL

A. After the systems are installed, inspect them as follows:

1. Perform a continuity check on each tubing run to assure that lines are terminated correctly.

2. Carefully coordinate the location of system components to reserve space for instrument removal and maintenance.

3. Ensure that tubing and fittings are the type and sizes specified.

4. Ensure that tubing straight sections and bends are free of wrinkles, flats, and humps.

5. Ensure that tubing has been properly supported and protected from damage.

B. Make repairs required after visual inspection prior to testing.

C. System Testing

1. Furnish labor, materials, equipment, tools, and services necessary for testing and cleaning the systems.

2. The CM will furnish the nitrogen or plant compressed oil-free dry air for testing and cleaning.

3. Perform leak testing as follows:

   a. Blank off or replace with spool pieces items of equipment (e.g., vessels, instruments, controls, and safety and relief valves) rated for pressures below the test pressure.

   b. Apply pressurized nitrogen or dry air to the system at 1 1/2 times the maximum working pressure. In no case shall test pressure be less than 50 psig.

   c. Soap test entire system for leaks, especially at threaded connections.

   d. Repair leaks and retest the repaired joints.

3.04 ADJUSTING AND CLEANING

A. Perform cleaning as follows:

1. Remove blanks and/or spool pieces used for temporary aids during leak testing.

2. Clean instrument air tubing by flushing with nitrogen or dry air for 5 min.

B. After system cleaning is completed, reconnect instruments and equipment.

C. After instruments and equipment have been reconnected, pressurize and soap test these connections at maximum operating pressure. Repair leaks and retest repaired joints.

3.05 PROTECTION

A. Deliver tubing material including valves and fittings to the site degreased, dry, and sealed to protect physical parts and cleanliness.

B. Exercise care in the handling and storage of tubing materials and prefabricated tubing so that contamination by moisture, grease, or dirt does not occur.

END OF SECTION

SECTION 15954

PLASTIC CONTROL TUBING
PNEUMATIC CONTROLS

PART 1 GENERAL

1.01 SECTION INCLUDES: Installation of plastic control tubing.

1.02 REFERENCES

A. ANSI C80.3-91, Electrical Metallic Tubing - Zinc Coated.

B. ASTM D635-91, Standard Test Method for Rate of Burning and/or Extent and Time of Burning of Self-Supporting Plastics in a Horizontal Position.

C. ASTM D638-91, Standard Test Method for Tensile Properties of Plastic.

D. ASTM D792-91, Standard Test Method for Density and Specific Gravity (Relative Density) of Plastics by Displacement.

E. ASTM D1238, Rev. B-90, Standard Test Method for Flow Rates of Thermoplastics by Extrusion Plastometer.

F. ASTM D1693-70, (R 1989), Standard Test Method for Environmental Stress-Cracking of Ethylene Plastics.

G. UL 797-93, UL Standard for Safety Electrical Metallic Tubing, Sixth Edition.

PART 2 PRODUCTS

2.01 MATERIALS

A. Conduit: EMT, thin wall, mild steel, circular in cross section, galvanized outside, enamel inside, and uniform wall thickness and coatings in accordance with ANSI C80.3 and UL 797.

B. Terminal boxes and pull boxes: Code gage galvanized sheet steel with conduit knockouts and screwed cover plates, sizes as required for application and approved by NEC.

C. EMT conduit couplings, connectors, etc., to be NEC approved.

D. Plastic tubing: Made of flame-retardant, stress-crack resistant black polyethylene and in accordance with the following:

1. Melt index ASTM D1238.

2. Density ASTM D792.

3. Tensile strength and elongation ASTM D638.

4. Stress cracking ASTM D1693.

5. Flame retardation ASTM D635.

6. Suitable for a safe working pressure of 100 psig at 130°F.

7. Available in sizes and tolerances as follows:

Nominal size	Average O.D.	Average I.D.	Wall
1/4 in. O.D.	.250 in. ± .004 in.	.170 in. ± .004 in.	.040 in. ± .003 in.
3/8 in. O.D.	.375 in. ± .005 in.	.250 in. ± .005 in.	.062 in. ± .003 in.

Tubing: "Instube" by Plexco.

E. Use brass-tubing compression fittings with integral inside tube support and polypropylene ferrules by Imperial-Eastman Corporation, Poly-Flo.

F. Tubing slip-on fittings: Brass barbed-type fittings and accessories by Johnson Service Company.

G. Use needle-type shutoff valves with brass body "Poly-Flo" and male pipe thread connections by Imperial-Eastman Corporation, Nos. 310-C, 311-C, and 312-C.

H. Solution for soap testing: Soapless lather, leak detector solution as manufactured by Industrial Colloids and Chemical, Inc., Knoxville, Tennessee.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify instrument locations for tubing terminals.

B. Verify clearances for routing support conduit, tubing, and supports.

3.02 INSTALLATION/APPLICATION/ERECTION

A. Do not install plastic tubing outside buildings or in extremely high and low temperature environments.

B. Do not install exposed plastic tubing. Exposed tubing to be copper from a bulkhead fitting on conduit terminal box routed to instrument.

C. Install EMT conduit, boxes, and fittings for support and shielding of plastic tubing in accordance with drawings and as follows:

1. Base conduit sizes on the distribution requirements as follows:

Conduit size (nominal in.)	Maximum span between supports	Maximum number of tubes 1/4 in. O.D.	3/8 in. O.D.
1/2	10 ft	1	do not use
3/4	12 ft	4	1
1	16 ft	7	3
1-1/4	18 ft	12	5
1-1/2	19 ft	16	7
2	21 ft	27	12

2. Maintain a minimum head room of 6 ft 8 in. above finished floor in all areas. [**Designer Note:** Meets requirements of 29 CFR 1910.37.i. Designer to indicate specific dimension if other than what's listed.]

3. Conceal conduit runs within new partitions and walls. Those involving existing partitions and walls may be exposed.

4. Conceal conduit above suspended ceilings.

5. Run exposed and concealed conduit in horizontal and vertical planes. Horizontal lines to be parallel to the building walls and partitions.

6. Close conduit openings into which dirt, plaster, mortar mix, or debris may fall with caps or tight fitting plugs during the construction period. Thoroughly clean conduits in which such material has accumulated. Where such accumulations cannot be readily removed, replace the conduit.

7. Support and secure conduit to walls, building frame, etc., by the use of malleable iron galvanized U bolts, beam clamps, conduit straps, or "Unistrut" fittings where "Unistrut" racks or supports are used.

8. Securely fasten conduit to boxes with lock nuts and insulating bushings for prevention of tubing damage.

9. Unused box knockouts to remain closed or be sealed with knockout closures.

10. Cut conduit square with an approved cutter, ream burrs, and clean metal shavings and cutting lubricants.

11. Make conduit bends where practical using tools which leave tubing free from wrinkles, flats, or humps. Where a number of conduits are run together, the radii of required bends to be neat in appearance.

12. Provide conduit pull boxes at such intervals to limit the number of 90^{o} bends between boxes to three.

D. Label conduits as follows:

1. Use self-adhesive labels of suitable background color upon which is printed the name "Pneumatic" in upper case Gothic type, 5/8-in. high, bold face stem, black lettering.

2. Use identification labels on straight sections at maximum intervals of 40 ft.

3. Identify conduit passing through walls or floors on each side by a label located not more than 5 ft from the wall or floor.

E. Install plastic instrument tubing inside conduit in accordance with drawings and as follows.

1. Tubing to be continuous between boxes; splicing between boxes is not acceptable.

2. Install compression and/or slip-on fittings at boxes.

3. Install tubing with ends cut square, not stretched or compressed, without bends and kinks.

4. Number tubing on each end and on both sides of any brass fitting with numbers similar to those used to identify electrical wiring.

5. Provide shutoff valves where shown on drawings.

3.03 FIELD QUALITY CONTROL

A. After the systems are installed inspect them as follows:

1. Perform a continuity check on each tubing run to assure that lines are terminated correctly.

2. Carefully coordinate the location of system components to reserve space for instrument removal and maintenance.

3. Ensure that tubing and fittings are the type and sizes specified.

4. Ensure that conduit has been properly supported, protected from damage, and free of bend defects.

B. Make repairs required prior to testing.

C. System Testing

1. Furnish labor, materials, equipment, tools, and services necessary for testing and cleaning the system(s).

2. The CM will furnish the nitrogen or plant compressed oil-free dry air for testing and cleaning.

3. Perform leak testing as follows.

a) Blank off or replace with spool pieces items of equipment (e.g., vessels, pumps, instruments, controls, and safety and relief valves) rated for pressures below the test pressure.

b) Apply pressurized nitrogen or dry air to the system at 1 1/2 times the maximum working pressure. In no case shall test pressure be less than 50 psig.

c) Soap test parts of the system for leaks, especially at threaded connections.

d) Repair leaks and retest the repaired joints.

3.04 ADJUSTING AND CLEANING

A. Perform cleaning as follows.

1. Remove blanks and/or spool pieces used for temporary aids during leak testing.

2. Clean instrument air tubing by flushing with nitrogen or dry air for 5 min.

a) After system cleaning is completed, reconnect instruments and equipment.

b) After instruments and equipment have been reconnected, pressurize and soap test these connections at maximum operating pressure. Repair leaks and retest repaired joints.

3.05 PROTECTION

A. Deliver tubing material, including valves and fittings, to the site in a clean and protected condition.

B. Exercise care in the handling and storage of tubing and conduit materials and prefabricated tubing so that contamination by moisture, grease, or dirt shall not occur.

END OF SECTION

SECTION 15955

DIRECT DIGITAL CONTROLS

PART 1 GENERAL

1.01 SECTION INCLUDES: Requirements for a Direct Digital Control (DDC) system to control, monitor, and manage the HVAC heat pump systems serving the building. [**Designer Note:** It is the intention of this specification to provide sufficient performance requirements to a controls subcontractor such that the controls subcontractor can design a DDC system to meet the job requirements. Requirements in the form of the control diagram, sequences of operation, and the control loop schedule (found on the drawings) and the graphical operator interface are coupled with specification requirements for such hardware devices as sensors, controllers, workstations, networking devices, etc. It is not intended for the designer to perform the detailed hardware design layout, but to specify the performance and hardware requirements for such a control system.]

1.02 REFERENCES

A. American National Standards Institute, ANSI B31.1-1983 Power Piping

B. ANSI C2-1984 National Electrical Safety Code.

C. ANSI MC96.1-1982 Temperature Measurement Thermocouples.

D. American Society of Heating, Refrigeration and Air-Conditioning Engineers, ASHRAE Publication, Handbook, Fundamentals, 1997.

E. Federal Communications Commission (FCC) Rules and Regulations Part 68, Connection of Terminal Equipment to the Telephone Network Vol. X, 1977.

F. Electronic Industries Associated (EIA) Publications RS-232-C, Circuit Terminating Equipment Employing Serial Binary Data Interchange, 1987.

G. EIA RS-485 Standard for Electrical Characteristics for Generators and Receivers for Use in Balanced Digital Multipoint Systems, 1983.

H. Institute of Electrical and Electronics Engineers (IEEE) Publications Std 587-1980 Guide for Surge Voltage in Low Voltage AC Power Circuits.

I. IEEE Std 142-1982 Recommended Practice for Grounding of Industrial and Commercial Power Systems.

J. National Fire Protection Association (NFPA) NFPA 70 National Electrical Code - 1999.

K. Occupational Safety and Health Administration (OSHA) OSHA 1910 General Industry.

1.03 DEFINITIONS

A. Analog signal: A continuous electrical or pneumatic signal which communicates a change in a controlled/monitored variable by varying amplitude or frequency over time.

B. Binary signal: An electrical signal which communicates a change in a controlled/monitored variable by changing state (voltage or current) between one of two possible values.

C. Direct Digital Control (DDC): The use of microprocessor based controllers utilizing preprogrammed software instructions to monitor and control a variable(s).

D. Distributed Control: The use of stand-alone digital controllers to perform all control responsibilities without the required use of a supervisory host computer or controller.

E. Erasable, Programmable, Read-Only Memory (EPROM): A semi-permanent form of memory which is retained when power is lost. EPROM memory may be over-ridden if desired.

F. Field Access Terminal (FAT): A portable laptop computer which operates as a workstation when connected into the LAN bus by a modem.

G. Firmware: Software which resides in a stand-alone controller which provides the algorithms and performs all calculations necessary to monitor and control a variable(s).

H. Gateway: A communications bus interface which allows access to a local area network, thus allowing communications between stand-alone digital controllers (SADC) and operator workstations.

I. Local Area Network (LAN): A communications link interfacing SADC's thus affording peer-to-peer communication between all devices on the network.

J. Operator Workstation: A personal computer-based terminal residing on the local area network which interfaces with the SADCs, allowing the operator to interrogate and status all control functions and change setpoints of all devices on the system.

K. Peer to Peer: The layout of SADCs operating on a LAN giving each equivalent status in communications and control hierarchy and affording distributed control of its control loops.

L. Point: A source of input monitored or output controlled by the control loop.

M. Portable Operator's Tool (POT): A hand held instrument used to provide local interrogation and programming of SADC's in the field.

N. Programmable Field Control Unit (PFCU): A stand-alone digital controller which operates on a peer to peer bus and manages distributed control for multiple control loops on large equipment such as air handling units, chillers, etc. The PFCU provides a means for global control, information management, and network communications for the peer bus and any lower tier buses operating PTCU's.

O. ProgrammableTerminal Control Unit (PTCU): A stand-alone digital controller which provides distributed control for one or two control loops on small terminal equipment such as fan coil units, VAV boxes, reheat valves, etc.

P. Random Access Memory (RAM): A volatile form of memory which requires continuous power to exist.

Q. Real Time Clock: The internal clock in a controller which tracks time, day, day of week, month, and year.

R. Stand-Alone Digital Controller (SADC): A digital controller which contains all the hardware and software necessary to control a variable(s) without external supervisory instruction, thus affording distributed control. This includes Programmable Field Control Units, Programmable Terminal Control Units, etc. Master/Slave controller arrangements are not SADC's.

1.04 SUBMITTALS

A. Submit the following for approval:

1. A power and controls schematic illustrating the control system including power and control hardware components in a single-line format.

2. A terminal strip diagram for components identifying wiring terminations with termination identifiers.

3. Physical drawings showing the location of space-mounted devices, i.e., sensors, panels, transformers, controllers, workstations, etc.

4. Vendor data in the form of a hardware manual containing product descriptions and specifications, operation and maintenance procedures, and software manual containing product description of programs, algorithms, and the graphical operator interface.

5. A point description table containing description, identification and nomenclature of each point including identification of the point as a "RAM" point or "EPROM" point.

6. A separate point list of point addresses and descriptors.

7. A hardcopy of the source code for all controller application programming.

8. Step-by-step testing procedures for the Functional & Diagnostic Test, and the Operational Acceptance Test prior to beginning testing.

9. As-designed Sequence of Operation, prior to beginning construction. Sequence of Operation to include specific control logic to be programmed into the controllers, including setpoints, input parameters, time delays, etc.

B. Submit the following for information:

1. As-built drawings of items in 1.04.A.

2. Results of Functional and Diagnostic Tests in 1.04.A.8 prior to initiation of Operational Acceptance test.

3. As-built Sequence of Operation after construction is complete.

4. 8-1/2" x 11" color hardcopy plots of control loop trends

PART 2 PRODUCTS

2.01 MATERIAL

A. Thermowells to be monel, brass or copper for use in copper pipe and 300 series stainless steel for other applications.

B. Enclosures to conform to requirements of NEMA 250 for the types specified. Finish color to be manufacturers standard. [**Designer Note:** Designer may specify otherwise.]

Enclosures located in a clean, dry indoor environment may be NEMA 1, and NEMA 12 otherwise. Enclosures located outdoors to be NEMA 4. [**Designer Note:** Unless otherwise specified.]

C. Control wiring for 24 VDC circuits to be 18 AWG min, twisted, 100% shielded, and rated for 300 VAC service. Analog control wiring to contain a stranded drain. Wire size to be in accordance with NEC Article 310.

D. Multicolor control cables to be moisture-resistant. Cables run in wireways or cable trays to be Type TC (tray cable), 600 F, 90 degrees C per NEC Article 340. Cable size to be in accordance with NEC Article 310.

2.02 SENSORS/SWITCHES

A. Resistance Temperature Detectors (RTD) to be platinum elements encapsulated in epoxy, series 300 stainless steel, anodized aluminum or copper. Sensor accuracy to be 0.1% of actual resistance at 32^{o}F. Stability error over 5 years must not exceed 0.25^{o}F, cumulative. RTDs to use three wire or four wire configuration for compensation of the lead wire resistance. Total error for a RTD circuit not to exceed 0.5^{o}F, including sensor error, lead resistance error or transmitter error, and A/D conversion resolution error.

B. Thermistors to have a range of 40^{o}F to 100^{o}F with an accuracy within 0.4^{o}F. Stability error over 5 years must not exceed 0.25^{o}F. Lead resistance error not to exceed 0.1^{o}F. Total error for thermistor not to exceed 0.5^{o}F, including sensor and lead resistance error.

C. Temperature transmitters to have 4-20 ma output linearly scaled to the variable being sensed. Transmitter to be matched to the resistance range of the sensor, factory calibrated and sealed. The output error not to exceed 0.1 percent of the calibrated span. Input power to be 24 VDC. The transmitter to include offset and span adjustments that are noninteractive unless the RTD element is integral to the transmitter and system calibration is provided. Transmitter stability not to exceed 0.02% of calibrated span over a 6-month period.

D. Room temperature sensors may be either RTD or thermistor type as specified above. Temperature sensor/transmitters to be a concealed element type behind a protective cover matched to the room interior. The sensor/transmitter shall have a minimum span of 50^{o}F. Room temperature sensor to have thumbwheel control which provides an analog input to the local TCU (or PFCU) for space temperature control during occupied hours. Provide pushbutton (override) with LED indicator to allow the user to take command of the space temperature setpoint during unoccupied times using the thumbwheel. The period of temporary override control to be fixable at the operator workstation as desired by CM Operations. Subsequent energizing of the pushbutton will reset the temporary override condition.

E. Duct-mounted sensors and associated transmitters to be RTD type as specified above. Temperature sensor/transmitters to be continuous averaging type for ductwork applications of 12 sq-ft cross-sectional area and greater. Ductwork sensors/transmitters to have a (-50) - (275) ^{o}F minimum span. Continuous averaging sensors to be a low-mass quick response type with a maximum element diameter of 3/16".

F. Pipe-mounted sensors and associated transmitters to be RTD type as specified above. The pipe-mounted temperature sensor to be installed in a thermowell with thermal transmission material compatible with the immersion sensor. The minimum sensor span to be 200^{o}F.

G. Outside air sensor may be either RTD or thermistor type as specified above. The sensor to be provided with a sunshade which does not inhibit the flow of air across the sensor and protects the sensor from snow, ice, rain, and direct sunlight. The outside air temperature/sensor to have a minimum span of 125^{o}F.

H. Differential pressure switches to be diaphragm type for binary (two-position) operation. Switch to withstand pressures up to 150% of rated pressure. Contacts to be single pole, double throw and to be capable of being wired in normally open or normally closed operation. Trip setpoint to be adjustable. Pressure switch to be sized so that operating pressure drop point is approximately midpoint of pressure switch adjustable range. Switch contact rating to be in accordance with NEMA ICS. Repetitive accuracy to be within 2%.

I. Differential pressure sensor range to provide 150% of maximum differential pressure.

J. Relative humidity sensor/transmitter to be integral humidity transducer and transmitter. Output of device to be a 4-20 ma signal proportional to 0-100% relative humidity input. Accuracy to be within 2.5% of full scale within the range of 20-80% relative humidity. Noninteracting zero and span controls to be provided if required to maintain calibration. Sensing element to be chilled mirror type, polymer, or thin film polymer type.

K. Freezestat to be a continuous serpentine sensing type element capable of sensing the coldest 12-inch section for low-limit temperature. Freezestat to be furnished with two SPST snap switches, one 120/208/240 v switch to provide direct "hard-wired" shutdown of motor-driven equipment, the second 24v switch to provide alarm status for input to DDC. Freezestat setpoint to be selectable by manual setting on furnished controller. Temperature sensing range to be 15 ^{o}F to 55 ^{o}F.

L. Motor analog current sensor to have 4-20 ma. linear output. Sensor to be adjustable between 3 to 135 amps with 1.5 amp accuracy. Sensor to be 100% solid state with power and status LEDs. Sensor to be split core design to allow installation without removing conductor.

M. Local Hand-Off-Auto (HOA) switches to be double pole type for the purpose of status indication.

2.03 LOCAL AREA NETWORK

A. SADC's and local operator workstations to be connected through a single communication local area network (LAN). The LAN shall include but not be limited to the following features:

1. Permit sharing input and output information between PFCUs, TCUs and workstations allowing execution of dynamic control strategies and coordinated response to alarm conditions.

2. Interrogation from the workstation of all point information accessible from SADC's.

3. Communicate at a minimum of 9600 baud.

4. Communicate via existing voice grade telephone lines with remotely located operator workstations using modems. Communication shall be two way, allowing unsolicited alarm and trending information to be sent to the workstation as well as commands sent to the SADCs from the workstation.

5. Communications with remotely located operator workstations shall be via phone lines. Provide the necessary communications equipment for the transmission of data over the existing telephone lines.

6. The failure of a device on the network shall not impair communications between remaining devices on the network.

7. A maximum of eight PTCUs may be powered from one transformer. Each PFCU to have its own transformer.

8. Provide for remote dialup from a remote workstation utilizing one or more modems via a phone connection into the LAN. A gateway may serve as the point of interface between the workstations and the LAN.

2.04 STAND-ALONE DIGITAL CONTROLLERS (SADC's)

A. SADC's to be listed by Underwriters Laboratories (UL) against fire and shock hazard as a signal system appliance unit and be completely enclosed in a NEMA 1 metal cabinet min. One SADC shall be provided to control each piece of HVAC equipment (AHU's, VAV boxes, etc.)

B. Programmable Field Control Units (PFCU)

1. Each PFCU to have its own microcomputer controller, power supply, I/O modules, termination modules, communications controller, battery, spare A/C outlet, clock, and calendar.

2. An additional 25% point capacity to be provided above and beyond the binary and analog inputs and outputs brought directly to the PFCU from the field devices.

3. Provide back up of RAM memory for a minimum of 24 continuous hours. An AC power failure not to inhibit the PFCU or PTCU from performing previous control functions once power is restored.

4. PFCU's shall have a main power switch for isolation of the PFCU from AC power.

5. PFCU cabinets to contain a 120 VAC, 15 amp, 60 Hz duplex power outlet. The outlet to be on a separate circuit from the PFCU.

6. PFCU cabinets to be locked by a key lock. One key shall access all PFCU cabinets in the building.

7. Provisions for connection of a Field Access Terminal for network-wide information access and control.

2.05 MISCELLANEOUS DEVICES

A. LAN wiring to have surge protection rated for the application. Surge protection devices to be mounted in a NEMA 1 metal control cabinet.

B. Motor control relays to be double pole, double throw (DPDT), with contacts rated to the application, and enclosed in a dustproof enclosure. Relay to be equipped with a light indicator which is lit when the coil is energized and off when the coil de-energizes. Relays to be socket type, plug into a fixed base, and be replaceable without need of tools or removing wiring. Motor control relays to be mounted in a NEMA 1 metal control cabinet.

C. Current to pressure (I/P) transducers to convert a 4-20ma DC input signal to a proportional 3-15 psig pressure output signal. Accuracy to be within 0.25% of span (including linearity, hysteresis, and deadband). Supply voltage shall be 24 volts DC. The transducer to be rated for an operating temperature of 0 to 140^{o}F. I/P transducer to be manufactured by the SADC manufacturer.

D. Pressure to current (P/I) transducers to convert a 3-15 psig input signal to a proportional 4-20ma DC output signal. Supply voltage, accuracy, and operating temperature requirements to be the same as specified for I/P transducers.

E. Transducers to be mounted in a NEMA 1 metal control cabinet.

F. Pressure gauges, 0-30 psig.

2.06 OPERATOR WORKSTATION

A. Operator workstations (both local and remote) to be used for system interrogation, database management, and alarm monitoring. An operator command issued from an operator workstation (and changes in monitored conditions from the lowest level controller) to be witnessed in no more than 20 seconds between the lowest level controller and the operator workstation. Temperature control strategies, monitoring and energy management routines for each SADC to be accessible by an operator from each workstation (remote or local) on the LAN. The workstation to be configured with equipment and documentation necessary to allow an operator full access to each SADC's controlling and monitoring capability (all point information). [**Designer Note:** Describe the number and location of workstations to be provided.]

B. The central processing unit to be a commercially available, general purpose personal computer. The computer shall not be required by the control system for daily operation. The computer to utilize DOS and MS-Windows, have an Intel Pentium microprocessor, and include the following features:

1. Minimum of one 1Gbyte hard drive configured with DOS operating system.

2. Minimum of 16 Mbytes on-board RAM

3. 1024 x 768 SVGA card with a minimum of 2Mbytes RAM

4. Minimum of two serial ports

5. Minimum of two parallel ports

6. Battery backed real time clock

7. One 1.4 Mbyte 3.50 inch floppy drive

8. 101 key keyboard and a mouse

9. Internal Hayes compatible auto dial/auto answer modem capable of communicating at 9600 baud

10. One 2Gbyte 4mm internal tape backup system

C. The monitor to be color VGA with a minimum size of 19 inches (measured diagonally) with capability to support 1024 x 768 pixel resolution and a display of 256 colors minimum.

D. Printer, Hewlett Packard Laserjet 5, parallel port laser with 600 dpi printing resolution to print all visual output shown on the monitor including graphics and reports. Print speed to be 8 pages/minute minimum, have 8 Mbytes RAM, use the PCL 5 printer language and Postscript. Lower cassette assembly for 500 sheets of letter or legal size paper.

2.07 PORTABLE OPERATOR's TERMINAL (POT)

[**Designer Note:** If required by project.]

A. Provide portable operator's tool (POT) which allows access to all points located on a specific SADC. The POT to have the capability to completely interrogate, command and display data on all SADC points in the system (locally).

2.08 FIELD ACCESS TERMINAL (FAT)

[**Designer Note:** If required by project.]

A. Provide a portable Field Access Terminal (FAT) which allows access to all points on each SADC on the network. The FAT to be capable of accessing data and performing commands, graphical and otherwise as a workstation, when connected to the LAN. The operator shall have the capability to make program changes from the FAT. Access to the network through the FAT shall use the same passwords as for access through the operator workstations. The FAT shall have access to the network through a network interface port at any PFCU or peer bus and shall include all necessary hardware for connection to the LAN. FAT to be a laptop style PC computer, Texas Instruments TI Travelmate 32 bit 80486 WinDX with the following features:

1. minimum operating speed of 66 MHz

2. minimum of 16 Mbyte RAM

3. integral active matrix Liquid Crystal display

4. VGA card with 1 Mbyte of RAM

5. minimum of 450 Mbyte hard disk

6. 3.5-inch floppy drive with minimum 1.44 Mbyte capacity

7. rechargeable battery pack with AC power adapter

8. bus port mouse

2.09 SADC SOFTWARE

A. Configure the PFCU with necessary software for system operation, communication, programming, and control applications. As a minimum, each PFCU to be capable of controlling the HVAC system as described in the control diagram and performing the following energy management routines:

1. Time of day/week scheduling for equipment

2. Start/stop time optimization for equipment

3. Duty cycling for redundant equipment

4. Supply air temperature reset at each air handling unit (AHU) based on space

5. Simultaneous heating and cooling monitoring at each AHU

6. Event initiated programs

7. Manual operator override of automatic functions

8. Time and date of each alarm occurrence

B. SADC's to support two-position, proportional, proportional plus integral, and proportional plus integral plus derivative (PID) control with built-in self-tuning PID algorithms.

C. Database modification for the entire system to be accessible via an operator workstation or FAT. Database and program modification to be accomplished with menu-driven software which prompts the operator for input and does not require interfacing directly to the line-by-line programming.

D. Provide necessary software, documentation, and training to allow the operator to completely and autonomously configure a controller for a new application and to make modifications to existing controller configurations and setpoints. On-line help to be available to provide general operating instructions and context-specific help.

2.10 OPERATOR WORKSTATION AND FAT SOFTWARE

A. Configure each operator workstation and FAT such that the operator may use other software applications such as word processors, spreadsheets, and database management programs with the same operating system software used to run the DDC workstation software.

B. Workstation and FAT software to provide for data exchange between the host computer and the SADC's. This data to include, but not be limited to, system parameters, alarms, and operator commands.

C. User access to be controlled through use of multiple levels of password protection. A minimum of three user assignable password levels to be available. Passwords to be the same for all operator devices and to be downloaded to all PFCUs/Gateways when modified.

D. Commands to be clear, easily understood words or acronyms to allow use of the system without extensive training or a data processing background. The operator workstation to use a mouse-oriented operator interface and prompt the user for the input of words, phrases, acronyms, or mouse point-and-click commands. The software to be capable to provide change in setpoints, schedules, and equipment operation by using the mouse point-and-click feature on an object-oriented graphical screen. Operator workstation software to provide a means for the entry of control and monitoring commands which to include but not be limited to the following:

1. Requests for and termination of communications with SADC's
2. Operator selected displays or printouts of input or output points connected to SADC's
3. Startup or shut down selected devices
4. Modify time and event scheduling
5. Adjust setpoints
6. Generate reports
7. Adjust PFCU time base
8. Trending
9. Alarms

E. The software to provide capability to create and execute sequences for automated control of equipment based on times, events, and conditions without extensive training or a data processing background. On-line help to be available to the operator providing general operating instructions and context specific help.

[**Designer Note:** The following descriptive requirements are primarily performance oriented. In addition to these requirements, the designer may choose to specify the exact number and type of graphics required for the project, including the use of hypertext to navigate through the various graphics. Also, the designer may choose to provide the graphical programming in lieu of the controls subcontractor.]

F. The operator workstation to have high resolution graphics for monitoring the operation of the system and making changes in the setpoints, schedules, and equipment operation. Operator interaction with the system to be through a mouse-driven, menu-prompted interface. Provide animated color graphic displays for floor plans and mechanical system schematics such as AHUs, chilled water, and hot water systems. Display current updated status indication for data values in their actual location on the floorplan Color to be used to represent the alarm status of building space temperature in relation to the setpoint. Access to the various graphic floor plans and mechanical system schematics to be provided by menu selection, mouse point-and-click, or text commands. Graphic displays to be linked allowing the operator to move to another graphic using a mouse. Status changes and alarms shall be indicated by objects changing color, location, or by blinking.

G. Additional software to be provided to enable the CM to edit and/or add new graphic screens using graphic libraries provided. The library to include symbols and shapes common to the HVAC industry. The graphic software to have built-in control panel objects such as buttons, knobs, gauges, and line graphs that mimic the mechanical equivalents.

H. The operator workstation software to provide the capability to generate and create user defined summaries on any point in the system. Reports to be generated automatically or manually and displayed in an easy to read format to a CRT. The user to have the capability to output the report to a printer for a hard copy, or file the report to disk. The format of the report to be logically arranged for ease of interpretation.

I. Data available at the SADC's to be uploaded to the operator workstation hard disk when desired. Uploading to be performed at user-defined intervals.

J. Logging of historical data for trending any point on the system shall be provided. The point shall be sampled at user-defined intervals and stored for a period of no less than 24 hours. Up to eight points to be sampled at individually assigned intervals. The capability to define and edit sample intervals on-line shall be provided.

K. Each workstation to be notified of alarm conditions by a visual and audible alarm contained in the graphics. Communication of alarms to the operator workstations shall be unsolicited. Alarm messages to provide the point identification, time, date, and an alarm message up to 60 characters in length. The alarm to remain in the visual alarm mode until the alarm condition clears. Each workstation printer shall print the alarm message when the alarm is received. Specific alarm conditions required are identified as follows: [**Designer Note:** Insert specific alarm requirements if desired.]

L. The operator workstation software to provide the capability to change the operating parameters, the alarm limits, and the start/stop schedules of equipment for downloading to the field control units. The software shall have the capability to schedule system operation based on but not limited to the following parameters:

1. Summer, winter or intermediate season operation

2. Day of week

3. Holidays

4. Time of day

5. Occupancy schedules

6. Equipment constraints

7. Temporary schedule override

2.11 REAL TIME CLOCK

A. Real time clock to maintain network devices on the LAN to clock resolution of 0.1 second. Internal 4 day battery backup provided. Internal 60 hz. line frequency, temperature conpensated crystal oscillator. Clock to be a serial device with RS-232C, RS-422, RS-423 and 20ma current loop compatibility. Clock to provide calendar year, month, date, hour (12 and 24 hour formats), minute and second time. Display to be re-settable from manual switches on front panel. Chrono-Log Corp. K-series**.** [**Designer Note:** The Real Time Clock is a feature required for a large DDC network. Only one real time clock is required on a single network. Small control applications would not require this feature.]

PART 3 EXECUTION

3.01 INSTALLATION/APPLICATION/ERECTION

A. Install pipe mounted temperature sensors and other temperature sensors that are subject to corrosion and/or vibration in a thermowell with a thermal conductive medium. Size thermowells to accommodate the temperature sensor and be rigidly supported. Installation to allow for easy replacement of the sensor.

B. Ductwork mounted sensors to be inserted a sufficient distance into the duct so as to obtain an accurate representation of the air stream temperature.

C. Mount outdoor temperature sensors a minimum of 3 inches from the building. Accompanying transmitter electronics and associated terminations mounted outside to be enclosed in a NEMA 4X enclosure.

D. Provide laminated plastic nameplates for all equipment devices furnished in accordance with Engineering Standard ES-2.2-1. Each nameplate to identify the device and its function with a minimum 1/4 inch high engraved block lettering. Laminated plastic to be one-eighth inch thick, white with black center core. Attach nameplates to the device when possible, or securely fastened in the immediate vicinity of the device. Label each SADC cabinet with its own unique identification number and node number.

E. Analog control wiring to contain a stranded drain which ultimately connects to a dedicated ground in the PFCU cabinet. Drains at the sensor/transducer to remain open and not be permitted to contact ground or any other conductor.

F. Conceal installation of wiring in finished areas whenever possible. Where concealing is not possible, written approval for exposed work must be obtained from the CM prior to installation. Conceal wiring in exposed areas in conduit painted to match the decor of the interior finishes. Exposed wiring may be run above the ceiling with the prior written approval of the CM. Clearly identify exposed wiring/cabling a minimum of every 100 feet with tags.

G. Install 0-30 psi pressure gauge in-line just after SADC transducer pneumatic outputs. Mount a similar gauge in-line on the main air supply.

3.02 FIELD QUALITY CONTROL

A. Provide field testing, adjustment, and on-site operational testing of the complete DDC system. Provide the personnel, equipment, instrumentation, and supplies necessary to perform testing. Provide written notification of planned testing at least 14 calendar days prior to the testing. Perform and supervise all tests unless specifically noted otherwise in this specification. Coordinate testing with the CM. Do not perform testing without the prior written approval of the CM. The CM will witness testing.

B. Functional and Diagnostic Test: Upon completion of installation of equipment, perform the following:

1. Calibrate field equipment and verify transmission media operation before the system is placed on line.

2. Perform a detailed cross-check by comparing the reading at the sensor to the reading at the operator workstation. Use a calibration standard that is traceable to the National Bureau of Standards

3. Provide a cross-check of each control point within the system by comparing the control command at the operator workstation to operation of the field-controlled device.

4. Verify the stand-alone noncommunicating operation mode capabilities.

5. Verify systems return to PFCU control automatically upon resumption of power.

6. Verify the system shutdown mode capabilities.

7. Verify each graphic point is linked to the appropriate point information.

8. Verify alarm setpoints are set at appropriate levels.

9. Provide a historical trend on each point in the system. Results to be plotted on each point within each of the control loops within the system. Plot each control loop on a separate color graph for comparison of actual control characteristics vs. desired control characteristics. Each control loop to be demonstrated "under control" by inducing a step change in setpoint from the workstation, with the variable change to meet setpoint observed on each graph. Acceptance of the project is contingent upon submittal of each control loop trend plot with satisfactory control demonstrated for each control loop. Submit graphs as 8-1/2"x11" color hard-copy plots.

10. Submit the results of the Functional and Diagnostic Tests and equipment calibrations in accordance with the approved test plans prior to initiation of the Operational Acceptance Test.

C. Operational Acceptance Test: The Operational Acceptance Test to begin after successful completion of the Functional and Diagnostic Test. The test to be conducted for 30 consecutive days, 24 hours per day, on the entire DDC system to demonstrate that the system functions in accordance with requirements. The correct operation of monitored and controlled points, as well as the operation and capabilities of software to be demonstrated. The equipment to operate at an availability of at lease 95% of the 30 consecutive calendar days. In the event the required availability is not maintained during the period, extend the test on a day-to-day basis until the required availability is reached for 30 consecutive calendar days. Availability is defined as follows:

Availability = (TP - Summation of Outages)/TP
Where: TP is the test period in hours

Summation of Outages: The total number of points out of service divided by the total number of points in the system times the length of outage in hours. The summation shall be totalized and updated each hour of the test period.

D. Outages result whenever the DDC system is unable to fulfill required functions due to malfunction of hardware or software. Outages of the system resulting from the following causes will not be considered failures:

1. An outage of the main power supply in excess of the capability of backup power source for the PFCU, provided that the automatic initiation of backup sources was accomplished and that automatic shutdown and restart of the system fulfills the requirements.

2. Failure of a communications link, provided that the PFCU automatically and correctly operates in the non-communicating stand-alone mode and that the failure was not due to Contractor-supplied equipment.

3. Failure of existing equipment.

4. Failure resulting from a sensor or controller provided that the system has recorded the fault and no more than one percent of the sensors and controllers are out of service at any time.

5. A system hardware failure, provided that the initiation of the DDC functional requirements for backup provisions are accomplished, and if hardware is restored to service within 72 hours.

3.03 OPERATOR/MAINTENANCE TRAINING

A. Conduct training courses for designated personnel on the maintenance and operation of the DDC system. Provide training manuals for each trainee with two additional copies provided for record. The manuals shall include an agenda, defined objectives for each lesson, and a detailed description of the subject matter for each lesson. Furnish audiovisual equipment and other training materials and supplies. For portions of the course presented using audiovisuals, supply copies of the audiovisuals. A training day is defined as eight hours of classroom instruction which includes two 15-minute breaks and excludes lunchtime, Monday through Friday, during the normal first shift in effect at the facility. The personnel to be trained should be assumed to have a high school education or equivalent. Instruction to be provided by competent instructors and to include the adjustment, operation, maintenance, and custom process programming. Orient the training specifically to the system installed. Forty hours of training to be provided for a class size of 10 persons. [**Designer Note:** The actual length of the course and size of the class vary according to the needs of the customer. Also, specific course information may be added here.]

B. The CM will perform maintenance of the entire system after the warranty period. Maintenance training to provide the CM maintenance department with all the knowledge, literature, and tools necessary to perform all maintenance operations. The maintenance portion of the training to be separate from the operator portion of the training.

END OF SECTION

SECTION 15956

CONTROL PANELS AND INSTRUMENTS

PART 1 GENERAL

1.01 SECTION INCLUDES: Fabrication and installation of control panels and instrumentation.

1.02 RELATED SECTIONS

A. Section 15100, Valves.

1.03 REFERENCES

A. ASTM B32-93, Standard Specification for Solder Metal.

B. ASTM B280-93, Rev. A, Standard Specification for Seamless Copper Tube for Air Conditioning and Refrigeration Field Service.

C. ASTM D635-91, Standard Test Method for Rate of Burning and/or Extent and Time of Burning of Self-Supporting Plastics in a Horizontal Position.

D. ASTM D638-91, Standard Test Method for Tensile Properties of Plastics.

E. ASTM D792-91, Standard Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement.

F. ASTM D1238, Rev. B-90, Standard Test Method for Flow Rates of Thermoplastics by Extrusion Plastometer.

G. ASTM D1693-70, (R 1989), Standard Test Method for Environmental Stress-Cracking of Ethylene Plastics.

H. NEC.

I. NEMA 250-1991, Enclosures for Electrical Equipment (1000 V maximum).

1.04 SUBMITTALS

A. Submit the following for approval.

1. Shop drawings on each control panel and sub-panel prior to fabrication. Include dimensions of the overall panel, overall instrument size, panel cutouts for recessed instruments, spacing between instruments, schematic layout and interrelationship of each control item used either in or on the control panel including model numbers, flow rates, capacities, operating ranges, set points, throttling ranges, spring ranges, calibration instructions, and other pertinent data for describing the system operation.

[**Designer Note:** Provisions for lockout/tagout of equipment and system components to be coordinated with other disciplines and incorporated into the design in accordance with 29 CFR 1910.147, "The Control of Hazardous Energy," and 29 CFR 1910.333, "Selection and Use of Work Practices."]

B. Submit the following for information.

1. Operation and maintenance manuals.

2. Manufacturer's certified record brochures containing "as built" copies of the above drawings and data.

PART 2 PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. Johnson Controls, Inc., Control Cabinets M-8100 Series

B. Powers Automatic Controls, Standard Control Cabinets CP 567

C. Barber-Colman Company, Local Cabinets AE Series

2.02 PRODUCTS AND MATERIALS

A. Copper control tubing: UNS C12200, seamless, 1/4-in. OD, hard-drawn 0.025-in. wall or soft drawn 0.030-in. wall in accordance with ASTM B280.

B. Use globe-type copper tubing shutoff valves with brass body, Buna N or Teflon trim with compression fitting ends 1/4-in. V-6193 per Sect. 15100.

C. Solder: 95-5 tin-antimony, solid wire, ASTM B32, alloy Grade Sb5. Acid cord or rosin core solder is not permitted. Use solder with a noncorrosive paste flux.

D. Plastic tubing: Made of flame-retardant, stress-crack resistant black polyethylene and in accordance with the following:

1. Melt index ASTM D1238.

2. Density ASTM D792.

3. Tensile strength and elongation ASTM D638.

4. Stress cracking ASTM D1693.

5. Flame retardation ASTM D635.

6. Tubing to be suitable for a safe working pressure of 100 psig at 130• F.

7. Tubing to be available in sizes and tolerances as follows:

Nominal size	Average O.D.	Average I.D.	Wall
1/4 in. O.D.	.250 in. ± .004 in.	.170 in. ± .004 in.	.040 in. ± .003 in.
3/8 in. O.D.	.375 in. ± .005 in.	.250 in. ± .005 in.	.062 in. ± .003 in.

8. Tubing: "Instube" by Plexco.

E. Use brass tubing compression fittings with integral inside tube support and polypropylene ferrules by Imperial-Eastman Corporation, Poly-Flo.

F. Tubing slip-on fittings: Brass barbed-type fittings and accessories by Johnson Service Company.

G. Use needle-type shutoff valves with brass body "Poly-Flo" and male pipe thread connections by Imperial-Eastman Corporation, Nos. 310-C, 311-C, and 312-C.

H. Use permanent-type nameplates fabricated from either aluminum by the photometal process or engraved bakelite.

I. Control panel:

1. Cabinet type, UL listed for line voltage application, totally enclosed with a hinged, full-face, flush-mounted door and key operated latch, and knockouts in the panel sides, top, bottom, or back to allow for the entrance of tubing and/or wiring. [**Designer Note**: Meets requirements of 29 CFR 1910.303.i.]

2. Cabinet used for instrumentation to be a NEMA Type 12 enclosure that is dusttight and driptight. Enclosure to be designed for wall mounting. [**Designer Note:** Specify if other type mounting is required.]

2.03 FABRICATION

A. Mark cabinet permanently with the manufacturer's name, voltage, current, wattage, or other electrical ratings as necessary. [**Designer Note:** Meets requirements of 29 CFR 1910.303.e.]

B. Fabricate the enclosure of not less than 14-gage steel with seams continuously welded. Provide a rolled lip around three sides of the door and four sides of the cabinet body.

C. Provide cabinets with a 12-gage (min) interior steel panel. Use the same finish as that specified for the cabinet interior.

D. Door or doors to be mounted on a continuous hinge pin, be sealed by a perimeter gasket, and have adjustable door stop.

E. The door latching mechanism to be of the three point type operated by a steel lever type latch handle designed to accept a padlock. The handle to have a plated finish.

F. Install the controls on or in the cabinet or panel in accordance with attached equipment data sheets. [**Designer Note:** List data sheets.]

G. Arrange controls for a neat appearance with sufficient space around each instrument for servicing and maintaining the equipment.

H. Mount controls recessed or flush either on the door or inside according to design specifications.

I. Make control-panel cutouts in accordance with certified drawings by vendors supplying the instruments. Cut out centerlines to be in accordance with the applicable drawings and to be machine cut rather than flame cut.

J. Attach nameplates beneath each instrument or control device located in or on the control panel. Attach plates with permanent cement of sufficient strength to resist nameplate warping. Nameplate information to consist of equipment numbers, instructions, and other specified information. Use a minimum of 1/4-in.-high letters.

K. Controls to be pretubed and/or wired to bulkhead fittings and/or electric disconnect box. Unused box knockouts to remain closed or be sealed with knockout closures. [**Designer Note**: Meets requirements of 29 CFR 1910.305.b.1.]

L. Tag bulkhead fittings for identification.

M. Route [plastic] [copper] tubing from a bulkhead fitting with a temporary cap at the outside of enclosure to instruments inside of or on door of enclosure. Tubing to be flexible between door and enclosure. Position tubing for ease of opening and closing door.

N. Tubing to be neat, of good workmanship, leak tested, and arranged for removal and service of controls.

O. Electrical wiring and workmanship to conform to Article 310 or the latest NEC code. [**Designer Note**: See Div. 16, Electrical.]

P. Position wiring between door and enclosure for ease of opening and closing door.

Q. Wiring to be neat, of good workmanship, tested, and arranged for removal and service of controls. Wiring to be in bundles with either tie wraps or tape fasteners.

R. Wires which terminate at a screw type terminal to have a flat ring tongue insulated pressure type lug made up with a crimping tool, properly sized for both wire gage and screw size.

S. Identify wiring at each termination point utilizing embossed-type polyvinyl chloride sleeve-type wire markers. Wire tagging and terminal point labeling to agree with the elementary wire numbering system made from the control diagrams.

T. Furnish control panel for mounting with bolts through rear or floor of unit to an existing structure.

U. Furnish control panel complete with a free-standing support for mounting above the floor. Elevation of supported cabinet to be as shown on the drawings.

V. Provide a terminal strip for terminating conductors that must be connected to points external to the panel.

2.04 SOURCE QUALITY CONTROL

A. Visually inspect control cabinets including instruments, controls, indicators, and recorders with associated piping, wiring, and identification for complete compliance with specifications and drawings as well as top quality workmanship. This inspection to be performed by the fabricator assembling the control panels at his factory.

PART 3 EXECUTION

3.01 INSTALLATION/APPLICATION/ERECTION

A. Alternating-current electrical power in the enclosure is not to exceed 125 V unless authorized otherwise and no energized exposed terminals will be permitted.

B. Maintain a minimum working space of 3 ft on the door side of the cabinet, except where nominal voltage within the cabinet exceeds 150 V; where a minimum working space of 4 ft is required. [**Designer Note:** Meets the requirements of 29 CFR 1910.303.g.]

3.02 PROTECTION

A. After final factory testing of each completely assembled control cabinet with its specified instruments, controls, indicators, and recorders, prepare it for shipment. Carefully seal pneumatic control lines with a light holding charge of dry nitrogen. Block relays and other instruments protected in a suitable manner to prevent damage during shipment.

B. Crate control cabinets with sufficient packing and padding to prevent damage in shipment.

C. Package and ship accessory items related to the instruments, recorders, indicators, etc., in the control cabinet such as fluids, ink, charts, or other items required or incidental to operation with its corresponding control cabinet.

D. Fully label items shipped to show the contents of the crate or package, the building number, job number, purchasers order number, and any other pertinent information.

END OF SECTION

SECTION 15970

PLATE HEAT EXCHANGERS

[Designer Note: This equipment is generally advisable unless an **extensive** water chemistry analysis has been performed and there is a high confidence level that scaling or corrosion will not affect the heat pump unit heat exchangers.]

PART 1 GENERAL

1.01 SECTION INCLUDES: Details for installation of plate heat exchangers used in GHP ground water, surface water systems, and hybrid systems with cooling tower.

1.02 RELATED SECTIONS

A. Section 15050, Piping Systems.

B. Section 15501, Heating, Ventilating, and Air Conditioning Systems Installation and Equipment.

1.03 SUBMITTALS

A. Submit certified dimensional drawings for approval by the CM prior to fabrication of plate frame heat exchanger.

B. Submit certified factory performance test procedures and performance test results for CM approval prior to fabrication.

PART 2 PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. Alfa Lavel, Mueller, B&G ITT and as approved by the CM.

2.02 PRODUCTS

A. Design pressure: 150 psig. [**Designer Note**: All design parameters are subject to verification for the specific application in question.]

B. Design temperature: 230 deg.F.

C. Fluid flow rate: [**Designer Note:** Per specific application.]

2.03 MATERIALS

A. End plates: SA-515 or SA-516 steel.

B. Plate hanger: 304 stainless steel

C. Compression bolts: SA-193-B7 zinc plated steel.

D. Compression nut: SA-194-2H zinc plated steel.

E. Channel plates: .6 mm 316 stainless steel.

F. Gaskets: Nitrile [**Designer Note:** Other gasket materials are available to match the service temperature and fluid service requirements for different types of HVAC applications]

G. Connections: Carbon steel 2" NPT. [**Designer Note:** Connections and material vary with application requirements, i.e. flanged and stainless steel, etc.]

PART 3 EXECUTION

3.01 INSTALLATION

A. Install plates and gaskets per manufacturer's sequence and flow diagram.

B. Gasket adhesive shall be compatible with the service temperature and gasket material.

C. Piping connections shall not impose a load on the nozzles. Use isolators to prevent transfer of vibration from pipe to nozzles.

D. Torque all bolts and pressure plates per manufacturer's recommendations.

E. Install necessary vacuum relief devices to prevent the equipment from being subjected to a negative pressure.

F. Provide adequate space for maintenance and disassembly of plates.

G. Provide sufficient isolation valves to allow unit to be removed from service without draining the system.

3.02 PROTECTION

A. Gasket removal tools and brushes shall be of a material compatible with the plates. Carbon steel shall not be used on stainless steel.

B. Provide a shroud for personnel protection if surface temperatures exceed 105 degrees F.

END OF SECTION

SECTION 15972

PACKAGE COOLING TOWERS

PART 1 GENERAL

1.01 SECTION INCLUDES: Details for installation of factory assembled, induced draft, cross flow, single inlet, vertical discharge cooling towers used in GHP hybrid systems.

1.02 RELATED SECTIONS

A. Section 15050, Piping Systems.

B. Section 15501, Heating, Ventilating, and Air Conditioning Systems Installation and Equipment.

1.03 SUBMITTALS

A. Submit certified dimensional drawings for approval by the CM prior to fabrication of cooling tower

B. Submit certified factory performance test procedures and performance test results for CM approval prior to fabrication.

PART 2 PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. Marley, BAC, Tower Tech, and as approved by the CM.

2.02 PRODUCTS

A. Design range and approach: [**Designer Note**: All design parameters are subject to verification for the specific application in question.]

B. Design WB temperature: 78 deg.F. [**Designer Note**: ASHRAE/CTI specifies a 78 deg design WB temperature unless site conditions dictate otherwise]

C. Fluid flow rate: [**Designer Note:** Per specific application.]

2.03 MATERIALS

A. <u>Basin section</u>: The pan shall be constructed of G-235 hot-dip galvanized steel for long life and durability. G-235 hot-dip galvanized steel designates an average coating thickness of 2.35 ounces of zinc per square foot on the steel. Standard pan accessories shall include overflow, drain, anti-vortexing hood, Type 304 Stainless Steel strainers, and brass make-up valve with plastic float. The entire pan area shall incorporate a stepped configuration for reduced water volume, lower operating weight and easier pan maintenance. Depressed side outlet sumps which are not an integral part of the basin shall not be acceptable.

B. Air inlet louvers: The louver shall be constructed from polyvinyl chloride (PVC) and mounted in easily removable frames on all four sides of the cooling tower for access to the entire basin area for maintenance. The louvers shall have a minimum of two changes in air direction to prevent splash out, block direct sunlight from entering basin, and have a minimum 3/4" opening to prevent debris from entering the basin. Cooling Tower shall be provided with corrosion resistant air inlet screens.

C. Water distribution system: The spray header and branches shall be constructed of Schedule 40 polyvinyl chloride (PVC) pipe for corrosion resistance and shall have a steel connection to attach the external piping. The spray header and branches shall be removable for cleaning purposes. The water shall be distributed over the fill by precision molded ABS spray nozzles with large 3/8 by 1 inch orifice openings and integral sludge ring to eliminate clogging. The nozzles shall be threaded into the water distribution piping to assure positive positioning. If open type gravity distribution pans are used, they shall be constructed of a corrosion resistant material. Handrails and a ladder to the top of the tower must be provided for servicing the distribution pans.

D. Fill: The cooling tower fill shall be PVC (polyvinyl chloride) of cross fluted design for maximum heat transfer efficiency. The cross fluted sheets shall be bonded together for strength and durability. The fill shall be fabricated, formed, and installed by the cooling tower manufacturer and shall be elevated a minimum of 6" above the floor of the cold water basin to facilitate cleaning. The fill shall be suitable for use as a working platform. The PVC fill shall be self-extinguishing for fire resistance with a flame spread rating of 5 per ASTM E84-81a. It shall also be resistant to rot, decay, or biological attack. The fill shall be able to withstand a water temperature of 130°F.

E. Eliminators: The eliminators shall be constructed entirely of inert polyvinyl chloride (PVC) in easily handle sections and be completely separate from the fill section for maximum efficiency. The eliminator design shall incorporate three changes in air directions to assure removal of entrained moisture from the discharge air stream. Maximum drift rate shall be less than 0.001% of the re-circulating water rate.

F. Mechanical Equipment:

1. Fan Motor(s)

Totally enclosed air over (TEAO) ball bearing fan motor(s) with a 1.15 service factor shall be suitable for cooling tower service on 440 volts, 60 hertz, and 3 phase. Motor(s) shall be mounted on an adjustable base which allows motor to swing to the outside of the unit for servicing.

2. Drive

The fan drive shall be multi-groove, solid back V-belt type with taper lock sheaves designed for 150% of the motor nameplate horsepower. The belt material shall be neoprene reinforced with polyester cord and specifically designed for cooling tower service. Fan and motor sheave shall be aluminum alloy construction. Belt adjustment shall be accomplished from the exterior of the unit. Bearing lube lines shall be extended to the exterior of the unit for easy maintenance. All sheaves located in the air stream shall be constructed of aluminum alloy, vented guard shall not be acceptable. If internal belt adjustment is necessary, an internal working platform and ladder is required to access the drive system.

3. Axial Propeller Fans

Fans shall be heavy duty axial propeller type statically balance. The fans shall be fabricated by the cooling tower manufacturer for single source responsibility and reliability. The fans shall be constructed of extruded aluminum alloy blades, installed in a closely fitted cowl with venturi air inlet for maximum fan efficiency. Each fan blade shall be individually adjustable. Fan cowl shall be covered with a heavy gauge hot dip galvanized steel wire fan guard.

4. Fan Shaft Bearings

Fan shaft bearings shall be heavy duty self-aligning type with grease fittings extended to the outside of the unit. Bearings shall be designed for a minimum L-10 life of 75,000 hours.

5. Fan Drive Warranty

Cooling tower fan drive components shall be covered by a three year manufacturer's plan. Drive components protected by this warranty shall include the fans, bearings, fan shaft, drive sheaves and fan motors.

G. Casing: The casing shall be constructed of G-235 hot-dip galvanized steel. The casing panels shall totally encase the sides of the fill section to protect the surface from direct atmospheric contact.

H. Finish: All pan and casing material shall be constructed of G-235 heavy gauge mill hot-dip galvanized steel for maximum protection against corrosion. During fabrication, all panel edges shall be coated with a 95% pure zinc-rich compound.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install tower per manufacturer’s sequence of instruction.

B. Piping connections shall not impose a load on the tower. Use isolators to prevent transfer of vibration ,if applicable.

C. Torque all bolts per manufacturer's recommendations.

D. Provide adequate space for maintenance and disassembly of tower.

E. Provide sufficient isolation valves to allow unit to be removed from service without draining the system.

3.02 TESTING

A. The cooling tower will be tested by a CTI (Cooling Tower Institute) certified testing agency for conformance to the performance specifications. The testing agency will be hired by the Contractor and approved by the CM. All tests shall conform to CTI standard procedures. Upon failure of the performance test, the Contractor shall be responsible for installing all remedies necessary to bring the cooling tower up to performance specifications. Fan pitch adjustment shall not be allowed as a method to increase tower performance deficiencies. The Contractor will also be responsible for reimbursing the Owner for all subsequent performance tests required to validate performance.

END OF SECTION

SECTION 15975

FIELD ERECTED COOLING TOWERS

PART 1 GENERAL

1.01 DESCRIPTION

A. General provisions and other mechanical systems are specified in other Sections of Division 15. This section applies to cooling towers used in GHP hybrid system service.

1.02 RELATED SECTIONS

A. Section 15505, Heating, Ventilating and Air Conditioning Systems Installation and Equipment.

1.03 QUALITY ASSURANCE

A. Pressure/temperature ratings of components and accessories shall meet or exceed design conditions for the system in which they are installed.

B. Cooling towers: manufacturer shall certify tower performance for the actual installed space conditions.

1.04 CODES

A. HVAC systems shall conform to the Standard Mechanical Code [**Designer Note**: Use latest local codes].

B. NFPA 90A-1999.

PART 2 PRODUCTS

2.01 COOLING TOWERS

A. Furnish all material, equipment and appurtenances required for a complete counter flow induced draft cooling tower. This cooling tower shall include fill, fill support lintels, drift eliminators, fan assemblies, fan drives, water distribution system, and all other materials and parts required to make this cooling tower complete.

B. Upon completion, the cooling tower manufacturer shall issue a written guarantee, duly signed, covering the following components, and should any of these components fail during the following specified times they shall be replaced F.O.B. job site.

1. The fill and fill support lintels shall be guaranteed against performance or functional failure or for a period of 15 years. [**Designer Note**: If tile fill is used, the guarantee should be 25 years.]

2. The drift eliminator and hot water distribution system shall be guaranteed against performance or functional failure for 5 years.

3. Remaining internal components shall carry the manufacturer's standard warranty of 1 year of service.

C. The cooling tower manufacturer shall take the space limitations of the cooling tower structure into consideration for the various designs required, including water cooling capacity and performance, fan air handling, and motor brake horsepower requirements.

D. The following shall be furnished by the cooling tower manufacturer and installed under his supervision.

1. Lintels:

a) Fill support lintels: heavy-duty cast iron lintels shall span the concrete fill support beams. Lintels shall be designed to support tile fill material and shall conform to ASTM/A48. Material shall be gray iron casting, Class 30 minimum, and shall have a design safety factor of 3, with an additional 1/8" thickness for corrosion allowance. Other materials with a minimum of 10 years successful experience in this application may be substituted.

2. Fill:

a) Shall be poly vinyl chloride (PVC) thermoplastic, especially formulated for use in cooling tower applications. The top and bottom edges of the individual sheets shall be folded over a minimum of 1/2" inch to improve strength. The finished individual fluted sheets shall be solvent-bonded at all contact points and shall be 27 mils thick with ¾" minimum flute openings. The fill shall be Munters 19060 or equal by Brentwood. PVC material shall conform to ASTM D1784, Type I, Grade 1, and shall have a flame spread rating of 10 when tested in accordance with ASTM Procedure E-84. The finished fill pack shall be bottom supported from the structural concrete fill support beams. Fill top surface shall be of sufficient strength to withstand the weight of maintenance workers (approx. 50 lbs./sq. ft.).

[**Designer Note:** The following fill can be used in lieu of PVC fill.]

Fill - The fill shall be of a multi-cell tile design, set without mortar, in a pattern, and of sufficient height to meet the performance specifications. The tile fill shall be hard-burned clay, with a low water absorption such that it will pass a freeze-thaw test conducted in accordance with ASTM C67. Further, the tile fill shall have minimum crushing strength of 2000 psi over the gross area of the tile when the load is applied parallel to the cells as tested in accordance with ASTM C67.

3. Drift eliminators:

a) Drift eliminators: shall be of the wave formed PVC type, 15-mil minimum sheet thickness, UV protected capable of supporting maintenance traffic without damage to the top surface. Support shall be of pultruded FRP structural shapes sufficiently sized and spaced to permit a loading of 50 lbs./sq. ft. and shall be suspended from 5/16" diameter (minimum) brass or stainless steel rods connected to stainless steel embeds in the underside of the roof deck. Drift eliminators supported on the hot water distribution piping shall not be permitted. Allowable drift shall be limited to 0.0005% of circulating water flow. Mist eliminators shall have a flame spread rating of 15 or less when tested in accordance with ASTM/E84. Provide a framed stainless steel access door for passage through the eliminators to the fill. Provide a 24" wide FRP grating maintenance walkway from access opening to the center of each cell. A hot dipped galvanized maintenance access ladder shall be provided from walkway to gearbox.

4. Speed Reducers:

a) A vibration switch shall be supplied to protect mechanical equipment against excessive damage due to a malfunction of rotating members. The vibration switch shall be mounted on the gear reducer. The cooling tower manufacturer shall also supply a control module which automatically provides a 15 second time delay upon fan start up to prevent false shut down. An off level switch shall be provided by the cooling tower manufacturer to provide protection for sudden loss of oil or low oil level in the gear reducer.

b) An oil level sight glass, fill/drain line, and vent line shall be installed, terminating outside the fan stack. All piping shall be stainless steel.

c) The speed reducer gears shall be rated in accordance with practices of the American Gear Manufacturer Association, using service factor of 2.0 minimum for cooling tower services. These shall be in accordance with CTI STD-111. Gear reducers shall be of the spiral bevel, 2 reduction type. The gear reducer shall be bolted on a galvanized steel base plate and bolted to the structure. Manufacturer shall be Amarillo.

5. Fan Assembly:

a) The complete fan assembly (fan and mounting) shall be designed to give maximum fan efficiency and long life when handling saturated air at high velocities. The fan shall be of a multi-blade design. The fan blades shall be "wide-chord" FRP type with hot dipped galvanized steel plate hub. Manufacturer shall be Hudson or equal approved by the CM.

b) Provide a removable aluminum fan stack safety screen.

c) [**Designer Note:** Provide item b. above when public access to the fan is possible or when debris can be thrown on the fan by the public.]

6. Drive Connection:

a) The motor shall be coupled to the gearbox by means of a flexible coupling. The motor shall be located outside the air stream, and the drive shaft shall be the full floating type with flexible couplings at both ends. Drive shafts shall be of all stainless steel, fitted on each end with flexible couplings (stainless steel plate type). Each drive shaft coupling shall be provided with a hot dipped galvanized steel guard to prevent damage to surrounding equipment in case of shaft failure.

7. Motors:

a) The motor horsepower shall be of the next larger standard motor than that calculated as required for the individual fan brake horsepower. Motors shall be bolted on a galvanized steel base plate through bolted and grouted to the roof deck.

b) Fan drive motor(s) and base plate(s) shall be supplied by the cooling tower manufacturer.

8. Distribution System:

a) The distribution system for each cell shall consist of a centrally located header, complete with side laterals, fittings and nozzles. All piping and fittings shall be schedule 40 PVC. Nozzles are PVC or ABS. Nozzles shall be capable of passing a 3/16" diameter sphere without clogging. System shall be dual type with a turndown ratio of 4: 1. Pipe laterals shall be secured to the tower walls with stainless steel saddles.

b) Distribution piping, including spray nozzles, pipe, and fittings shall be supplied complete to flange face located at a point 6" below the top of the fill support beam or optionally flush with the inside of the tower wall.

c) All penetrations through the basin structure shall be installed in a manner to ensure a waterproof joint.

9. Tower Access:

a) A hot dipped galvanized steel access door shall be provided for roof deck access by manufacturer. A hot dipped galvanized ladder shall be furnished by the manufacturer for access from the fan deck level to the fill.

E. Manufacturer: Ceramic Cooling Tower (Baltimore Air Coil), Marley, or Tower Engineering.

PART 3 EXECUTION

3.01 TESTING

A. The cooling tower will be tested by a CTI (Cooling Tower Institute) certified testing agency for conformance to the performance specifications. The testing agency will be hired by the Contractor and approved by the CM. All tests shall conform to CTI standard procedures. Upon failure of the performance test, the Contractor shall be responsible for installing all remedies necessary to bring the cooling tower up to performance specifications. Fan pitch adjustment shall not be allowed as a method to increase tower performance deficiencies. The Contractor will also be responsible for reimbursing the Owner for all subsequent performance tests required to validate performance.

END OF SECTION

SECTION 15980

CLOSED CIRCUIT COOLERS

PART 1 GENERAL

1.01 SECTION INCLUDES: Details for installation of closed circuit coolers used in GHP hybrid systems. Coolers shall be factory-assembled closed circuit cooling tower(s) of induced draft design with single side air inlet and vertical air discharge. Principal construction shall be hot dip galvanized steel.

1.02 RELATED SECTIONS

A. Section 15050, Piping Systems.

B. Section 15501, Heating, Ventilating, and Air Conditioning Systems Installation and Equipment.

1.03 QUALITY ASSURANCE

A. The closed circuit cooling tower shall be guaranteed by the manufacturer to have capacity as specified in section 2.02 below.

1.04 SUBMITTALS

A. Submit certified dimensional drawings for approval by the CM prior to fabrication of cooler.

B. Submit certified factory performance test procedures and performance test results for CM approval prior to fabrication.

PART 2 PRODUCTS .

2.01 ACCEPTABLE MANUFACTURERS

A. BAC, Marley, Evapco and as approved by the CM.

2.02 PRODUCTS

A. Design range and approach: [**Designer Note**: All design parameters are subject to verification for the specific application in question.]

B. Design WB temperature: 78 deg.F. [**Designer Note**: All design parameters are subject to verification for the specific application in question. ASHRAE/CTI recommend 78 deg unless otherwise specified.]

C. Fluid flow rate: [**Designer Note:** Per specific application.]

2.03 MATERIALS

A. Coil Section: The heat transfer section of the closed circuit cooling tower shall be encased with heavy-gauge galvanized steel panels and shall be removable. The coil shall be constructed of continuous serpentine all prime surface steel, have a design pressure of 280 psig, be tested at 350 psig air pressure under water, and be hot-dip galvanized after fabrication. The coil shall be designed for free drainage of fluid.

B. Wet Deck Surface and Drift Eliminators: The wet deck surface and integral drift eliminators shall be formed from polyvinyl chloride (PVC) and shall be impervious to rot, decay, fungus or biological attack. The surface shall be manufactured and performance tested by the closed circuit cooling tower manufacturer to provide single source responsibility and assure control of the final product. A separate set of drift eliminators shall be removable in easily handled sections for quick access to the coil. Eliminators shall have a minimum of three changes in air direction and be removable in easily handled sections. Drift loss shall be limited to less than 0.001% of the total water circulated.

C. Cold Water Basin: The cold water basin shall be constructed of heavy-gauge hot-dip galvanized steel. The basin shall include a depressed section with drain/clean-out connection. All routine maintenance may be performed from outside the unit. Standard accessories shall include large-area, lift-out steel strainers with perforated openings sized smaller than water distribution nozzle orifices, an integral anti-vortexing hood to prevent air entrainment, waste water bleed line, and brass make-up valve with large-diameter plastic float arranged for easy adjustment.

D. Air Inlet Louvers: Air inlet louvers shall be wave-formed, fiberglass-reinforced polyester (FRP), spaced to minimize air resistance and prevent water splash-out.

E. Water Distribution System: Water shall be distributed evenly over the coil at a flow rate sufficient to ensure complete wetting of the coil at all times. The system shall consist of a hot-dip galvanized steel header and schedule 40 PVC spray branches with large-diameter, non-clog, 360o plastic distribution nozzles. The branches and spray nozzles shall be held in place by snap-in rubber grommets, allowing quick removal of individual nozzles or complete branches for cleaning or flushing.

F. Mechanical Equipment: Fan(s) shall be heavy-duty, axial flow, with aluminum alloy blades. Air shall discharge through a fan cylinder designed for streamlined air entry and minimum fan blade tip clearance for maximum fan efficiency. Fan(s) and shaft(s) shall be supported by heavy-duty, self-aligning, grease-packed ball bearings with moisture-proof seals and integral slinger rings, designed for minimum L10 life of 40,000 hours. Fan(s) shall be driven by a one-piece, multi-groove neoprene/polyester belt designed specifically for evaporative cooling service. Fan and motor sheave(s) shall be fabricated from cast aluminum. Fan motor(s) shall be totally-enclosed air-over (TEAO), reversible, with 1.15 service factor, suitable for evaporative cooling duty on 440 volt/60 hertz/ 3phase electrical service. The motor shall be furnished with special moisture protection on windings, shafts and bearings. Each motor shall be mounted on an easily-adjusted, heavy-duty motor base. All major mechanical components, including fans, fan shafts, bearings, sheaves, supports, and the fan motor are covered by a five-year mechanical warranty.

G. Water Re-circulation Pump: A close-coupled, bronze-fitted centrifugal pump equipped with a mechanical seal shall be mounted on the basin and piped from the suction strainer to the water distribution system. It shall be installed to drain freely when the basin is drained.

H. Access: A large, hinged access door and internal walkway shall be provided for access to the coil, drift eliminators, and fan plenum section. The water make-up valve, float ball, and sump suction strainer shall be accessible from outside the unit.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install cooler per manufacturer's sequence of instructions.

B. Piping connections shall not impose a load on the nozzles. Use isolators to prevent transfer of vibration.

C. Torque all bolts per manufacturer's recommendations.

D. Provide adequate space for maintenance and disassembly of plates.

E. Provide sufficient isolation valves to allow unit to be removed from service without draining the system.

3.02 TESTING

A. When water is the process fluid, the performance shall be certified by the Cooling Tower Institute in accordance with CTI Certification Standard STD-201 or, lacking such certification, a field acceptance test shall be conducted within the warranty period in accordance with CTI Acceptance Test Code ATC-105, by the Cooling Tower Institute, or other qualified independent third party testing agency.

END OF SECTION

SECTION 15995

MECHANICAL SYSTEMS COMMISSIONING

PART 1 GENERAL

1.01 DESCRIPTION

A. The purpose of this section is to provide a guide for the Contractor/Seller to specify the Division 15 responsibilities in the commissioning process.

B. The systems to be commissioned are listed in the Contract Documents.

C. Commissioning requires the participation of Division 15 to ensure that all systems are operating in a manner consistent with the Contract Documents. The general commissioning requirements and coordination are detailed in Division 1. Division 15 shall be familiar with all parts of Division 1 and the commissioning plan issued by the CA and shall execute all commissioning responsibilities assigned to them in the Contract Documents.

1.02 RELATED SECTIONS

A. Refer to Division 1 for a listing of all sections where commissioning requirements are found.

B. Refer to Division 1 for systems to be commissioned.

1.03 SUBMITTALS

A. Division 15 shall provide submittal documentation relative to commissioning as required in this Section Part 1.

1.04 RESPONSIBILITIES

A. Mechanical, Controls and TAB Contractors. The commissioning responsibilities applicable to each of the mechanical, controls and TAB Contractors of Division 15 are as follows (all references apply to commissioned equipment only):

Construction and Acceptance Phases

1. Include and itemize the cost of commissioning in the contract price.

2. Attend a commissioning scoping meeting and other meetings necessary to facilitate the commissioning process.

3. Contractors shall provide the Commissioning Agent (CA) with normal cut sheets and shop drawing submittals of commissioned equipment.

4. Provide additional requested documentation, prior to normal O&M manual submittals, to the CA for development of start-up and functional testing procedures.

   a) Typically this will include detailed manufacturer installation and start-up, operating, troubleshooting and maintenance procedures, full details of any owner-contracted tests, fan and pump curves, full factory testing reports, if any, and full warranty information, including all responsibilities of the Owner to keep the warranty in force clearly identified. In addition, the installation, start-up and checkout materials that are actually shipped inside the equipment and the actual field checkout sheet forms to be used by the factory or field technicians shall be submitted to the Commissioning Agent.

   b) The Commissioning Agent may request further documentation necessary for the commissioning process.

   c) This data request may be made prior to normal submittals.

5. Provide a copy of the O&M manuals and submittals of commissioned equipment, through normal channels, to the CA for review and approval.

6. Contractors shall assist (along with the design engineers) in clarifying the operation and control of commissioned equipment in areas where the specifications control drawings or equipment documentation is not sufficient for writing detailed testing procedures.

7. Provide limited assistance to the CA in preparing the specific functional performance test procedures required. Sub-Contractors shall review test procedures to ensure feasibility, safety and equipment protection and provide necessary written alarm limits to be used during the tests.

8. Develop a full start-up and initial checkout plan using manufacturers start-up procedures and the pre-functional checklists from the CA for all commissioned equipment. Submit to CA for review and approval prior to startup.

9. During the startup and initial checkout process, execute the mechanical-related portions of the pre-functional checklists for all commissioned equipment.

10. Perform and clearly document all completed startup and system operational checkout procedures, providing a copy to the CA.

11. Address current A/E punch list items before functional testing. Air and water TAB shall be completed with discrepancies and problems remedied before functional testing of the respective air- or water-related systems.

12. Provide skilled technicians to execute starting of equipment and to execute the functional performance tests. Ensure that they are available and present during the agreed upon schedules and for sufficient duration to complete the necessary tests, adjustments and problem solving.

13. Perform functional performance testing under the direction of the CA for specified equipment. Assist the CA in interpreting the monitoring data, as necessary.

14. Correct deficiencies (differences between specified and observed performance) as interpreted by the CA, CM and A/E and retest the equipment.

15. Prepare O&M manuals according to the Contract Documents, including clarifying and updating the original sequences of operation to as-built conditions.

16. Prepare redline as-built drawings for all drawings and final as-builds for Contractor-generated coordination drawings.

17. Provide training of the Owner's operating personnel as specified.

18. Coordinate with equipment manufacturers to determine specific requirements to maintain the validity of the warranty.

Warranty Period

19. Execute seasonal or deferred functional performance testing, witnessed by the CA, according to the specifications.

20. Correct deficiencies and make necessary adjustments to O&M manuals and as-built drawings for applicable issues identified in any seasonal testing.

B. Mechanical Contractor. The responsibilities of the HVAC mechanical Contractor, during construction and acceptance phases in addition to those listed in (A) are:

1. Provide startup for all HVAC equipment.

2. Assist and cooperate with the TAB Contractor and CA by:

   a) Putting all HVAC equipment and systems into operation and continuing the operation during each working day of TAB and commissioning, as required.

   b) Including cost of sheaves and belts that may be required by TAB.

   c) Providing test holes in ducts and plenums where directed by TAB to allow air measurements and air balancing. Providing an approved plug.

   d) Providing temperature and pressure taps according to the Construction Documents for TAB and commissioning testing.

3. Install a P/T plug at each water sensor that is an input point to the control system.

4. List and clearly identify on the as-built drawings the locations of all airflow stations.

5. Prepare a preliminary schedule for Division 15 pipe and duct system testing, flushing and cleaning, equipment start-up and TAB start and completion for use by the CA. Update the schedule as appropriate.

6. Notify the CM or CA, depending on protocol, 5 working days prior to the time scheduled when pipe and duct system testing, flushing, cleaning, startup of each piece of equipment and TAB will occur. Be responsible to notify the CM or CA, ahead of time, when commissioning activities not yet performed or not yet scheduled will delay construction. Be proactive in seeing that commissioning processes are executed and that the CA has the scheduling information needed to efficiently execute the commissioning process.

C. <u>Mechanical Contractor:</u> The responsibilities of the HVAC mechanical Contractor, during construction and acceptance phases in addition to those listed in (A) are:

1. Controls Contractor. (As Sub-Contractor to the Mechanical Contractor) The commissioning responsibilities of the controls Contractor, during construction and acceptance phases in addition to those listed in (A) are:

   a) <u>Sequences of Operation Submittals.</u> The Controls Contractor's submittals of control drawings shall include complete detailed sequences of operation for each piece of equipment, regardless of the completeness and clarity of the sequences in the specifications. They shall include:

   b) An overview narrative of the system (1 or 2 paragraphs) generally describing its purpose, components and function.

   c) All interactions and interlocks with other systems.

   d) Detailed delineation of control between any packaged controls and the building automation system, listing what points the BAS monitors only and what BAS points are control points and are adjustable.

   e) Written sequences of control for packaged controlled equipment. (equipment manufacturers' stock sequences may be included, but will generally require additional narrative).

   f) Start-up sequences.

   g) Warm-up mode sequences.

   h) Normal operating mode sequences.

   i) Unoccupied mode sequences.

j) Shutdown sequences.

k) Capacity control sequences and equipment staging.

l) Temperature and pressure control: setbacks, setups, resets, etc.

m) Detailed sequences for all control strategies, e.g., economizer control, optimum start/stop, staging, optimization, demand limiting, etc.

n) Effects of power or equipment failure with all standby component functions.

o) Sequences for all alarms and emergency shut downs.

p) Seasonal operational differences and recommendations.

q) Initial and recommended values for all adjustable settings, set-points and parameters that are typically set or adjusted by operating staff; and any other control settings or fixed values, delays, etc. that will be useful during testing and operating the equipment.

r) Schedules, if known.

s) All sequences shall be written in small statements, each with a number for reference. For a given system, numbers will not repeat for different sequence sections, unless the sections are numbered.

2. Control Drawings Submittal

a) The control drawings shall have a key to all abbreviations.

b) The control drawings shall contain graphic schematic depictions of the systems and each component.

c) The schematics will include the system and component layout of any equipment that the control system monitors, enables or controls, even if the equipment is primarily controlled by packaged or integral controls.

d) Provide a full points list with at least the following included for each point:

1) Controlled system
2) Point abbreviation
3) Point description
4) Display unit
5) Control point or set-point (Yes / No)
6) Monitoring point (Yes / No)
7) Intermediate point (Yes / No)
8) Calculated point (Yes / No)

Key:

Point Description: DB temp, airflow, etc.

Control or Set-point: Point that controls equipment and can have its set-point changed (OSA, SAT, etc.)

Intermediate Point: Point whose value is used to make a calculation which then controls equipment (space temperatures that are averaged to a virtual point to control reset).

Monitoring Point: Point that does not control or contribute to the control of equipment, but is used for operation, maintenance, or performance verification.

Calculated Point: "Virtual" point generated from calculations of other point values.

The Controls Contractor shall keep the CA informed of all changes to this list during programming and setup.

3. An updated as-built version of the control drawings and sequences of operation shall be included in the final controls O&M manual submittal.

4. Assist and cooperate with the TAB Contractor in the following manner:

   a) Meet with the TAB Contractor prior to beginning TAB and review the TAB plan to determine the capabilities of the control system toward completing TAB. Provide the TAB any needed unique instruments for setting terminal unit boxes and instruct TAB in their use (handheld control system interface for use around the building during TAB, etc.).

   b) For a given area, have all required pre-functional checklists, calibrations, startup and selected functional tests of the system completed and approved by the CA prior to TAB.

   c) Provide a qualified technician to operate the controls to assist the TAB Contractor in performing TAB, or provide sufficient training for TAB to operate the system without assistance.

5. Assist and cooperate with the CA in the following manner:

   a) Execute the functional testing of the controls system as specified for the controls Contractor.

b) Assist in the functional testing of all equipment specified to be commissioned.

c) Execute all control system trend logs.

6. The controls Contractor shall prepare a written plan indicating in a step-by-step manner, the procedures that will be followed to test, checkout and adjust the control system prior to functional performance. At minimum, the plan shall include for each type of equipment controlled by the automatic controls:

a) System name.

b) List of devices.

c) Step-by-step procedures for testing each controller after installation, including:

1) Process of verifying proper hardware and wiring installation.
2) Process of downloading programs to local controllers and verifying that they are addressed correctly.
3) Process of performing operational checks of each controlled component.
4) Plan and process for calibrating valve and damper actuators and all sensors.
5) A description of the expected field adjustments for transmitters, controllers and control actuators should control responses fall outside of expected values.

d) A copy of the log and field checkout sheets that will document the process. This log must include a place for initial and final read values during calibration of each point and clearly indicate when a sensor or controller has "passed" and is operating within the contract parameters.

e) A description of the instrumentation required for testing.

f) Indicate what tests on what systems should be completed prior to TAB using the control system for TAB work. Coordinate with the CA and TAB Contractor for this determination.

7. Provide a signed and dated certification to the CA and CM upon completion of the checkout of each controlled device, equipment and system prior to functional testing for each piece of equipment or system, that all system programming is complete as to all respects of the Contract Documents, except functional testing requirements.

8. Beyond the control points necessary to execute all documented control sequences, provide monitoring, control and virtual points as specified.

9. List and clearly identify on the as-built duct and piping drawings the locations of all static and differential pressure sensors (air, water and building pressure).

D. <u>TAB Contractor</u>: The duties of the TAB Contractor, in addition to those listed in (A) are:

1. Six weeks prior to starting TAB, submit to the CM the qualifications of the site technician for the project, including the name of the Contractors and facility managers of recent projects the technician on which was lead. The CM will approve the site technician's qualifications for this project.

2. Submit the outline of the TAB plan and approach for each system and component to the CA, CM and the controls Contractor six weeks prior to starting the TAB. This plan will be developed after the TAB has some familiarity with the control system.

3. The submitted plan will include:

   a) Certification that the TAB Contractor has reviewed the construction documents and the systems with the design engineers and Contractors to sufficiently understand the design intent for each system.

   b) An explanation of the intended use of the building control system. The controls Contractor will comment on feasibility of the plan.

   c) All field checkout sheets and logs to be used that list each piece of equipment to be tested, adjusted and balanced with the data cells to be gathered for each.

   d) Discussion of what notations and markings will be made on the duct and piping drawings during the process.

   e) Final test report forms to be used.

   f) Detailed step-by-step procedures for TAB work for each system and issue: terminal flow calibration (for each terminal type), diffuser proportioning, branch/sub-main proportioning, total flow calculations, rechecking, diversity issues, expected problems and solutions, etc. Criteria for using airflow straighteners or relocating flow stations and sensors will be discussed. Provide the analogous explanations for the waterside.

   g) List of all air flow, water flow, sound level, system capacity and efficiency measurements to be performed and a description of specific test procedures, parameters, formulas to be used.

   h) Details of how *total* flow will be determined (Air: sum of terminal flows via BAS calibrated readings or via hood readings of all terminals, supply (SA) and return air (RA) pitot traverse, SA or RA flow stations. Water: pump curves, circuit setter, flow station, ultrasonic, etc.).

   i) The identification and types of measurement instruments to be used and their most recent calibration date.

   j) Specific procedures that will ensure that both air and water side are operating at the lowest possible pressures and provide methods to verify this.

k) Confirmation that TAB understands the outside air ventilation criteria under all conditions.

l) Details of whether and how minimum outside air cfm will be verified and set, and for what level (total building, zone, etc.).

m) Details of how building static and exhaust fan/relief damper capacity will be checked.

n) Proposed selection points for sound measurements and sound measurement methods.

o) Details of methods for making any specified coil or other system plant capacity measurements.

p) Details of any TAB work to be done in phases (by floor, etc.), or of areas to be built out later.

q) Details regarding specified deferred or seasonal TAB work.

r) Details of any specified false loading of systems to complete TAB work.

s) Details of all exhaust fan balancing and capacity verifications, including any required room pressure differentials.

t) Details of any required interstitial cavity differential pressure measurements and calculations.

u) Plan for hand-written field technician logs of discrepancies, deficient or uncompleted work by others, contract interpretation requests and lists of completed tests (scope and frequency).

v) Plan for formal progress reports (scope and frequency).

w) Plan for formal deficiency reports (scope, frequency and distribution).

4. A running log of events and issues shall be kept by the TAB field technicians. Submit hand-written reports of discrepancies, deficient or uncompleted work by others, contract interpretation requests and lists of completed tests to the CA and CM at least twice a week.

5. Communicate in writing to the controls Contractor all set point and parameter changes made or problems and discrepancies identified during TAB which affect the control system setup and operation.

6. Provide a draft TAB report within two weeks of completion. A copy will be provided to the CA. The report will contain a full explanation of the methodology, assumptions and the results in a clear format with designations of all uncommon abbreviations and column headings. The

report should follow the latest and most rigorous reporting recommendations by AABC, NEBB or ASHRAE Standard 111.

7. Provide the CA with any requested data, gathered, but not shown on the draft reports.

8. Provide a final TAB report for the CA with details, as in the draft.

9. Conduct functional performance tests and checks on the original TAB as specified for TAB in Section 15950.

PART 2 PRODUCTS

2.01 TEST EQUIPMENT

A. Division 15 shall provide all test equipment necessary to fulfill the testing requirements of this Division.

B. Refer to Division 1 for additional Division 15 requirements.

PART 3 EXECUTION

3.01 STARTUP

A. The HVAC mechanical and controls Contractors shall follow the start-up and initial checkout procedures listed in the Responsibilities list in this section. Division 15 has start-up responsibility and is required to complete systems and sub-systems so they are fully functional, meeting the design objectives of the Contract Documents. The commissioning procedures and functional testing do not relieve or lessen this responsibility or shift that responsibility partially to the commissioning agent or Owner.

B. Functional testing is intended to begin upon completion of a system. Functional testing may proceed prior to the completion of systems or sub-systems at the discretion of the CA and CM. Beginning system testing before full completion, does not relieve the Contractor from fully completing the system, including all pre-functional checklists as soon as possible.

3.02 TESTING , ADJUSTING AND BALANCING (TAB)

A. Refer to the TAB responsibilities in Part 1.2 above.

3.03 FUNCTIONAL PERFORMANCE TESTS

A. Refer to Division 1 for a list of systems to be commissioned.

3.04 TESTING DOCUMENTATION, NON-CONFORMANCE AND APPROVALS

A. Refer to Division 1 for specific details on non-conformance issues relating to pre-functional checklists and tests.

B. Refer to Division 1 for issues relating to functional performance tests.

3.05 OPERATION AND MAINTENANCE (O&M) MANUALS

A. The following O&M manual requirements do not replace O&M manual documentation requirements elsewhere in these specifications.

B. Division 15 shall compile and prepare documentation for all equipment and systems covered in Division 15 and deliver this documentation to the CONTRACTOR for inclusion in the O&M manuals, according to this section, prior to the training of owner personnel.

C. The CA shall receive a copy of the O&M manuals for review.

D. Special Control System O&M Manual Requirements. In addition to documentation that may be specified elsewhere, the controls Contractor shall compile and organize at minimum the following data on the control system in labeled 3-ring binders with indexed tabs.

1. Operation and Maintenance Manuals containing:

    a) Specific instructions on how to perform and apply all functions, features, modes, etc. mentioned in the controls training sections of this specification and other features of this system. These instructions shall be step-by-step. Indexes and clear tables of contents shall be included. The detailed technical manual for programming and customizing control loops and algorithms shall be included.

    b) Full as-built set of control drawings (refer to Submittal section above for details).

    c) Full as-built sequence of operations for each piece of equipment.

    d) Full points list. In addition to the updated points list required in the original submittals (Part 1 of this section), a listing of all rooms shall be provided with the following information for each room:

        1. Floor
        2. Room number
        3. Room name
        4. Air handler unit ID
        5. Reference drawing number
        6. Air terminal unit tag ID
        7. Heating and/or cooling valve tag ID
        8. Minimum cfm

9. Maximum cfm

e) Full print out of all schedules and set points after testing and acceptance of the system.

f) Full as-built print out of software program.

g) Electronic copy on disk of the entire program for this facility.

h) Marking of all system sensors and thermostats on the as-built floor plan and mechanical drawings with their control system designations.

i) Maintenance instructions, including sensor calibration requirements and methods by sensor type, etc.

j) Control equipment component submittals, parts lists, etc.

k) Warranty requirements.

l) Copies of all checkout tests and calibrations performed by the Contractor (not commissioning tests).

2. The manual shall be organized and subdivided with permanently labeled tabs for each of the following data in the given order:

a) Sequences of operation

b) Control drawings

c) Points lists

d) Controller / module data

e) Thermostats and timers

f) Sensors and DP switches

g) Valves and valve actuators

h) Dampers and damper actuators

i) Program setups (software program printouts)

3. Field checkout sheets and trend logs should be provided to the CA for inclusion in the Commissioning Record Book.

E. Special TAB Documentation Requirements. The TAB will compile and submit the following with other documentation that may be specified elsewhere in the *Specifications*.

1. Final report containing an explanation of the methodology, assumptions, test conditions and the results in a clear format with designations of all uncommon abbreviations and column headings.

2. The TAB shall mark on the drawings where all traverse and other critical measurements were taken and cross-reference the location in the TAB report.

F. Review and Approvals. Review of the commissioning related sections of the O&M manuals shall be made by the A/E and by the CA.

3.06 TRAINING OF OWNER PERSONNEL

A. The Contractor shall be responsible for training coordination and scheduling and ultimately to ensure that training is completed.

B. The CA shall be responsible for overseeing and approving the content and adequacy of the training of Owner personnel for commissioned equipment or systems.

C. Mechanical Contractor. The mechanical Contractor shall have the following training responsibilities:

1. Provide the CA with a training plan two weeks before the planned training.

2. Provide designated Owner personnel with comprehensive orientation and training in the understanding of the systems and the operation and maintenance of each piece of HVAC equipment including, but not limited to, pumps, boilers, furnaces, chillers, heat rejection equipment, air conditioning units, air handling units, fans, terminal units, controls and water treatment systems, etc.

3. Training shall normally start with classroom sessions followed by hands-on training on each piece of equipment, which shall illustrate the various modes of operation, including startup, shutdown, fire/smoke alarm, power failure, etc.

4. During any demonstration, should the system fail to perform in accordance with the requirements of the O&M manual or sequence of operations, the system will be repaired or adjusted as necessary and the demonstration repeated.

5. The appropriate trade or manufacturer's representative shall provide the instructions on each major piece of equipment. This person may be the start-up technician for the piece of equipment, the installing Contractor or manufacturer's representative. Practical building operating expertise as well as in-depth knowledge of all modes of operation of the specific piece of equipment is required. More than one party may be required to execute the training.

6. The controls Contractor shall attend sessions other than the controls training, as requested, to discuss the interaction of the controls system as it relates to the equipment being discussed.

7. The training sessions shall follow the outline in the Table of Contents of the operation and maintenance manual and illustrate whenever possible the use of the O&M manuals for reference.

8. Training shall include:

   a) Use of the printed installation, operation and maintenance instruction material included in the O&M manuals.

   b) A review of the written O&M instructions emphasizing safe and proper operating requirements, preventative maintenance, special tools needed and spare parts inventory suggestions. The training shall include start-up, operation in all modes possible, shutdown, seasonal changeover and any emergency procedures.

   c) Discussion of relevant health and safety issues and concerns.

   d) Discussion of warranties and guarantees.

   e) Common troubleshooting problems and solutions.

   f) Explanatory information included in the O&M manuals and the location of all plans and manuals in the facility.

   g) Discussion of any peculiarities of equipment installation or operation.

   h) The format and training agenda in *The HVAC Commissioning Process, ASHRAE Guideline 1-1989R*, 1996 is recommended.

9. Hands-on training shall include start-up, operation in all modes possible, including manual, shutdown and any emergency procedures and preventative maintenance for all pieces of equipment.

10. The mechanical Contractor shall fully explain and demonstrate the operation, function and overrides of any local packaged controls, not *controlled* by the central control system.

11. Training shall occur after functional testing is complete, unless approved otherwise by the Project Manager.

D. <u>Controls Contractor.</u> The controls Contractor shall have the following training responsibilities:

1. Provide the CA with a training plan four weeks before the planned training.

2. The controls Contractor shall provide designated Owner personnel training on the control system in this facility. The intent is to clearly and completely instruct the Owner on all the capabilities of the control system.

3. The training will be tailored to the needs and skill-level of the trainees.

4. The trainers will be knowledgeable on the system and its use in buildings. For the on-site sessions, the most qualified trainer(s) will be used. The Owner shall approve the instructor prior to scheduling the training.

5. During any demonstration, should the system fail to perform in accordance with the requirements of the O&M manual or sequence of operations, the system will be repaired or adjusted as necessary and the demonstration repeated.

6. The controls Contractor shall attend sessions other than the controls training, as requested, to discuss the interaction of the controls system as it relates to the equipment being discussed.

3.07 DEFERRED TESTING

A. Refer to Division 1 for requirements of deferred testing.

3.08 WRITTEN WORK PRODUCTS

A. Written work products of Contractors will consist of the start-up and initial checkout plan described in Division 1 and the completed start-up, initial checkout and pre-functional checklists.

END OF SECTION

DIVISION 15

MECHANICAL

ENGINEERING STANDARDS

3-31-2000

DIVISION 15

MECHANICAL – ENGINEERING STANDARDS

Number	Title	Pages
ES-2.2-1	NAMEPLATES, TAGS, AND LABELS FOR INSTRUMENT ASSEMBLIES AND COMPONENTS	4
ES-4.5-2	PIPE HANGERS – GENERAL NOTES	14
ES-4.5-3	PIPE SUPPORT SPACING	2
ES-4.5-5	COPPER TUBING – SUPPORT SPACING	1
ES-5.11-1	INSTRUMENT TEST PORTS – RECTANGULAR DUCT WITH OR WITHOUT EXTERNAL INSULATION	1
ES-5.11-5	INSTRUMENT TEST PORTS – ROUND DUCT WITH OR WITHOUT EXTERNAL INSULATION	1
ES.5.12-1	FIRE DAMPER – FIRE PARTITION – FRAME MOUNTED	1
ES.5.12-2	FIRE DAMPER – FIRE PARTITION – DUCT MOUNTED	1
ES.5.12-3	FIRE DAMPER – FIRE PARTITION – DUCT MOUNTED	1
ES.5.12-4	FIRE DAMPER – FIRE PARTITION – DUCT MOUNTED	1
ES.5.12-5	FIRE DAMPER – FIRE WALL – OPENING MOUNTED	1
ES.5.12-6	FIRE DAMPER – FIRE WALL – FRAME MOUNTED	1
ES.5.12-7	FIRE DAMPER – FIRE BARRIER – FRAME MOUNTED	1
ES.5.12-8	FIRE DAMPER – FLOOR BARRIER – FRAME MOUNTED	1
ES.5.12-9	FIRE DAMPER – FLOOR BARRIER – DUCT MOUNTED	1
ES.5.12-10	FIRE DAMPER – FLOOR BARRIER – DUCT MOUNTED	1

ENGINEERING STANDARD	NUMBER ES-2.2-1
	DATE 6-26-89
OAK RIDGE, TENNESSEE -	REVISED 6-6-95
NAMEPLATES, TAGS, AND LABELS FOR INSTRUMENT ASSEMBLIES AND COMPONENTS	PAGE 1 OF 4

1. SCOPE

This standard prescribes various acceptable methods and materials used to identify instrumentation hardware or provide information regrading its use.

2. PURPOSE

The purpose of this standard is to provide specifications for procuring or designing uniform and acceptable types of nameplates, tags, and labels and their required methods of attachment to a designated item.

3. REFERENCES

Unless otherwise specified, the latest revision of all references shall be used.

A. Instrument Society of America (ISA) Recommended Practice ISA-RP60.6 (latest issue), “Nameplates, Labels, and Tags for Control Centers,” Appendics A, B, and D.

B. ISA Recommended Practice ISA-RP60.8 (latest issue), “Electrical Guide for Control Centers.”

4. DEFINITIONS

A. Nameplate

A nameplate displays the title and/or function of an item such as “RECYCLE VALVE LCV-4 OPEN” on a lamp, “PUMP J5" on a pump control switch, or “% FULL” on a level meter.

B. Tag

A tag displays detailed information about an item such as a wire number, instrument number, or terminal strip designation.

C. Label

A label displays detailed instructions about an item such as a caution statement or calibration procedure.

APPROVED BY D. R. Norris	AUTHOR

5. **GENERAL**

The preferred methods of generating nameplates, tags, and labels are given in this standard. Where the methods specified in this standard are not applicable, refer to Ref. A for guidance.

A. Nameplates

Appendix B of Ref. A shall be used as a guide when abbreviations are required on nameplates.

(1) Materials

a. Laminated Plastics
The top, or background, layer shall be white or other light shade. The core, or letter color, shall be black or other dard shade. The color scheme shall be consistent per assembly or area. Plastic nameplates shall be attached only to the instrument or panel surfaces using screws or contact cement. Clearance holes shall be large enough to prevent stressing (and cracking) the nameplates if screws are used. If pointed screws are used, the protruding points on the backside of the mounting surface shall be covered to prevent injury to personnel, but the covering shall not prevent future removal.

b. Direct Engraving
Nameplates engraved directly on metal instrument panels shall have black-filled letters. Panels shall be either a light shade of the cabinet frame or a light neutral.

c. Direct Photoetching
Photometal panels shall have flat black lettering on a clear anodized background. Panels shall be metalphoto Corp. CB-76-F core, 1100H-14 clad, and processed with a No. 4 finish or Company-approved equal.

d. Metallic Tape
Photoetched metallic tape shall be used for nameplates only inside cabinets or when there is a need to apply a nameplate directly to instrumentation, such as an in-line mounted valve. The tape shall be silver; lettering shall be black. Extreme caution must be exercised if used inside a cabinet where energized electrical circuits are present.

e. Silk Screening
This method is normally used for nameplates when a process diagram is required on an instrument panel, and the entire panel is then silk screened. Nameplates on the panel shall be black; symbols and lines on the panel shall be colored as required by the purchase specification.

(2) Lettering

Lettering shall be oriented horizontally and centered on the nameplate or the designated item. Minimum spacing between words shall be the width of the letter “E”. The guidelines shown on pp. A-2 and A-3 of Ref. A shall be followed. Lettering style shall be condensed gothic. Some examples are shown in Appendix D of Ref. A.

(3) Location

Nameplate location in relation to the designated item shall be consistent throughout the design and shall leave no question as to which item is being identified. Nameplate sizes shall be uniform for items of a similar functional level or importance. Nameplates identifying groups of items or for assemblies shall be larger than for individual items.

B. Tags

(1) Wire

Each wire in an assembly shall be uniquely numbered at each end. Wire numbers shall correspond to wire numbers on the design documents. If the design does not indicate wire numbers, the fabricator shall mark the numbers on the drawings “as-built”. Numbers shall be applied using a heat-stamping method directly on the insulation or on white heat-shrink tubing over the wires. Letters and numbers shall be black. Wiring manufactured with numbered insulation may be used if the numbers appear at intervals of 6 inches or less. Duplicate numbers shall not be used in any wire bundle or in the vicinity of each other in an assembly. Numbers shall be black.

Color-coded wiring may be used only for subassembly wiring or conductors within a manufactured cable. Colors used shall be marked on the design drawings and shall not be duplicated within a chassis or cable unless wires of the same color also bear a unique number.

Insulation for alternating current or direct current power conductors shall meet the color coding recommendations in Ref. B.

(2) Cable

Cables shall be tagged at each end using the heat-stamping method on the cable jacket or on white, heat-shrink tubing over the jacket. Letters and numbers shall be black. Cable numbers shall match the design drawings as in Item 1. An alternate method of cable tagging shall be using aluminum or stainless steel tags securely tied to each cable end by nonmetallic means, which is resistant to ultraviolet light and other ambient conditions, through a hole in the tag. Edges shall be smooth to prevent cutting the tie material. Metallic tags shall be engraved, stamped, embossed, or photoetched with the cable designation.

(3) Terminals

Terminals shall be tagged to match the drawings. Terminal numbers shall be applied by using the terminal manufacturer's method. This shall be either a writing strip attached to the center of the terminal strip or preprinted numbers which snap into the terminal strip. Numbers shall be legibly printed on the writing strip using a black marker.

(4) Components

Items such as terminal strips, tubing at the point of panel penetration, and instruments mounted inside enclosures shall be tagged to match their design document designation. Tags shall be in accordance with the nameplate specifications described above or as follows:

a. For components or assemblies not normally visible or not normally used for operation (such as items inside a cabinet) tags may be in the form of dry transfer or adhesive-backed lettering applied to the mounting panel adjacent to the item. Either type of lettering s hall be covered by a clear coat of lacquer for durability.

b. Field-mounted components shall be tagged using aluminum or stainless steel tags securely fastened to the component with a wire or chain thorugh a hole in the tag and shall be compatible with the expected ambient environment. Tags shall be engraved, stamped, embossed, or photoetched with the component designation.

C. Labels

Labels are special items, and their form and appearance is dependent on their function. Instructional labels shall be applied using the appropriate specifications for nameplates or tags. Warning labels regarding hazards to personnel or equipment will be considered on an individual basis by the Company.

ENGINEERING STANDARD

OAK RIDGE, TENNESSEE

NUMBER	ES-4.5-2
DATE	9-6-73
REVISED	12-5-95
PAGE	1 OF 14

PIPE HANGERS - GENERAL NOTES

1. STRUCTURAL STEEL SHALL CONFORM TO ASTM A-283 AND A-306. PIPE FOR COLUMNS SHALL BE CARBON STEEL, SCHEDULE 40, CONFORMING TO ASTM A-53, GRADE A.

2. THE AISC SPECIFICATION FOR THE DESIGN, FABRICATION, AND ERECTION OF STRUCTURAL STEEL FOR BUILDINGSAND THE AISC CODE OF STANDARD PRACTICE SHALL GOVERN THIS WORK. BOLTED CONNECTIONS FOR STRUCTURAL JOINTS SHALL BE MADE USING ASTM A-325 BOLTS.

3. WELDING SHALL BE IN ACCORDANCE WITH THE AMERICAN WELDING SOCIETY STANDARD CODE FOR ARC AND GAS WELDING IN BUILDING CONSTRUCTION.

4. ALL METAL SURFACES SHALL BE PAINTED IN ACCORDANCE WITH TECHNICAL SPECIFICATION A-4.3, SUBSECTION 4.

5. CONCRETE SHALL HAVE A MINIMUM COMPRESSIVE STRENGTH OF 3000 PSI AT 28 DAYS AND SHALL BE OBTAINED FROM AN APPROVED SOURCE.

6. THE FOLOWING SET OF PIPE HANGER STANDARDS HAS BEEN DEVELOPED TO MEET THE REQUIREMENTS FOR ORDINARY PIPING SYSTEMS. FOR THE SAKE OF SIMPLICITY, PIPE SIZES, LOADS, SPANS AND LENGTHS OF SUPPORTS HAVE BEEN LIMITED. PIPE HANGERS FOR CONDITIONS NOT COVERED SHOULD BE CUSTOM DESIGNED AND PATTERNED AS FAR AS POSSIBLE AFTER THESE STANDARDS.

7. IT IS THE PURPOSE OF THE STANDARDS TO PROVIDE A UNIFORM AND PRE-ENGINEERED SYSTEM FOR HANGING PIPE AND TO ELIMINATE THE NECESSITY OF COMPLETELY DETAILING HANGERS ON THE DRAWINGS.

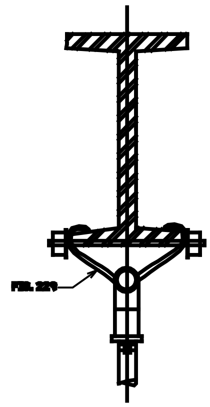
8. BY SELECTING THE PROPER COMPONENTS FROM THE VARIOUS STANDARDS, THE DESIRED HANGER OR SUPPORT MAY BE ASSEMBLED TO SUIT DESIGN REQUIREMENTS.

9. THE MAXIMUM LOADS GIVEN IN THE STANDARDS ARE FOR THE HANGER COMPONENTS ONLY, IN EVERY CASE, THE SUPPORTING STRUCTURES SUCH AS WOODEN JOISTS, STEEL AND CONCRETE BEAMS, FLOOR AND WALLS MUST BE CHECKED FOR STRENGTH BEFORE ADDING ANY ADDITIONAL HANGER LOAD.

10. TO USE THE STANDARDS, THE DESIGNER SHOULD INDICATE ON THE PIPING DRAWINGS THE LOCATION AND SPACING OF HANGERS, GIVING EACH A NUMBER. HANGERS WHICH ARE ALIKE SHOULD HAVE THE SAME NUMBER. THE SYMBOL FOR A HANGER MAY BE A SHORT HEAVY LINE DRAWN AT RIGHT-ANGLES TO THE PIPING.

APPROVED BY Charles Garren

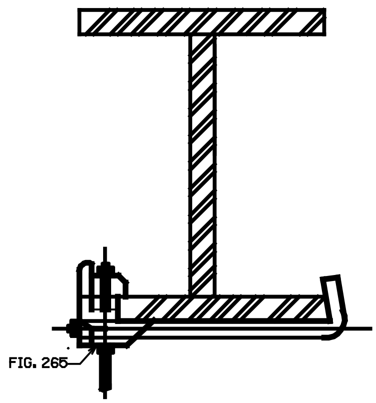
PIPE HANGERS – BUILDING CONNECTIONS – BC SERIES



BC-1

FOR PIPE SIZES 8" AND SMALLER USE ON AM. STD. I BEAMS AND WF BEAMS WHERE FLANGE WIDTH IS 2⅜" TO 7" AND THICKNESS .60" MAX.

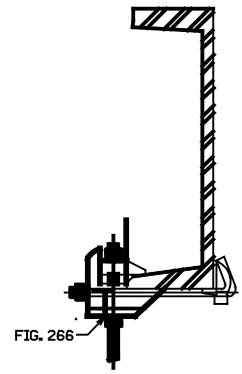
ADADA



BC-2

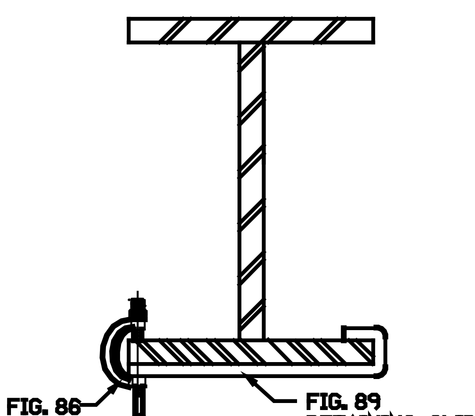
FOR PIPE SIZES 8" AND SMALLER USE ON AM. STD. I BEAMS WF BEAMS, AND ANGLE ROOF TRUSSES WHERE THE FLANGE THICKNESS IS NOT LESS THAN 5/16" AND NOT OVER 1¾"

KKKKKK



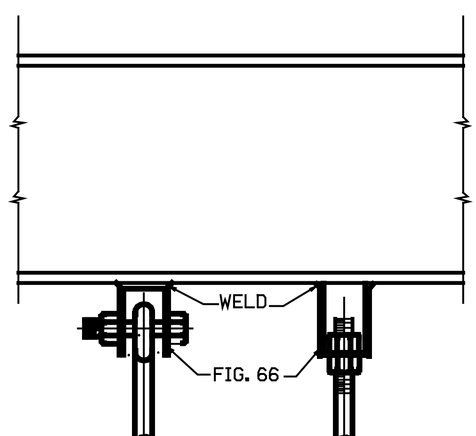
BC-3

FOR PIPE SIZES 8" AND SMALLER. USE WITH CHANNELS ONLY THICKNESS OF FLANGE NOT TO EXCEED 1¾".



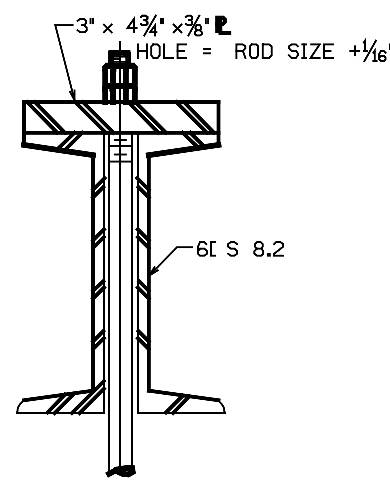
BC-4

FOR PIPE SIZES 6" AND SMALLER USE ON AN. STD. I BEAMS AND WF BEAMS



BC-5 BC-6

PIPE SIZE UNLIMITED MAY BE ATTACHED TO ANY SUITABLE STRUCTURAL STEEL

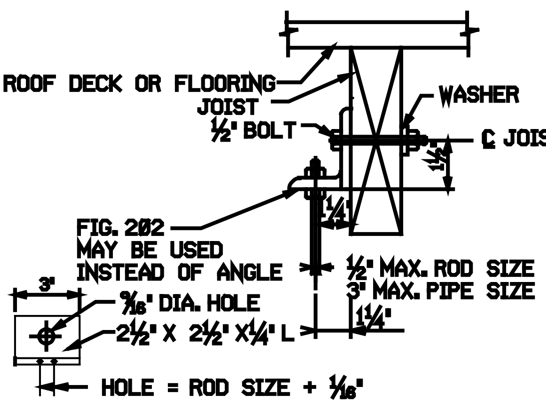


BC-7

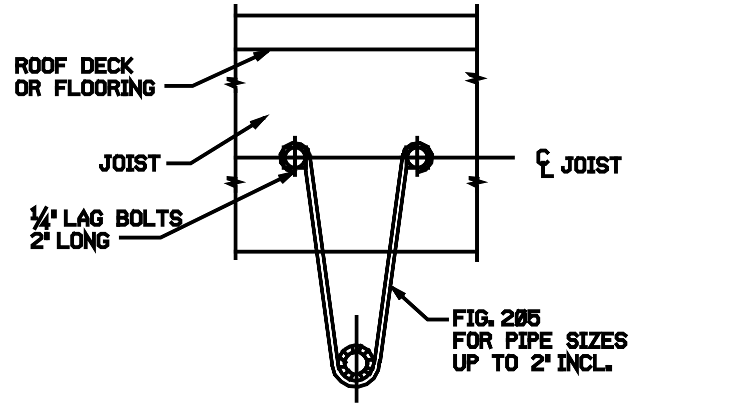
FOR PIPE SIZES 16" AND SMALLER.

NOTE: ALL FIGURE NUMBERS REFER TO GRINNELL CO. HANGERS

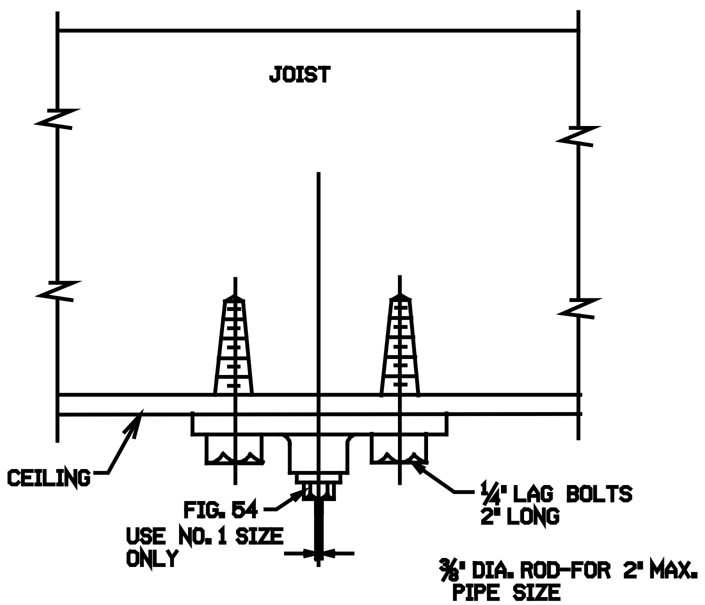
PIPE HANGERS – BUILDING CONNECTIONS – BC SERIES



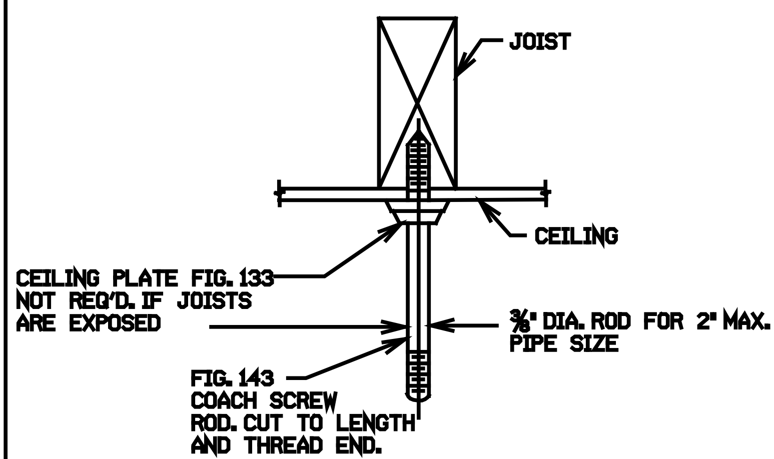
BC-8



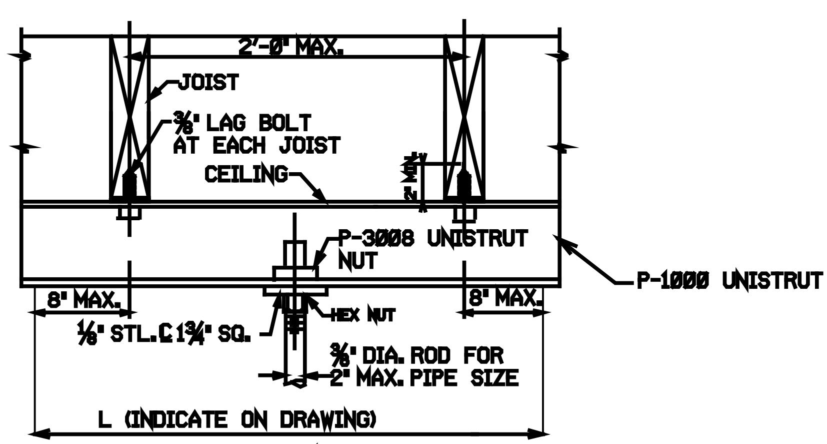
BC-9



BC-10



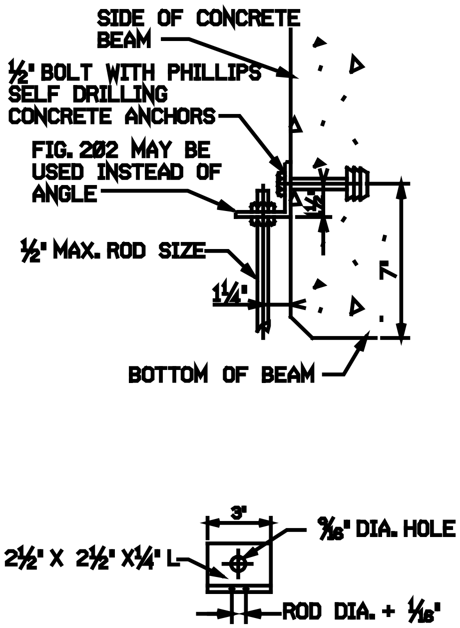
BC-11



BC-12

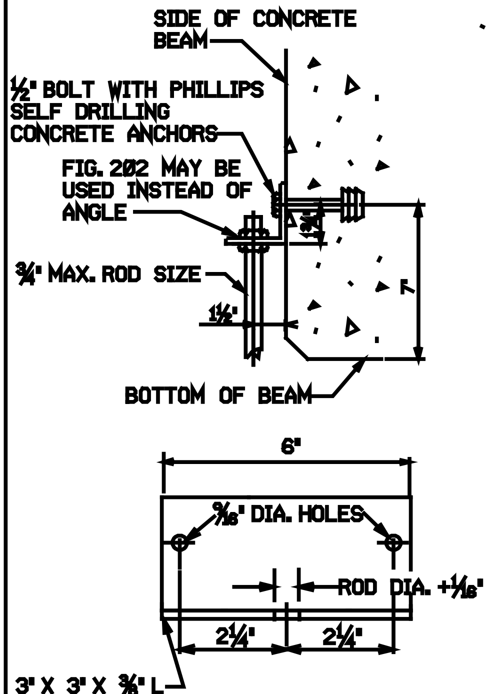
NOTE: ALL FIGURE NUMBERS REFER TO GRINNELL CO. HANGERS

PIPE HANGERS - BUILDING CONNECTIONS - BC SERIES



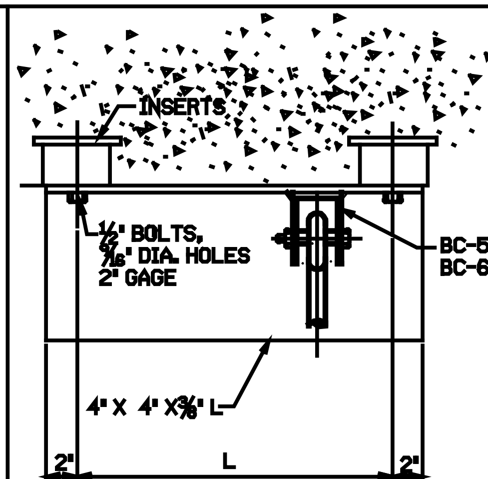
MAX. LOAD 300#

BC-13



MAX. LOAD 800#

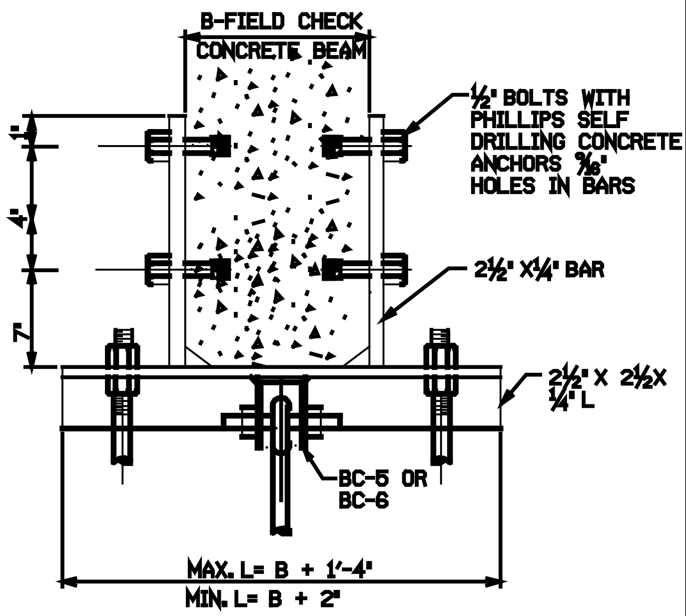
BC-14



FOR EXISTING INSERTS TEST WITH 1½ TIMES THE TOTAL LOAD.
FOR NEW INSERTS DESIGN FOR 1½ TIMES THE MAX. LOAD

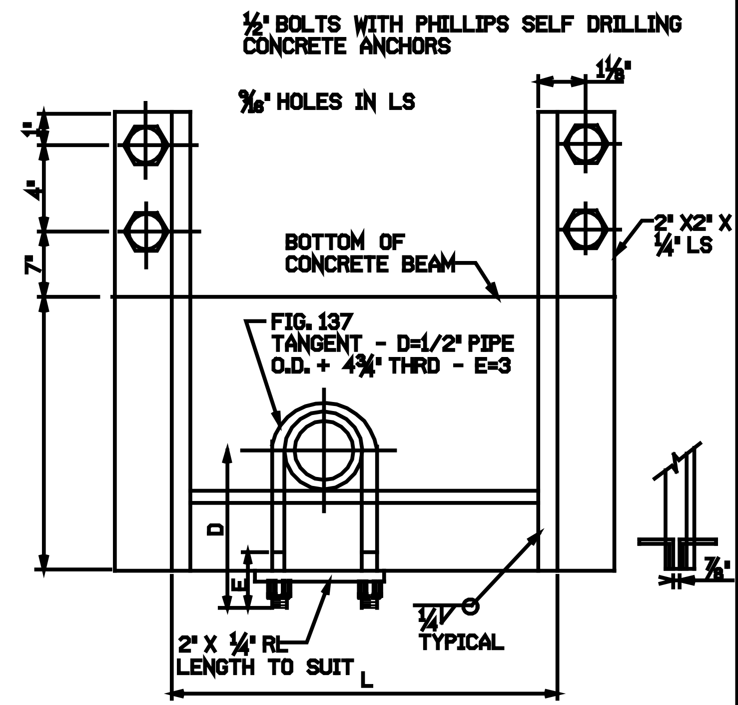
L	MAX. LOAD
50" OR LESS	2400#
51" TO 70"	1700#
71" TO 90"	1300#

BC-15



MAX. TOTAL LOAD 2000#
NO LIMIT ON ROD SIZE

BC - 16

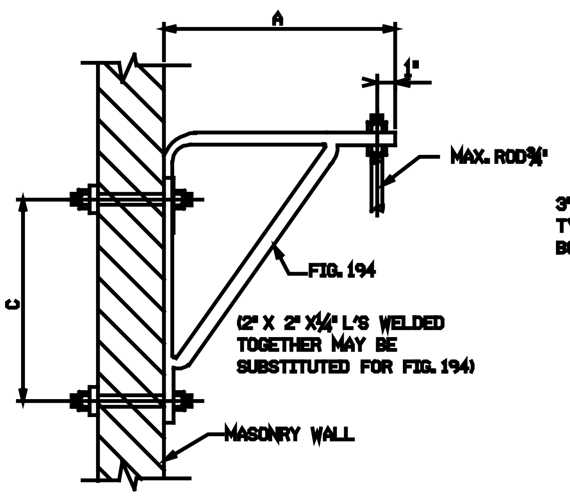


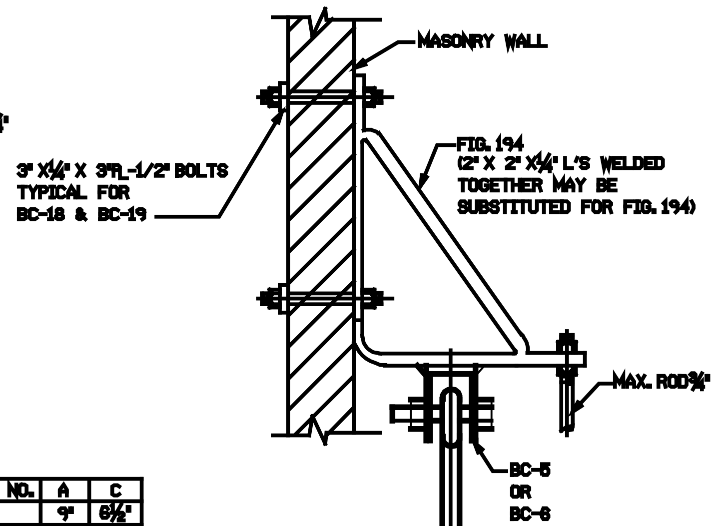
L	ANGLE SIZE	MAX. LOAD LBS
24" OR LESS	2" X 2" X¼"	1660
25" TO 36"	2½" X 2½" X¼"	1740
25" TO 36"	2½" X 2½" X¼"	1950

NOTE: ALL FIGURE NUMBERS REFER TO GRINNELL CO. HANGERS

BC - 17

PIPE HANGERS – BUILDING CONNECTIONS – BC SERIES





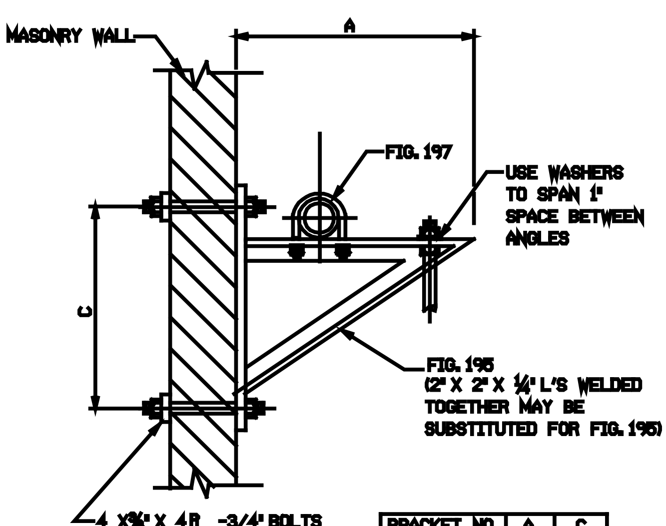
BRACKET NO.	A	C
1	9"	6½"
2	13"	10½"
3	19"	16½"

MAX. LOAD 1500#

BC-18

MAX. LOAD 750#

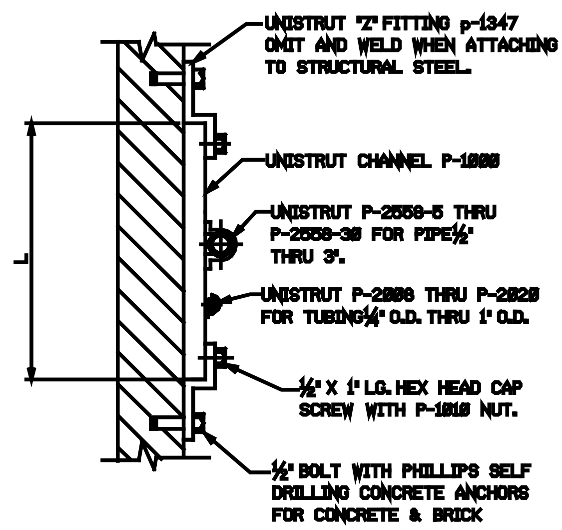
BC-19



BRACKET NO.	A	C
0	12"	15½"
1	18"	21½"
2	24"	27½"

MAX. LOAD 1500#

BC-20



MASONRY WALL

½" THRU BOLTS/WASHER FOR
HOLLOW MASONRY.

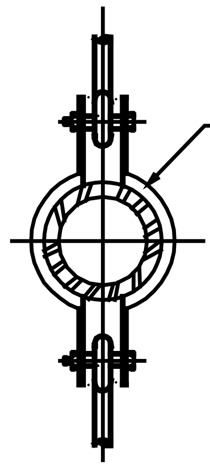
½" X 2½" LG. LAG SCREWS
FOR WOOD TIMBERS

MAX. LOAD 1500#

BC-21

NOTE: ALL FIGURE NUMBERS REFER TO GRINNELL CO. HANGERS

PIPE HANGERS – BUILDING CONNECTIONS – BC SERIES



PC-5

USE FOR COLD WATER, HOT WATER, HOT PROCESS STEAM LINES WHICH ARE INSULATED.

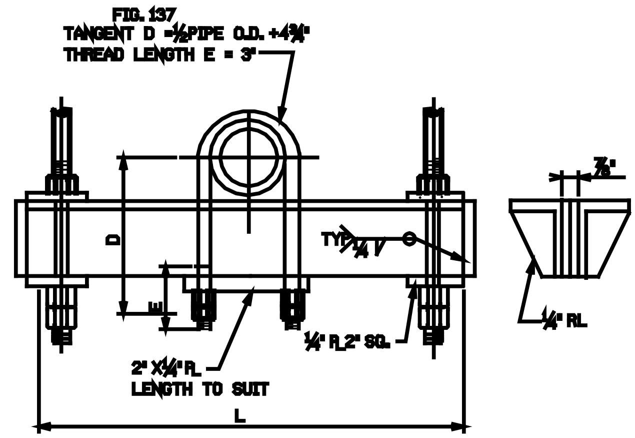
FIG. 212 IS SUITABLE FOR MAXIMUM SPANS GIVEN IN Y-ES-4.5-3 FOR PIPE SIZES THRU 10". TABLE BELOW SHOWS MAXIMUM SPANS FOR PIPE SIZES ABOVE 10". FOR PIPE SIZES 12" & UP WHERE MAXIMUM SPAN IN Y-ES-4.5-3 IS DESIRED USE FIG. 216

FIG. 212 HANGER

PIPE SIZE	MAX. SPAN
12"	24'-0"
14"	21'-0"
16"	17'-0"
18"	16'-0"
20"	14'-0"

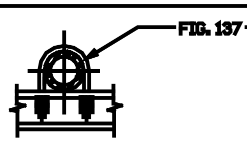
ABOVE SPANS ARE BASED ON INSULATED PIPE FULL OF WATER. LOADS SUCH AS VALVES AND BRANCH LINES ARE NOT TAKEN INTO ACCOUNT. SHORTER SPANS MUST BE USED FOR THESE CONDITIONS.

MAXIMUM HANGER LOADS & ROD SIZES ARE GIVEN IN GRINNELL CATALOG.



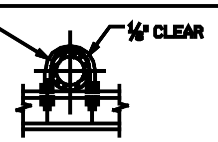
L	ANGLE SIZE	MAX. LOAD LBS.
24" OR LESS	2" X 2" X¼"	1660
25" TO 36"	2½" X 2½" X¼"	1740
37" TO 48"	3" X 3" X¼"	1950

PC-7



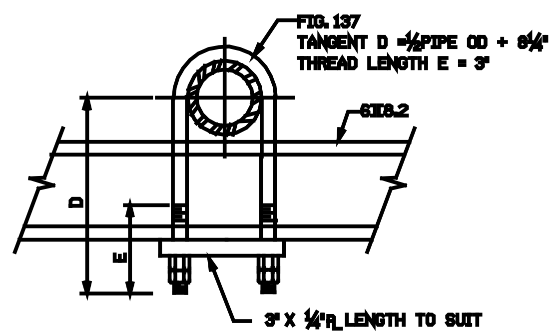
PC-3

FOR UNINSULATED LINES AMBIENT TEMPERATURE ALL SIZES



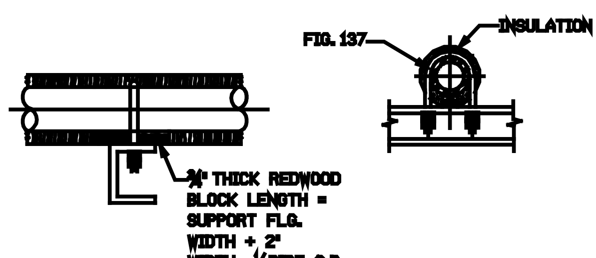
PC-4

FOR HOT WATER, STEAM CONDENSATE & OTHER HOT INSULATED OR HOT UNINSULATED LINES-ALL SIZES



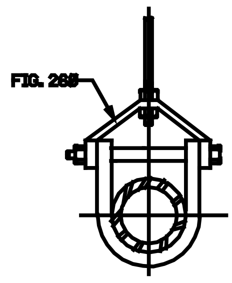
PC-3A

USED FOR SECURING PIPE TO PS 5, 6, & 7



PC-2

FOR COLD WATER LINES INSULATED WITH ¾" THICK FIBROUS GLASS, ALL SIZES.

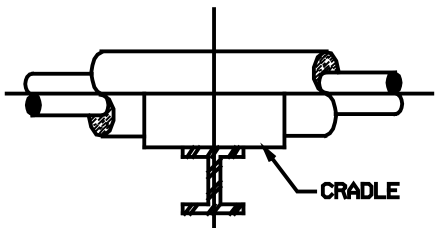


PC-1

FOR UNISULATED LINES.
ALL SIZES

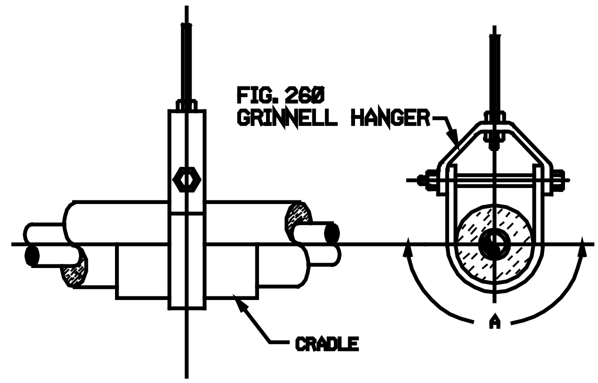
NOTE: ALL FIGURE NUMBERS REFER TO GRINNELL CO. HANGERS

PIPE HANGERS – PIPE CONNECTIONS FOR COLD LINES ONLY – PC SERIES



SLIDING TYPE

PC-8



CLEVIS TYPE

PC-9

CRADLES FOR USE WITH CELLULAR GLASS PIPE INSULATION

PIPE SIZE	CRADLE LENGTH	CRADLE THICKNESS
½" TO 2½"	8"	16 GA.
3" TO 10"	10"	3/16"
12"	12"	3/16"
14"	14"	1/4"
16"	16"	1/4"
18"	18"	5/16"
20"	20"	5/16"
24"	24"	3/8"

1. MATERIAL FOR CRADLE SHALL BE CARBON STEEL SHEET OR PLATE.
2. A = WIDTH OF CRADLE BEFORE FORMING AND IS EQUAL TO O.D. OF INSULATION X 1.5 FORM TO FIT UNIFORMLY AROUND INSULATION.
3. CRADE LENGTHS IN TABLE ARE SUITABLE FOR MAXIMUM SPANS OF 25 FEET FOR LONGER SPANS DETERMINE CRADLE LENGTHS FROM THE FOLLOWING FORMULA. CRADLE THICKNESS SHALL BE 3/8" FOR 24" PIPE.

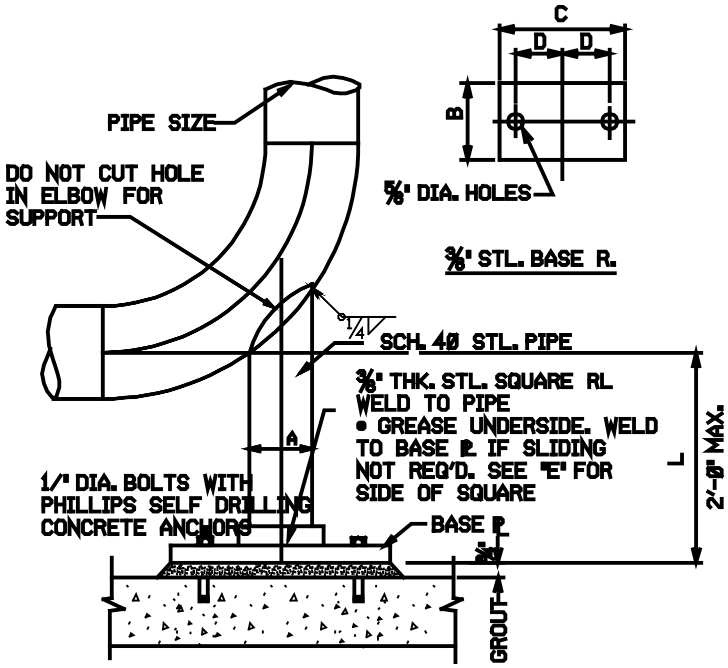
$$L = \frac{WS}{RF} \text{ WHERE}$$

L = LENGTH OF CRADLE.
W = UNIT WT. PER FOOT OF PIPE, WATER AND INSULATION PLUS 10% SAFETY FACTOR.
S = SPAN BETWEEN SUPPORTS IN FEET.
R = ½" O.D. OF INSULATION.
F = BEARING VALUE OF INSULATION (30 PSI.)

- FOR CHILLED WATER, BRINE & REFRIGERANT LINES - ALL SIZES.

NOTE; ALL FIGURE NUMBERS REFER TO GRINNELL CO. HANGERS

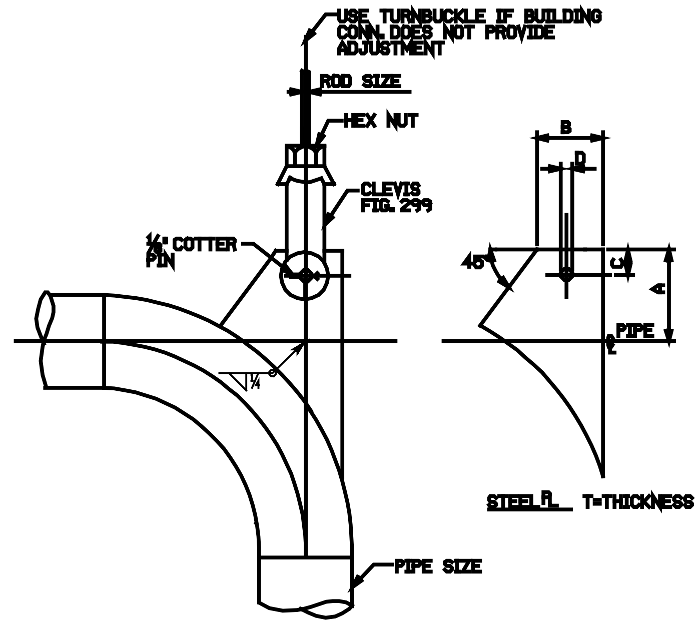
PIPE HANGERS – PIPE CONNECTIONS FOR COLD LINES ONLY – PC SERIES



• EQUAL PARTS HEAVY GREASE AND FLAKE GRAPHITE

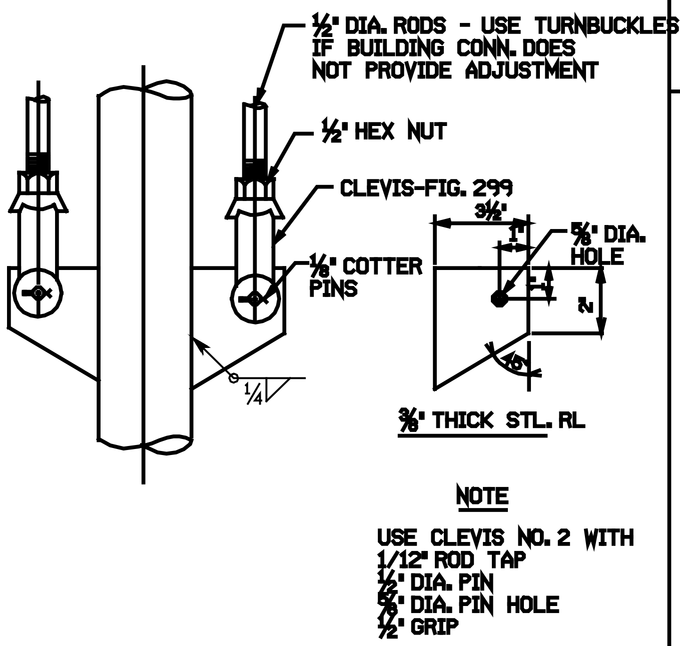
PIPE SIZE	3"	4"	6"	8"	10"	12"
A (NOM.)	1½"	2"	3"	3"	4"	4"
B	3"	3½"	4½"	4½"	5½"	5½"
C	6½"	7"	8"	8"	9"	9"
D	2½"	2¾"	3¼"	3¼"	3¾"	3¾"
E	2½"	3"	4"	4"	5"	5"

PC-10



PIPE SIZE	3"	4"	6"	8"	10"	12"
A	3½"	3½"	3½"	3½"	4¼"	4¼"
B	2"	2"	2"	2"	2½"	2½"
C	1"	1"	1"	1"	1¼"	1¼"
D	½"	⅝"	⅝"	¾"	⅞"	1"
T	⅜"	⅜"	⅜"	⅜"	½"	½"
ROD SIZE	⅜"	½"	½"	⅝"	¾"	⅞"
CLEVIS SIZE	2"	2"	2"	2"	2½"	2½"
ROD TAP	⅜"	½"	½"	⅝"	¾"	⅞"
PIN DIA.	⅜"	½"	½"	⅝"	¾"	⅞"
PIN HOLE	½"	⅝"	⅝"	¾"	⅞"	1"
GRIP	½"	½"	½"	½"	⅝"	⅝"

PC - 11

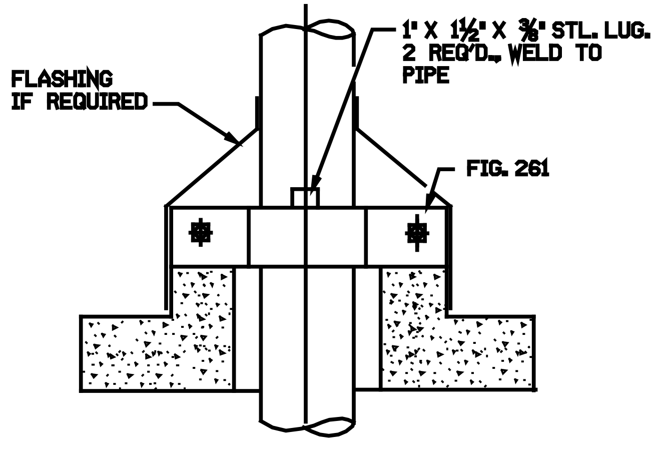


NOTE

USE CLEVIS NO. 2 WITH
1/12" ROD TAP
½" DIA. PIN
⅝" DIA. PIN HOLE
½" GRIP

FOR PIPE SIZES 3" TO 12" INCL.

PC-12

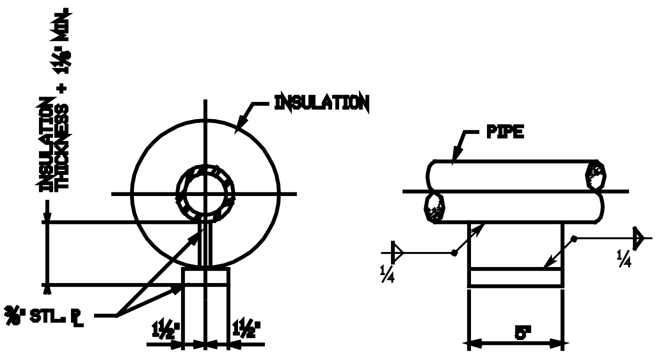


PC - 13

NOTE: ALL FIGURE NUMBERS REFER TO GRINNELL CO. HANGERS

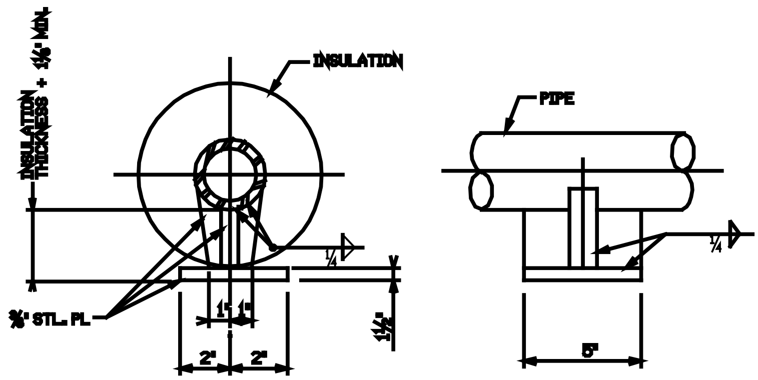
PIPE HANGERS – PIPE ANCHORS AND SLIDES FOR HOT LINES – PA SERIES

NOTE: WHEN USED AS ANCHOR WELD TO SUPPORT – USE GUIDES WITH SLIDES



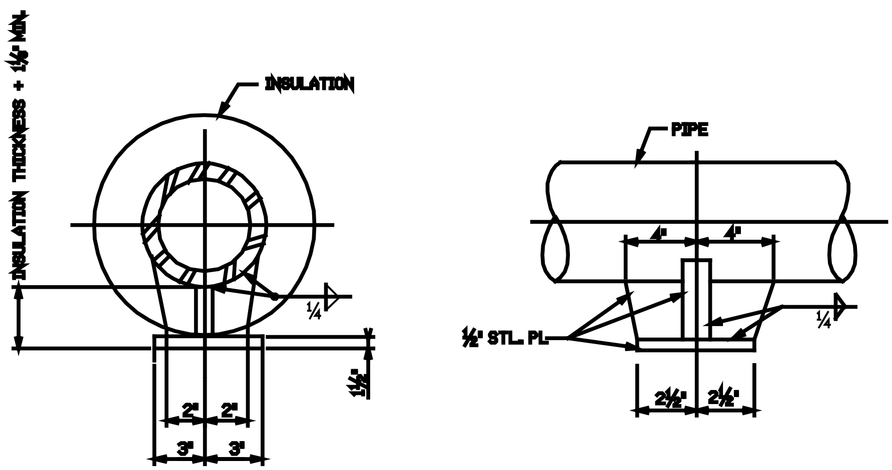
PA-1

FOR PIPE UP TO 2" INCL.



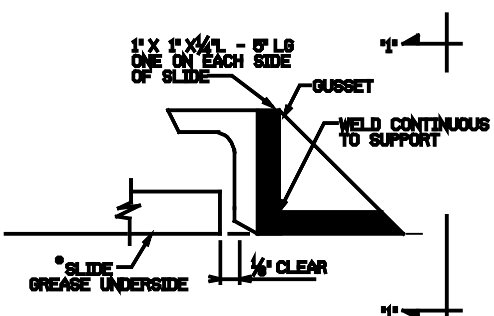
PA-2

FOR PIPE 2½" TO 4" INCL.



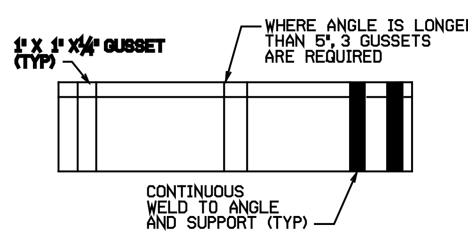
PA-3

FOR PIPE 6" TO 12" INCL.



•EQUAL PARTS HEAVY GREASE AND FLAKE GRAPHITE

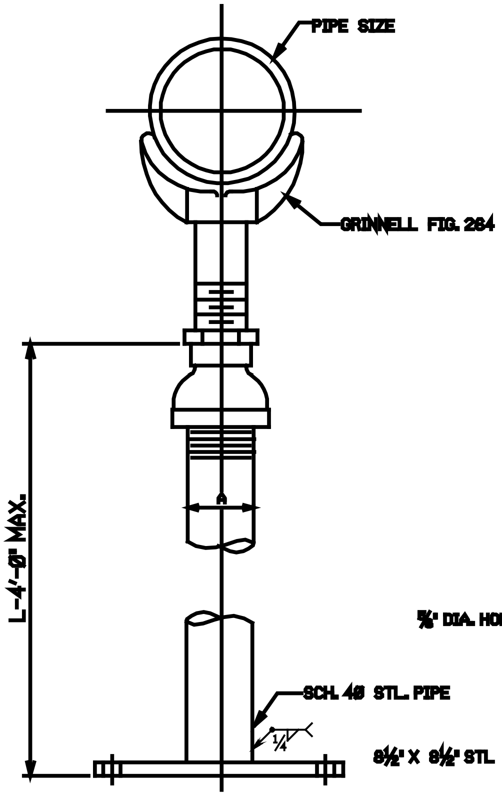
DETAIL OF GUIDE



"1" - "1"

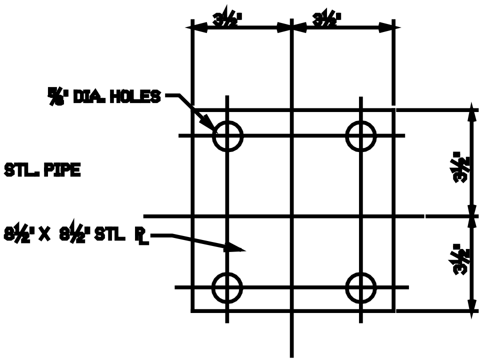
NOTE: ALL FIGURE NUMBERS REFER TO GRINNELL CO. HANGERS

PIPE HANGERS – BUILDING CONNECTIONS – BC SERIES

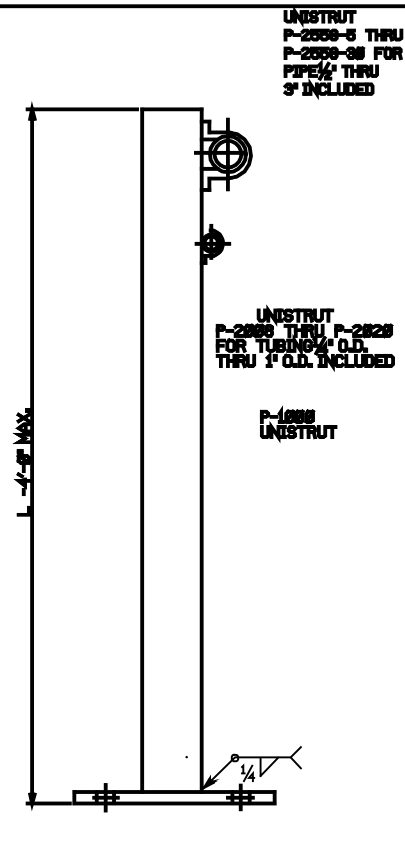


PS – 1

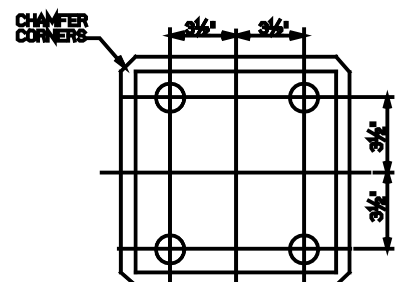
PIPE SIZE	A
2½"	2½"
3"	2½"
4"	2½"
6"	3"
8"	3"
10"	3"
12"	3"



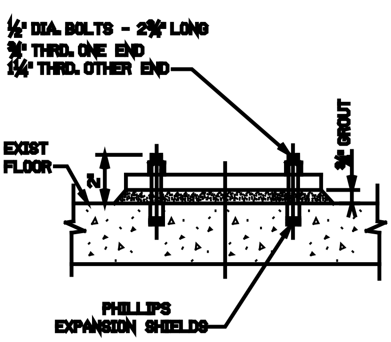
BASE PLATE
FOR PS-1 & PS-2



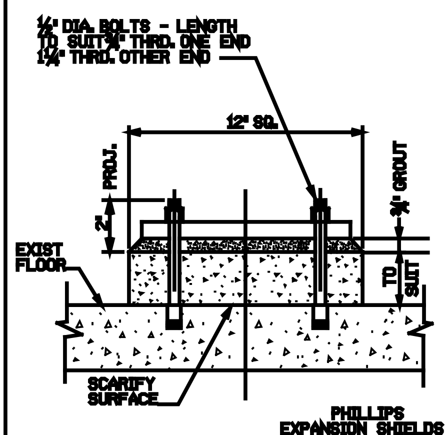
PS-2



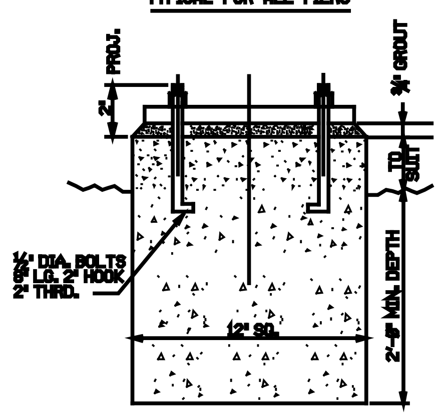
PLAN VIEW
TYPICAL FOR ALL PIERS



PIER – A



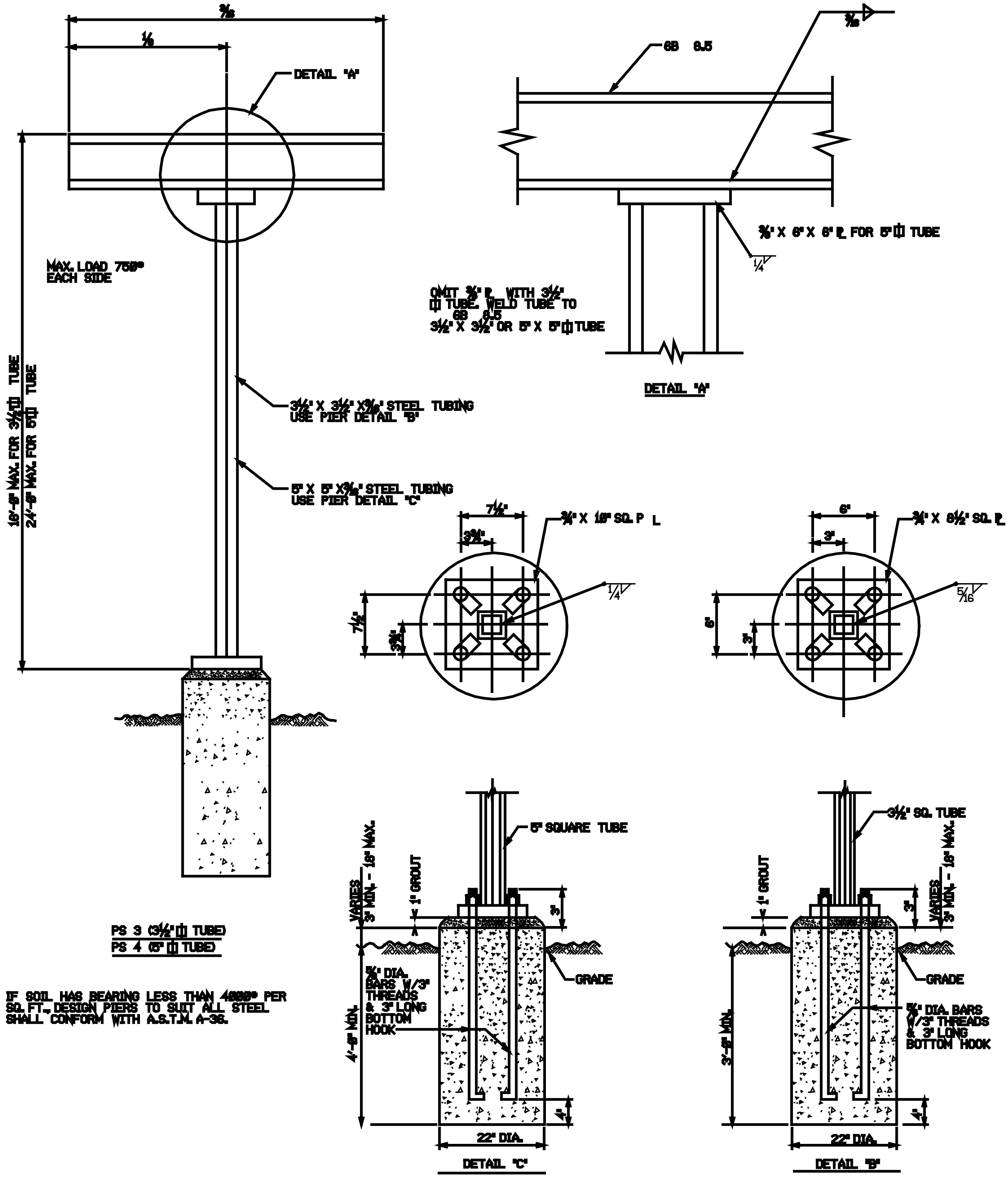
PIER – B



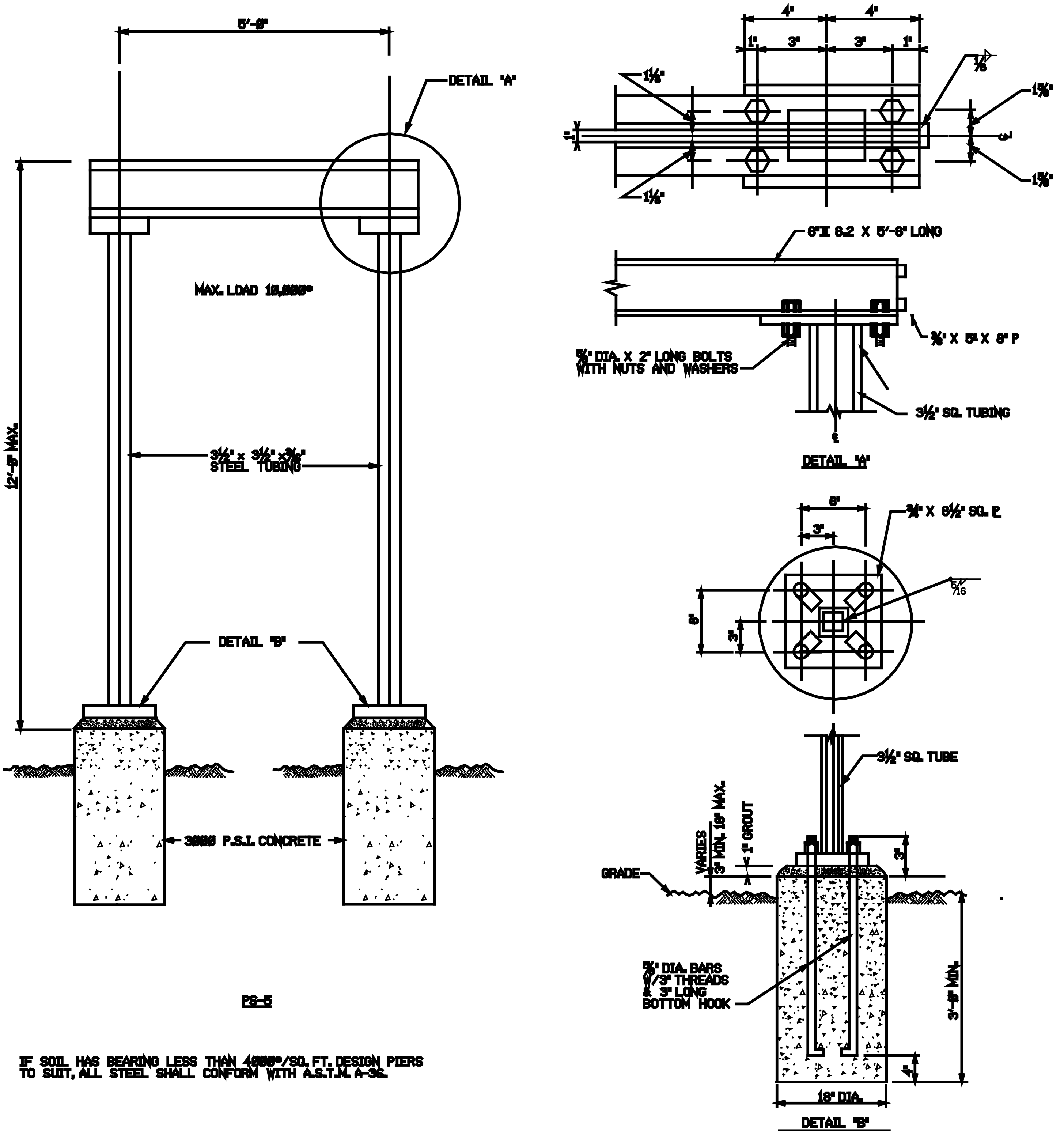
PIER – C

NOTE: ALL FIGURE NUMBERS REFER TO GRINNELL CO. HANGERS

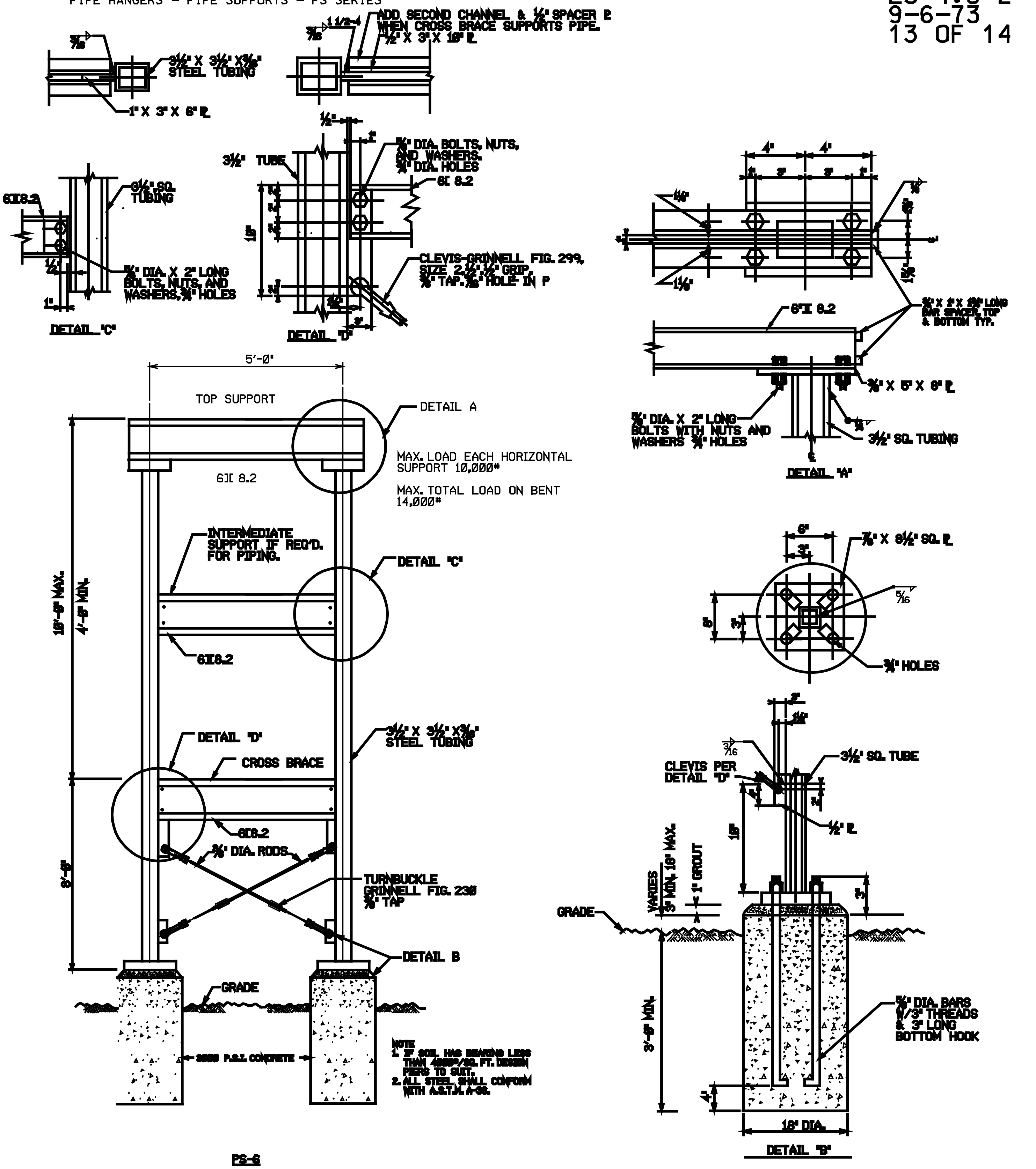
PIPE HANGERS – BUILDING CONNECTIONS – BC SERIES



PIPE HANGERS – PIPE SUPPORTS – PS SERIES



IF SOIL HAS BEARING LESS THAN 4000#/SQ. FT. DESIGN PIERS TO SUIT, ALL STEEL SHALL CONFORM WITH A.S.T.M. A-36.



PS-6

NOTE; ALL FIGURE NUMBERS REFER TO GRINNELL CO. HANGERS

PIPE HANGERS – BUILDING CONNECTIONS – BC SERIES

PIPE HANGERS – PIPE SUPPORTS – PS SERIES

ES-4.5-2
9-6-73
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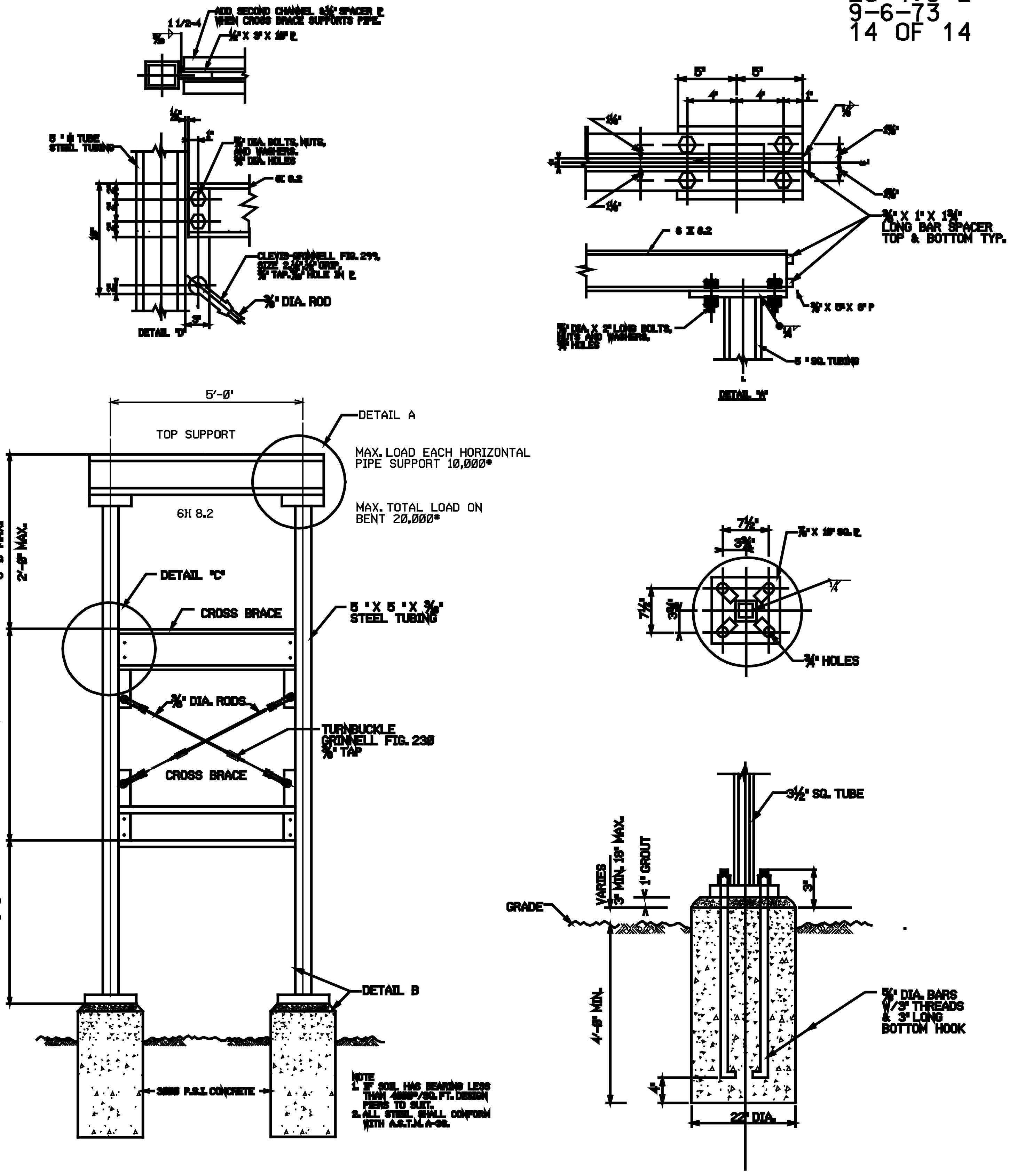

PS-6

NOTE; ALL FIGURE NUMBERS REFER TO GRINNELL CO. HANGERS

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OAK RIDGE, TENNESSEE

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PIPE SUPPORT SPACING

MAXIMUM SPAN IN FEET

SCHEDULE NUMBER	INSULATION THICKNESS	Nominal Pipe Size, Inches 1/2	3/4	1	1-1/2	2	3	4	6	8	10	12	14	16	18
10S	0"	–	–	14	16	17	20	21	24	26	28	29	–	–	–
	1"	–	–	13	14	15	18	20	23	25	27	29	–	–	–
	1-1/2"	–	–	11	13	14	17	19	22	24	26	28	–	–	–
	2"	–	–	10	12	13	17	18	21	24	26	28	–	–	–
	3"	–	–	8	10	11	15	17	20	23	25	27	–	–	–
20	0"	–	–	–	–	–	–	–	–	30	32	33	36	37	37
	1"	–	–	–	–	–	–	–	–	29	31	32	35	36	37
	1-1/2"	–	–	–	–	–	–	–	–	28	30	31	34	35	36
	2"	–	–	–	–	–	–	–	–	28	30	31	34	35	36
	3"	–	–	–	–	–	–	–	–	27	29	30	33	34	35
30	0"	–	–	–	–	–	–	–	–	31	33	35	37	–	–
	1"	–	–	–	–	–	–	–	–	29	32	34	37	–	–
	1-1/2"	–	–	–	–	–	–	–	–	29	31	34	36	–	–
	2"	–	–	–	–	–	–	–	–	29	31	34	36	–	–
	3"	–	–	–	–	–	–	–	–	27	31	33	35	–	–
40 and 40s	0"	9	11	14	16	18	22	24	28	31	33	35	37	–	–
	1"	8	10	12	15	16	20	23	27	29	32	34	37	–	–
	1-1/2"	7	9	11	14	15	19	22	26	29	31	34	36	–	–
	2"	7	8	10	13	14	19	22	26	29	31	34	36	–	–
	3"	–	–	8	11	13	17	20	25	27	31	33	35	–	–
80	0"	9	11	14	17	19	23	25	30	–	–	–	–	–	–
	1"	8	10	12	15	17	22	24	29	–	–	–	–	–	–
	1-1/2"	7	9	11	14	16	21	23	28	–	–	–	–	–	–
	2"	7	8	10	13	15	21	23	28	–	–	–	–	–	–
	3"	–	–	8	12	14	18	22	27	–	–	–	–	–	–

APPROVED BY Charles Garren

AUTHOR

THE MAXIMUM SPANS IN THE TABLE ARE FOR CARBON STEEL AND STAINLESS STEEL PIPE USING A STRESS VALUE(S) OF 12,000 PSI.

FOR PIPE OF OTHER MATERIALS SUCH AS ALUMINUM, COPPER OR OTHER NONFERROUS ALLOYS, THE SPANS MUST BE CALCULATED INSERTING THE PROPER VALUES IN THE FORMULAS ON PAGE 2.

FOR STANDARD WEIGHT PIPE (WALL THICKNESS 0.375 INCHES) IN SIZES 12 INCHWS THROUGH 18 INCHES, USE SPANS FOR THE SCHEDULE NUMBER HAVING A WALL THICKNESS OF 0.375 INCHES OR LESS.

NOTES:

LENGTH OF CALCULATED SPANS HAVE BEEN ROUNDED OFF TO THE NEAREST FOOT.

TABULATED SPANS ARE BASED ON THE FOLLOWING:

UNIFORM LOAD CONSISTS OF WEIGHT OF PIPE FILLED WITH WATER WHEN BARE. THE ADDITIONAL WEIGHT OF INSULATION, HAVING A DENSITY OF 11 IBS. PER CUBIC FOOT, IS ADDED WHEN PIPING IS INSULATED.

EXCESSIVE VIBRATION AND CONCENTRATED LOADS SUCH AS VALVES AND BRANCH LINES ARE NOT TAKEN INTO ACCOUNT. SHORTER SPANS MUST BE USED FOR THESE CONDITIONS.

THE FOLLOWING FORMULAS WERE USED TO COMPUTE THE SPAN:

FORMULA "A"

(MAXIMUM SPAN LIMITED BY STRESS)

$$L = \sqrt{\frac{SZ}{4W}}$$

FORMULA "B"

(MAXIMUM SPAN LIMITED BY DEFLECTION NOT IN EXCESS OF 15% OF PIPE ID)

$$L = .417\sqrt[4]{\frac{EI(ID)}{W}}$$

WHERE:

L = SPAN, FEET

I = MOMENT OF INERIA, INCHES^4

W = UNIFORM LOAD, LBS PER FOOT

Z = SECTION MODULUS = $\frac{1}{.5(OD)}$ INCHES^3

ID = INSIDE DIAMETER OF PIPE, INCHES

S = STRESS = 12,000 PSI FOR STEEL

E = MODULUS OF ELASTICITY , 25,000,000 PSI FOR STEEL

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COPPER TUBING – SUPPORT SPACING

MAXIMUM SPAN IN FEET

CONDITION	NOMINAL TUBING SIZE, INCHES							
	1/2	3/4	1	1 1/4	1 1/2	2	2 1/2	3
BARE	7	8	9	10	11	13	14	15

NOTES:

TABULATED SPANS ARE BASED ON THE FOLLOWING:

SEAMLESS HARD-DRAWN COPPER TUBING, TYPES K AND L, ASTM B-88.

UNIFORM LOAD CONSISTING OF WEIGHT OF TUBING FULL OF WATER WHEN BARE.

EXCESSIVE VIBRATION AND CONCENTRATED LOADS SUCH AS VALVES AND BRANCH LINES ARE NOT TAKEN INTO ACCOUNT. SHORTER SPANS MUST BE USED FOR THESE CONDITIONS.

THE FOLLOWING FORMULAS WERE USED TO COMPUTE THE SPAN:

(MAXIMUM SPAN LIMITED BY STRESS)

$$L = \sqrt{\frac{SZ}{4W}}$$

(MAXIMUM SPAN LIMITEDF BY DEFLECTION NOT IN EXCESS OF 15% OF TUBE ID)

$$L = .417\sqrt[4]{\frac{EI(ID)}{W}}$$

WHERE:

L - SPAN IN FEET

W - UNIFORM LOAD, LBS. PER FOOT

Z - SECTION MODULUS - $\frac{1}{.5(OD)}$ INCHES^3

S - STRESS - 9,000 PSI. FROM TABLE 502.3.1 OF ANSI B31.5, REFRIGERATION PIPING

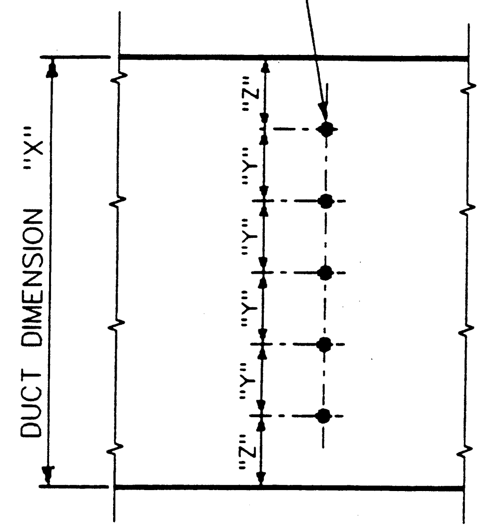
I- MOMENT OF INERTIA, INCHES^4

ID - INSIDE DIAMETER OF TUBE, INCHES

E- MODULUS OF ELASTICITY, 15,600,000 PSI

APPROVED BY	AUTHOR
Charles Garren	

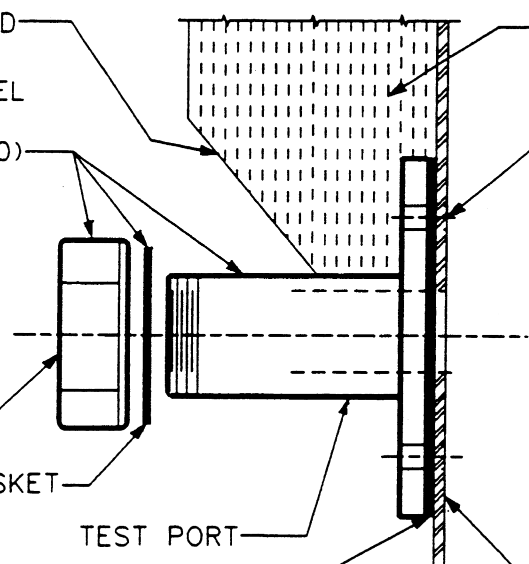
INSTRUMENT TESTS PORTS - RECTANGULAR DUCT - WITH OR WITHOUT EXTERNAL INSULATION



TEST OPENING SPACING

DUCT DIMENSION "X"	TEST OPENINGS REQUIRED	"Z"	"Y"	NO. OF "Y" SPACES
0 THRU 7	1	X/2	0	0
8 THRU 11	2	X/4	X/2	1
12 THRU 17	3	X/6	X/3	2
18 THRU 23	4	X/8	X/4	3
24 THRU 35	6	X/12	X/6	5
36 THRU 47	8	X/16	X/8	7
48 THRU 59	10	X/20	X/10	9
60 AND OVER	12	X/24	X/12	11

ALL DIMENSIONS ARE IN INCHES



TEST PORT

INSTALL INSTRUMENT TEST PORT OVER EACH OPENING REQUIRED PER TEST OPENING SPACING TABLE ABOVE

APPROVED BY Charles Warren 10/25/94

ENGINEERING STANDARD

OAK RIDGE, TENNESSEE

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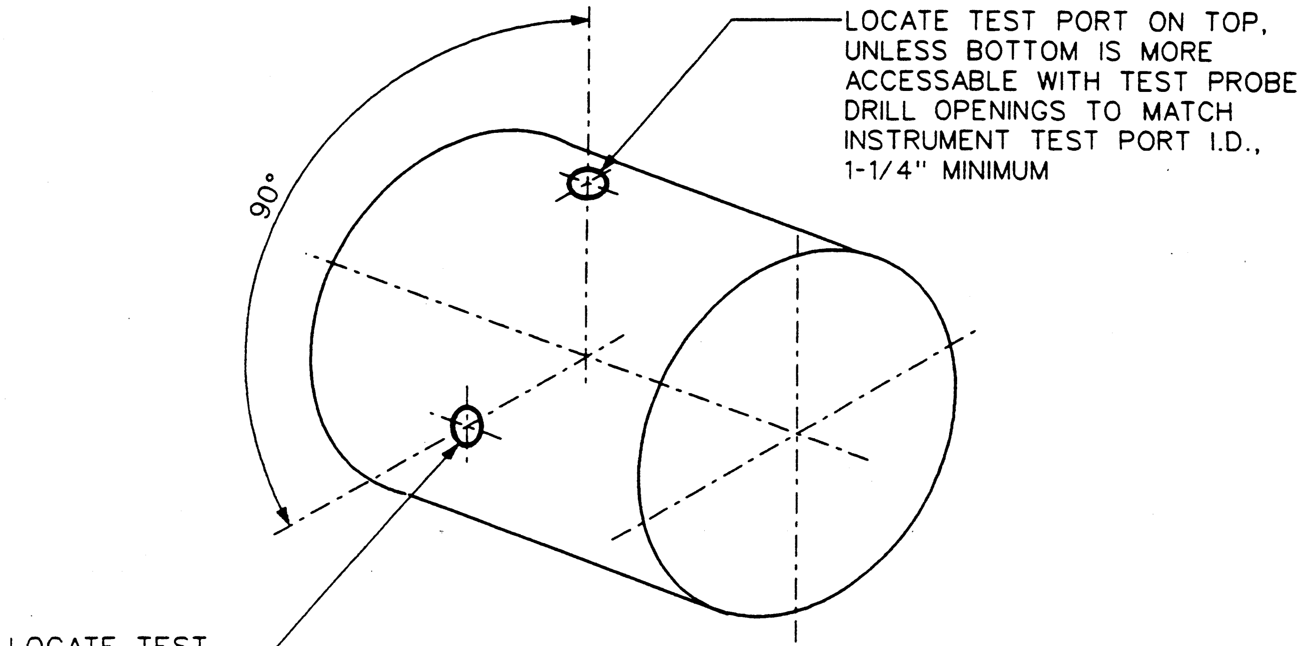
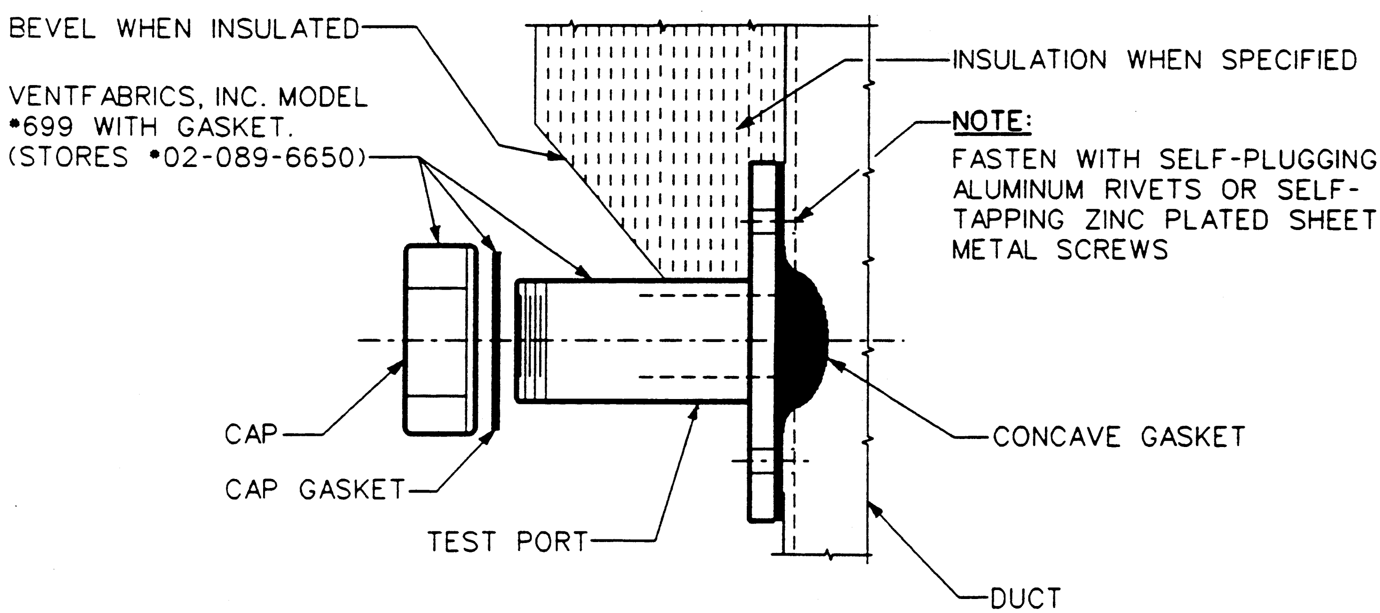
INSTRUMENT TESTS PORTS - ROUND DUCT - WITH OR WITHOUT EXTERNAL INSULATION



DUCT



TEST PORT

INSTALL INSTRUMENT TEST PORT OVER EACH OPENING

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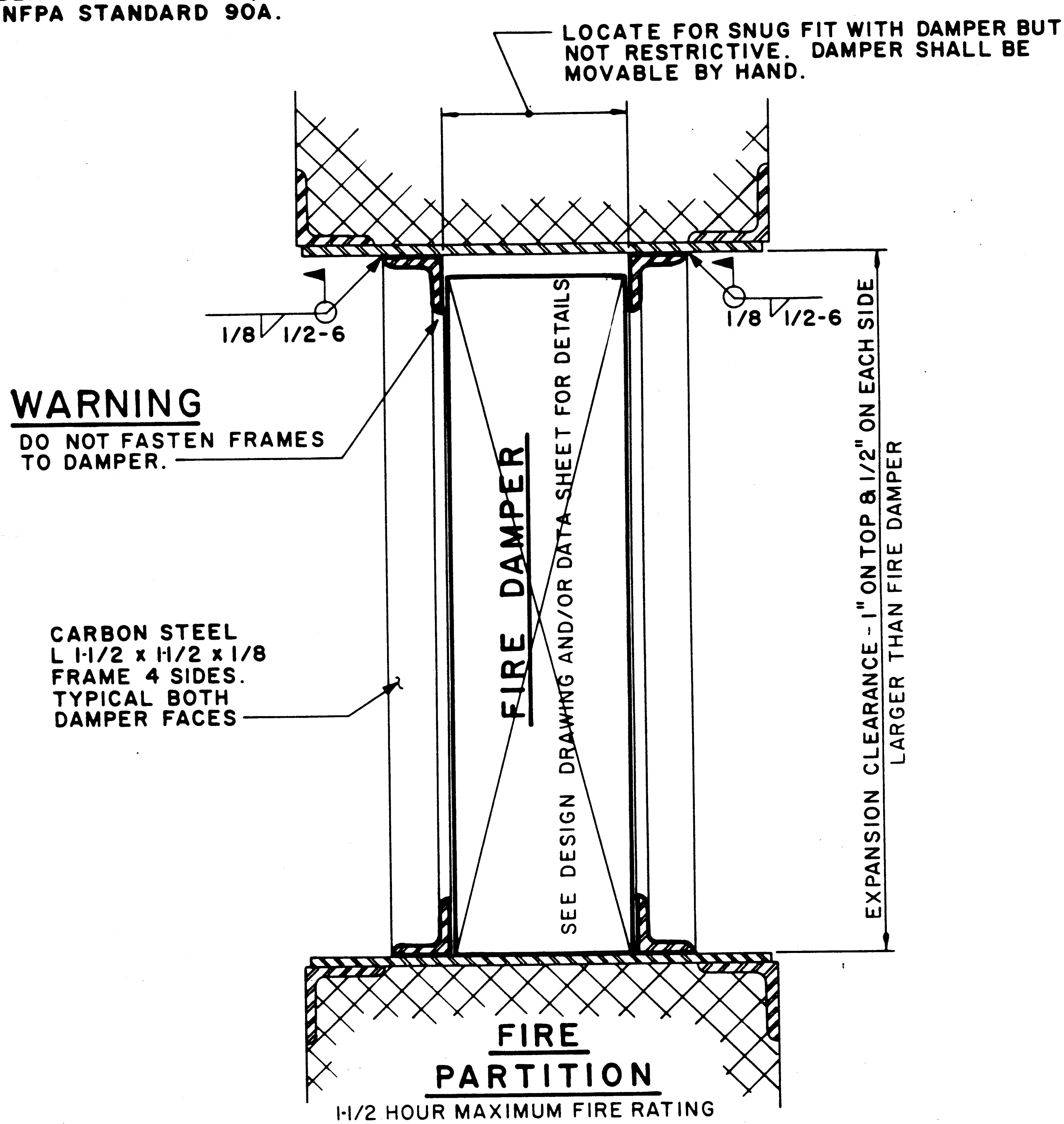
FIRE DAMPER - FIRE PARTITION - FRAME MOUNTED

NOTES

1. ALL FIRE DAMPER INSTALLATIONS SHALL BE INSPECTED AND APPROVED BY FIRE DEPARTMENT. DAMPER, OPERATION AND INSTALLATION SHALL BE IN ACCORDANCE WITH NFPA STANDARD 90A.

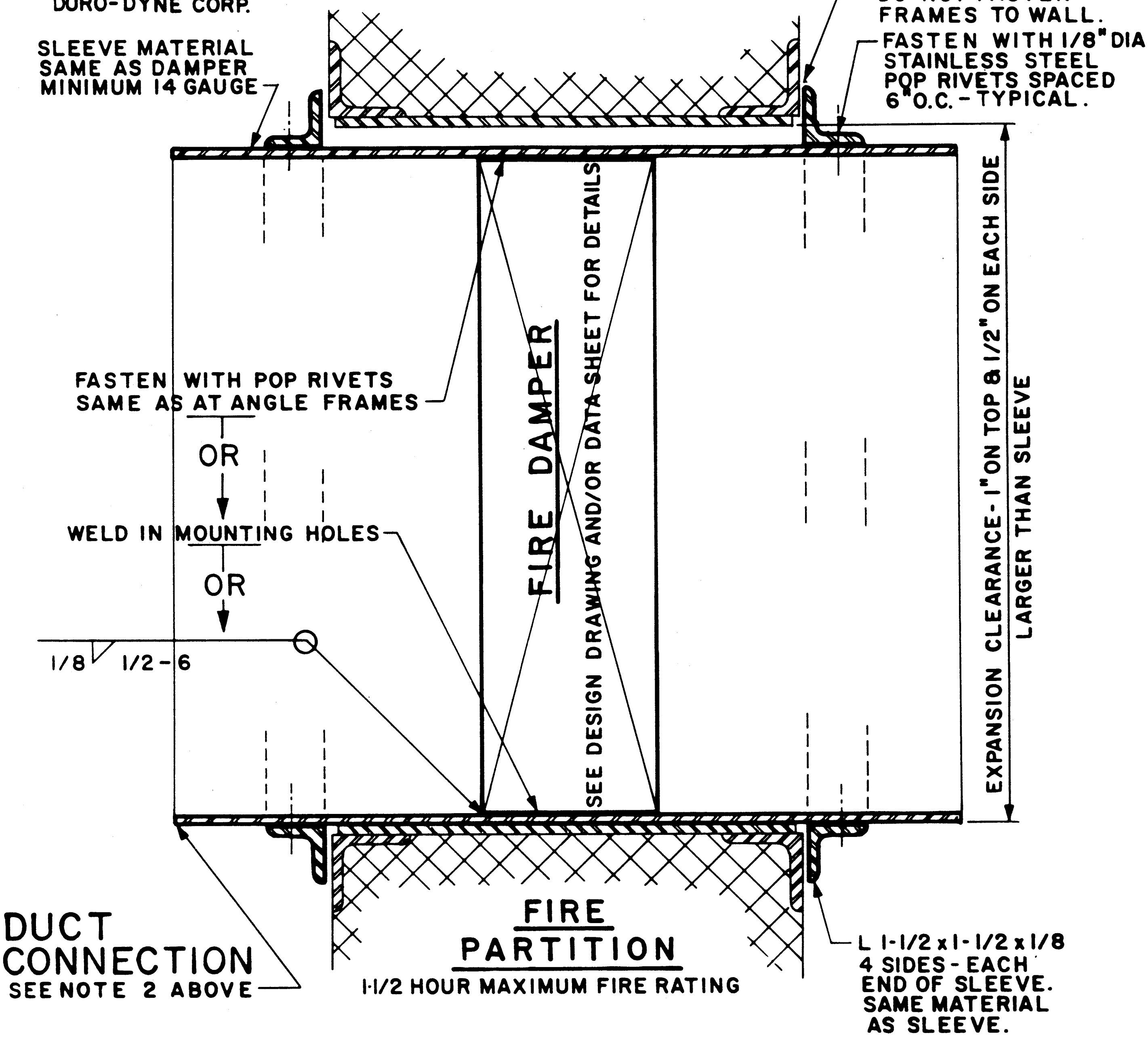


APPROVED BY

FIRE DAMPER - FIRE PARTITION - DUCT MOUNTED

NOTES

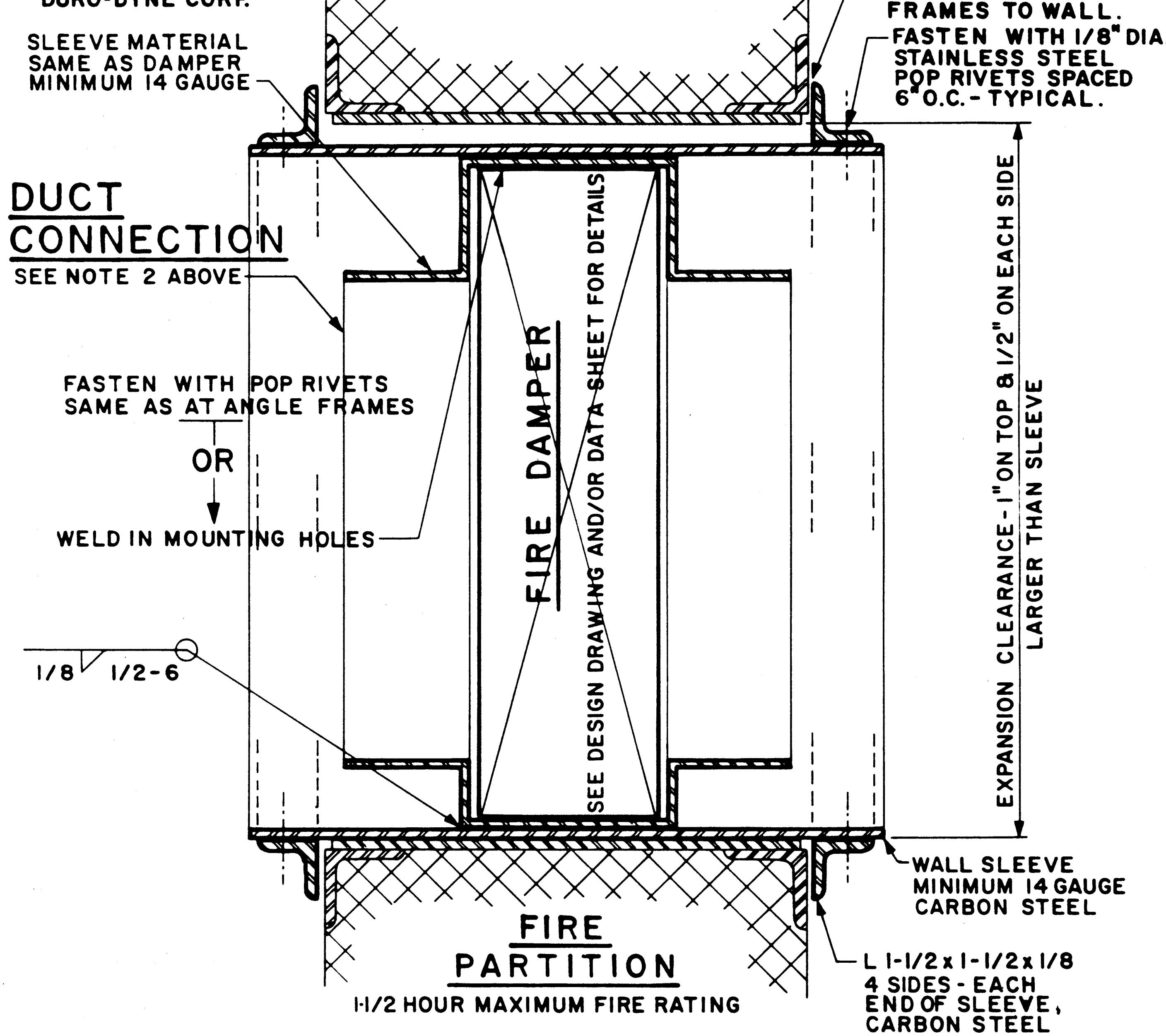
1. ALL FIRE DAMPER INSTALLATIONS SHALL BE INSPECTED AND APPROVED BY FIRE DEPARTMENT. DAMPER, OPERATION AND INSTALLATION SHALL BE IN ACCORDANCE WITH NFPA STANDARD 90A.
2. DUCT CONNECTION AT EACH END OF SLEEVE SHALL BE DONE IN ACCORDANCE WITH DESIGN DRAWINGS AND DUCTWORK SPECIFICATIONS.
3. ACCESS DOOR SHALL BE LOCATED AS NEAR AS POSSIBLE TO FUSE, LATCH AND LINKAGE. DOOR SHALL BE A MINIMUM 16 x 24 DUAL METAL WALL WITH 1" INSULATION BY VENTFABRICS, INC., OR DURO-DYNE CORP.



FIRE DAMPER - FIRE PARTITION - DUCT MOUNTED

NOTES

1. ALL FIRE DAMPER INSTALLATIONS SHALL BE INSPECTED AND APPROVED BY FIRE DEPARTMENT. DAMPER, OPERATION AND INSTALLATION SHALL BE IN ACCORDANCE WITH NFPA STANDARD 90A.
2. DUCT CONNECTION AT EACH END OF SLEEVE SHALL BE DONE IN ACCORDANCE WITH DESIGN DRAWINGS AND DUCTWORK SPECIFICATIONS.
3. ACCESS DOOR SHALL BE LOCATED AS NEAR AS POSSIBLE TO FUSE, LATCH AND LINKAGE. DOOR SHALL BE A MINIMUM 16x24 DUAL METAL WALL WITH 1" INSULATION BY VENTFABRICS, INC., OR DURO-DYNE CORP.



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ENGINEERING STANDARD

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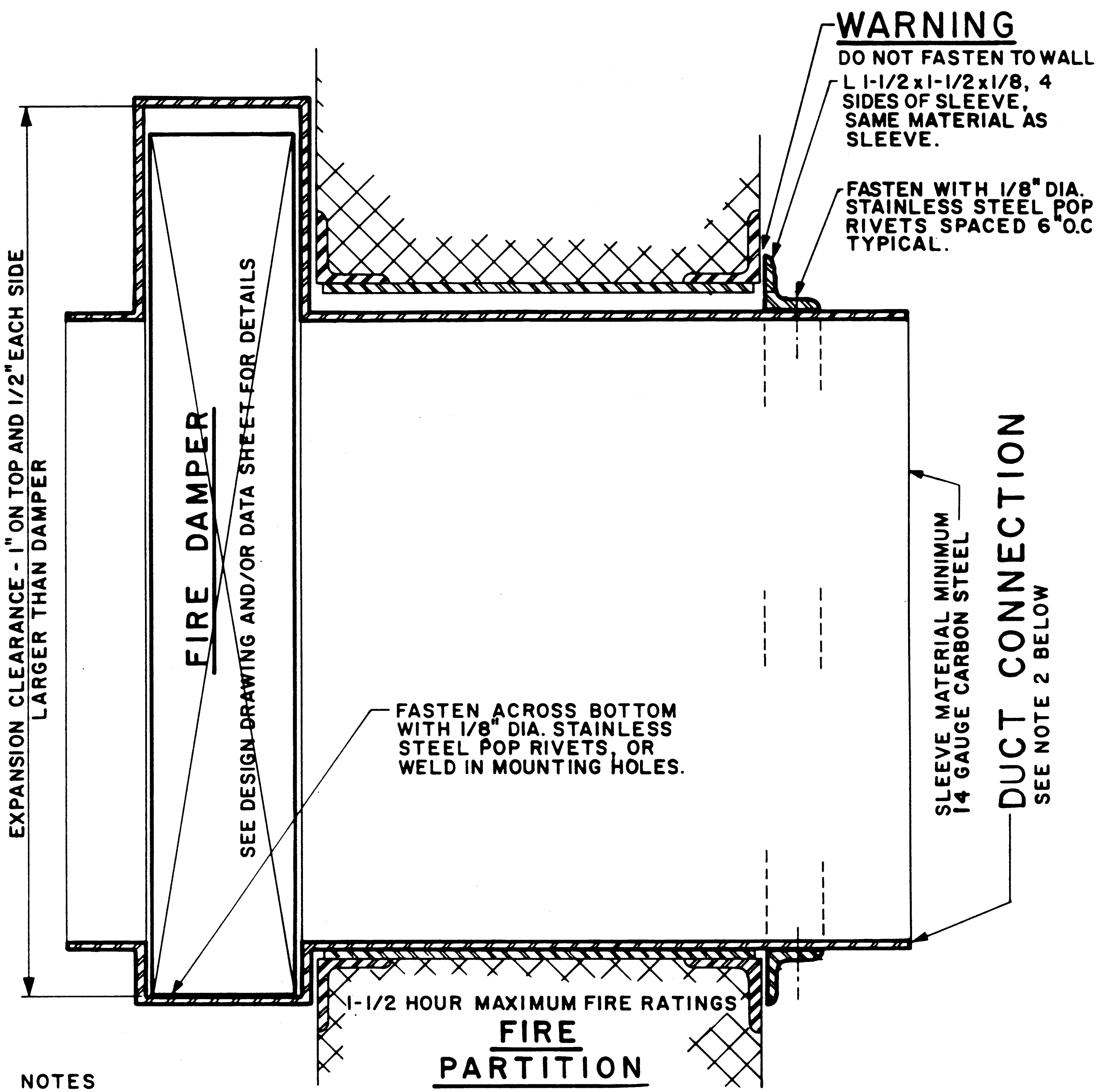
FIRE DAMPER - FIRE PARTITION - DUCT MOUNTED



NOTES

1. ALL FIRE DAMPER INSTALLATIONS SHALL BE INSPECTED AND APPROVED BY FIRE DEPARTMENT. DAMPER, OPERATION AND INSTALLATION SHALL BE IN ACCORDANCE WITH NFPA STANDARD 90A.
2. DUCT CONNECTION AT EACH END OF SLEEVE SHALL BE DONE IN ACCORDANCE WITH DESIGN DRAWINGS AND DUCTWORK SPECIFICATIONS.
3. ACCESS DOOR SHALL BE LOCATED AS NEAR AS POSSIBLE TO FUSE, LATCH AND LINKAGE. DOOR SHALL BE A MINIMUM 16 x 24 DUAL METAL WALL WITH 1" INSULATION BY VENTFABRICS, INC., OR DURO-DYNE CORP.

APPROVED BY W. E. Whatcoaks

NUMBER ES-5.12-4

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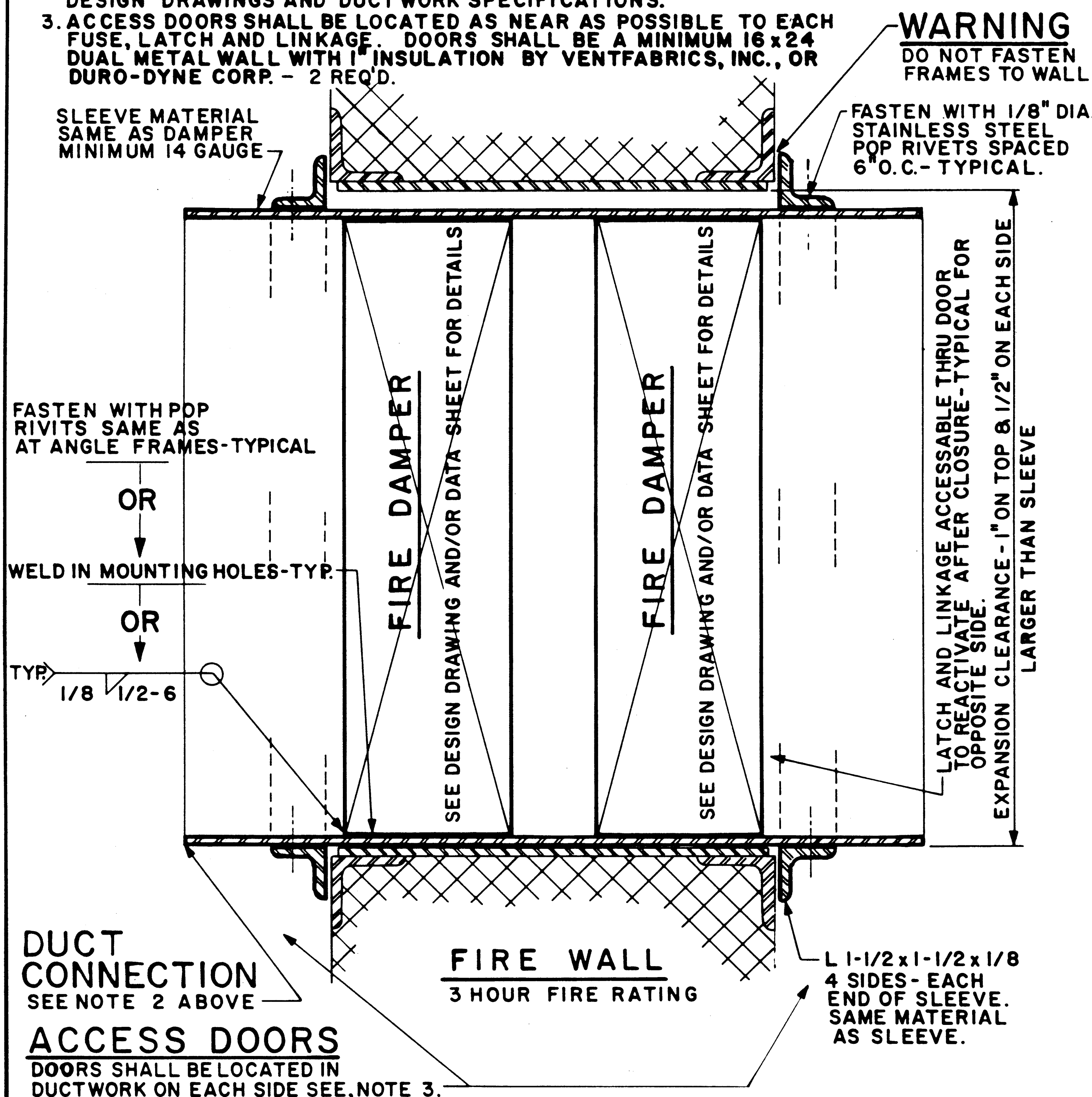
FIRE DAMPER - FIRE WALL - OPENING MOUNTED

NOTES

1. ALL FIRE DAMPER INSTALLATIONS SHALL BE INSPECTED AND APPROVED BY FIRE DEPARTMENT. DAMPER, OPERATION AND INSTALLATION SHALL BE IN ACCORDANCE WITH NFPA STANDARD 90A.
2. DUCT CONNECTION AT EACH END OF SLEEVE SHALL BE DONE IN ACCORDANCE WITH DESIGN DRAWINGS AND DUCTWORK SPECIFICATIONS.
3. ACCESS DOORS SHALL BE LOCATED AS NEAR AS POSSIBLE TO EACH FUSE, LATCH AND LINKAGE. DOORS SHALL BE A MINIMUM 16 x 24 DUAL METAL WALL WITH 1" INSULATION BY VENTFABRICS, INC., OR DURO-DYNE CORP. - 2 REQ'D.



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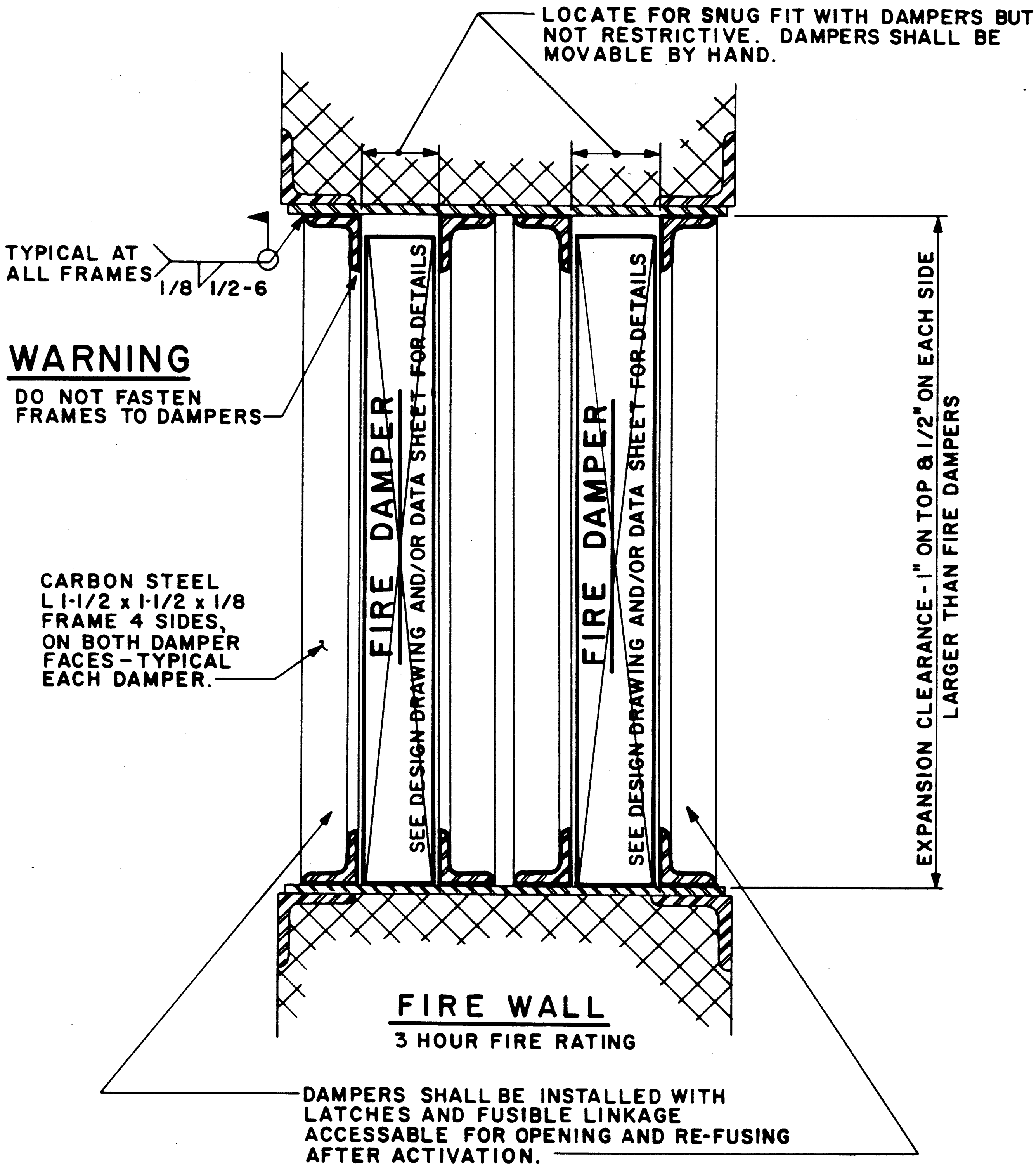
FIRE DAMPER - FIRE WALL - FRAME MOUNTED

NOTES

1. ALL FIRE DAMPER INSTALLATIONS SHALL BE INSPECTED AND APPROVED BY FIRE DEPARTMENT. DAMPER, OPERATION AND INSTALLATION SHALL BE IN ACCORDANCE WITH NFPA STANDARD 90A.



APPROVED BY W. E. Weatherly

ENGINEERING STANDARD

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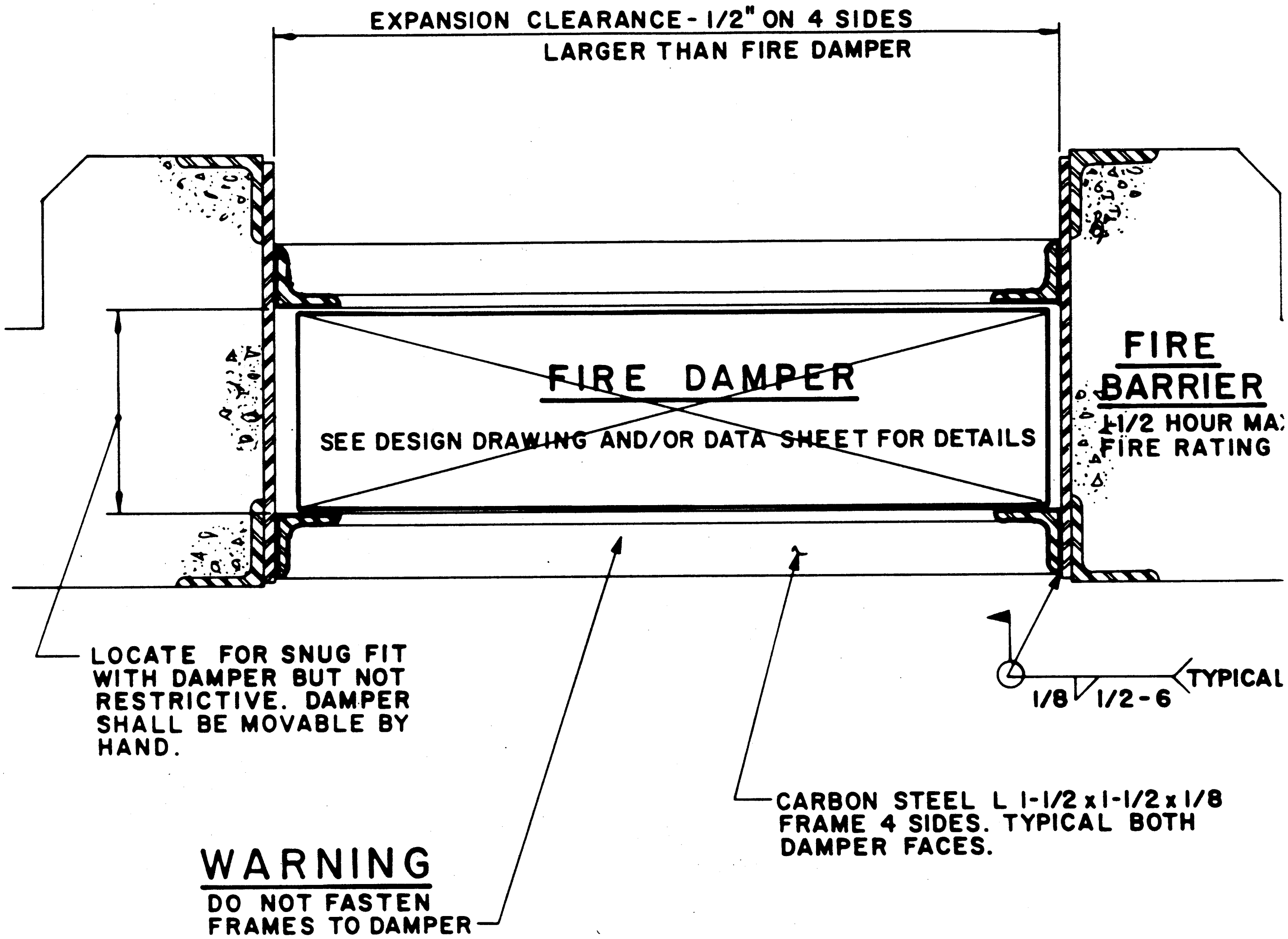
FIRE DAMPER - FLOOR BARRIER - FRAME MOUNTED

NOTES

1. ALL FIRE DAMPER INSTALLATIONS SHALL BE INSPECTED AND APPROVED BY FIRE DEPARTMENT. DAMPER, OPERATION AND INSTALLATION SHALL BE IN ACCORDANCE WITH NFPA STANDARD 90A.



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ENGINEERING STANDARD

OAK RIDGE TENNESSEE

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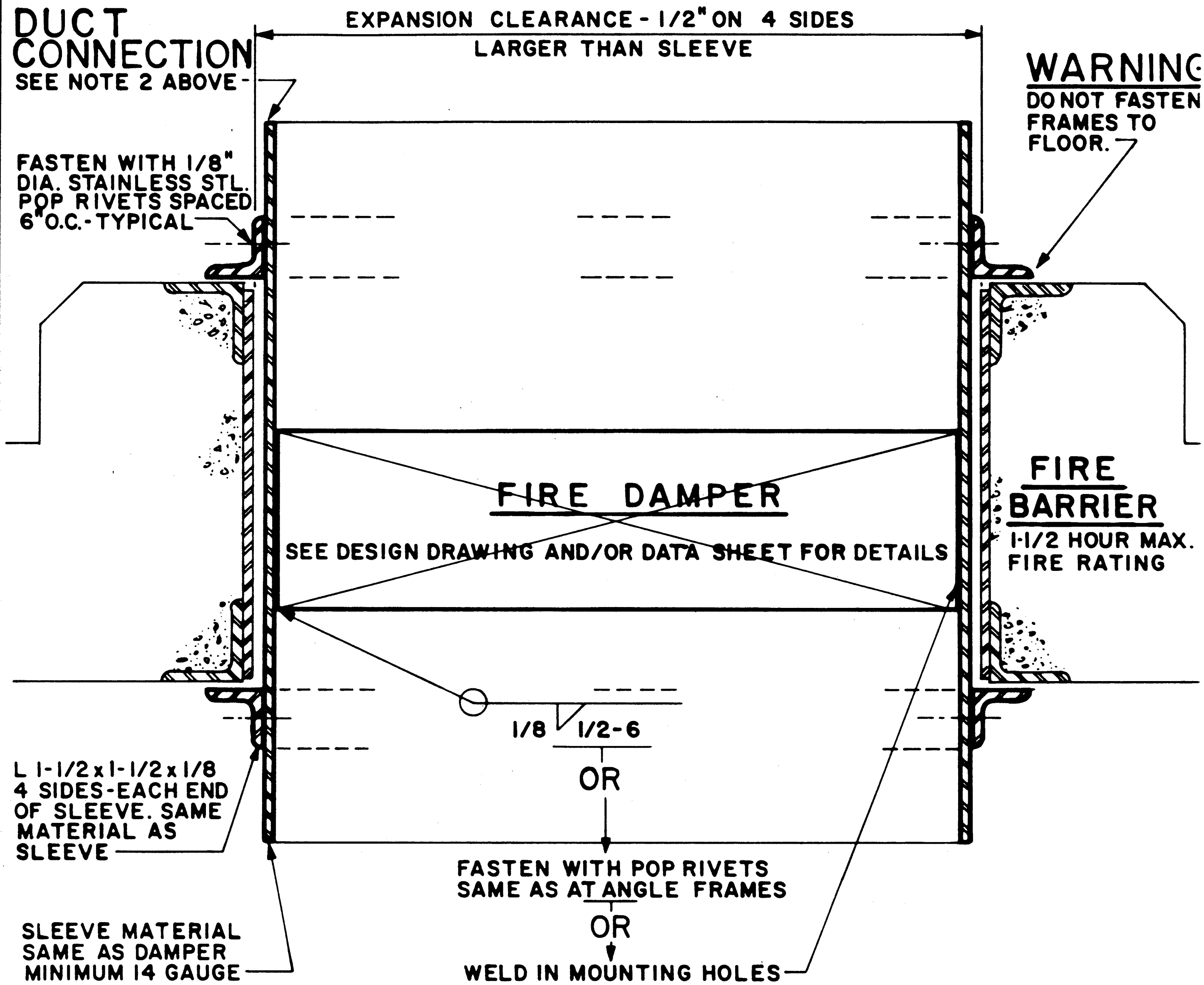
FIRE DAMPER - FLOOR BARRIER - DUCT MOUNTED

NOTES

1. ALL FIRE DAMPER INSTALLATIONS SHALL BE INSPECTED AND APPROVED BY FIRE DEPARTMENT. DAMPER, OPERATION AND INSTALLATION SHALL BE IN ACCORDANCE WITH NFPA STANDARD 90A.
2. DUCT CONNECTION AT EACH END OF SLEEVE SHALL BE DONE IN ACCORDANCE WITH DESIGN DRAWINGS AND DUCTWORK SPECIFICATIONS.
3. ACCESS DOOR SHALL BE LOCATED AS NEAR AS POSSIBLE TO FUSE, LATCH AND LINKAGE. SEE DESIGN DRAWINGS FOR LOCATION. DOOR SHALL BE A MINIMUM 16x24 DUAL METAL WALL WITH 1" INSULATION BY VENTFABRICS, INC., OR DURO-DYNE CORP.



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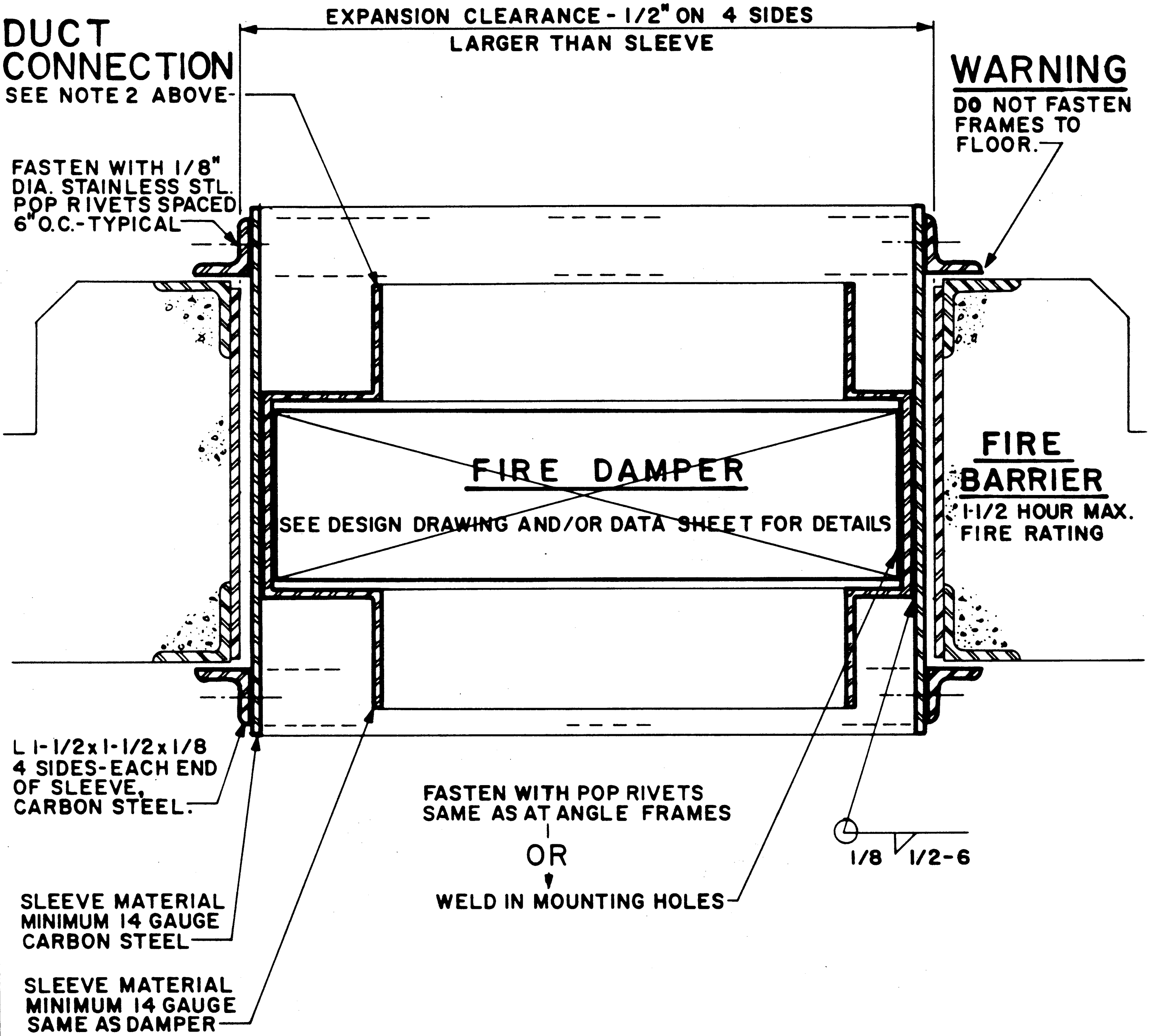
FIRE DAMPER - FLOOR BARRIER - DUCT MOUNTED

NOTES

1. ALL FIRE DAMPER INSTALLATIONS SHALL BE INSPECTED AND APPROVED BY FIRE DEPARTMENT. DAMPER, OPERATION AND INSTALLATION SHALL BE IN ACCORDANCE WITH NFPA STANDARD 90A.
2. DUCT CONNECTION AT EACH END OF SLEEVE SHALL BE DONE IN ACCORDANCE WITH DESIGN DRAWINGS AND DUCTWORK SPECIFICATIONS.
3. ACCESS DOOR SHALL BE LOCATED AS NEAR AS POSSIBLE TO FUSE, LATCH AND LINKAGE. DOOR SHALL BE A MINIMUM 16 x 24 DUAL METAL WALL WITH 1" INSULATION BY VENTFABRICS, INC., OR DURO-DYNE CORP.



APPROVED BY W. G. Weatherly	NUMBER ES-5.12-9

FIRE DAMPER - FLOOR BARRIER - DUCT MOUNTED

NOTES

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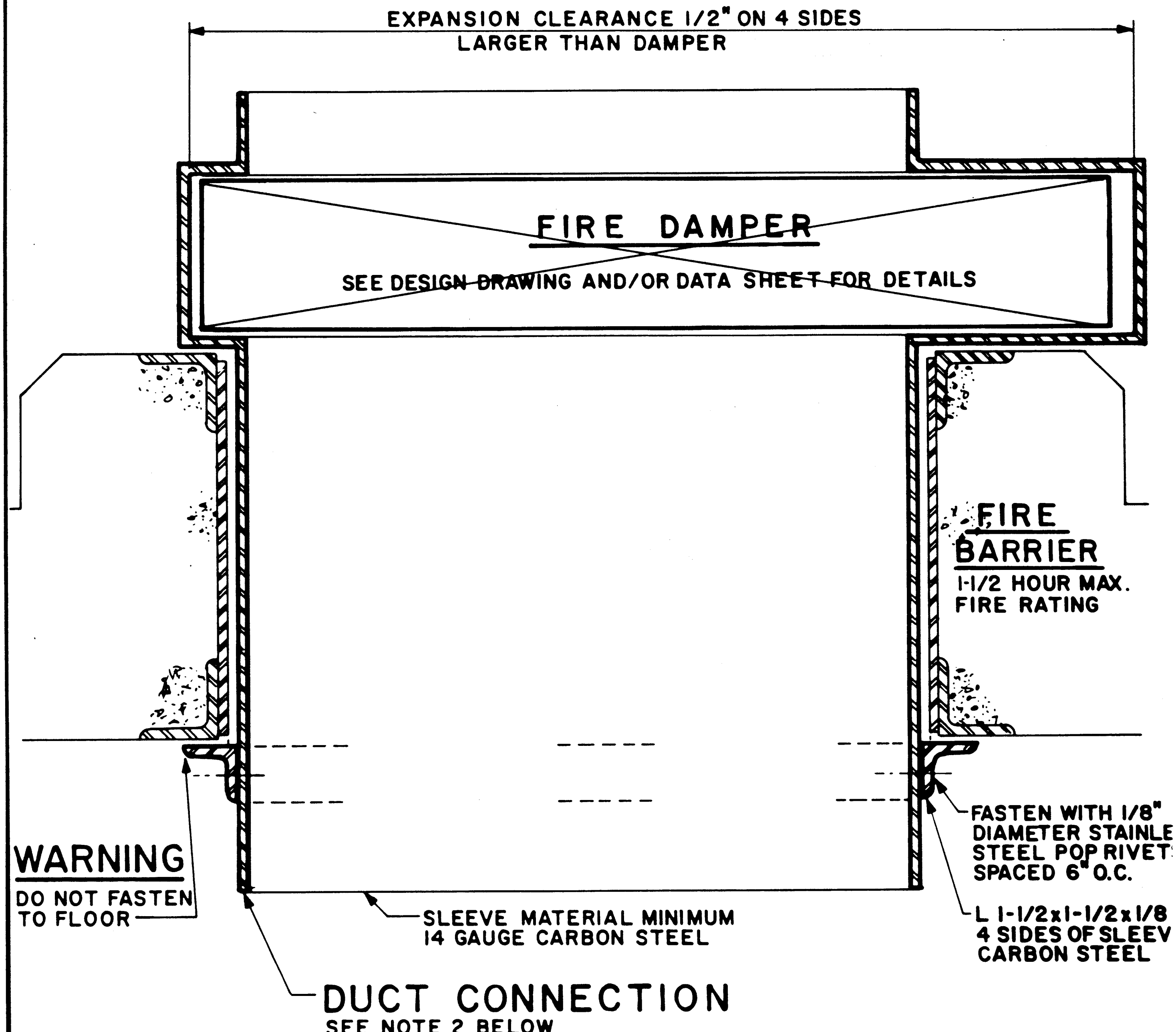

APPROVED BY *W. E. Weathersby*

DIVISION 15

MECHANICAL

DATA SHEETS

DIVISION 15

MECHANICAL – DATA SHEETS

Number	Title	Pages
UCN-10533A	AIR DIFFUSERS	1
UCN-2641W	AIR LOUVER	1
UCN-264EE	AUTOMATIC AIR DAMPER	1
UCN-2641A	AXIAL FLOW FAN	1
UCN-2641P	BALANCING DAMPER	1
UCN-2641BH	BASEBOARD HEATERS	1
UCN-2641J	BRINE COOLING COIL	1
UCN-2641	CENTRIFUGAL FAN	1
UCN-2641N	CONTROL VALVE	1
UCN-2641T	DATA SHEET (PLAIN)	1
UCN-2641T2	DATA SHEET (CONTINUATION)	1
UCN-2641M	ELECTRIC DUCT HEATING COIL	1
UCN-2641Y	ELECTRIC UNIT HEATER	1
UCN-10533B	EXHAUST OR RETURN GRILLES/REGISTERS	1
UCN-2641F	FAN-COIL AIR CONDITIONING UNIT	1
UCN-2641R	FIRE DAMPERS	1
UCN-2641E	HEATING AND VENTILATING UNIT	1
UCN-2641L	HOT WATER HEATING COILS	1
UCN-2641V	HOT WATER UNIT HEATER	1
UCN-2641BB	MANOMETERS	1
UCN-2641S	MOTOR	1
UCN-2641C	PROPELLER FANS	1
UCN-2641D	ROOF OR WALL VENTILATOR	1
UCN-2641X	STEAM UNIT HEATER	1
UCN-10533C	SUPPLY GRILLES/REGISTERS	1
UCN-2641Q	V-BELT DRIVE	1

DATA SHEET			AIR DIFFUSERS				
REVISIONS			PROJECT		DATA SHEET NO. DS-EC- PAGE 1 OF 1		REV
REV.	APPROVAL	DATE					
			PLANT	BLDG.	PREPARED BY	SHEET PART 15501	
			W.O. OR E.S.O.		APPROVAL	DATE	
			REQUISITION NO.		PROCURED BY Contractor	INSTALLED BY Contractor	

EQUIPMENT NUMBERS			
SELECTION: Manufacturer		**FINISH:**	
Model No.		Mfg. Std., Other	
TOTAL QUANTITY		Color	
INSTALLATION:		**ACCESSORIES:**	
Ht. Above Floor, Ft.		Damper, Type	
Ceiling (Flush, T-Grid)		Removable Core	
Exposed Duct		Control Grid	
PERFORMANCE:		Air Extractor	
Air Volume, scfm		Other	
Terminal Velocity, fpm			
Throw, Ft.			
Air Pattern			
Fixed			
Adjustable			
1, 2, 3, or 4-Way			
NC Rating, Max.			
S.P. Loss, In. W.G. Max.			
PHYSICAL:			
Nominal Neck Size, Inches			
Face Size, Inches			
Face Type: Round			
Square			
Rectangular			
Perforated			
Linear			
MATERIAL:			
Steel, Aluminum, Other			

REMARKS: 1. Static pressure loss includes loss across accessories.

* Information to be furnished by equipment manufacturer.

FURNISH THE FOLLOWING MANUFACTURER'S DATA:	SUBMITTALS REQUIRED			TYPE OF DATA (CONTINUED)	SUBMITTALS REQUIRED		
	W/BIDS	APPR.	CERT.		W/BIDS	APPR.	CERT.
1. Outline dimensional drawings				4. Installation instructions			
2. Weight of equipment				5. Descriptive literature			
3. Performance data							

DATA SHEET			AIR LOUVER				
REVISIONS			PROJECT		DATA SHEET NO. DS-EC- PAGE 1 OF 1		REV
REV.	APPROVAL	DATE					
			PLANT	BLDG.	PREPARED BY	SHEET PART 15501	
			W.O. OR E.S.O.		APPROVAL	DATE	
			REQUISITION NO.		PROCURED BY Contractor	INSTALLED BY Contractor	

EQUIPMENT NUMBERS			
SELECTION: Manufacturer			
Model No.			
TOTAL QUANTITY REQUIRED			
PHYSICAL: Length (in.)			
Height (in.)			
Depth (in.)			
Air Quantity (CFM)			
Pressure Drop (in. W.G.)			
Face Velocity (FPM)			
CONSTRUCTION: Type Louver			
Application			
Blade Type			
Blade (Operable or Fixed)			
Material			
Material Thickness, (Min.)			
Frame Type: Head			
Jamb			
Sill			
Frame Thickness (Min.)			
Mullions (Exposed or			
ACCESSORIES: Screen Material			
Screen Location			
Screen Size			
Type Operator			
Damper (Manual or Auto.)			
Fasteners			
FINISH: Manufacturer's Standard			
Special (Describe)			

REMARKS: Louvers shall prevent moisture carry-over at the face velocity indicated.

* Information to be furnished by equipment manufacturer.

FURNISH THE FOLLOWING MANUFACTURER'S DATA:	SUBMITTALS REQUIRED W/BIDS	APPR.	CERT.	TYPE OF DATA (CONTINUED)	SUBMITTALS REQUIRED W/BIDS	APPR.	CERT.
1. Outline dimensional drawings				4. Installation instructions			
2. Weight of equipment				5. Descriptive literature			
3. Performance data							

AXIAL FLOW FAN

DATA SHEET	PROJECT	DATA SHEET NO. DS-EC- PAGE 1 OF 1	REV
	PLANT / BLDG.	PREPARED BY	SHEET PART 15501
	W.O. OR E.S.O.	APPROVAL	DATE
	REQUISITION NO.	PROCURED BY Contractor	INSTALLED BY Contractor

REVISIONS		
REV.	APPROVAL	DATE

EQUIPMENT NUMBERS			
SELECTION: Manufacturer		**CONSTR (cont.):**	
Model No.		Shaft material	
Size		**MOTOR:** Equipment Number	
TOTAL QUANTITY REQUIRED:		Horsepower	
PERFORMANCE: Volume, CFM		Volts, phase, Hz	
Static pressure, In. W.G.		Electrical type	
Service-Supply, Exhaust, etc.		Enclosure	
Flowing medium		Adjustable base required	
Temperature at inlet EF		Service factor	
Barom. press. at inlet, In. Hg.		Full load RPM	
Outlet velocity, FPM max.		NEMA design letter	
Rotor diameter, In.		NEMA Frame No.	
Rotor speed, RPM max.		**DRIVE:** Type	
Brake HP max.		HP rating	
ARRANGEMENT: Vane or Tube type		Motor sheave: Fixed, Vari-pitch	
AMCA Arrangement No.		**ACCESSORIES:**	
Horiz. or Vert. mounting		Streamline inlet (no duct)	
Diameter of basic fan, In.		Inlet cone for duct	
Dia. of connecting duct, In.		Outlet cone	
Motor location looking in air-flow direction		Flanged duct connections req'd	
		Belt guard (external)	
Base for Floor, Wall or Ceiling		Tunnel belt enclosure	
CONSTRUCTION: AMCA sparkproof		Inlet screen	
Housing material		Access door position	
Housing construction		Weatherproof motor cover	
Rotor material		Weatherproof drive cover	
Rotor construction		Spring type vibration base sized for 10% transmissibility	
Adjustable rotor blades req'd			
Bearings: Roller or Ball (All bearings shall be self-aligning external grease lube type. Roller bearings shall be taper-lock spherical type.)		**PAINTING:** Manufacturer's	
		Special (describe)	
		COATING: (Describe)	

REMARKS: Fan shall be AMCA rated and tested. Fan unit shall be both statically and dynamically balanced.

* Information to be furnished by equipment manufacturer.

FURNISH THE FOLLOWING MANUFACTURER'S DATA:	SUBMITTALS REQUIRED W/BIDS	APPR.	CERT.	TYPE OF DATA (CONTINUED)	SUBMITTALS REQUIRED W/BIDS	APPR.	CERT.
1. Performance curves or tables indicating actual fan speed, outlet velocity, and brake HP for specified conditions.				3. Weight of equipment			
				4. Installation instructions			
2. Outline dimensional drawings				5. AMCA sound rating			

BALANCING DAMPER

DATA SHEET			PROJECT		DATA SHEET NO. DS-EC- PAG 1 OF 1		REV.
REVISIONS							
REV.	APPROVAL	DATE					
			PLANT	BLDG.	PREPARED BY	SHEET PART 15501	
			W.O. OR E.S.O.		APPROVAL	DATE	
			REQUISITION NO.		PROCURED BY Contractor	INSTALLED Contractor	

EQUIPMENT NUMBERS			
		SHAFT SPECIFICATION:	
SELECTION: Manufacturer		Material	
Model No.		Diameter - in.	
TOTAL QUANTITY		Operator Extension	
SIZE: Width, in.		Extension Length - in.	
Height, in.		**BEARING**	
DAMPER TYPE: Single Blade		Nylon	
Multi-Blade		Oilite	
POSITION: Horizontal, Airflow		Bottom Thrust Type	
Vertical, Airflow Horz.			
BLADE ACTION: Opposed		Other	
Parallel		**SEALS:**	
BLADE SPECIFICATION:		Frame	
Type - Airfoil/Flat		Blade	
Width - in. (max.)		Material	
Length - in. (max.)		**PERFORMANCE:**	
Material		Airflow, CFM	
Gauge (min.)		Pressure Drop In. S.P.	
Linked Together		Pressure Drop In. S.P.	
Parallel to Short/Long Side		Leakage, CFM (max.)	
FRAME SPECIFICATION:		**OPERATOR TYPE:**	
Material		Manual	
Gauge (min.)		Automatic	
Size - in.		**FINISH:**	
Slip-In		Manufacturer's Std.	
Flanged		Other (Describe)	
Flange Size - in.			

REMARKS: Blades to be parallel to short side of damper.
Multi-dampers to be used if blade length exceeds maximum listed above.

* Information to be furnished by equipment manufacturer.

FURNISH THE FOLLOWING MANUFACTURER'S DATA:	SUBMITTALS REQUIRED W/BIDS	APPR.	CERT.	TYPE OF DATA (CONTINUED)	SUBMITTALS REQUIRED W/BIDS	APPR.	CERT.
1. Outline dimensional drawings				4. Installation instructions			
2. Weight of equipment				5. Descriptive literature			
3. Performance data							

BASEBOARD HEATERS

DATA SHEET			PROJECT		DATA SHEET NO. DS-EC- PAGE 1 OF 1		REV
REVISIONS							
REV.	APPROVAL	DATE	PLANT	BLDG.	PREPARED BY	SHEET PART 15501	
			W.O. OR E.S.O.		APPROVAL	DATE	
			REQUISITION NO.		PROCURED BY Contractor	INSTALLED BY Contractor	

EQUIPMENT NUMBERS			
SELECTION: Manufacturer			
Model No.			
TOTAL QUANTITY			
PERFORMANCE:			
Sensible Heat (Btuh)			
Power (KW)			
Volts / Phase / Hz			
CONSTRUCTION:			
Heating Element			
Height (in.)			
Width (in.)			
Depth (in.)			
ACCESSORIES:			
Built-in Thermostat			
Thermal Limit Switch			
Mounting Bracket Type -			
FINISH:			
Manufacturer's Standard			
Special (describe)			

REMARKS:

* Information to be furnished by equipment manufacturer.

FURNISH THE FOLLOWING MANUFACTURER'S DATA:	SUBMITTALS REQUIRED W/BIDS	APPR.	CERT.	TYPE OF DATA (CONTINUED)	SUBMITTALS REQUIRED W/BIDS	APPR.	CERT.
1. Outline dimensional drawings				4. Installation instructions			
2. Weight of equipment				5. Descriptive literature			
3. Performance data							

DATA SHEET	BRINE COOLING COIL			
REVISIONS	PROJECT	DATA SHEET NO. DS-EC- PAGE 1 OF 1		REV
REV. | APPROVAL | DATE	PLANT / BLDG.	PREPARED BY	SHEET PART 15501	
	W.O. OR E.S.O.	APPROVAL	DATE	
	REQUISITION NO.	PROCURED BY Contractor	INSTALLED BY Contractor	

REV.	APPROVAL	DATE

EQUIPMENT NUMBERS			
SELECTION: Manufacturer		**MATERIALS:** Tubes	
Model No.		Fins	
TOTAL QUANTITY		Headers	
AIRSIDE: CFM Std. air		Casing	
Entering temp., EF DB/WB		**PIPING CONNECTIONS:**	
Leaving temp., EF DB/WB		Same or opposite ends	
Total heat, BTU/Hr.		Left or right hand supply viewing air entering side	
Wet resistance, In. W.G. max.			
COOLANT:		**LEAKTEST:**	
Brine (% solution by weight of Methanol and water		Hydrostatic press. psig.	
		ACCESSORIES:	
Thermal conductivity @ 32EF, BTU/hr/ft^2/EF/ft		Header drains and vents	
		Cleanable tubes	
Specific gravity @ 32EF		Turbulators	
Specific heat @ 32EF			
Abs. Visc. @ 32EF Centpoises			
Freezing point, EF			
GPM			
Entering temp., EF			
Leaving temp., EF			
Pressure drop, psig. max.			
PHYSICAL: Coil face area, Sq.			
Tube length, inches			
No. of tubes in face			
Tube size, Inches O.D.			
Tube wall thickness, In. (min.)			
Fins per inch			
Fin mat'l thickness, In. (min.)			
Rows of tubes (depth)			
Coolant circuit arrangement			
Casing overall dimensions: width x height x depth, In.			

REMARKS: Coolant flow shall be counter to airflow.

* Information to be furnished by equipment manufacturer.

FURNISH THE FOLLOWING MANUFACTURER'S DATA:	SUBMITTALS REQUIRED W/BIDS	APPR.	CERT.	TYPE OF DATA (CONTINUED)	SUBMITTALS REQUIRED W/BIDS	APPR.	CERT.
1. Outline dimensional drawings				4. Installation instructions			
2. Weight of equipment				5. Descriptive literature			
3. Performance data							

DATA SHEET			CENTRIFUGAL FAN			
REVISIONS			PROJECT	DATA SHEET NO. DS-EC- PAGE 1 OF 1		REV.
REV.	APPROVAL	DATE				
			PLANT BLDG.	PREPARED BY	SHEET PART 15501	
			W.O. OR E.S.O.	APPROVAL	DATE	
			REQUISITION NO.	PROCURED BY Contr.	INSTALLED BY Contr.	

EQUIPMENT NUMBERS			
SELECTION: Manufacturer		**CONSTR (cont.):** Wheel type	
Model No.		Wheel material	
Size		Wheel construction	
TOTAL QUANTITY REQUIRED:		**MOTOR:** Equipment Number	
PERFORMANCE: Volume CFM		Horsepower	
Static pressure, In. W.G.		Volts, phase, Hz	
Service-Supply, Exhaust, etc.		Constant or variable speed	
Flowing medium		Enclosure	
Temperature at inlet EF		Adjustable base required	
Barom. press. at inlet, in. Hg.		Service factor	
Outlet velocity, FPM max.		Full load RPM	
Wheel diameter, in.		High Efficiency	
Fan speed, RPM max.		NEMA frame No.	
Brake HP max.		Elec. type: Squirrel-	
ARRANGEMENT: AMCA Arrangement		**DRIVE:** Type	
SISW or DIDW		HP rating	
Rotation		Motor sheave Fixed, Vari-	
AMCA discharge position		**ACCESSORIES:** Belt guard	
AMCA motor position		Variable inlet vanes	
Housing: Fixed, 45E Adjustable		Opposed blade disch.	
Inlet connection type		Inlet screens	
Outlet connection type		Access door: Flush or	
CONSTRUCTION: AMCA Class		Access door position	
AMCA sparkproof class		Drain connx size, In. IPS	
Housing material		Weatherproof drive cover	
Housing seams		Bearing cooling type	
Housing design: Full or Split		Spring-type vibration base common to fan & motor	
Shaft material			
Bearings: Roller or Ball (All bearings shall be self-aligning external grease lube type. Roller bearings shall be taper-lock spherical type.)		**PAINTING:** Manufacturer's	
		Special (describe)	
		COATINGS: (Describe)	

REMARKS: Fan shall be AMCA rated and tested. Fan unit shall be both statically and dynamically balanced.

* Information to be furnished by equipment manufacturer.

FURNISH THE FOLLOWING MANUFACTURER'S DATA:	SUBMITTALS REQUIRED			TYPE OF DATA (CONTINUED)	SUBMITTALS REQUIRED		
	W/BIDS	APPR.	CERT.		W/BIDS	APPR.	CERT.
1. Performance curves or tables indicating actual fan speed, outlet velocity, and brake HP for specified conditions.				3. Weight of equipment			
				4. Installation instructions			
2. Outline dimensional drawings				5. AMCA sound rating			

CONTROL VALVE

DATA SHEET			PROJECT		DATA SHEET NO. DS-EC- PAGE 1 OF 1	REV
REVISIONS						
REV.	APPROVAL	DATE	PLANT	BLDG.	PREPARED BY	SHEET PART 15501
			W.O. OR E.S.O.		APPROVAL	DATE
			REQUISITION NO.		PROCURED BY Contractor	INSTALLED BY Contractor

EQUIPMENT NUMBERS							
SELECTION: Manufacturer							
Model No.							
TOTAL QUANTITY REQUIRED:							
BODY:							
Body Size	Port Size						
Form							
Material							
End Connections							
Bonnet Type							
Packing or Seal							
Guides							
TRIM: Material							
No. of Seats							
Plug Form							
Plug & Seat Material							
Seat - Integral	Screwed-In						
ACTION:							
Close @ psi	Open @ psi						
Failure Position							
POSITIONER:							
By-Pass	Gages						
Top Mounted	Side Mounted						
Range: Close	Open @						
SERVICE CONDITIONS:							
Flowing Medium							
Flow Rate & Units							
Inlet psia	Outlet psia						
DP Sizing	DP Shut-Off						
Temp. Max.	Superheat EF						
Flow Coefficient, C_v							
Sp. Gr. @ 60E	@ Flow Temp.						
OPERATOR - TYPE:							
Size	Supply						

REMARKS:

* Information to be furnished by equipment manufacturer.

FURNISH THE FOLLOWING MANUFACTURER'S DATA:	SUBMITTALS REQUIRED W/BIDS	APPR.	CERT.	TYPE OF DATA (CONTINUED)	SUBMITTALS REQUIRED W/BIDS	APPR.	CERT.
1. Outline dimensional drawings				4. Installation instructions			
2. Weight of equipment				5. Descriptive literature			
3. Performance data							

DATA SHEET			blank			
REVISIONS			PROJECT	DATA SHEET NO. DS-EC-		REV.
REV.	APPROVAL	DATE		PAGE 1 OF 1		
			PLANT BLDG.	PREPARED BY	SHEET PART 15501	
			W.O. OR E.S.O.	APPROVAL	DATE	
			REQUISITION NO.	PROCURED BY Contr.	INSTALLED BY Contr.	

EQUIPMENT NUMBERS			

REMARKS:

FURNISH THE FOLLOWING MANUFACTURER'S DATA:	SUBMITTALS REQUIRED			TYPE OF DATA (CONTINUED)	SUBMITTALS REQUIRED		
	W/BIDS	APPR.	CERT.		W/BIDS	APPR.	CERT.
1.				3.			
				4.			
2.				5.			

DATA SHEET - blank

EQUIPMENT NUMBERS			

REMARKS:

ELECTRIC DUCT HEATING COIL

DATA SHEET			PROJECT		DATA SHEET NO.	REV
REVISIONS					DS-EC-	
REV.	APPROVAL	DATE			PAGE 1 OF 1	
			PLANT	BLDG.	PREPARED BY	SHEET PART 15501
			W.O. OR E.S.O.		APPROVAL	DATE
			REQUISITION NO.		PROCURED BY Contractor	INSTALLED BY Contractor

EQUIPMENT NUMBERS			
SELECTION: Manufacturer		**CONTACTORS:**	
Model No.		Furnished by coil manufacturer, yes or no?	
TOTAL QUANTITY			
PERFORMANCE: Flowing		Remote or Built-in type	
Flow rate, CFM		Mercury or Magnetic type	
Temperature, In/Out, EF		Remote enclosure NEMA	
Sensible heat, BTU/Hr.		Oper. coil volts, phase, Hz	
Face velocity, FPM		**SPECIALS:** Built-in fuses	
Resistance, In. water max.		Weatherproof terminal box	
Flow: Horizontal		Insulated terminal box	
Vertically up		Internally insulated duct	
Vertically down		Built-in pilot lights	
POWER: KW		Built-in pilot switch	
Volts, phase, Hz		Built-in disconnect switch	
No. of equal circuits		Built-in control transformer	
CASING: Duct width x height,		Transf. volts, phase, Hz	
Flanged or Slip-in		Built-in protective screens	
External flange dimension, In.		Single phase line voltage circuits for 3-phase	
Location of terminals viewing air entering side			
Material		Single phase line-to-neutral voltage circuits for 3-phase operation	
HEATER: Exposed Nichrome			
Enclosed finned tube		Welded airtight casing	
PROTECTORS:		Temperature uniformity across face of coil, EF	
Primary: Auto reset disc			
Auto reset bulb			
Secondary: Manual reset disc			
Manual reset bulb			

REMARKS: Coil shall be designed for zero-clearance installation and shall bear a UL label.

* Information to be furnished by equipment manufacturer.

FURNISH THE FOLLOWING MANUFACTURER'S DATA:	SUBMITTALS REQUIRED W/BIDS	APPR.	CERT.	TYPE OF DATA (CONTINUED)	SUBMITTALS REQUIRED W/BIDS	APPR.	CERT.
1. Outline dimensional drawings				4. Installation instructions			
2. Wiring diagrams				5. Descriptive literature			
3. Performance data							

DATA SHEET	ELECTRIC UNIT HEATER				
REVISIONS	PROJECT		DATA SHEET NO. DS-EC- PAGE 1 OF 1		REV
REV. | APPROVAL | DATE	PLANT	BLDG.	PREPARED BY	SHEET PART 15501	
	W.O. OR E.S.O.		APPROVAL	DATE	
	REQUISITION NO.		PROCURED BY Contractor	INSTALLED BY Contractor	

REV.	APPROVAL	DATE

EQUIPMENT NUMBERS			
SELECTION: Manufacturer			
Model No.			
TOTAL QUANTITY REQUIRED			
AIRSIDE: CFM Std. Air			
Temperature In/Out, EF			
Sensible Heat, Btuh			
Direction of Airflow			
Resistance, in. W.G. (max.)			
Required Throw, ft			
POWER: KW			
Volts / Phase / Hz			
CONSTRUCTION: Height x Width x			
Casing Material			
Exposed Nichrome Wire			
Enclosed Finned Tube			
MOTOR: Type			
Enclosure			
HP			
Volts / Phase / Hz			
ACCESSORIES: Air Deflectors			
Thermostat			
Magnetic Starter			
Fan Safety Guard			
Diffuser			
Mounting Bracket Type			
Transformer			
High Temperature Cutout			
Contactor (Type)			
Fan Delay Switch			
FINISH: Manufacturer's Standard			
Special (Describe)			

REMARKS: Heater shall be UL approved and labeled.

* Information to be furnished by equipment manufacturer.

FURNISH THE FOLLOWING MANUFACTURER'S DATA:	SUBMITTALS REQUIRED W/BIDS	APPR.	CERT.	TYPE OF DATA (CONTINUED)	SUBMITTALS REQUIRED W/BIDS	APPR.	CERT.
1. Outline dimensional drawings				4. Installation instructions			
2. Weight of equipment				5. Descriptive literature			
3. Performance data							

EXHAUST OR RETURN GRILLES/REGISTERS

DATA SHEET			PROJECT		DATA SHEET NO. DS-EC- PAGE 1 OF 1		REV
REVISIONS							
REV.	APPROVAL	DATE					
			PLANT	BLDG.	PREPARED BY	SHEET PART 15501	
			W.O. OR E.S.O.		APPROVAL	DATE	
			REQUISITION NO.		PROCURED BY Contractor	INSTALLED BY Contractor	

EQUIPMENT NUMBERS			
SELECTION: Manufacturer			
Model No.			
TOTAL QUANTITY REQUIRED			
INSTALLATION:			
Ceiling (Flush or T-Grid)			
Wall			
Exposed Duct			
PERFORMANCE:			
Air Volume, scfm			
NC Rating, max.			
S. P. Loss, in. W.G. (max.)			
PHYSICAL:			
Nominal Size, in.			
Face Size, in.			
Face Type - Vane			
Perforated			
Other			
Vanes - Horizontal			
Vertical			
MATERIAL:			
Steel			
Aluminum			
Other			
FINISH:			
Mfg. Standard			
Other			
Color			
ACCESSORIES:			
Opposed Blade Damper			
Frame			
Other			

REMARKS: Static pressure loss includes loss across accessories.

* Information to be furnished by equipment manufacturer.

FURNISH THE FOLLOWING MANUFACTURER'S DATA:	SUBMITTALS REQUIRED W/BIDS	APPR.	CERT.	TYPE OF DATA (CONTINUED)	SUBMITTALS REQUIRED W/BIDS	APPR.	CERT.
1. Outline dimensional drawings				4. Installation instructions			
2. Weight of equipment				5. Descriptive literature			
3. Performance data							

DATA SHEET	FAN-COIL AIR CONDITIONING UNIT		
REVISIONS	**PROJECT**	**DATA SHEET NO.** DS-EC- **PAGE** 1 **OF** 1	**REV**

REV.	APPROVAL	DATE

PLANT **BLDG.**	**PREPARED BY**	**SHEET PART** 15501
W.O. OR E.S.O.	**APPROVAL**	**DATE**
REQUISITION NO.	**PROCURED BY** Contractor	**INSTALLED BY** Contractor

EQUIPMENT NUMBERS			
SELECTION: Manufacturer		**DRIVE -** Type	
Model No.		HP Rating	
TOTAL QUANTITY REQUIRED:		Motor Sheave: Fixed or Vari-pitch	
CASING - Horizontal or Vertical			
Low, Medium or High		**FILTERS -** Flat, Vee or Zee	
Material of Construction		Media Velocity, FPM (max.)	
Type: Standard		NBS Efficiency Rating, %	
Multi-zone		Clean Press. Drop, in. W.G.	
Spray coil		Type: Throw-away or	
FAN - Airflow, SCFM		**OPTIONS -** Mixing Box	
External S.P., in. W.G.		Comb. Filters-Mixing Box	
Brake HP		F&B.P. Dampers: Inter. or	
Speed, RPM (max.)		Face Damper Only	
Outlet Velocity, FPM (max.)		Humidifier: Grid or Pan	
AMCA Discharge Position		Steam Humidifier Cap., lb/hr	
Wheel Type		Weatherproof Unit	
MOTOR - HP		Belt Guard Required	
Volts / Phase / Hz		Hangers for Clg. Suspension	
Location Viewing Top of Unit in Airflow Direction		Supports for Floor Mounting	
		Spring Type Vibration Isolators for 10% transmissibility	
Electrical Type			
Enclosure		Internally Insulated Casing	
NEMA Frame No.		Insulated Drain Pan	
Full Load RPM		Drain Size, in. IPS	
Adjustable Mtg. Base Req'd.		Drain Location Viewing Top of Unit in Airflow Direction	
COILS - See separate pages for coil specs. The coil sequence in the direction of airflow shall be as			
		Eliminators	
		Spray Pump Furn. with Unit	
		Pump Volts / Phase / Hz	

REMARKS: Fan shall be AMCA rated and tested. Fan wheel shall be both statically and dynamically balanced.

* Information to be furnished by equipment manufacturer.

FURNISH THE FOLLOWING MANUFACTURER'S DATA:	SUBMITTALS REQUIRED W/BIDS	APPR.	CERT.	TYPE OF DATA (CONTINUED)	SUBMITTALS REQUIRED W/BIDS	APPR.	CERT.
1. Performance curves or tables indicating actual fan speed, outlet velocity, and brake HP for specified conditions.				3. Weight of equipment			
				4. Installation instructions			
2. Outline dimensional drawings				5. AMCA sound rating			

DATA SHEET			FIRE DAMPERS			
REVISIONS			**PROJECT**	**DATA SHEET NO.** DS-EC- PAGE 1 OF 1		**REV**
REV.	APPROVA	DATE				
			PLANT **BLDG.**	**PREPARED BY**	**SHEET PART** 15501	
			W.O. OR E.S.O.	**APPROVAL**	**DATE**	
			REQUISITION NO.	**PROCURED BY** Contractor	**INSTALLED BY** Contractor	

EQUIPMENT NUMBERS			
SELECTION: Manufacturer		Collar Required	
Model No.		Material	
TOTAL QUANTITY REQUIRED:		Gauge	
Type:		Collar Length, In.	
Multiblade		Air Inlet Side	
Curtain		Air Outlet Side	
Trap Door			
Other		Sleeve Required	
Damper Position:		Material	
Vertical		Gauge	
Horizontal - Air Flow Up		Total Length	
Horizontal - Air Flow Down			
Duct Size: (Inches)		Rating (UL Approved) - Hrs.	
Round - Diameter		% Free Area	
Oval - Width/Height		Fusible Link - (See	
Rectangular - Width/Height		Closure Method:	
		Spring	
Blade:		Weighted Blades	
Material			
Gauge		Spring Locking Latch	
Single			
Opposed			
Interlocking			
Bearings			
Width (Max.) - In.			
Length (Max.) - In.			

REMARKS:

Fusible links shall be Grinnell, 30 lb. load rated, Issue D, with a 165E F temperature rating.
Multiple dampers shall have a fusible link for each individual damper.
Blades shall be parallel to the width.
Dampers shall be listed and labeled under Label Service of Underwriters' Laboratories, Inc. for mounting position listed.
Fusible links and spring latches shall be on same side of damper.

* Information to be furnished by equipment manufacturer.

FURNISH THE FOLLOWING MANUFACTURER'S DATA:	**SUBMITTALS REQUIRED** W/BIDS	APPR.	CERT.	**TYPE OF DATA (CONTINUED)**	**SUBMITTALS REQUIRED** W/BIDS	APPR.	CERT.
1. Outline dimensional drawings				4. Installation instructions			
2. Weight of equipment				5. Descriptive literature			
3. Performance data							

DATA SHEET			HEATING AND VENTILATING UNIT			
REVISIONS			**PROJECT**	**DATA SHEET NO.** DS-EC-		**REV**
REV.	APPROVAL	DATE		**PAGE** 1 **OF** 1		
			PLANT **BLDG.**	**PREPARED BY**	**SHEET PART** 15501	
			W.O. OR E.S.O.	**APPROVAL**	**DATE**	
			REQUISITION NO.	**PROCURED BY** Contractor	**INSTALLED BY** Contractor	

EQUIPMENT NUMBERS			
SELECTION: Manufacturer		**DRIVE -** Type	
Model No.		HP Rating	
TOTAL QUANTITY REQUIRED:		Motor Sheave: Fixed or Vari-pitch	
CASING - Horizontal or Vertical			
Low, Medium or High Pressure		**FILTERS -** Flat, Vee or Zee	
Material of Construction		Media Velocity, FPM (max.)	
FAN - Airflow, SCFM		NBS Efficiency Rating, %	
External S.P., In. W.G.		Clean Press. Drop, In. W.G.	
Brake HP		Type: Throw-away or	
Speed, RPM (max.)		**OPTIONS -** Mixing Box	
Outlet Velocity, FPM (max.)		Comb Filter-Mixing Box	
AMCA Discharge Position		F&B.P. Dampers: Inter. or	
Wheel Type		Face Damper Only	
MOTOR - HP		Humidifier: Grid or Pan	
Volts / Phase / Hz		Steam Humidifier Cap., lb/hr	
Location Viewing Top of Unit in Airflow Direction		Drain pan	
		Weatherproof unit	
Electrical Type		Belt Guard Required	
Enclosure		Hangers for clg Suspension	
NEMA Frame No.		Supports for Floor Mounting	
Full Load RPM		Spring Type Vibration Isolators for 10%	
Adjustable Mtg. Base Req'd.			
COILS - See separate pages for coil specs. The coil sequence in the direction of airflow shall be as follows:			

REMARKS:

* Information to be furnished by equipment manufacturer.

FURNISH THE FOLLOWING MANUFACTURER'S DATA:	SUBMITTALS REQUIRED W/BIDS	APPR.	CERT.	TYPE OF DATA (CONTINUED)	SUBMITTALS REQUIRED W/BIDS	APPR.	CERT.
1. Performance curves or tables indicating actual fan speed, outlet velocity, and brake HP for specified conditions.				3. Weight of equipment			
				4. Installation instructions			
2. Outline dimensional drawings				5. AMCA sound rating			

HOT WATER HEATING COILS

DATA SHEET			PROJECT		DATA SHEET NO. DS-EC- PAGE 1 OF 1	REV.
REVISIONS						
REV.	APPROVAL	DATE	PLANT	BLDG.	PREPARED BY	SHEET PART 15501
			W.O. OR E.S.O.		APPROVAL	DATE
			REQUISITION NO.		PROCURED BY Contractor	INSTALLED BY Contractor

EQUIPMENT NUMBERS			
SELECTION: Manufacturer			
Model No.			
TOTAL QUANTITY REQUIRED			
AIRSIDE: CFM Std. air			
Entering temp., EF DB			
Leaving temp., EF DB			
Sensible heat, BTU/Hr.			
Resistance, In. W.G. max.			
WATER: GPM			
Temperature In/Out, EF			
Pressure drop, Ft. water			
PHYSICAL: Coil face area, Sq. Ft.			
Tube length, Inches			
No. of tubes in face			
Tube size, Inches O.D.			
Rows of tubes (depth)			
Tube wall thickness, In. (min.)			
Fins per inch			
Fin mat'l thickness, In. (min.)			
Water circuit arrangement			
Casing overall dimensions width x height x depth, In.			
MATERIALS: Tubes			
Fins			
Headers			
Casing			
PIPING CONNXS: Same or opposite			
Left or right hand supply viewing air entering side			
LEAKTEST: Hydrostatic press., psig.			
ACCESSORIES: Header drains and			
Cleanable tubes			
Tubulators			

REMARKS: Water flow shall be counter to airflow.

* Information to be furnished by equipment manufacturer.

FURNISH THE FOLLOWING MANUFACTURER'S DATA:	SUBMITTALS REQUIRED W/BIDS	APPR.	CERT.	TYPE OF DATA (CONTINUED)	SUBMITTALS REQUIRED W/BIDS	APPR.	CERT.
1. Outline dimensional drawings				4. Installation instructions			
2. Weight of equipment				5. Descriptive literature			
3. Performance data							

DATA SHEET	HOT WATER UNIT HEATER		
REVISIONS	PROJECT	DATA SHEET NO. DS-EC- PAGE 1 OF 1	REV.
	PLANT / BLDG.	PREPARED BY	SHEET PART 15501
	W.O. OR E.S.O.	APPROVAL	DATE
	REQUISITION NO.	PROCURED BY Contractor	INSTALLED BY Contractor

REV.	APPROVAL	DATE

EQUIPMENT NUMBERS			
SELECTION: Manufacturer			
Model No.			
TOTAL QUANTITY			
AIRSIDE: CFM Standard Air			
Temperature In/Out, EF			
Sensible Heat, BTU/Hr			
Direction of Airflow			
Resistance, In. W.G. Max.			
Required Throw, Ft.			
WATER: Flow, GPM			
Temperature In/Out, EF			
Inlet Pressure, PSIG			
Pressure Drop, Ft. W.G.			
CONSTRUCTION: Physical Height x Width x Depth			
Casing Material			
Tube Material			
Fin Material			
MOTOR: Type			
Enclosure			
HP			
Volts/Phase/Hertz			
ACCESSORIES: Air			
Thermostat			
Magnetic Starter			
Fan Safety Guard			
Diffuser			
Mounting Bracket Type			
LEAKTEST:			
Hydro. Press., PSIG, Min.			
FINISH: Manufacturer's			
Special (Describe)			

REMARKS:

* Information to be furnished by equipment manufacturer.

FURNISH THE FOLLOWING MANUFACTURER'S DATA:	SUBMITTALS REQUIRED			TYPE OF DATA (CONTINUED)	SUBMITTALS REQUIRED		
	W/BIDS	APPR.	CERT.		W/BIDS	APPR.	CERT.
1. Outline dimensional drawings				4. Installation instructions			
2. Weight of equipment				5. Descriptive literature			
3. Performance data							

MANOMETERS

DATA SHEET			PROJECT		DATA SHEET NO. DS-EC- PAGE 1 OF 1		REV.
REVISIONS							
REV.	APPROVAL	DATE	PLANT	BLDG.	PREPARED BY	SHEET PART 15501	
			W.O. OR E.S.O.		APPROVAL	DATE	
			REQUISITION NO.		PROCURED BY Contractor	INSTALLED BY Contractor	

EQUIPMENT NUMBERS			
SELECTION:		**PRESSURE**	
Model No.		High Side - 1/4" NPT, etc.	
TOTAL QUANTITY		Low Side - 1/4" NPT, etc.	
NUMBER OF TUBES:		Max. Pressure Rating -	
INSTRUMENT RANGE:		**ACCESSORIES:**	
Minimum		3-Valve Vent Manifold	
Maximum		Venting Petcock	
Graduations		Static Pressure Probes	
Units - In., CM, etc.		Velocity Pressure Probes	
Actual Scale Length -		Check Valve (Inlet, Outlet)	
Scale Adjustment			
Level Adjustment			
FLUID:			
Type			
SP. Grav.			
Color			
CONSTRUCTION:			
Approximate Height			
Approximate Width			
Basic U-Tube			
Straight U-Tube			
Well and Tube			
Inclined Tube			
Tube Material			
Body Material			
Finish			
Mounting Style - Wall, Pipe, etc.			

REMARKS: The manufacturer shall furnish a complete supply of the above-specified fluid and necessary mounting brackets.

* Information to be furnished by equipment manufacturer.

FURNISH THE FOLLOWING MANUFACTURER'S DATA:	SUBMITTALS REQUIRED W/BIDS	APPR.	CERT.	TYPE OF DATA (CONTINUED)	SUBMITTALS REQUIRED W/BIDS	APPR.	CERT.
1. Outline dimensional drawings				4. Installation instructions			
2. Weight of equipment				5. Descriptive literature			
3. Performance data							

DATA SHEET			MOTOR			
REVISIONS			PROJECT	DATA SHEET NO. DS-EC- PAGE 1 OF 1		REV
REV.	APPROVAL	DATE				
			PLANT BLDG.	PREPARED BY	SHEET PART 15501	
			W.O. OR E.S.O.	APPROVAL	DATE	
			REQUISITION NO.	PROCURED BY Contractor	INSTALLED Contractor	

EQUIPMENT NUMBERS			
SELECTION: Manufacturer		**PERFORMANCE:**	
Model No.		Power Factor Percent	
TOTAL QUANTITY		Efficiency Percent	
SPECIFICATIONS:		**GENERAL INFORMATION:**	
Rated HP		Serial No.	
Volts/Phase/Hz		Frame No.	
Full Load RPM		Net Weight, Lbs.	
Locked Rotor Current,		**TYPE MOUNTING:**	
Temperature Rise, Degrees		Foot, Face or Flanged	
Locked Rotor KVA Code		Ceiling, Floor or Wall	
Full Load Torque, lb. ft.		Horizontal or Vertical	
Rotation Facing Coupling			
Electrical Type			
Enclosure			
Altitude			
Full Load Current, Amps			
Ambient Temp., Degrees C			
NEMA Design Letter			
Starting Torque, lb. ft.			
Pull-out Torque, lb. ft.			
Duty Rating			
Sound Level			
Bearings			
Lubrication			
Insulation			
Couplings Furnished By			
Base Furnished By			
Non-Standard Mount or Extensions			

REMARKS: Motors shall comply with applicable NEMA Standards.

* Information to be furnished by equipment manufacturer.

FURNISH THE FOLLOWING MANUFACTURER'S DATA:	SUBMITTALS REQUIRED			TYPE OF DATA (CONTINUED)	SUBMITTALS REQUIRED		
	W/BIDS	APPR.	CERT.		W/BIDS	APPR.	CERT.
1. Outline dimensional drawings				5. Installation instructions			
2. Operation & performance data				6. Test & inspection reports			
3. Literature & parts list				7. Materials certification			
4. Operating & maint. instructions							

DATA SHEET	PROPELLER FANS			
	PROJECT	**DATA SHEET NO.** DS-EC- **PAGE** 1 **OF** 1		**REV.**
PLANT **BLDG.**		**PREPARED BY**	**SHEET PART** 15501	
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REVISIONS		
REV.	APPROVAL	DATE

EQUIPMENT NUMBERS			
SELECTION: Manufacturer			
Model No.			
Size			
TOTAL QUANTITY REQUIRED:			
PERFORMANCE: Airflow, SCFM			
Static pressure, In. W.G.			
Fan speed, RPM max.			
Brake HP, max.			
Blade diameter, In.			
CONSTRUCTION: Blade material			
Housing material			
Finish			
MOTOR: Equipment number			
Horsepower			
Volts, phase, Hz			
Electrical type			
Enclosure			
Service factor			
Full load RPM			
Bearings			
Lubrication			
DRIVE: Direct or V-belt			
Motor sheave--Fixed or Varipitch			
Belt guard required			
ACCESSORIES: Protective inlet			
Shutter type: Manual, gravity, automatic or motor operated			
Shutter blade material			
Shutter frame material			
Shutter motor volts, phase, Hz			
Shutter motor transformer req'd			
Transformer volts, phase, Hz			

REMARKS:

* Information to be furnished by equipment manufacturer.

FURNISH THE FOLLOWING MANUFACTURER'S DATA:	SUBMITTALS REQUIRED W/BIDS	APPR.	CERT.	TYPE OF DATA (CONTINUED)	SUBMITTALS REQUIRED W/BIDS	APPR.	CERT.
1. Outline dimensional drawings				4. Descriptive literature			
2. Performance data				5. AMCA sound ratings			
3. Installation instructions							

DATA SHEET			ROOF OR WALL VENTILATOR			
REVISIONS			PROJECT	DATA SHEET NO. DS-EC- PAGE 1 OF 1		REV.
REV.	APPROVAL	DATE				
			PLANT BLDG.	PREPARED BY	SHEET PART 15501	
			W.O. OR E.S.O.	APPROVAL	DATE	
			REQUISITION NO.	PROCURED BY Contractor	INSTALLED Contractor	

EQUIPMENT NUMBERS			
SELECTION: Manufacturer			
Model			
Size			
TOTAL QUANTITY REQUIRED			
FAN SPECIFICATIONS & PERFORMANCE			
Airflow, CFM			
Static Pressure, in. W.G.			
RPM, max.			
Brake HP, max.			
Type of Wheel			
Material of Construction			
Finish			
Roof or Wall Mounting			
MOTOR SPECIFICATIONS			
Electrical Type			
Enclosure			
Duty Rating			
Bearings			
Lubrication			
Frame Number			
Rated HP			
Volts / Phase / Hz			
ASSESSORIES			
V-Belt Drive			
Fixed			
Adjustable			
Backdraft Damper			
Inlet Grille			
Belt Guard			
Bird Screen			
Acoustical Roof Curb			
Outlet Grille			

REMARKS: Fans shall be AMCA certified and U.L. listed.

* Information to be furnished by equipment manufacturer.

FURNISH THE FOLLOWING MANUFACTURER'S DATA:	SUBMITTALS REQUIRED W/BIDS	APPR.	CERT.	TYPE OF DATA (CONTINUED)	SUBMITTALS REQUIRED W/BIDS	APPR.	CERT.
1. Outline dimensional drawings				4. Installation instructions			
2. Weight of equipment				5. Descriptive literature			
3. Performance data							

DATA SHEET			STEAM UNIT HEATER			
			PROJECT	**DATA SHEET NO.** DS-EC- **PAGE** 1 **OF** 1		**REV.**
REVISIONS						
REV.	APPROVAL	DATE				
			PLANT **BLDG.**	**PREPARED BY**	**SHEET PART** 15501	
			W.O. OR E.S.O.	**APPROVAL**	**DATE**	
			REQUISITION NO.	**PROCURED BY** Contractor	**INSTALLED BY** Contractor	

EQUIPMENT NUMBERS			
SELECTION: Manufacturer			
Model No.			
TOTAL QUANTITY			
AIRSIDE: CFM Standard Air			
Temperature In/Out, EF			
Sensible Heat, BTU/Hr			
Direction of Airflow			
Resistance, In. W.G. Max.			
Required Throw, Ft.			
STEAM: Flow Lbs/Hr			
Inlet Pressure, PSIG			
Saturated Temp., EF			
Inlet Temp., EF			
CONSTRUCTION: Physical Height x Width x Depth			
Casing Material			
Tube Material			
Fin Material			
MOTOR: Type			
Enclosure			
HP			
Volts/Phase/Hertz			
ACCESSORIES: Air			
Thermostat			
Magnetic Starter			
Fan Safety Guard			
Diffuser			
Mounting Bracket Type			
LEAKTEST:			
Hydro. Press., PSIG, Min.			
FINISH: Manufacturer's			
Special (Describe)			

REMARKS:

* Information to be furnished by equipment manufacturer.

FURNISH THE FOLLOWING MANUFACTURER'S DATA:	**SUBMITTALS REQUIRED**			**TYPE OF DATA (CONTINUED)**	**SUBMITTALS REQUIRED**		
	W/BIDS	**APPR.**	**CERT.**		**W/BIDS**	**APPR.**	**CERT.**
1. Outline dimensional drawings				4. Installation instructions			
2. Weight of equipment				5. Descriptive literature			
3. Performance data							

DATA SHEET			SUPPLY GRILLES/REGISTERS				
REVISIONS			PROJECT		DATA SHEET NO. DS-EC- PAGE 1 OF 1		REV
REV.	APPROVAL	DATE	PLANT	BLDG.	PREPARED BY	SHEET PART 15501	
			W.O. OR E.S.O.		APPROVAL	DATE	
			REQUISITION NO.		PROCURED BY Contractor	INSTALLED BY Contractor	

EQUIPMENT NUMBERS			
SELECTION: Manufacturer			
Model No.			
TOTAL QUANTITY REQUIRED			
INSTALLATION:			
Surface (Wall, Ceiling, Other)			
PERFORMANCE:			
Air Volume, scfm			
Terminal Velocity, fpm			
Throw, ft.			
Deflection			
Drop			
NC Rating (Max.)			
S.P. Loss, in. W.G. (Max.)			
PHYSICAL:			
Nominal Size, in.			
Face Size, in.			
Face Type (Vane, Perforated, Other)			
Vanes (Adjustable or Fixed)			
Face Vanes (Horizontal or Vertical)			
Rear Vanes (Horizontal or Vertical)			
MATERIAL:			
Steel, Aluminum, Other			
FINISH:			
Manufacturer's Standard			
Other			
Color			
ACCESSORIES:			
Air Extractor			
Control Grid			
Opposed Blade Damper			
Frame			
Other			

REMARKS: Static pressure loss includes loss across accessories.

* Information to be furnished by equipment manufacturer.

FURNISH THE FOLLOWING MANUFACTURER'S DATA:	SUBMITTALS REQUIRED W/BIDS	APPR.	CERT.	TYPE OF DATA (CONTINUED)	SUBMITTALS REQUIRED W/BIDS	APPR.	CERT.
1. Outline dimensional drawings				4. Installation instructions			
2. Weight of equipment				5. Descriptive literature			
3. Performance data							

DATA SHEET			V-BELT DRIVE				
REVISIONS			PROJECT		DATA SHEET NO. DS-EC- PAGE 1 OF 1		REV.
REV.	APPROVAL	DATE	PLANT	BLDG.	PREPARED BY	SHEET PART 15501	
			W.O. OR E.S.O.		APPROVAL	DATE	
			REQUISITION NO.		PROCURED BY Contractor	INSTALLED BY Contractor	

EQUIPMENT NUMBERS			
SELECTION:			
Driver Model No.			
Driven Model No.			
Belt Model No.			
HORSEPOWER:			
Variable Speed			
DRIVER			
Speed, RPM			
Grooves			
Section Type			
Pitch Dia., In.			
Bore, In.			
Keyway, In.			
Bushing Req'd.			
DRIVEN			
Speed RPM			
Grooves			
Section Type			
Pitch Diameter, In.			
Bore, In.			
Keyway, In.			
Bushing Req'd.			
BELT SPECIFICATION:			
Number Required			
Section Type			
Pitch Length, In.			
Center Distance, In.			
Matched Set			

REMARKS: Sheaves to be dynamically balanced.

* Information to be furnished by equipment manufacturer.

FURNISH THE FOLLOWING MANUFACTURER'S DATA:	SUBMITTALS REQUIRED W/BIDS	APPR.	CERT.	TYPE OF DATA (CONTINUED)	SUBMITTALS REQUIRED W/BIDS	APPR.	CERT.
1. Outline dimensional drawings				4. Installation instructions			
2. Weight of equipment				5. Descriptive literature			
3. Performance data							

DIVISION 16

ELECTRICAL

Number	Title	Pages
16050	BASIC MATERIALS AND METHODS	2
16060	ELECTRICAL DEMOLITION	3
16111	CONDUIT AND FITTINGS	4
16120	BUILDING WIRE AND CABLE - 600 VOLTS AND BELOW	7
16127	SPLICES AND TERMINATIONS – 600 VOLTS AND BELOW	9
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16481	MOTOR CONTROL CENTERS	9
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16942	FIELD COMPONENTS INSTALLATION	8
16943	CONSOLES, PANELS, CABINETS AND RACKS INSTALLATION	3
16960	ELECTRICAL TESTING	3

SECTION 16050

BASIC MATERIALS AND METHODS

PART 1 GENERAL

1.01 SECTION INCLUDES: Basic electrical requirements and associated cutting, patching, openings, penetrations, inserts, and painting.

1.02 REFERENCES

A. ANSI C2-93, National Electrical Safety Code (NESC).

B. NFPA 70-99, National Electrical Code (NEC).

PART 2 PRODUCTS

2.01 MATERIALS AND EQUIPMENT

A. Furnish new materials and equipment, unless otherwise noted, approved by UL or other nationally recognized testing laboratories whenever standards have been established by one of these agencies.

PART 3 EXECUTION

3.01 PREPARATION

A. Locate chases, sleeves, and inserts for hangers, supports, and fastenings in advance of new construction in order to minimize interferences.

3.02 APPLICATION

A. Perform labor required for installation of electrical material and equipment using craftsmen skilled in the electrical trade.

B. Perform cutting and patching, repairing, and other similar alterations required for installation of electrical material and equipment by craftsmen skilled in the trade involved.

3.03 INSTALLATION

A. Install work to conform with requirements of NEC and NESC.

B. Install temporary lighting and power circuits required for construction in compliance with Article 305 of NEC.

C. Install equipment in compliance with contract documents, manufacturer's instructions, and wiring diagrams furnished with equipment.

3.03 PENETRATIONS

A. Provide openings required for work.

B. Seal around conduits penetrating floors and concrete or masonry fire-zone walls per details on drawings.

C. Seal cable tray and bus duct penetrations of floors and fire-zone walls per details on drawings.

D. Seal around raceways penetrating exterior building walls of wood, asbestos, or sheet metal with silicone rubber sealant, GE RTV-102 or Dow Corning 732.

3.04 PAINTING

A. Clean rust and scale from unfinished members used in fabrication of hangers, supports, and equipment racks. Paint with one coat of metal primer after fabrication.

B. Paint unfinished surfaces of conduit, panels, cabinets, and pull boxes.

3.05 RESTORATION

A. Patch, or replace to match, existing work which is cut, removed, or damaged during installation of electrical material and equipment.

END OF SECTION

SECTION 16060

ELECTRICAL DEMOLITION

PART 1 GENERAL

1.01 SECTION INCLUDES: Electrical demolition necessary to complete work.

PART 2 PRODUCTS

2.01 MATERIALS AND EQUIPMENT

A. Materials and equipment for patching and extending work.

PART 3 INSPECTION

3.01 EXAMINATION

A. Verify field measurements and circuiting arrangements.

B. Verify abandoned wiring and equipment serve only abandoned facilities.

C. Report discrepancies to Construction Manager before disturbing existing installation.

3.02 PREPARATION

A. Disconnect electrical systems in walls, floors, and ceilings scheduled for removal.

B. Schedule with Construction Manager work to be performed in existing facilities. Perform work at times and under conditions approved by Construction Manager.

C. Provide temporary wiring and connections to maintain existing systems in service during construction.

3.03 APPLICATION

A. Existing Electrical Service: Maintain existing system in service until new system is complete and ready for service. Disable system only to make switchovers and connections. Notify Construction Manager 30 d prior to disabling system. Minimize outage duration. Make temporary connections to maintain service in areas adjacent to work area.

3.04 DEMOLITION AND EXTENSION OF EXISTING ELECTRICAL WORK

A. Remove electrical equipment not required to remain in service. Reconnect existing circuits to other sources of supply.

B. Remove abandoned wiring to source of supply.

C. Remove exposed abandoned conduit including abandoned conduit above accessible ceiling finishes. Cut conduit flush with walls and floors, and patch surfaces.

D. Disconnect abandoned outlets and remove devices. Remove abandoned outlets if conduit servicing them is abandoned and removed. Provide blank cover for abandoned outlets which are not removed.

E. Disconnect and remove abandoned panelboards and distribution equipment.

F. Disconnect and remove electrical devices and equipment serving utilization equipment that has been removed.

G. Disconnect and remove abandoned luminaires. Remove brackets, stems, hangers, and other accessories.

H. When a circuit is interrupted by removal of a device or fixture from that circuit, install wire, conduit, and accessories to restore service to remaining devices and fixtures on that circuit.

I. Use water sprinkling and other suitable methods to limit amount of dust and dirt rising and scattering in air to lowest level of air pollution practical.

J. Provide barricades and observe safety regulations.

K. Maintain access to existing electrical installations which remain active.

L. Extend existing installations using materials and methods compatible with existing electrical installations.

3.05 REPAIR

A. Repair adjacent construction and finishes damaged during demolition and extension work.

B. Repair existing materials and equipment which remain or are to be reused.

C. Panelboards

1. Check tightness of electrical connections.

2. Provide closure plates for vacant positions.

3. Provide typed circuit directory showing revised circuiting arrangement.

END OF SECTION

SECTION 16111

CONDUIT AND FITTINGS

PART 1 GENERAL

1.01 SECTION INCLUDES:

A. Rigid metal conduit and fittings.

B. Electrical metallic tubing and fittings.

C. Flexible metal conduit and fittings.

D. Liquidtight flexible metal conduit and fittings.

E. Non-metallic conduit and fittings.

1.02 RELATED SECTIONS

A. Section 16191, Supporting Devices.

B. Section 16196, Electrical Identification.

C. Section 16451, Secondary Grounding.

1.03 REFERENCES

A. ANSI C80.1-90, Rigid Steel Conduit, Zinc Coated.

B. ANSI C80.3-91, Electrical Metallic Tubing, Zinc Coated.

C. NEMA FB 1-93, Fittings, Cast Metal Boxes, and Conduit Bodies for Conduit and Cable Assemblies.

D. NEMA TC 3-90, PVC Fittings for Use with Rigid PVC Conduit and Tubing.

E. NFPA 70-99, National Electrical Code.

F. UL 1-85, UL Standard for Safety - Flexible Metal Conduit.

G. UL 6-81, UL Standard for Safety - Rigid Metal Conduit.

H. UL 360-86, UL Standard for Safety - Liquidtight Flexible Steel Conduit.

I. UL 651-89, UL Standard for Safety - Schedule 40 and 80 Rigid PVC Conduit.

J. UL 797-83, UL Standard for Safety - Electrical Metallic Tubing.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Deliver conduit to job site in 10-ft lengths. Inspect for damage.

B. Protect conduit from corrosion and entrance of debris by storing above grade. Provide appropriate covering.

C. Protect PVC conduit from sunlight.

PART 2 PRODUCTS

2.01 RIGID METAL CONDUIT AND FITTINGS

A. Heavy-Wall Rigid Galvanized Steel Conduit: ANSI C80.1; UL 6 listed; Schedule 40 hot dipped galvanized or electrogalvanized conduit.

B. Fittings and Conduit Bodies: NEMA FB 1; threaded type, material to match conduit; Appleton, Crouse-Hinds, or Killark.

C. Bushings: Nonmetallic, insulating-type; O-Z/Gedney Type A, Thomas & Betts Series 200, or Appleton Type BBU.

2.02 ELECTRICAL METALLIC TUBING (EMT) AND FITTINGS

A. EMT: ANSI C80.3; UL 797 listed; zinc-coated, enamel-lined, threadless, thin-wall steel tubing.

B. Fittings and Conduit Bodies: NEMA FB 1; steel compression type.

2.03 FLEXIBLE METAL CONDUIT AND FITTINGS

A. Flexible Metal Conduit: UL 1 listed: hot-dipped galvanized or electrogalvanized, inside and outside; made in one continuous length of spirally-wound steel strip with uniform interlocking convolution.

B. Fittings and Conduit Bodies: NEMA FB 1.

2.04 LIQUIDTIGHT FLEXIBLE METAL CONDUIT AND FITTINGS

A. Liquidtight Flexible Metal Conduit: UL 360 listed; galvanized steel flexible tubing with synthetic jacket extruded over tubing.

B. Fittings and Conduit Bodies: NEMA FB 1.

C. Liquidtight Conduit Assemblies: Thomas & Betts Company Series 5300; insulated, straight, or 90-degree angle connector on each end.

2.05 PLASTIC CONDUIT AND FITTINGS

A. Rigid PVC Conduit: NEMA TC 2; UL 651 listed; Schedule 40 and 80 PVC.

B. Fittings and Conduit Bodies: NEMA TC 3.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify field measurements.

B. Verify conduit routing and termination locations, sleeve sizes, and locations prior to rough-in.

3.02 INSTALLATION

A. General

1. Route conduit in approximate locations unless dimensioned.

2. Cut conduit square with approved conduit cutter and thread with approved conduit threader. Ream ends of burrs, and remove metal shavings and cutting lubricants before conduit is connected to conduit system.

3. Coat field-cut threads in IMC and rigid steel conduit with Thomas & Betts "KOPR-SHIELD."

4. Make conduit connections with appropriate fittings and tighten securely.

5. Close conduit openings into which dirt, plaster, mortar mix, or debris may fall with caps or tight-fitting plugs during construction. Clean conduits in which such material has accumulated. Replace the conduit where such accumulations cannot be removed.

6. Seal conduits for the purpose of preventing airflow and rodent and insect access with a pliable, duct-sealing compound such as John-Manville "Duxseal." Use compounds which solidify, such as Crouse-Hinds "Chico," with sealing-type conduit fittings.

7. Use appropriate tools to install PVC-coated conduit; avoid damage to exterior coating. After installation, repair damaged area with Plasti-Bond touch-up compound.

8. Install flexible metal conduit that is liquidtight where exposed to weather, water, or other liquids.

B. Aboveground (Exposed or Concealed)

1. Install exposed conduits at right angles to or parallel to building structural members.

2. Do not secure conduit directly to other piping. Separate conduit parallel to or crossing uninsulated hot water or steam pipes by 12 in. if parallel or 6 in. if crossing. Where these lines are insulated, conduit parallel to or crossing them must clear insulation surface by 2 in. Separate conduit from cold water lines by at least 3 in. Do not run conduit directly under cold water lines.

3. Support IMC, rigid metal conduit, PVC conduit, and EMT, whether concealed or exposed, in accordance with paras. 345-12, 346-12, 347-8, and 348-12 of the NEC, respectively.

4. Secure metallic conduit to walls and building framing using malleable iron, galvanized U-bolts, beam clamps, conduit straps, or "Unistrut" fittings where "Unistrut" racks or supports are used.

5. Fasten IMC and rigid metal conduit to outlet boxes, pull boxes, cabinets, and switch boxes with double lock nuts and insulating bushings unless boxes with hubs are furnished.

6. Terminate EMT with raintight, compression-type connectors with insulated throats. Use couplings for EMT that are raintight, compression type. Set screw-type connectors and couplings are not acceptable.

7. Install expansion couplings in conduit runs crossing building expansion joints; locate between conduit supports adjacent to expansion joint.

8. Use liquidtight conduit assemblies between motor terminal boxes or other equipment subject to vibration or mechanical adjustment, and rigid conduit systems.

9. Size liquidtight conduit length terminating in motor terminal boxes not less than 12 times the trade size but not less than 12 in.

C. Underground

1. Install conduit in floor slab or underground as dimensioned.

2. Use IMC, PVC conduit, or rigid galvanized steel conduit in underground installations.

3. Coat threaded connections in conduits installed in building floor slabs or underground with Thomas & Betts "KOPR-SHIELD" sealant. Conduit must be clean and dry and must pass standard sizing test after concrete is poured. Cap unused conduits, utilizing watertight caps in conduits subject to being filled with water.

END OF SECTION

SECTION 16120

BUILDING WIRE AND CABLE - 600 V AND BELOW

PART 1: GENERAL

1.01 SUMMARY

A. Section includes: Building wire and cable, nonmetallic-sheathed cable, underground feeder and branch circuit cable, and service entrance cable.

1.02 RELATED SECTIONS

A. Section 16111, Conduit and Fittings.

B. Section 16127, Splices and Terminations - 600 V and Below.

C. Section 16131, Boxes.

D. Section 16196, Electrical Identification.

E. Section 16960, Electrical Testing.

1.03 REFERENCES

A. NFPA 70-1999, National Electrical Code.

B. NEMA WC5-1973, Thermoplastic-Insulated Wire and Cable.

1.04 SUBMITTALS

A. Submit test reports for approval.

1.05 REGULATORY REQUIREMENTS

A. Furnish products listed and classified by UL.

PART 2: PRODUCTS

2.01 BUILDING WIRE

A. Description: Single conductor insulated wire.

B. Conductor: Copper or aluminum except copper for sizes No. 4 AWG and smaller.

C. Stranding:

1. Wire No. 8 and larger: Stranded.

2. Wire No. 10 AWG and smaller feeding lights and receptacles: Solid.

3. Wire No. 10 AWG and smaller for motor leads and control wiring: Stranded.

4. Standard stranding for cable sizes as follows: 7 strands up through No. 2; 19 strands from No. 1 through No. 4/0; 37 strands from 250 MCM through 500 MCM; and 61 strands from 600 MCM through 1000 MCM.

D. Insulation Voltage Rating: 600V.

E. Insulation: Conductors in raceways; NFPA 70:

1. THW or XHHW for sizes larger than No. 10 AWG.

2. THHN/THWN for sizes No. 10 AWG and smaller.

3. THHN/THWN for conductors enclosed in fluorescent lighting fixtures.

F. Color Coding:

1. Grounding conductors may be bare or insulated. Identify insulated conductors intended solely for grounding purposes by a continuous green color; a continuous green color with one or more yellow stripes; or by wrapping with green self-adhesive, vinyl-plastic electrical tape, Scotch 35, at terminal or junction points. Tape sufficient length of conductor nearest terminal or junction point so that grounding conductors are identifiable when covers are removed.

2. Grounded (neutral) Conductors No. 2 AWG and Smaller: White insulation. Identify grounded conductors larger than No. 2 AWG at terminal or junction points by wrapping with white, self-adhesive, vinyl-plastic electrical tape, Scotch 35. Tape sufficient length of cable nearest terminal or junction point so that neutral conductors are identifiable when covers are removed.

3. Color code system conductors as follows:

   a. Color and Number Coding for 120-V, Single-Phase, Two-Wire Systems

      1) Grounded neutral, white (first or only neutral in raceway, box, auxiliary gutter, or other types of enclosures).

      2) Grounded neutral, white with black stripe running entire length of insulation (when neutral is installed in raceway, box, auxiliary gutter, or other types of enclosures with another neutral).

3) Grounding conductor, green, green with one or more yellow stripes, green tape, or bare.
4) Ungrounded conductor, black with marker "120V-1PH."

b. Color and Number Coding for 240/120-V, Single-Phase, Three-Wire Systems

1) Grounded neutral, white (first or only neutral in raceway, box, auxiliary gutter, or other types of enclosures).

2) Grounded neutral, white with brown stripe running entire length of insulation (when neutral is installed in raceway, box, auxiliary gutter, or other types of enclosures with another neutral).

3) Grounding conductor, green, green with one or more yellow stripes, green tape, or bare.
4) Ungrounded conductor, black with marker "240/120V-1PH-A."

5) Ungrounded conductor, red with marker "240/120V-1PH-B."

c. Color and Number Coding for 208Y/120-V, Three-Phase, Four-Wire Systems

1) Grounded neutral, white (first or only neutral in raceway, box, auxiliary gutter, or other types of enclosures).

2) Grounded neutral, white with red stripe running entire length of insulation (when neutral is installed in raceway, box, auxiliary gutter, or other types of enclosures with another neutral).

3) Grounding conductor, green, green with one or more yellow stripes, green tape, or bare.
4) Phase A (ungrounded) conductor, black with marker "208Y/120V-3PH-A."

5) Phase B (ungrounded) conductor, red with marker "208Y/120V-3PH-B."

6) Phase C (ungrounded) conductor, blue with marker "208Y/120V-3PH-C."

d. Color and Number Coding for 240-V, Delta, Three-Phase, Three-Wire Systems

1) Grounding conductor, green, green with one or more yellow stripes, green tape, or bare.
2) Phase A (ungrounded) conductor, black with marker "240VD-3PH-A."

3) Phase B (ungrounded) conductor, black with marker "240VD-3PH-B."

4) Phase C (ungrounded) conductor, black with marker "240VD-3PH-C."

e. Color and Number Coding for 480Y/277-V, Three-Phase, Four-Wire Systems

1) Grounded neutral, white (first or only neutral in raceway, box, auxiliary gutter, or other types of enclosures).

2) Grounded neutral, white with yellow stripe running entire length of insulation (when neutral is installed in raceway, box, auxiliary gutter, or other types of enclosures with another neutral).

3) Grounding conductor, green, green with one or more yellow stripes, green tape, or bare.

4) Phase A (ungrounded) conductor, brown with marker "480Y/277V-3PH-A."

5) Phase B (ungrounded) conductor, orange with marker "480Y/277V-3PH-B."

6) Phase C (ungrounded) conductor, yellow with marker "480Y/277V-3PH-C."

f. Color and Number Coding for 480-V, Delta, Three-Phase, Three-Wire Systems

1) Grounding conductor, green, green with one or more yellow stripes, green tape, or bare.

2) Phase A (ungrounded) conductor, brown with marker "480VD-3PH-A."

3) Phase B (ungrounded) conductor, orange with marker "480VD-3PH-B."

4) Phase C (ungrounded) conductor, yellow with marker "480VD-3PH-C."

4. Furnish ungrounded single-conductor control circuit wiring a combination of colors other than white, gray, or green.

2.02 NONMETALLIC-SHEATHED CABLE

A. Description: NFPA 70; Type NMC or NM.

B. Conductor: Copper or aluminum except copper for sizes smaller than No. 4 AWG.

C. Insulation Voltage Rating: 600V.

2.03 UNDERGROUND FEEDER AND BRANCH CIRCUIT CABLE

A. Description: NFPA 70; Type UF.

B. Conductor: Copper or aluminum except copper for sizes smaller than No. 4 AWG.

C. Insulation Voltage Rating: 600V

D. Insulation Temperature Rating: 90 deg C

2.04 SERVICE ENTRANCE CABLE

A. Description: NFPA 70; Type SE or USE.

B. Conductor: Copper or aluminum except copper for sizes smaller than No. 4 AWG.

C. Insulation Voltage Rating: 600V.

D. Insulation: Type RHW, RHH, or XHHW.

2.05 600-V CONTROL CABLE

A. Multiconductor Control Cables: NEMA WC5; moisture resistant, small diameter, Type TC, 600 V, 90°C per NEC Article 340.

B. Conductors: Stranded copper with heat- and moisture-resistant PVC insulation, 15 mils thick min, and covered with clear nylon jacket, 5 mils thick min.

C. Color Coding: NEMA WC5, Appendix I, Table I-1 for NEC applications or Table I-2 for control circuit applications.

D. Sheath: Flame-resistant PVC.

PART 3: EXECUTION

3.01 EXAMINATION

A. Verify interior of building is protected from weather.

B. Verify mechanical work likely to damage wire and cable is complete.

3.02 PREPARATION

A. Pull wire and cable after conduit system is complete from pull point to pull point.

B. Swab raceway before installing wire.

C. Use Ideal Industries' "POLY-WATER" compound to pull nonarmored conductors.

3.03 APPLICATION

A. Concealed Dry Interior Locations: Use building wire (Type THHN/THWN insulation) in raceway or nonmetallic-sheathed cable.

B. Exposed Dry Interior Locations: Use building wire (Type THHN/THWN insulation) in raceway nonmetallic-sheathed cable.

C. Above Accessible Ceilings: Use building wire (Type THHN/THWN insulation) in raceway or nonmetallic-sheathed cable.

D. Wet or Damp Interior Locations: Use building wire (Type THHN/THWN insulation) in raceway or underground feeder and branch-circuit cable.

E. Exterior Locations: Use building wire (Type THHN/THWN insulation) in raceway, underground feeder and branch-circuit cable, or service-entrance cable.

F. Underground Installations: Use building wire (Type THHN/THWN insulation) in raceway, underground feeder and branch-circuit cable, or service-entrance cable.

3.04 INSTALLATION

A. Wiring

1. Install products according to manufacturer's instructions.

2. Pull conductors into raceway at same time.

3. Use no wire smaller than No. 12 AWG for power and lighting circuits and no smaller than No. 16 AWG for control wiring.

4. Use No. 10 AWG conductors for 20-A, 120-V branch circuit home runs longer than 75 ft and for 20-A, 277-V branch circuit home runs longer than 200 ft.

5. Place equal number of conductors for each phase of a circuit in same raceway or cable.

6. Splice in junction or outlet boxes.

7. Train and lace wiring inside boxes, equipment, and panelboards.

8. Make conductor lengths for parallel circuits equal.

9. Bending Radius of Wire or Cable: Not less than minimum recommended by manufacturer.

10. Maximum Pulling Tension and Sidewall Pressure of Wire or Cable: Not to exceed manufacturer's recommended values.

B. Cable

1. Protect exposed cables from damage.

2. Support cables above accessible ceilings from structure or ceiling suspension system with spring metal clips or plastic cable ties. Include bridle rings or drive rings.

3. Use suitable cable fittings and connectors.

4. Where specified, Type NM cable in sizes up to and including No. 10 AWG may be utilized for circuit runs within stud walls, above ceilings, or in locations where it would not be subject to mechanical damage or weather exposure.

5. Install Type UF cable for direct buried underground feeder and branch circuit conductors.

3.05 FIELD QUALITY CONTROL

A. Visually check wire and cable for physical damage and proper connection.

B. Check for continuity and correctness of wiring and identification.

C. Perform check with direct current test device, such as bell, buzzer, or light.

D. For 600-V, insulated cables No. 4 AWG and larger installed as branch circuit conductors from 480-V switchgear, perform an "Insulation Resistance Test" using a Simpson Model 405 1000-V insulation tester.

1. Test with conductors disconnected at the equipment. Test between one conductor and ground, with the other conductors grounded. Test each conductor in same manner. Apply voltage for a minimum of 3 min until reading reaches a constant value.

2. Replace conductor if resistance readings are less than 50 megohms and test replacement conductor.

3. More than one conductor may be listed on same cable test report if conductors listed are tested and accepted on same date. Include complete identification of feeder, Megger readings vs time data, ambient temperature, and weather conditions on reports.

END OF SECTION

SECTION 16127

SPLICES AND TERMINATIONS - 600 V AND BELOW

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Wire nuts.

B. Mechanical connectors.

C. Compression connectors.

1.02 RELATED SECTIONS

A. Section 16120, Building Wire and Cable - 600 V and below.

B. Section 16131, Boxes.

1.03 REFERENCES

A. ANSI A449, Steel Bolts.

B. ANSI B18.2.2-87, Square and Hex Nuts.

C. ANSI B18.22.1-65, Plain Washers.

D. UL 486A-91, UL Standard for Safety Wire Connectors and Soldering Lugs for Use with Copper Conductors.

E. UL 486B-91, UL Standard for Safety Wire Connectors for Use with Aluminum Conductors.

F. UL 486C-91, UL Standard for Safety Splicing Wire Connectors.

G. UL 486D-93, UL Standard for Safety Insulated Wire Connectors for Use with Underground Conductors.

H. UL 486E-94, UL Standard for Safety Equipment Wiring Terminals for Use with Aluminum and/or Copper Conductors.

PART 2 PRODUCTS

2.01 COPPER CONDUCTOR CONNECTORS

A. Splices

1. No. 10 AWG and Smaller

a. Solid Conductors

1) 300 V or less: Split-bolt connectors or insulated wire nuts, Thomas & Betts "PIGGY."

2) Over 300 V: Split-bolt connectors.

b. Stranded Conductors: Pressure connectors, Thomas & Betts "STA-KON", or insulated wire nuts, Thomas & Betts "PIGGY".

2. No. 8 AWG Through No. 1 AWG

a. Mechanical: Split-bolt connectors, Thomas & Betts 2T through 8T.

b. Compression: Two-way connector, Thomas & Betts 54500.

3. No. 1/0 AWG Through No. 4/0 AWG: Compression, two-way connector, Thomas & Betts 54500.

4. 250 MCM and Larger: Compression, two-way connector, Thomas & Betts 54500.

B. Taps

1. No. 10 AWG and Smaller

a. Solid Conductors

1) 300 V or Less: Split-bolt connectors or insulated wire nuts, Thomas & Betts "PIGGY."

2) Over 300 V: Split-bolt connectors.

b. Stranded Conductors: Pressure connectors, Thomas & Betts "STA-KON", or insulated wire nuts, Thomas & Betts "PIGGY".

2. No. 8 AWG Through No. 1 AWG

a. Mechanical: Split-bolt connector, Thomas & Betts 2T through 8T.

b. Compression: "C" tap, Thomas & Betts 54700.

3. No. 1/0 AWG and Larger: Compression, "C" tap, Thomas & Betts 54700.

C. Terminations

1. No. 10 AWG and Smaller

a. Solid Conductors: Bend conductor to fit under screw head.

b. Stranded Conductors: Pressure connectors, Thomas & Betts "STA-KON."

2. No. 8 AWG Through No. 1 AWG

a. Mechanical: One-hole lug, Thomas & Betts 31000.

b. Compression: One-hole lug, Thomas & Betts 54100.

3. No. 1/0 AWG Through No. 4/0 AWG: Compression, two-hole lug, Thomas & Betts 54200.

4. 250 MCM and Larger: Compression, two-hole lug, Thomas & Betts 53200.

2.02 ALUMINUM CONDUCTOR CONNECTORS

A. Splices

1. No. 4/0 AWG and Smaller

a. Aluminum-to-Aluminum: Two-way, Thomas & Betts 60500.

b. Aluminum-to-Copper: Reducing, Thomas & Betts 60900.

2. No. 250 MCM and Larger

a. Aluminum-to-Aluminum: Two-way, Thomas & Betts 53500A.

b. Aluminum-to-Copper: Reducing, Thomas & Betts 53500A.

B. Taps

1. Aluminum-to-Aluminum: "H" tap, Thomas & Betts 63100.

2. Aluminum-to-Copper: "H" tap, Thomas & Betts 63100.

C. Terminations

1. Lugs

a. No. 1 AWG and smaller: One-hole lug, Thomas & Betts 60100.

b. No. 1 AWG through No. 4 AWG: Two-hole lug, Thomas & Betts 60200.

c. 250 MCM and Larger: Two-hole lug, Thomas & Betts 53200A.

2. Compression - Equipment Adapters (Pin Connectors)

a. Thomas & Betts BI - Metal Pin Connectors, 61900 series.

b. BURNDY "HYPLUG."

c. HOMAC Type "MPT."

d. Mac-Products "MAC-ADAPT."

D. Joint Compound: Thomas & Betts 21059.

2.03 HARDWARE

A. Indoor, Dry, Noncorrosive Installations

1. Bolts: ASTM 449; regular, semifinished, hex-head, cadmium-plated, medium carbon steel, SAE Grade 5, high-strength type with UNC, Class 2B threads.

2. Nuts: ANSI B18.2.2; regular, semifinished, hexagon, cadmium, medium carbon steel, SAE Grade 5, high-strength type with UNC, Class 2B threads.

3. Flat Washers: ANSI B18.22.1; Type "A" plain, wide-series, cadmium-plated, mild steel, dimensions as follows:

a. With 1/4-in. Bolts: Use 3/4-in. OD, 5/16-in. ID, 0.065 in. thick.

b. With 3/8-in. Bolt: Use 1-in. OD, 7/16-in. ID, 0.083 in. thick.

c. With 1/2-in. Bolt: Use 1 3/8-in. OD, 9/16-in. ID, 0.109 in. thick.

d. With 5.8-in. Bolt: Us 1 3/4-in. OD, 11/16-in. ID, 0.134 in. thick.

4. Cadmium-plated 0.0005-in.-thick, "BELLEVILLE" conical type, dimensions and strength as follows:

   a. With 1/4-in. Bolt: Use 11/16-in. OD (max), 800-lb load at 100% deflection (min), Thomas & Betts 60800.

   b. With 3/8-in. Bolt: Use 15/16-in. OD (max), 1400-lb load at 100% deflection (min), Thomas & Betts 60802.

   c. With 1/2-in. Bolt: Use 1 3/16-in. OD (max), 2700-lb load at 100% deflection (min), Thomas & Betts 60803.

   d. With 5/8-in. Bolt: Use 1 1/2-in. OD (max), 4000-lb load at 100% deflection (min), Thomas & Betts 60804.

2.04 CONTACT SURFACES

A. Finish

1. Bolted Connections of Copper Bus: Tin-plated to minimum thickness of 0.1 mil.

2. Bolted Connections of Aluminum Bus: Tin-plated to minimum thickness of 0.1 mil.

B. Joint Compound

1. Copper: A. B. Chance Company "CONTACT-AID."

2. Aluminum: Thomas & Betts "ALUMA-SHIELD."

2.05 INSULATION

A. Pads

1. 3M Company "SCOTCHFIL" pad.

2. Plymouth Rubber Company "PLYSEAL" pad.

3. Okonite Company No. 75 filler tape.

B. Sleeves: Heat-shrinkable.

1. Raychem Company Type "WCS."

2. Thomas & Betts Type "HS."

C. Tubing: Prestretched, 3M Company Type "PST."

D. Tape

1. Rubber

a. 3M Company No. 130C.

b. Plymouth Rubber Company "PLYVOLT."

c. Okonite Company No. 10.

2. All-Weather, Vinyl-Plastic

a. 3M Company No. 88.

b. Plymouth Rubber Company "PREMIUM GREY."

3. Friction

a. Plymouth Rubber Company, "Special ASTM."

b. Okonite Company "MANSON" No. 5.

E. Insulators for Splices and Taps: Burndy "POLY-TAP."

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify that aluminum conectors are factory supplied with appropriate amount of aluminum joint compound inside the connector.

B. Verify contact surfaces of bolted connections in aluminum bus are tin-plated.

C. Verify contact surfaces of bolted connections in copper bus are tin-plated.

3.02 PREPARATION

A. Clean and coat contact surfaces of bolted connections in aluminum bus with aluminum joint compound.

B. Apply aluminum joint compound to exposed aluminum conductor, and wire brush through it to remove aluminum oxide film.

C. Using wire brush and aluminum joint compound, remove aluminum oxide film on unplanted surfaces of aluminum bus where cable lugs are to be terminated. Wipe clean and immediately coat with clean aluminum joint compound prior to terminating lugs.

D. Remove oxide and coat surfaces of bolted connections in copper bus and areas of bus on which cable lugs are to be bolted with joint compound.

3.03 INSTALLATION

A. General

1. Make splices and taps in junction boxes or wiring gutters.

2. Install pressure type connectors for splices, taps, and terminations per manufacturer's instructions; use only wire sizes and number of conductors identified (listed) by manufacturer's data.

   a. Identify terminals listed for more than one conductor.

   b. Identify terminals used to connect aluminum conductors.

   c. Use tightening torques as listed in UL 486A, 486B, 486C, 496D and 486E unless manufacturer has assigned another value.

3. Install compression connectors according to manufacturer's instructions, using properly sized and keyed connectors and dies.

B. Copper Conductor Connectors

1. Make splices and taps of stranded conductors No. 10 AWG and smaller with pressure connectors or insulated wire nuts.

2. Make terminations of stranded conductors No. 10 AWG and smaller with pressure connectors.

3. Make splices and taps in solid No. 10 AWG and smaller with split-bolt connectors or, if 300 V or less, with insulated wire nuts.

4. Make terminations of solid conductors No. 10 AWG and smaller by forming wire to fit under a screw head, thus requiring no connector.

5. Make splices and taps in copper conductors No. 8 AWG through No. 1 AWG and terminations of these conductors using copper mechanical connectors or wrought-copper compression connectors.

6. Make splices and taps in copper conductors No. 1/0 AWG through No. 4/0 AWG and terminations of these conductors with wrought-copper compression connectors.

7. Make splices in copper conductors 250 MCM and larger and terminations of these conductors with heavy-duty, cast-copper compression connectors. Make taps in these conductors with wrought-copper "C" taps.

C. Aluminum Conductor Connectors

1. Make aluminum-to-aluminum and aluminum-to-copper conductor splices and taps and terminations of aluminum conductors with tin-plated, aluminum-bodied, compression-type connectors.

2. Make splices and taps in aluminum conductors up through No. 4/0 AWG and terminations of these conductors with wrought-aluminum compression connectors.

3. Make splices in aluminum conductors 250 MCM and larger and terminations of these conductors with heavy-duty, cast-aluminum compression connectors. Make taps in these conductors with wrought-aluminum "H" taps.

4. Install compression fitting on aluminum conductor immediately after wire brushing conductor.

5. Terminate aluminum conductors on circuit breakers, switches, motor control centers, and similar equipment furnished with lugs other than tin-plated, compression-type aluminum fittings by one of the following methods.

   a. Terminate aluminum conductors in compression-equipment adapters, and terminate the compression-equipment adapters in equipment lugs.

   b. Run aluminum conductors in conduit to an appropriately sized junction box mounted adjacent to subject equipment. Splice aluminum conductors to copper conductors of equivalent ampacity with tin-plated aluminum, compression-reducing connectors inside junction box. Extend copper conductors into subject equipment and terminate in equipment lugs.

   c. An acceptable alternative is to provide equipment supplied with tang terminals and extra enclosure space to allow termination of lug-type compression fittings.

D. Bus Connections and Attachment of Cable Lugs

1. Make bolted connections in both copper and aluminum bus and attach cable lugs to both types of bus using "Belleville" conical, compression-type washers. Make connections according to details.
2. Tighten bolts used in bus connections and cable lug terminations until "Belleville" compression washer is completely flat. Connections are not to be torqued, but tightening the joint to flatten the "Belleville" washer is required.

E. Insulation of Splices and Taps 600 V or less

1. Insulate splices and taps in thermoplastic and rubber-insulated conductors by one of the following methods.

   a. Insulate connection first with rubber tape. Wrap connection with all-weather, vinyl-plastic tape in a manner so as to pad sharp edges and fill indents of connector. Apply outer tape until total area of inner taping is covered with a minimum of four layers. Make total thickness of combination of tapes equal to thickness of conductor insulation.

   b. Pad sharp edges and indents of connection with insulation pad. Cover connection with heat-shrinkable sleeve or prestretched tubing.

2. For insulated connections not housed in junction box or other metal enclosure, apply additional protective wrapping of friction tape to protect connection from abrasions.

3. For insulated connections outdoors, such as splices at service entrances, and connections which are subjected to high humidity, wrap connection with linen cloth tape and apply two brushed-on coats of GE "Glyptal."

4. Use insulators for splices and taps where specified. Insulate splices and taps by one of the following methods.

END OF SECTION

SECTION 16131

BOXES

PART 1 GENERAL

1.01 SECTION INCLUDES:

A. Wall and ceiling outlet boxes

B. Pull and junction boxes.

1.02 RELATED SECTIONS

A. Section 16111, Conduit and Fittings.

B. Section 16141, Wiring Devices.

C. Section 16160, Equipment Cabinets and Enclosures.

1.03 REFERENCES

A. NEMA OS 1-89, Sheet-steel Outlet Boxes, Device Boxes, Covers, and Box Supports.

B. NEMA 250-91, Enclosures for Electrical Equipment (100 Volts Maximum).

C. NFPA 70-99, National Electrical Code.

1.04 SYSTEM DESCRIPTION

A. Provide electrical boxes as indicated and where required for splices, taps, conductor pulling, equipment connections, and in compliance with NFPA 70.

PART 2 PRODUCTS

2.01 OUTLET BOXES

A. Construction: NEMA OS 1; pressed steel, galvanized unless otherwise specified.

B. Size: Not smaller than 4-in. octagon by 1 ½ in. deep. All unused knockouts to remain closed or be sealed with knockout closures.

C. Knockouts: Provide proper size knockouts for conduits used.

D. Device or Utility Boxes: Unit construction; size required for number of wiring devices specified. Sectional device boxes are not permitted.

2.02 PULL AND JUNCTION BOXES

A. Size: As specified or according to Article 370 of the NEC.

B. Style

1. Indoors in Nonhazardous Areas: Code gage, galvanized sheet steel; welded construction, with conduit knockouts or raceway openings and hinged or screwed covers as noted.

2. Outdoor and Wet Location Installations: NEMA 250; Type 4 and Type 6, galvanized cast iron boxes, flat flanged, surface mounted; box and cover with ground flange, neoprene gasket, and stainless steel cover screws; UL listed as raintight.

3. Underground Installations: NEMA 250; Type 4, galvanized cast iron boxes, outside flanged, flush mounted with recessed cover; box and plain cover with neoprene gasket and stainless steel cover screws; UL listed as raintight.

PART 3 EXECUTION

3.01 EXAMINATION

A. Electrical box locations shown are approximate unless dimensioned.

B. Verify location of floor boxes and outlets in offices and work areas prior to rough-in.

3.02 INSTALLATION

A. Outlet Boxes

1. Locate and install boxes to allow access.

2. Secure outlet or utility boxes concealed in construction in place. Set boxes true, square, and flush with finish surfaces for application of appropriate cover plate.

3. Install surface-mounted outlet boxes for wiring devices located in industrial areas.

4. Install knockout closures for unused openings.

5. Support boxes independently of conduit. Exception: Cast boxes when connected to two rigid metal conduits, both supported within 12 in. of box.

6. Install multiple gang boxes where more than one device is mounted together. Provide barriers to separate wiring of different voltage systems.

7. Mounting Height

   a. Boxes for Wall Switch and Thermostats: 54 in. above finished floor.

   b. Boxes for Convenience Receptacle: 24 in. above finished floor.

8. Align wall-mounted outlet boxes for switches, thermostats, and similar devices.

9. Install cast outlet boxes in exterior locations exposed to weather and wet locations.

B. Pull and Junction Box Installation

1. Locate pull boxes and junction boxes above accessible ceilings or in unfinished areas.

2. Support pull and junction boxes independent of conduit.

END OF SECTION

SECTION 16141

WIRING DEVICES

PART 1 GENERAL

1.01 SECTION INCLUDES:

A. Wall switches.

B. Receptacles.

C. Device plates and decorative box covers.

1.02 RELATED SECTIONS

A. Section 16131, Boxes.

B. Section 16196, Electrical Identification.

1.03 REFERENCES

A. NFPA 70-99, National Electrical Code.

B. NEMA WD 1-83, General Purpose Wiring Devices.

C. NEMA WD 6-88, Wiring Device Configurations.

1.04 REGULATORY REQUIREMENTS

A. Conform to requirements of NFPA 70.

B. Furnish products UL listed and classified as suitable for purpose specified.

PART 2 PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. Arrow-Hart, Bryant, General Electric, Hubbell, Leviton, Pass & Seymour, and Slater.

2.02 WALL SWITCHES

A. Wall Switches: NEMA WD 1; Specification-Grade, "1221" series, ivory finish, flush-tumbler type with operating mechanism totally enclosed in a molded urea or nylon composition case rated at 20 A at 125 V unless otherwise noted.

B. Provide "ac only" switches for alternating current circuits.

C. Provide "ac-dc T" switches for direct current circuits.

2.03 RECEPTACLES

A. Receptacles: NEMA WD 1 and NEMA WD 6; Specification Grade, "5262" series, ivory finish, double wipe contacts, side/back wired, with nylon back and face, rated at 15 A at 125 V unless otherwise noted.

B. Enclosures: As indicated.

C. Mounting: Surface, recessed or floor, as indicated.

D. Caution Signs for 480-V Receptacles: Furnished by Company.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify outlet boxes are installed at proper height.

B. Verify branch circuit wiring installation is complete, tested, and ready for connection to wiring devices.

C. Verify openings in access floor are proper locations.

3.02 PREPARATION

A. Clean debris from outlet boxes.

3.03 INSTALLATION

A. Install products according to manufacturer's instructions.

B. Install devices plumb and level.

C. Install switches with OFF position down.

D. Install wall dimmers to achieve full rating after derating for ganging.

E. Connect wiring device grounding terminal to branch circuit equipment grounding conductor.

F. Connect three-phase, four-wire power receptacles so that the A-B-C-phase sequence of the circuit is counterclockwise.

3.04 FIELD QUALITY CONTROL

A. Check each wiring device for defects.

B. Verify each wall switch and dimmer circuit is energized.

C. Verify proper operation of each wall switch and dimmer.

D. Verify each receptacle device is energized.

E. Randomly check 120-V receptacles for proper neutral and ground wire connections.

1. After installation, check for correct wiring by use of a Daniel Woodhead Model 1750 tester.

2. After completion of wiring check, perform an "Equipment Ground Impedance Test" using a Daniel Woodhead Model 7040, "Ground Loop Impedance Tester." Maximum allowable impedance: 1.0 ohms. <u>Caution</u>: Test each receptacle with no loads plugged into other receptacles sharing the same equipment ground conductor.

3. Check each receptacle for contact tension using a Daniel Woodhead Model 1760, "Receptacle Tension Tester." Minimum tension for current-carrying contacts: 20 oz. Minimum tension for grounding contact: 10 oz.

4. Replace receptacles not satisfying requirements.

F. 208-V and 240-V Receptacles

1. Check receptacles for proper wiring with voltage tester, such as "Ideal" No. 61-055.

2. After completion of wiring check, perform an "Equipment Ground Impedance Test" using a Daniel Woodhead Model 7040, "Ground Loop Impedance Tester," modified for l88 V through 260 V. Maximum allowable impedance: 1.0 ohm. <u>Caution</u>: Test each receptacle with no loads plugged into other receptacles sharing the same equipment ground conductor.

G. Power Receptacles

1. Check phase sequence by using a phase-indicating meter, such as Electro Mechanical Company, Inc., Oakland, CA, Cat. No. 4600. Check phase-indication meter against Company's standard meter.

2. Correct wiring for receptacles found incorrectly wired.

3.05 ADJUSTING

A. Adjust devices and wall plates flush and level.

END OF SECTION

SECTION 16160

EQUIPMENT CABINETS AND ENCLOSURES

PART 1 GENERAL

1.01 SECTION INCLUDES:

A. Hinged or screw cover enclosures.

B. Cabinets.

C. Terminal blocks and accessories.

1.02 RELATED SECTIONS

A. Section 16191, Supporting Devices.

B. Section 16196, Electrical Identification.

1.03 REFERENCES

A. NEMA 250-91, Enclosures for Electrical Equipment (1000 Volts Maximum).

B. NEMA ICS 1-88, Industrial Control and Systems.

C. NEMA ICS 4-83, Terminal Blocks for Industrial Control Equipment and Systems.

D. NEMA ICS 6-88, Enclosures for Industrial Control Equipment and Systems.

E. NFPA 70-99, National Electrical Code.

1.04 SUBMITTALS

A. Submit Shop Drawings of equipment cabinets for approval. Include wiring schematic diagram, wiring diagram, outline drawing, and construction diagram according to NEMA ICS 1.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Deliver equipment cabinets and enclosures on-site, and inspect for damage. If damage is found, return damaged equipment and replace with undamaged equipment.

B. Store equipment in its original container in a secure and dry location.

PART 2 PRODUCTS

2.01 HINGED OR SCREW COVER ENCLOSURES

A. Construction: NEMA 250; steel construction, unless otherwise noted.

1. General interior use: NEMA Type 1.

2. General exterior use: NEMA Type 3R.

3. Hostile (corrosive) environments: NEMA Type 4X.

4. NEC classified hazardous locations: NEMA Type 7, 8, or 9.

5. Interior use where protection from dust, dirt, fiber flyings, dripping water, or external condensation of noncorrosive liquids is necessary: NEMA Type 12.

B. Finish: ANSI 61 gray polyester powder coating inside and out over phosphatized surfaces for NEMA Types 1, 3R, and 12 enclosures. Provide finish appropriate for individual application for NEMA Type 4X, 7, 8, and 9 enclosures.

C. Covers: Continuous or separate hinge held closed by screws or flush latch that is operable by key.

D. Panel for Mounting Terminal Blocks or Electrical Components: 14-gage steel, white enamel finish.

2.02 CABINETS

A. Cabinet Boxes: Galvanized steel with removable endwalls and dimensioned as indicated. Provide 3/4-in.-thick plywood backboard painted matte white for mounting terminal blocks.

B. Cabinet Fronts: Steel, flush or surface type as indicated; screw cover front; gray baked enamel finish.

2.03 TERMINAL BLOCKS AND ACCESSORIES

A. Terminal Blocks: NEMA ICS 4; UL listed.

B. Power Terminals: Unit construction type, closed-back type; tubular pressure screw connectors, rated 600 V.

C. Signal and Control Terminals: Modular construction type, channel mounted; tubular pressure screw connectors, rated 300 V.

2.04 FABRICATION

A. Shop assemble enclosures and cabinets housing terminal blocks or electrical components according to NEMA ICS 6.

B. Provide conduit hubs or knockouts on enclosures as indicated.

C. Provide protective pocket inside front cover with schematic diagram, connection diagram, and layout drawing of control wiring and components within enclosure.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify equipment cabinets and enclosure supports are installed.

B. Verify terminal blocks are installed in equipment cabinets and enclosures.

3.02 INSTALLATION

A. Install cabinets and enclosures plumb; anchor to wall or floor and structural supports at each corner as a minimum.

B. Provide accessory feet for freestanding equipment enclosures.

C. Install trim plumb.

D. Identify cabinets and enclosures as indicated on outside or inside face of doors.

END OF SECTION

SECTION 16191

SUPPORTING DEVICES

PART 1 GENERAL

1.01 SECTION INCLUDES:

A. Conduit supports.

B. Equipment supports.

C. Fastening hardware.

PART 2 PRODUCTS

2.01 MATERIAL

A. Support Channel: Galvanized or painted steel.

B. Hardware: Corrosion resistant.

PART 3 EXECUTION

3.01 INSTALLATION

A. Fabricate conduit support hangers from angle iron, channel iron, "Unistrut," or galvanized rods. Space conduit hangers in accordance with Sect. 16111, Part 3.

B. Fabricate equipment racks from P-1000, "Unistrut," utilizing bolted or off-site welded construction. Mount equipment to racks with hexagon head bolts, spring nuts, and lock washers.

C. Fasten hanger rods, conduit clamps, and outlet and junction boxes to building structure using precast insert system, expansion anchors, preset inserts, or beam clamps.

D. Use toggle bolts or hollow wall fasteners in hollow masonry, plaster, or gypsum board partitions and walls; expansion anchors or preset inserts in solid masonry walls; self-drilling anchors or expansion anchors on concrete surfaces; sheet metal screws in sheet metal studs; and wood screws or lag bolts in wood construction.

E. Do not fasten supports to piping, ductwork, mechanical equipment, or conduit. Do not use powder-actuated anchors. Do not drill structural steel members.

F. In wet locations, install freestanding electrical equipment on concrete pads or steel channels.

G. Install surface-mounted cabinets and panelboards with minimum of four anchors. Bridge studs top and bottom with channels to support flush-mounted cabinets and panelboards in stud walls.

END OF SECTION

SECTION 16196

ELECTRICAL IDENTIFICATION

PART 1 GENERAL

1.01 SECTION INCLUDES:

A. Nameplates.

B. Tape labels.

C. Wire and cable markers.

D. Conduit markers.

E. Underground conduit and direct buried cable markers.

1.02 SYSTEM IDENTIFICATION

A. Identify electrical equipment according to the one-line diagram.

B. Identify safety switches, circuit breakers, motor starters, lighting panels, power panelboards, and other similar electrical equipment with 3/4-in. black plastic adhesive tape having approximately ½-in.-tall letters.

C. Panelboard Directories: Indicate for each circuit the equipment served, floor and column location, and room number. Identify spare circuits.

D. Identify conduit as indicated.

1. Identify conduits at switchgear, entry and exit points of junction and pull boxes, on both sides of walls or floors which conduit penetrate, and at equipment in which conduits terminate.

2. Identify underground conduit at both ends.

3. Identify underground conduit not encased in concrete and direct burial cable by installing a 6-in.-wide red marker tape (with continuous warning message in black letters imprinted on the tape) 6 to 12-in. below grade for the length of the conduit or cable.

   a. Trenches 18 in. Wide or Less: Use a single tape located in center of trench.

   b. If cables or conduits installed less than 18 in. below grade, make tape elevation one-half the distance between the cable or conduit and grade.

E. Identify single-conductor power and control wiring originating from switchgear or MCCs.

1. Identify conductors in junction or pull boxes containing taps or splices and at terminations.

2. Identify three-phase power feeder conductors by phase designations (e.g., PH-A, PH-B, and PH-C).

3. Identify conductors with cloth markers or split sleeve or tubing-type markers.

F. Identify branch circuit conductors originating from panelboards.

1. Identify conductors with vinyl, wrap-around, self-laminating, printable wire markers utilizing alphanumeric characters of 1/8 to 3/16 in. height, printed with black ink on white background.

2. Place markers within 1 in. of where insulation has been removed for junctions or terminations.

3. In addition to indicating the panelboard number and branch circuit number, identify conductors as follows:

a.	120-V, single-phase, two wire system	120V-1PH
b.	240/120-V, single-phase, three-wire systems	240/120V-1PH-A 240/120V-1PH-B
c.	208Y/120-V, three-phase, four-wire systems	208Y/120V-3PH-A 208Y/120V-3PH-B 208Y/120V-3PH-C
d.	240-V, Delta, three-phase, three-wire systems	240VD-3PH-A 240VD-3PH-B 240VD-3PH-C
e.	480Y/277V, three-phase, four-wire systems	480Y/277V-3PH-A 480Y/277V-3PH-B 480Y/277V-3PH-C
f.	480-V, Delta, three-phase, three-wire systems	480VD-3PH-A 480VD-3PH-B 480VD-3PH-C

G. Identify multiconductor cables installed in raceways at each termination with flag-type plastic ties.

PART 2 PRODUCTS

2.01 MATERIALS

A. Nameplates: Engraved three-layer laminated plastic, white letters on black background.

B. Tape Labels:

1. 3/4-in. black plastic embossed adhesive tape with approximately ½-in.-tall white letters on black background, "DYMO" 5134-09.

2. ½-in. black plastic embossed adhesive tape with approximately 5/32-in.-tall white letters on black background, "DYMO" 158-9.

C. Wire and Cable Markers:

1. Cloth Markers: W. H. Brady Company, "QUICK LABEL."

2. Split Sleeve or Tubing Type: 3M Company, "SCOTCH CODE."

3. Vinyl, Self-Laminating, Printable Markers: Thomas & Betts, Type WSL.

4. Multiconductor Cable Markers: "PANDUIT" flag-type plastic ties.

D. Conduit Markers: Aluminum or plastic tags with raised letters attached to conduit with sunlight resistant "TYRAPS."

E. Underground Conduit and Direct Buried Cable Markers: 6-in.-wide red polyethylene tape, minimum thickness of 3.5 mil, with continuous warning message in black letters imprinted on tape; Thomas & Betts NA-0600, Panduit HTU6R-E, or W. H. Brady Company 91296.

PART 3 EXECUTION

3.01 PREPARATION

A. Degrease and clean surfaces to receive nameplates, tape labels, and cable markers.

3.02 INSTALLATION

A. Install nameplates and tape labels parallel to equipment lines.

B. Install tape labels to equipment front cover plates.

C. Secure nameplates to equipment fronts using screws, rivets, or adhesive.

D. Secure nameplate to inside face of recessed troffers using adhesive.

E. Mask tape label during field painting with masking tape to prevent painting tape label.

F. Using a typewriter or other mechanized means, fill out panelboard directories and place directories in directory card holder.

G. Install conduit markers.

H. Install wire and cable markers.

END OF SECTION

SECTION 16441

DISCONNECT SWITCHES

PART 1 GENERAL

1.01 SECTION INCLUDES: Enclosed disconnect switches and fuses.

1.02 RELATED SECTIONS

A. Section 16196, Electrical Identification.

B. Section 16960, Electrical Testing.

1.03 REFERENCES

A. NEMA KS 1-90, Enclosed Switches and Miscellaneous Distribution Equipment Switches (600 V maximum).

B. UL 98-94, UL Standard for Safety Enclosed and Dead-Front Switches.

C. UL 198E-88, UL Standard for Safety Class R Fuses.

D. UL 512-93, UL Standard for Safety Fuseholders.

PART 2 PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS - DISCONNECT SWITCHES

A. General Electric.

B. Square D.

C. Cutler Hammer/Westinghouse.

D. Seimens.

2.02 DISCONNECT SWITCHES

A. General: Heavy-duty type, single throw, visible blades quick-make, quick-break, load interrupter enclosed knife switch with externally operable indicating handle interlocked to prevent opening front cover with switch in ON position; handle lockable in OFF position; ampere and voltage ratings, number of poles, fusible or nonfusible, as indicated; horsepower rating greater than motor horsepower when used on motor circuits.

B. Fusible Switch Assemblies: NEMA KS 1; UL 98.

C. Fuse Clips: UL 512; designed to accommodate Class R fuses.

D. Nonfusible Switch Assemblies: NEMA KS 1; Type HD, UL 98.

E. Enclosures: NEMA 1 for indoor use and NEMA 3R for outdoor use unless otherwise indicated.

2.03 ACCEPTABLE MANUFACTURERS - FUSES

A. Bussmann.

B. Gould-Shawmut.

C. Reliance.

2.04 FUSES

A. General: UL 198E; cartridge type, dual element.

B. Interrupting Rating: 200,000 RMS amperes.

C. 250-V Class: Bussmann FRN and LPN, Gould-Shawmut TR or AT-DE, and Reliance ECN or LEN.

D. 600-V Class: Bussmann FRS and LPS, Gould-Shawmut TRS or ATS-DE, and Reliance ECS and LES.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install disconnect switches where indicated. Identify disconnect switches.

B. Install fuses in fusible disconnect switches.

3.02 FIELD QUALITY CONTROL

A. Verify disconnect switches and fuses meet requirements of Part 2.

B. Verify wiring connections are tight.

C. Verify switch mechanism is rigidly mounted within enclosure. Verify switch operating lever is not binding and is free to move.

D. Verify insulating medium for isolating operating lever from energized switch contacts is firmly in place.

E. Verify proper phasing for motor loads.

F. With load connected, energize and observe load current.

END OF SECTION

SECTION 16451

SECONDARY GROUNDING

PART 1 GENERAL

1.01 SECTION INCLUDES:

A. Building ground grid.

B. Structural grounding.

C. Electrical equipment grounding.

D. Non-electrical equipment grounding.

1.02 RELATED SECTIONS

A. Section 16120, Building Wire and Cable 600 V and Below.

B. Section 16960, Electrical Testing.

1.03 REFERENCES

A. IEEE 81-83, Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System.

B. NFPA 70-99, National Electrical Code.

C. NEC Section 250.

1.04 SUBMITTALS

A. Submit approved test reports for information.

1.05 SYSTEM DESCRIPTION

A. Provide ground connections required by NFPA 70.

B. Minimum requirements of Article 250 of NFPA 70 apply where grounding conductor sizes are not indicated.

PART 2 PRODUCTS

2.01 MATERIALS

A. Ground Rods: Copperweld type, 3/4 in. diam, 10 ft long (min), Joslyn No. J8350.

B. Connectors: Cast copper, compression type.

1. Taps and splices: Thomas & Betts No. 53000 series.

2. Ground Rods: Thomas & Betts No. 52000 series.

C. Bonding: Thermic type, Cadweld.

D. Bonding Compound: Thomas & Betts "KOPR-SHIELD."

E. Conductors

1. Ground Mat: No. 2/0 AWG, bare, stranded copper.

2. Equipment Grounding Conductor

   a. Material: Bare or green insulated copper in steel or nonmetallic conduit; green insulated copper in aluminum conduit.

   b. Size: As indicated.

   c. Solid: No. 10 AWG and smaller.

   d. Stranded: No. 8 AWG and larger.

F. Oxidizing Prevention Compound: Thomas & Betts "KOPR-SHIELD."

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify grounding system has been installed before making thermic bonding-type connections.

B. Verify neutral bars in lighting and distribution panelboards are ungrounded.

3.02 INSTALLATION

A. General

1. Connect electrical service system neutral to grounding taps at service entrance equipment.

2. Connect separately derived system neutral to nearest specified grounding point.

3. Bond together system neutrals, service equipment enclosures, exposed noncurrent carrying metal parts of electrical equipment, metal raceway systems, grounding conductor in raceways and cables, and receptacle ground connectors, without creating ground loop.

B. Building Ground Grid

1. Install neutral grounding equipment according to manufacturer's instructions.

2. Install ground mat according to IEEE 80.

3. Install ground mat conductors 30 in. below grade.

4. Make underground connections by thermic process or with cast-copper compression connectors.

5. Before installation of compression connectors, coat points of connection with electrically conductive bonding compound.

6. Do not install ground rods underneath sidewalks, roadway, or other locations which may become inaccessible.

C. Structural Grounding

1. Ground building steel, ground busses, and ground inserts as indicated.

2. Make connections of ground cables to structural members by thermic process.

3. Terminate ground cables on ground busses with copper compression fittings.

D. Electrical Equipment Grounding (to include all Geothermal Heat Pumps)

1. Connect motor frames, panelboards, and enclosures housing electrical devices to building ground grid with an equipment grounding conductor.

2. Install equipment grounding conductor in same conduit with current carrying conductors.

3. Connect equipment grounding conductors to building ground grid at ground busses and ground inserts or to existing equipment grounding conductors.

   a. Grounding or bonding of equipment to building steel as a sole means of grounding is not acceptable.

   b. Use of conduit as the equipment grounding conductor is not permitted.

4. Make connections to ground busses and connections of equipment grounding conductors to switch boxes, panelboards, cabinets, and other similar equipment with either bolted mechanical lugs or compression connectors.

   a. Before connections are made, clean contact surfaces.

   b. Apply a compound to prevent oxidizing and ensure good electrical contact.

5. Terminate branch circuit equipment ground conductors on lighting and distribution panelboard ground bus.

6. Motor Grounding: Terminate equipment grounding conductor, either bare or insulated green, under one of the bolts holding the junction box to the motor frame.

a. Where junction box is welded in place or cast as part of frame, drill and tap junction box.

[Designer note: All geothermal heat pumps must carry a fourth conductor low impedance earth potential return.]

7. Receptacle Grounding: Connect receptacle grounding lug to the continuous ground conductor installed in same raceway as the circuit conductors and permanently bond ground conductor to building grounding system.

8. Transformer Neutral Grounding: Ground secondary neutrals of 120/240-V, single-phase, and 208Y/l20-V, three-phase lighting transformers according to Sect. 250-26 of the NEC.

3.03 FIELD QUALITY CONTROL

A. Test No. 1 - Individual Ground Rods

1. Before connection to ground mat, test each ground rod for resistance to earth using a Biddle Model "Megger DET 5/2".

2. Utilize the "Three-Point-Method" described in IEEE Standard 8l and two auxiliary rods.

3. Individual Ground Rod Resistance to Earth: 15 ohms or less.

4. If resistance is found to be higher than 15 ohms, drive additional ground rods and connect in multiple with rod under test until 15 ohms are obtained.

5. Spacing of Rods : 10 ft (min)

B. Inspection No. 1 - Complete Ground Mat

1. After completion of Test No. 1, connect ground rods to ground mat.

2. Before backfilling is done, visually inspect complete ground mat to ensure that connections are mechanically tight by the "Cadweld" or other approved process.

C. Test No. 2 - Complete Ground Mat

1. Backfill after satisfactory visual inspection and test resistance of complete ground mat to earth using the "Fall-of-Potential Method" described in IEEE Standard 81.

2. Acceptable Resistance for Complete Ground Mat: 1 ohm (max).

D. Inspection No. 2 - Ground Straps

1. Visually inspect terminations of ground straps coming up from buried ground mat on ground busses and building steel for solidness of connections.

END OF SECTION

SECTION 16471

PANELBOARDS

PART 1 GENERAL

1.01 SECTION INCLUDES:

A. Distribution panelboards.

B. Lighting and appliance branch circuit panelboards and fuses.

1.02 RELATED SECTIONS

A. Section 16191, Supporting Devices.

B. Section 16196, Electrical Identification.

C. Section 16483, Motor Control.

D. Section 16485, Contactors.

1.03 REFERENCES

A. FS W-C-375, Circuit Breakers, Molded Case, Branch Circuit and Service.

B. FS W-P-115, Power Distribution Panel.

C. NEMA AB 1-93, Molded Case Circuit Breakers and Molded Case Switches.

D. NEMA KS 1-90, Enclosed and Miscellaneous Distribution Equipment Switches (600 V max).

E. NEMA PB 1-90, Panelboards.

F. NEMA PB 1.1-91, General Instructions for Proper Installation, Operation, and Maintenance of Panelboards Rated 600 Volts or Less.

G. NEMA PB 2.2-88, Application Guide for Ground-Fault Protective Devices for Equipment.

H. UL 98-94, UL Standard for Safety Enclosed and Dead-Front Switches.

I. UL 512-93, UL Standard for Safety Fuseholders.

1.04 SUBMITTALS

A. Submit shop drawings of distribution panelboards and component devices for approval.

1. Include: Outline and support point dimensions, voltage, main bus ampacity, integrated short circuit ampere rating, circuit breaker, and fusible switch arrangement and sizes.

PART 2 PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS - PANELBOARDS

A. General Electric.

B. Square D.

C. Cutler Hammer/Westinghouse.

D. Siemens.

2.02 ACCEPTABLE MANUFACTURERS - FUSES

A. Bussman.

B. Gould-Shawmut.

C. Reliance.

2.03 DISTRIBUTION PANELBOARDS

A. Panelboards: NEMA PB 1, circuit breaker type; fusible switch type; or FS W-P-115, Type I, Class 1; Type II, Class 2; dead-front, safety type, surface or flush mounted; arranged for two-, three- or four- wire, single-phase or three-phase application; complete with a main circuit breaker when specified.

B. Service Rating: 600 V ac and 250 V dc.

C. Provide cabinet front with screw cover, and hinged door with flush lock.

D. Enclosure: NEMA PB 1, Type 1 or Type 3R.

E. Finish in manufacturer's standard gray enamel.

F. Bus: Aluminum, ratings as scheduled. Provide copper ground bus.

G. Minimum Integrated Short Circuit Rating: 10,000A rms symmetrical for 240-V panelboards, 14,000A rms symmetrical for 480-V panelboards, or as shown.

H. Fusible Switch Assemblies: NEMA KS 1, UL 512; quick-make, quick-break, load interrupter enclosed knife switch with externally operable handle.

1. Provide interlock to prevent opening front cover with switch in ON position.

2. Handle: Lockable in OFF position.

3. Fuse Clips: UL 512. Designed to accommodate Class R fuses, type as specified.

I. Molded Case Circuit Breakers: NEMA AB 1 or FS W-C-375, with integral thermal and instantaneous magnetic trip in each pole.

1. Provide UL listed Type HACR circuit breakers for air conditioning equipment branch circuits.

2.04 BRANCH CIRCUIT PANELBOARDS

A. Lighting and Appliance Branch Circuit Panelboards: NEMA PB1; circuit breaker type; FS W-P-115; Type I, Class 1; dead-front, safety type, surface or flush mounted; arranged for two-, three-, or four- wire, single-phase or three-phase application; complete with a main circuit breaker when specified.

B. Provide flush or surface cabinet front with concealed trim clamps, door with concealed hinge, and flush lock, all keyed alike.

C. Furnish circuit directory on rear of door.

D. Enclosure: NEMA PB 1; Type 1 or Type 3R.

E. Finish: Manufacturer's standard gray enamel.

F. Bus: Aluminum ratings as scheduled. Provide copper ground bus and isolated copper neutral bus.

G. Minimum Integrated Short Circuit Rating: 10,000A rms symmetrical for 240-V panelboards; 14,000 A rms symmetrical for 480-V panelboards, or as shown.

H. Molded Case Circuit Breakers: NEMA AB 1 or FS W-C-375, bolt-on type thermal magnetic trip circuit breakers, with common trip handle for all poles.

1. UL Listed Type SWD circuit breakers: Provide for lighting circuits.

2. UL Listed Class A GFI circuit breakers: NEMA PB 2.2; provide where scheduled.

3. UL Listed Type HACR circuit breakers: Provide for air conditioning equipment branch circuits.

2.05 FUSES

A. Fuses 600 A and Less: Dual element, current limiting, time delay, one-time fuse, 250, 600 V, UL Class RK 1, RK 5, J as scheduled.

B. Fuses 601 A and Larger: Current limiting, time delay, fast acting, or one time fuse, 600 V, UL Class L as scheduled.

C. Interrupting Rating: 200,000 A rms.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify field measurements are as shown.

B. Verify equipment enclosures, racks, field panels, and conduit support structures requiring conduit interconnections are installed.

3.02 INSTALLATION

A. Install panelboards plumb according to NEMA PB 1.1.

B. Mounting Height: Top of panel 6 ft above floor.

C. Provide filler plates for unused spaces in panelboards.

D. Provide typed circuit directory for each branch circuit panelboard. Revise directory to reflect circuiting changes required to balance phase loads.

3.03 FIELD QUALITY CONTROL

A. Check for physical damage, proper alignment, anchorage, and grounding.

B. Check proper installation and tightness of connections for circuit breakers, fusible switches, and fuses.

C. Verify clearances between live electrical parts and isolation of phase and neutral busses from cabinet.

D. Check main and branch breaker trip element ratings for compliance with panel schedule.

E. Check all breakers for correct mechanical and electrical operation. Test of breaker trip setting is not required.

F. Verify that wiring terminations and sizes of conductors are as specified.

G. Verify that ground conductors terminate on panelboard ground bus.

H. Check that wire connections are properly made and adequately tightened.

I. Check phasing of incoming, three-phase feeder termination.

1. Correct Phase Identification: 1-2-3, left to right.

2. Phase Branch Breakers 1-2-3, top to bottom, as viewed from front of panelboard.

END OF SECTION

SECTION 16476

ENCLOSED CIRCUIT BREAKERS

PART 1 GENERAL

1.01 SECTION INCLUDES: Enclosed molded-case circuit breakers.

1.02 RELATED SECTIONS

A. Section 16191, Supporting Devices.

B. Section 16196, Electrical Identification.

1.03 REFERENCES

A. FS W-C-375, Circuit Breakers, Molded Case, Branch Circuit, and Service.

B. NEMA AB 1-86, Molded Case Circuit Breakers.

1.04 REGULATORY REQUIREMENTS

A. Furnish circuit breakers listed and classified by UL as suitable for specific application.

PART 2 PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. Square D.

B. Siemens.

C. General Electric.

D. Cutler Hammer/Westinghouse.

2.02 MOLDED CASE CIRCUIT BREAKER

A. Circuit Breaker: NEMA AB 1; FS W-C-375; quick-make, quick-break, ambient compensated, thermal magnetic; capable of safely interrupting loads up to and including maximum interrupting rating listed below.

Frame size amps	Trip amps	Poles	Voltage	Symmetrical interrupting rating based on NEMA
100	15-100	1,2	120/240	7,500
100	15-100	3	240	10,000
100	15-70	3	480	14,000
225	70-225	3	480	22,000
400	250-400	3	480	30,000

B. Configuration: Inverse time automatic tripping, Instantaneous automatic tripping, Integrally fused with inverse time automatic tripping, or Integrally fused with instantaneous automatic tripping.

C. Field-Adjustable Trip Circuit Breaker: Provide circuit breakers with frame sizes 200A and larger with mechanism for adjusting long time, short time, continuous current or short time, long time, pickup current setting for automatic operation.

D. Field-Changeable Ampere Rating Circuit Breakers: Provide circuit breakers with frame sizes 225 A and larger with changeable trip units.

E. Ratings: NEMA AB 1.

F. Terminal Lugs: NEMA AB 1.

2.03 ENCLOSURE

A. Enclosure: NEMA AB 1, unless otherwise noted.

B. Fabricate enclosure from steel.

C. Finish using manufacturer's standard enamel finish.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify surfaces are ready to receive work.

B. Verify field measurements are as shown.

C. Verify required utilities are available, in proper location, and ready for use.

3.02 INSTALLATION

A. Install enclosed circuit breakers in accordance with manufacturer's instructions.

B. Install enclosures plumb.

C. Mounting Height: Top of enclosure maximum 6 ft above floor.

3.03 FIELD QUALITY CONTROL

A. Visually check and perform several mechanical ON-OFF operations on each circuit breaker.

B. Verify circuit continuity on each pole in closed position.

END OF SECTION

SECTION 16481

MOTOR CONTROL CENTERS

PART 1: GENERAL

1.01 SUMMARY

A. Section includes: The construction, arrangement, and testing for an enclosed, free-standing, floor-mounted, dead-front, low-voltage (600-V-max) MCC.

1.02 RELATED SECTIONS

A. Section 16191, Supporting Devices.

B. Section 16960, Electrical Testing.

1.03 REFERENCES

A. NEMA ICS 1-1988, General Standards for Industrial Control and Systems.

B. NEMA ICS 2-1988, Standards for Industrial Control Devices, Controllers, and Assemblies.

C. NFPA 70-1999, National Electrical Code (NEC).

D. UL 508-1993, Industrial Control Equipment.

E. UL 845-1988, Motor Control Centers.

1.04 SUBMITTALS

A. Submit shop drawings for approval.

1. Include overall dimensional drawings showing approximate weight and arrangement.

2. Indicate on shop drawings, front and side views of MCC enclosures with overall dimensions. Include conduit entrance locations and requirements; nameplate legends; size and number of bus bars per phase, (neutral, if required) and ground; electrical characteristics including voltage, frame size and trip ratings, withstand ratings, and time-current curves of all equipment and components.

B. Submit product data for approval on motor starters and combination motor starters, relays, pilot devices, and switching and overcurrent protective devices.

C. Submit manufacturer's certified inspection and standard production test reports for information.

D. Submit operation and maintenance data for information.

1. Include spare parts data listing and recommended maintenance procedures and intervals.

E. Submit field test reports for approval.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Protect equipment and other parts and auxiliary devices or accessories against corrosion, dampness, breakage, or vibration damage that might be encountered in transportation and handling. Store in a clean, dry space. Maintain factory wrapping or provide an additional heavy canvas or heavy plastic cover to protect units from dirt, water, construction debris, and traffic.

B. Handle in accordance with manufacturer written instructions. Lift only with lugs provided for the purpose. Handle carefully to avoid damage to motor control center components, enclosure, and finish.

PART 2: PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. Allen-Bradley.

B. GE.

C. Square-D.

2.02 MOTOR CONTROL CENTER REQUIREMENTS

A. Enclosure

1. The vertical sections shall be constructed of formed steel or sheet steel covers on angle framing. Each section shall be a rigid, self-supporting assembly. The bases shall be reinforced and provisions made for fastening the sections to the floor. The nominal height of the vertical sections shall be 90 in. with 72 in. of mounting space for plug-in units. The 72-in. mounting space shall provide six spaces of 12 in. each. The nominal width of each section shall be 20 in.

2. The vertical sections shall be arranged for either front-only or front-and-rear compartment sections as specified. Spaces shall be covered with blank panels and shall be available for future use. The enclosure shall be constructed in a manner that will permit end-to-end placement against similar control centers.

3. Enclosures for front-only mounting of plug-in units shall be designed such that the rear of the assembly may be placed directly against a wall. All equipment components, wiring connections, bus splices, etc., shall be accessible from the front.

B. Bus Structure

1. The bus structure shall be constructed of tin-plated high-conductivity copper or aluminum, as specified. The busses shall be designed for the ampacities specified. All bus and bus connections shall be capable of continuously carrying their rated currents without exceeding a temperature rise of 50°C over a 40°C ambient in conformance with Table 20.1 of UL-845.

2. The phase busses and neutral bus, when specified, shall be isolated from the enclosing structure and braced to provide the short-circuit current rating specified. Bus support insulators shall be flame-retardant, nonarc-tracking with mechanical and dielectric strength to provide the specified rating.

3. The three-phase main bus shall run horizontally the full length of the assembly. The main bus may be located in the top, middle, or bottom of the assembly.

4. A neutral bus shall be provided when specified. The bus shall be sized as specified and shall be installed in the bottom of the MCC assembly.

5. Each section shall contain a three-phase, vertical bus, to which the specified combination motor control units and feeder tap units are connected. Each vertical bus shall be permanently connected to the three-phase, horizontal bus and shall extend the full usable height of the vertical section.

6. There shall be a minimum of 1-in. clearance in air between phases and between each phase and ground. The vertical bus shall be arranged to provide a phasing of 1-2-3, left to right, when viewed from the front of the MCC. The main bus phasing shall be identified accordingly.

7. All busses shall be continuous (without splice) in each shipping split, and the Manufacturer/Vendor shall provide splicing kits containing bus and hardware for splicing the bus (phases, ground, and neutral if required) at each shipping split.

8. For the bus system provided to be acceptable, the design must have successfully passed the design test requirements of NEMA ICS-2-322 and UL-845.

C. Electrical Isolation

1. Barriers or baffles shall be provided to prevent an arc from leaving the compartment in which it originates and in any way damaging devices, wiring, or other equipment outside the compartment.

2. Insulating covers shall be provided for the vertical busses to isolate the bus from the removable units. The covers shall contain the necessary openings to permit insertion of the plug-in stab assemblies.

3. The horizontal and vertical wireways shall be isolated from the bus structure.

D. Control Units

1. Combination motor control units and feeder tap units (fused disconnect switches and circuit breakers) shall be plug-in type except that Size 5 combination nonreversing and Size 4 combination reversing starters (and larger units) may be nonremovable, permanently connected type.

2. Combination motor control units and feeder tap units shall be housed in individual compartments. The units shall be readily removable from the front by disconnecting the necessary control and load leads and removing a minimum number of mounting screws, bolts, or fasteners. It shall be possible to remove any unit without opening adjacent compartment doors, disconnecting adjacent equipment, or in any manner disturbing the operation of any other unit in the control center. Each unit shall have devices to assure accurate mechanical alignment, both horizontally and vertically. Units requiring the same size compartments shall be interchangeable. The assembly shall permit rearrangement of the units at a later date (such as replacing three single units with a unit requiring three spaces) without cutting or welding.

3. Doors provided for combination motor control units and feeder tap units shall be provided with an interlocking feature to prevent the opening of any door when the unit it houses is energized. Means of locking the switch or breaker handle in the "OFF" position shall be provided. The doors shall be provided with a defeater mechanism to permit the door to be opened while the operating lever is in the "ON" position. Operating handles shall clearly indicate the "ON" or "OFF" position of switches and circuit breakers.

4. Combination motor control units and feeder tap units shall have a short-circuit withstand rating equal to or greater than the bus bracing specified. For the control units to be acceptable, identical units to those supplied must have successfully passed the design test requirements in NEMA ICS-1-109 and UL-508.

E. Connections to Bus

1. The connections of the removable plug-in units to the vertical bus shall be made with stab-type clips with plated contact surfaces.

2. They shall make contact automatically upon inserting the unit and disconnect automatically upon removal of the unit.

3. The stab assembly shall be constructed so that line-to-line and line-to-ground short circuits will not be possible when a unit is being inserted or removed.

F. Arrangements of Removable Units

1. All components of each removable plug-in unit shall be accessible from the front. Components shall be mounted to permit normal maintenance and replacement of equipment in one compartment without interference with other compartments. No wiring except connections to stabs shall be located on the back of the removable units.

G. Fused Disconnect Switches

1. Fused disconnect switches shall be horsepower-rated and sized to accept the fuse sizes as specified.

2. Fuse clips shall have contact surface and springs tension to prevent heating or loosening of the fuses after continued operation or repeated removal and replacement.

3. Switch operation shall be by means of a snap-action mechanism which opens and closes all contacts simultaneously with a quick-make, quick-break operation.

H. Circuit Breakers

1. Circuit breakers shall be molded case type operated by a toggle mechanism of the quick-make, quick-break type and shall be trip free.

2. Each breaker shall open all phases and shall trip all poles simultaneously.

3. The trip rating and type of trip unit (thermal magnetic or magnetic only) for each circuit breaker shall be as specified.

4. All breakers shall be 600-V class and have 100-A-min frame size.

I. Magnetic Starters

1. Starters shall be of the type and size specified and shall be three-pole rated for 600 V.

2. Auxiliary contacts, where called for, shall be in addition to those supplied for the starter operating coil and are for the Contractor's use, unless otherwise indicated.

3. All auxiliary contacts, except those used to perform functions within the removable unit, shall be wired to the terminal boards.

J. Thermal Overload Relays

1. Thermal overload relays shall be provided on all motor control units.

2. Relays shall be metallic or eutectic-alloy type.

3. One relay shall be supplied in each phase.

4. Eutectic-alloy elements shall be of thin-film type construction.

5. Thermal overload relays shall be furnished complete with the heaters sized in accordance with full-load currents specified.

6. Overload relays shall be resettable without opening the compartment doors.

K. Wireways

1. A horizontal wireway shall be provided at the top and bottom of each section which shall extend the entire length of the control center. The wireway fronts shall have doors or screw covers.

2. Each section of the control center shall contain a vertical wireway that shall open into the horizontal wireways. The wireway shall be enclosed either by individual full-width compartment doors or by a single-hinged cover extending the full height of the section.

3. The horizontal and vertical wireways shall be accessible from the front, and the wireways shall be sized to accommodate interconnecting and incoming wiring.

L. Terminal Blocks

1. Terminal blocks for control wiring shall be provided, within the unit, for all combination motor control units. The blocks shall be rated 25 A at 600 V, 90°C, and have tubular screw-type terminals.

2. Terminal blocks for power wiring shall be provided within the unit for all combination motor control units, Size 2 and smaller. The blocks shall be rated 60 A at 600 V, 90°C, and have tubular screw type terminals.

3. Terminal blocks for power wiring are not required for combination motor control units larger than Size 2 and feeder tap units. The power conductors leaving units will terminate directly on devices.

M. Pilot Devices

1. Pilot devices, such as control switches and indicator lights, shall be heavy-duty type as recognized by the industry and shall conform with the requirements of NEMA ICS-2-216 and UL-508. Unless otherwise specified, control switches and indicator lights shall be mounted on the front of the compartments.

2. Indicator lights shall be transformer type. Lamps shall be incandescent type, rated 6.3 V, 50,000-h life, Type T-3 1/4 miniature bayonet, Chicago Miniature Lamp CM-755, or approved equal.

N. Control Transformers

1. Control transformers shall be 480-120 V and shall be firmly mounted on the removable unit with no wiring behind the unit.

2. One side of the secondary winding shall be fused, and the other side shall be grounded.

O. Wiring

1. All wiring in the MCC shall be single conductor stranded copper with 600-V Type SIS or MTW insulation.

2. Control wiring shall be No. 14 AWG min.

3. Power wiring shall be sized in accordance with the NEC but shall be No. 12 AWG min.

4. Wiring at door hinges shall be extra-flexible type.

5. The wiring of individual units shall conform to the diagrams on the procurement drawings.

6. Wiring between devices and terminal blocks shall be neatly arranged and supported.

P. Grounding

1. A copper ground bus, sized as specified, shall be provided. The bus shall be located near the bottom of the assembly. Two cable lugs shall be provided for connecting the bus to the ground system at the installation site. The lugs shall be copper compression type sized as specified.

2. The design of the MCC shall include provisions for effectively joining the steel housing of the removable units to the control center enclosure to ground the units when they are connected.

Q. Finish

1. Vertical sections, doors, and other parts shall all burrs and sharp edges removed and shall be smooth and without blemishes.

2. Parts to be painted shall be thoroughly cleaned of rust, slag, oil, grease, or other foreign material.

3. The exterior finish shall be gray and the interior finish shall be light gray or white.

2.03 IDENTIFICATION

A. The following nameplates shall be provided on the MCC assembly:

1. An assembly nameplate shall contain the MCC equipment number and service voltage as specified. This nameplate shall be attached at the top front of one of the middle vertical sections. Lettering shall be a minimum of 1 in. high.

2. Individual nameplates shall be provided for each compartment to identify the equipment served as specified. Lettering shall be a minimum of 1/2 in. high.

B. Nameplates shall be either photometal or engraved phenolic. They shall be attached with screws in a way that allows them to be removed. Rivets are not acceptable.

2.04 SOURCE QUALITY CONTROL

A. The Manufacturer shall perform a detailed inspection of the completed assembly to assure that the equipment conforms to the specification and the Manufacturer design drawings approved by the Construction Manager.

B. The Manufacturer standard production tests shall be performed on the completed assembly.

C. The Manufacturer/Vendor shall notify the Contractor 10 working days prior to the commencement of tests.

D. The Contractor/Construction Manager, at their option, may witness these tests.

E. Certified inspection and test results shall be furnished to the Construction Manager.

PART 3: EXECUTION

3.01 INSTALLATION

A. Install motor control center in accordance with the drawings and Manufacturer/Vendor's instructions.

B. Install fuses in fusible switches.

C. Select and install heater elements in motor starters to match installed motor characteristics.

D. Motor Data: Provide neatly typed label inside each motor starter enclosure door identifying motor served, nameplate horsepower, full load amperes, code letter, service factor, and voltage/phase rating.

3.02 FIELD QUALITY CONTROL

A. After completion of installation, inspect equipment to determine the equipment has not been damaged in transit and is properly installed, conditioned, and ready to be energized and accept design load.

B. Before energizing the MCC, make the following tests:

1. Take ohmmeter readings between the MCC ground bus and the MCC enclosure. The maximum acceptable resistance shall be 0.01 ohm.

2. Connect a "Kelvin Bridge" between the MCC ground bus (to which the equipment ground conductor is connected) and the nearest building ground bus or ground strap connected directly to the building ground grid. The readings taken will indicate the resistance between the MCC ground bus and the building ground grid. The maximum permissible resistance shall be 0.1 ohm.

C. After completing the above tests, additional checks shall include the following:

1. A visual check of all starter locations, nameplates, etc.

2. A check of all wiring against Manufacturer's and Contractor's drawings.

3. Check ratings of, and make settings on, all over-current protective devices.

4. An operational check of control circuits.

5. A check for tightness of all connections.

6. Check phasing of busses. All busses shall be phased and identified so that circuit breaker phase identification is 1-2-3, left to right, as viewed from the front of the breaker.

D. The main bus in all low-voltage MCCs shall be given an "Insulation Resistance Test" using a 1,000-V insulation tester (Simpson Model 405 or approved equal). Each phase shall be meggered to ground with the other two phases grounded.

1. Apply the voltage for a minimum of 3 min and until the reading reaches a nearly constant value. Tests shall be made with all branch circuit breakers connected to the bus and with all load side conductors disconnected.

2. Minimum acceptable resistance readings shall be 30 megohms.

E. Mechanical and electrical operational tests shall be performed on all breakers and their starters and associated alarm and indicating devices. All interlock devices must be tested operationally.

END OF SECTION

SECTION 16482

MOTOR-OPERATED EQUIPMENT

PART 1 GENERAL

1.01 SECTION INCLUDES: Motors furnished as integral components of equipment specified in other sections of specifications.

1.02 RELATED SECTIONS

A. Section 16483, Motor Control.

B. Section 16481, Motor Control Centers.

C. Section 16960, Electrical Testing.

1.03 SUBMITTALS

A. Submit approved field test reports for information.

PART 2 PRODUCTS

Not used.

PART 3 EXECUTION

3.01 FIELD QUALITY CONTROL

A. Visually check grounding of equipment.

B. Visually check alignment with driven equipment.

C. Visually check couplings and bearings.

D. Visually check lubrication system.

E. Perform an "Insulation Resistance Test" on motor generators and motors rated 100 hp and larger using a Simpson Model 405 insulation tester.

1. Test motors in 460-V range (440 V, 460 V, 480 V) using 1000-V setting.

2. Perform tests with motor windings at ambient temperature.

3. Apply voltage between all phases of motor winding, tied together, and grounded.

4. Apply voltage for minimum of 3 min and until reading reaches a constant value.

5. Minimum acceptable insulation resistance readings:

   a. 480 V: 5 megohms

F. Perform an "Operational Test" on motors with load on motor and under normal operating conditions.

1. Test must prove proper rotation, lubrication, and alignment.

2. Test must prove motors do not have excessive vibration and do not exceed nameplate current rating.

END OF SECTION

SECTION 16483

MOTOR CONTROL

PART 1 GENERAL

1.01 SECTION INCLUDES:

A. Manual motor starters.

B. Magnetic motor starters.

C. Combination magnetic motor starters.

D. Motor starter panelboards.

1.02 RELATED SECTIONS

A. Section 16191, Supporting Devices.

B. Section 16196, Electrical Identification.

1.03 REFERENCES

A. FS W-C-375 - Circuit Breakers, Molded Case, Branch Circuit and Service.

B. FS W-P-115, Power Distribution Panel.

C. NEMA AB 1-93, Molded Case Circuit Breakers and Molded Case Switches.

D. NEMA ICS 2-93, Industrial Control and Systems Controllers, Contractors, and Overload Relays Rated Not More Than 2000 Volts AC or 750 Volts DC.

E. NEMA ICS 6-93, Industrial Control and Systems Enclosures.

F. NEMA KS 1-90, Enclosed and Miscellaneous Distribution Equipment Switches (600 V Max).

G. NEMA PB 1-90, Panelboards.

H. NEMA PB 1.1-91, General Instructions for Proper Installation, Operation, and Maintenance of Panelboards Rated 600 Volts or Less.

I. UL 98-94, UL Standard for Safety Enclosed and Dead-Front Switches.

J. UL 198C-86, UL Standard for Safety High-Interrupting Capacity Fuses; Current-Limiting Types.

K. UL 198E-88, UL Standard for Safety Class R Fuses.

L. UL 512-93, UL Standard for Safety Fuseholders.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Store in clean, dry space. Maintain factory wrapping or provide an additional heavy canvas or heavy plastic cover to protect units from dirt, water, construction debris, and traffic.

B. Handle in accordance with manufacturer's written instructions. Lift only with lugs provided for the purpose.

PART 2 PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS - MOTOR STARTERS

A. Allen-Bradley.

B. Cutler Hammer/Westinghouse.

C. General Electric.

D. Seimens.

E. Square D.

2.02 MANUAL MOTOR STARTERS

A. Manual Motor Starter: NEMA ICS 2; size M-0, M-1, M-1P as specified; two or three pole, alternating current general-purpose Class A manually operated nonreversing or reversing full-voltage controller for induction motors rated in horsepower, with overload relay, low voltage protection, red LED pilot light, NO or NC auxiliary contact,or push button or toggle operator as specified.

B. Fractional Horsepower Manual Starter: NEMA ICS 2, alternating current general-purpose Class A manually operated, one or two pole, full-voltage controller for fractional horsepower induction motors, with thermal overload unit, red or green LED pilot light, and key or toggle operator as specified.

C. Motor Starting Switch: NEMA ICS 2, alternating current general-purpose Class A manually operated one or two pole, full-voltage controller for fractional horsepower induction motors, without thermal overload unit, low voltage protection, red LED pilot light, NO or NC auxiliary contact, and push button or toggle operator as specified.

D. Enclosure: ANSI/NEMA ICS 6; Type 1, 1B or 4 as specified.

2.03 COMBINATION MAGNETIC MOTOR STARTERS

A. Magnetic Motor Starters: NEMA ICS 2; alternating current general-purpose Class A magnetic controller for induction motors rated in horsepower; 600 V combination type with circuit breaker, motor circuit protector, fused disconnect or nonfused disconnect as specified.

B. Full Voltage Starting: Reversing or Nonreversing type as specified.

1. Reversing starters: include mechanical and electrical interlocking to prevent simultaneous energization of forward and reversing contactors.

C. Reduced Voltage Starting: Auto-transformer type with closed-circuit transition and circuit breaker or fused disconnect (as specified).

D. Two Speed Starting: Two speed, one or two winding, constant torque, variable torque or constant horsepower type as specified.

1. Include integral time delay transition between FAST and SLOW speeds.

E. Coil Operating Voltage: as specified.

F. Size: NEMA ICS 2; size as shown.

G. Overload Relay: NEMA ICS 2, bimetal or melting alloy type, as specified.

1. Three-Phase Motors: Magnetic Starters equipped with three thermal overload relays for overload protection.

H. Enclosure: NEMA ICS 6; Type 1, 3R, 4, 12, or Open type as specified.

2.04 CONTROL DEVICES

A. Auxiliary Contacts: NEMA ICS 2, two and NO, NC field convertible contacts in addition to seal-in contact, as specified.

B. Pushbuttons: NEMA ICS 2, heavy duty, oil-tight, START/STOP in front cover or in separate NEMA enclosure as specified.

C. Indicating Lights: NEMA ICS 2, heavy duty, oil-tight LED type, RUN: red in front cover or in separate NEMA enclosure with control switches as specified.

D. Selector Switches: NEMA ICS 2, heavy duty, oil-tight HAND/OFF/AUTO, in front cover or in separate NEMA enclosure as specified.

E. Provide individual units with standard size legend plates; Markings on plates in accordance with drawings.

F. Relays: NEMA ICS 2, 120-V, 60-Hz coils with convertible contacts, rated 0 A at 600 V.

G. Control Power Transformers: 120V secondary, in each motor starter, capacity as shown.

1. Fuse X1 terminal of control transformer secondary;

2. Ground X2 terminal of control transformer secondary.

2.05 COMBINATION STARTER OVERCURRENT PROTECTION AND DISCONNECTING MEANS

A. Construction: operable by hand from outside enclosure and interlocked with door such that it must be turned in "Off" position before door can be opened.

1. Include a semi-secret device to permit qualified personnel to open enclosure with breaker closed.

2. Operating handle: lockable in "OFF" position.

B. Molded Case Thermal-Magnetic Circuit Breakers: NEMA AB 1, FS W-C-375, circuit breakers with integral thermal and instantaneous magnetic trip in each pole.

C. Motor Circuit Protector: NEMA AB 1, FS W-C-375, circuit breakers with integral instantaneous magnetic trip in each pole.

D. Nonfusible Switch Assemblies: NEMA KS 1, UL 98, quick-make, quick-break, load interrupter enclosed knife switch.

E. Fusible Switch Assemblies: NEMA KS 1, UL 98, quick-make, quick-break, load interrupter enclosed knife switch. Fuse Clips: UL 512.

2.06 ACCEPTABLE MANUFACTURERS - MOTOR STARTER PANELBOARD

A. Allen Bradley.

B. Cutler Hammer/Westinghouse.

C. General Electric.

D. Siemens.

E. Square D.

2.07 MOTOR STARTER PANELBOARD

A. Motor Starter Panelboards: NEMA PB 1, circuit breaker or fusible switch type as specified.

B. Motor Starters: As indicated.

C. Enclosure: NEMA PB 1, Type 1 or 3R as specified.

D. Provide surface cabinet front with screw cover or hinged door with flush lock as specified.

E. Provide motor starter panelboards with aluminum bus, ratings as shown.

1. Provide copper ground bus in all motor starter panelboards.

F. Minimum Integrated Short Circuit Rating: as specified.

2.08 ACCEPTABLE MANUFACTURERS - FUSES

A. Bussman.

B. Gould-Shawmut.

C. Reliance.

2.09 FUSES

A. Fuses: ANSI/UL 198C, Class J; ANSI/UL 198E, Class RK1 or RK5 as indicated; dual element, current limiting, time delay, one-time fuse, 250 or 600 V as specified.

B. Interrupting Rating: 200,000 A rms.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install motor control equipment in accordance with manufacturer's instructions.

B. Motor Starter Panelboard Installation: In conformance with NEMA PB 1.1.

C. Install fuses in fusible switches.

D. Select and install heater elements in motor starters to match installed motor characteristics.

E. Motor Data: Provide neatly typed label inside each motor starter enclosure door identifying motor served, nameplate horsepower, full load amperes, code letter, service factor, and voltage/phase rating.

3.02 FIELD QUALITY CONTROL

A. Verify wiring connections are tight.

B. Verify movable contact assembly is not binding and is free to move.

C. Verify coil voltage is correct.

D. Verify proper phasing and rotation for connected motor.

E. Energize starter, measure motor load current and compare to motor nameplate data.

END OF SECTION

SECTION 16484

ADJUSTABLE FREQUENCY DRIVE FOR A-C INDUCTION MOTORS

PART 1 GENERAL

1.01 SYSTEM DESCRIPTION

A. This specification describes the manufacture, assembly, and testing of an electronic adjustable frequency/speed drive (AFD) to control existing centrifugal fan motors for variable air volume systems.

1.02 REFERENCES

A. National Electrical Manufacturers Association (NEMA)
ANSI/NEMA 250 - Enclosures for Electrical Equipment

B. National Fire Protection Association (NFPA)
NSI/NFPA 70 - National Electrical Code (NEC) 1999

C. Institute of Electrical and Electronics Engineers (IEEE)
IEEE Standard 519-1981, Guide for Harmonic Control and Reactive Compensation of Static Power Converters

D. Federal Communications Commission (FCC)
FCC Part 15, Class A - Radio Frequency Interference (RFI)

E. Underwriters Laboratories (UL)
UL 508, Electrical Testing Laboratories (ETL)

1.03 QUALIFICATIONS

Manufacturer: The AFD shall be the product of one manufacturer who has been regularly engaged in the design and production of packaged adjustable frequency drives for a minimum of 10 years.

1.03 WARRANTY

Provide 3-year warranty to include coverage of travel, labor, parts, and service.

1.04 MAINTENANCE SERVICE

Furnish service and maintenance of packaged AFD unit for 1 year from date of installation.

1.05 QUALITY ASSURANCE

A. Quality Assurance Plan

The Supplier shall use a system of recording and reporting information that will provide the Company with the required certified documentation that the item, materials of construction, and performance are in conformance with the specification and the applicable standards. The Quality Assurance (QA) Plan shall describe this system of documentation and shall be submitted for review. Reports shall include the following:

1. Certification that the materials and methods used in manufacturing meet the specification requirements.

2. Technical and test data pertaining to the finished product are in accordance with the methods and standards referenced in this specification.

B. Wavier or Deviation Request

In the event, as the equipment is being manufactured and tested, the Supplier determines that any requirement of this specification will not be met, a "Request for Waiver or Deviation" form shall be completed by the Supplier and submitted to the Company for approval or rejection. Forms will be provided by the Company upon request.

PART 2 PRODUCTS

2.01 GENERAL

A. The AFD shall consist of a three-phase, variable torque, microprocessor- controlled inverter capable of driving the AC induction motors described in this specification from 10% to 100% of the motor's 60 Hz base speed. The AFD shall operate the motor continuously at the setpoint speed without damage to the motor.

B. The AFD shall include a converter and an inverter section.

1. The converter section shall convert fixed frequency and voltage AC utility power to DC voltage. Input line filters shall be provided as an integral part of the input section of the AFD.

2. The inverter section of the AFD shall invert the DC voltage into a quality output waveform, with adjustable voltage and frequency for stepless motor speed control.

C. The AFD shall be capable of normal operation at a distance of 50 feet from the motor. It shall also be capable of operating without a motor or any other equipment connected to the drive output to facilitate start-up and troubleshooting.

2.02 POWER QUALITY

A. Design of the AFD shall incorporate features necessary to minimize harmonic voltages and currents, radio frequency interference, maintain high power factor, and provide maximum operating efficiency of the drive and motor combination.

1. Line noise generated by the AFD to the Company's power system shall be no greater than 3% individual voltage harmonic distortion, and 5% total voltage harmonic distortion (THD), with respect to the fundamental frequency. Commutation notch area in the line-to-line voltage shall be no greater than 16,400 volt-microsecond, in accordance with IEEE Standard 519.

2. Input line reactors shall be provided to minimize the harmonics introduced into the AC line and to provide additional protection from AC line transients.

3. Drive efficiency shall exceed 97% at 100% speed and load, and 90% at 50% speed and load. Displacement power factor shall exceed 0.95 regardless of speed and load.

4. The AFD shall not emit radiated RFI in excess of the limits set forth in the FCC Rules and Regulations, Part 15 for Class A computing devices. RFI filters shall be provided as necessary. The AFD shall carry an FCC compliance label.

5. Motor noise resulting from the AFD shall be limited to 3dB over across the line operation, measured at 3 feet from the motor.

B. The manufacturer shall supply a report on the AFD distortion levels with the price quotation based on the Company's power system data provided on Page 1 and Attachments A thru D of this specification.

2.03 ASSEMBLY

A. The AFD shall be protected inside a NEMA 12, floor-mounted, front-access enclosure for use inside an industrial area. The enclosure shall be provided with circulation fans and filters. The AFD shall be capable of operating at an ambient temperature range of 0^{O} to 40^{O} C (32^{O} to 104^{O} F) at 95% humidity.

B. The enclosure shall have conduit entry points at the top for the input and output power conductors and drive control cable. Two ground lugs shall be furnished, one for the incoming and one for the outgoing ground conductors. Lifting eyes shall be provided at the top of the enclosure.

C. All power semiconductors shall be located on a common heat sink for modularity and ease of service. The inverter and driver circuits shall contain LED's to indicate firing sequence and for troubleshooting.(See Section 2.05D)

D. The AFD shall carry an Electrical Testing Laboratories (ETL) label.

2.04 PROTECTIVE FEATURES

A. AFD Input

1. Undervoltage

2. Phase Loss

3. AC Line Transients

B. AFD Output

1. Motor Overload

2. Overcurrent

3. Ground Fault

C. DC Bus Overvoltage

D. Overtemperature

E. Logic Card Battery Back-up

F. The AFD shall incorporate stall prevention techniques by adjusting output voltage and frequency to avoid overload conditions during acceleration, deceleration, and continuous operation.

G. The AFD shall have the capability to start into a spinning motor. It shall be able to determine the motor speed in any direction and resume operation without tripping.

H. A door interlocked and pad-lockable switch shall be provided on the front of the unit to disconnect power to the AFD.

2.05 STATUS INDICATION

A. Self-check diagnostic capability shall be provided each time the drive is powered up, and potential fault conditions monitored while running. Critical parameters such as drive output current, voltage, kilowatts, frequency, and motor speed (as a percentage of base speed) shall be locally displayed on a multi-function digital meter.

B. A "Power On" light to indicate that the AFD is receiving utility power, a "Run" indication light, and a "Fault" light to indicate that the AFD has tripped shall be provided on the front panel.

C. Output form-C contacts from the "Run" and "Fault" modes shall be provided for customer use. A "Safety Shutdown" input shall also be provided to shut down the AFD when a normally closed remote contact opens. The customer input and output contacts shall be wired to a terminal strip.

D. The AFD shall contain internal, trouble-shooting LED's to include:

1. Overvoltage LED

2. Undervoltage LED

3. Overcurrent LED

4. Chopper operation LED

5. Inverter operation LED's

6. Driver operation LED's

7. Input Bus Charged LED

8. Output Bus Charged LED

E. The control card shall contain a multiple pin connector for use with a diagnostic test meter.

2.06 ADJUSTMENT FEATURES

A. The AFD shall accept a 4 to 20mA follower signal from an external source provided by the Company. Connection points shall be provided for the control signal cable.

B. Internal Speed Adjustments

1. Maximum speed, adjustable 50 to 100% base speed.

2. Minimum speed, adjustable 0 to 50% base speed.

3. Acceleration time, adjustable 3 to 60 seconds.

4. Deceleration time, adjustable 3 to 60 seconds, with override circuit to prevent nuisance trips if deceleration time set too short.

5. Offset and Gain to calibrate the customer input speed signal.

C. External Speed Control Potentiometer

D. Local/Remote Selector Switch

1. In the "Remote" position, motor speed is determined by the external follower signal.

2. In the "Local" position, motor speed is determined by the manual speed control potentiometer.

E. Current Limit, adjustable 0 to 105% of the drive's rated output current.

2.07 TEST AT SELLER'S PLANT

The AFD shall be tested (burned-in) and cycled with an induction motor load or dynamometer, for a 24 hour minimum period without an unscheduled shutdown, in an ambient temperature of at least 40^{O} C. The Supplier shall submit a description of the test procedures and results with the equipment.

2.08 SHIPPING AND RECEIVING

The preparation for shipment shall protect the equipment against breakage, dampness, corrosion, or vibration damage encountered in transporting and handling. The packaging shall discourage tampering and pilfering and be acceptable to the transporting company. Each shipping container shall be identified with the following: Purchase Order No., Data Sheet No., Description of Contents, Manufacturer's Name & Address, Company's Name & Address, Destination.

PART 3 EXECUTION

3.01 START-UP SERVICE

A. The manufacturer shall provide start-up commissioning of the AFD by a factory certified service technician who is experienced in start-up and repair services. The commissioning personnel shall be the same personnel that will provide the factory service and warranty repairs at the customer's site. Sales personnel and other agents who are not factory certified technicians for field repair shall not be acceptable as commissioning agents.

B. Start-up services shall include verification of proper operation and installation of the AFD, its options, and its interface wiring to the Company's power and control system. Included in this service shall be (as a minimum):

1. Verification of wire terminations to the AFD and its optional circuitry.

2. Verification of proper operation and reliability of the AFD and the motor being driven.

3. Measurements of the input and output waveforms using a "power quality analyzer" capable of performing real-time harmonic distortion analysis.

4. Calibration and adjustment of the minimum speed, maximum speed, acceleration/deceleration rates, and control input.

5. Company operator training on operation and service diagnostics at the time of the equipment commissioning.

END OF SECTION

SECTION 16485

CONTACTORS

PART 1 GENERAL

1.01 SECTION INCLUDES

A. General purpose contactors.

B. Enclosures.

C. Accessories.

1.02 REFERENCES

A. NEMA ICS 2-93, Industrial Control Devices, Controllers, and Assemblies.

B. NEMA ICS 6-93, Enclosures for Industrial Controls and Systems.

C. NFPA 70-99, National Electrical Code.

1.03 SUBMITTALS

A. Products furnished from listed manufacturers are pre-approved and require no submittal.

B. Submit proposed substitutions for approval.

1.04 REGULATORY REQUIREMENTS

A. Conform to requirements of NFPA 70.

B. Furnish products listed and classified by UL as suitable for purpose specified and shown.

PART 2 PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. Allen Bradley.

B. Cutler Hammer/Westinghouse.

C. General Electric.

D. Square D.

2.02 GENERAL PURPOSE CONTACTORS

A. Nonmotor loads: NEMA ICS 2; electrically held general purpose magnetic contractor without overload protection:

B. Operating Coils: l20 V, 60 Hz.

1. Mount a 480-120-V, single-phase, 60-Hz control transformer within the enclosure when used on 480 V system.

2. Fuse X1 terminal of control transformer secondary.

3. Ground X2 terminal of control transformer secondary.

C. Size: NEMA ICS 2, Size as indicated.

D. Contacts: 3 pole, 600 V, 60 Hz.

E. Provide solderless pressure wire terminals.

2.03 ENCLOSURE

A. Type: NEMA ICS 6, Type as indicated.

2.04 ACCESSORIES

A. Push Button or Selector Switch: as indicated

B. LED Type Indicating Light: as indicted

C. Auxiliary Contacts: as indicated

PART 3 EXECUTION

3.01 INSTALLATION

A. Install in accordance with manufacturer's instructions.

3.02 FIELD QUALITY CONTROL

A. Verify wiring connections are tight.

B. Verify movable contact assemblies are not binding and are free to move.

C. Verify coil voltage is correct.

D. With load connected, energize and observe load current for each circuit installed.

END OF SECTION

SECTION 16942

FIELD COMPONENTS INSTALLATION

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Requirements for installation and testing of field components provided as part of a complete instrument and control system.

B. Contractor procurement of materials and hardware necessary for mounting field components.

C. Fabrication of mounting brackets or supports required for a completed installation.

1.02 REFERENCES

A. American Society for Testing and Materials (ASTM), Annual Book of Standards

B. ASTM A-252-90, Standard Specification for Welded and Seamless Steel Pipe Piles

1.03 SUBMITTALS

A. Submit installation test reports for approval.

PART 2 PRODUCTS

2.01 MATERIALS

A. Mounting stands and brackets

1. Outdoor applications: 304 stainless steel.

2. Indoor, non-corrosive applications: carbon steel painted.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify that all support fabrication and preparation activities are complete prior to installing field components.

B. Examine field components after installation to ensure that design, installation, and operational requirements have been met as defined in project design drawings and this specification.

3.02 PREPARATION

A. Provide and install temporary and permanent supports required to facilitate the installation of field components.

B. Verify that required process piping, instrument tubing and conduit has been installed.

C. Verify that instrument process connections have been located and installed according to design drawings.

D. Protect components during brazing, welding, and soldering activities.

E. In cases where damage is possible and the body of the component cannot be kept cool to the touch during welding, brazing, or soldering, obtain permission from Construction Manager to disassemble the component before heat application.

F. Protect components during drilling and filing activities.

G. Do not allow filings and metal or wood shavings to fall onto or within components or into ports or connectors.

3.03 INSTALLATION

A. General

1. Fabricate instrument stands and component mounting brackets in accordance with project design drawings.

2. Verify an identification tag is attached to each field component bearing its instrument number in accordance with project drawings and tabulations.

3. Install instruments and equipment according to instrument installation detail drawings.

4. Safety items shall have special identification tags attached, in accordance with the safety component identification shown on project design drawings.

B. Pressure Instruments

1. Pressure Gauges shall be installed as follows:

a. Gauges shall be installed per manufacturer's recommendations and applicable instrument installation detail drawings.

b. Install an instrument isolation valve between the process and the gauge.

c. For gauges which are designated as safety items, the instrument isolation valve shall have a handle which can be locked in the open position.

d. Safety items shall have special identification tags attached, in accordance with safety component identification shown on project design drawings.

e. A calibration tap with valve shall be installed between the isolation valve and the gauge.

f. Pressure taps shall be located a minimum of five pipe diameters from an elbow or flow restriction device when manufacturer’s recommendations or instrument installation detail drawings are not provided.

g. Pressure taps shall not be installed in vertical lines unless such installation is clearly shown on design drawings.

h. Horizontal taps shall be installed above the horizontal centerline.

2. Pressure Switches

Pressure switches shall be installed as follows:

a. Switches shall be installed per instrument installation detail drawings.

b. An instrument isolation valve shall be installed between the process and the pressure switch.

c. For instruments which are designated as safety items, the instrument isolation valve shall have a handle which can be locked in the open position.

d. Safety items shall have special identification tags attached, in accordance with the safety component identification shown on the project design drawings.

e. A calibration tap with valve shall be installed between the isolation valve and the pressure switch.

f. Pressure taps shall be located a minimum of five pipe diameters from an elbow or flow restriction device when manufacturer’s recommendations or instrument installation detail drawings are not provided.

g. Pressure taps shall not be installed in vertical lines unless such installation is clearly shown on design drawings.

h. Horizontal taps shall be installed above the horizontal centerline.

3. Pressure/Differential Pressure Transmitters

Pressure and Differential Pressure transmitters shall be installed as follows:

a. Transmitters shall be installed per applicable instrument installation detail drawings.

b. An instrument isolation valve shall be installed between the process and the transmitter and on the calibration tap.

c. A calibration tap with valve shall be installed between the isolation valve and the transmitter.

d. For instruments which are designated as safety items, the instrument isolation valve shall have a handle which can be locked in the open position.

e. Safety items shall have special identification tags attached, in accordance with the safety component identification shown on the project design drawings.

f. Install instrument isolation valves at the connection to the transmitter.

g. Pressure taps shall be located as shown on the design drawings.

h. A valve manifold with block, equalizing and drain valves shall be used on all differential pressure transmitters.

C. Temperature Instruments

1. For instruments which are designated as safety items, special identification tags shall be attached, in accordance with the safety component identification shown on the project design drawings.

2. Resistance Temperature Detectors (RTDs) and Thermowells

a. RTD installations in process piping shall use thermowells mounted in appropriate couplings or pipe adapters per instrument installation detail drawings.

b. For mounting in pipes smaller than 2 in., swaged pipe shall be used with the thermowell at an angle unless otherwise shown on design drawings.

c. Thermowells shall be installed so that flow is from tip toward base unless otherwise shown on design drawings.

d. Install thermowells perpendicular to the pipe on piping that is 4 inches or larger.

e. Ensure that RTD element is well seated against the bottom of the thermowell.

f. Contractor shall use heat transfer fluid in thermowells where specified on installation detail.

g. Thermowells shall be located at a minimum of four pipe diameters downstream of pressure gauges unless otherwise shown on design drawings.

h. Thermowells shall be located within four pipe diameters of flanges to allow for inspection unless otherwise shown on design drawings.

3. Thermocouples and Thermowells

a. Thermocouple installations in process piping or vessels shall use thermowells mounted in appropriate couplings or pipe adapters per instrument installation detail drawings.

b. For mounting in pipe smaller than 2 inches, swaged pipe shall be used with the thermowell at an angle unless otherwise shown on design drawings.

c. For process pipe 4 inches or larger, install thermowells perpendicular to the pipe.

d. Thermowells shall be installed such that flow is from tip toward base unless otherwise shown on design drawings.

e. Thermocouples installed at locations other than process piping or vessels shall be installed as specified on the instrument installation detail drawings.

f. The Contractor shall ensure that the thermocouple wire does not touch its protective tube.

g. The Contractor shall use heat transfer fluid in thermowells where specified on installation detail.

h. Thermowells shall be located a minimum of four pipe diameters downstream of pressure gauges unless otherwise shown on design drawings.

i. Thermowells shall be located within four pipe diameters of flanges to allow for inspection unless otherwise shown on design drawings.

D. Flow Instruments

1. Flowmeters shall be installed per applicable instrument installation detail drawings.

2. Install electromagnetic, turbine, and vortex shedding flowmeters in accordance with instrument installation detail drawings.

3. Install only at the location shown in design drawings.

4. Observe any special orientation notes shown on design drawings.

5. Install orifice flanges and orifice plates at the location shown on design drawings.

6. Orient the orifice flanges so that the pressure taps are at the top of the installation.

7. Ensure that orifice plate is installed such that the marked “upstream” face of the plate is oriented toward the upstream direction.

8. Ensure that orifice plate is oriented such that the drain hole (typically a smaller hole in the orifice plate, near the outer edge) is at bottom.

9. Install sight flow gauges per applicable instrument installation detail drawings.

10. Install only at the location shown in design drawings.

11. Observe any special orientation notes shown on design drawings.

12. Install thermal dispersion flow transmitters per applicable instrument installation detail drawings.

13. Observe any special orientation markings and instructions when installing thermal dispersion flowmeters or flow switches.

14. Thermal dispersion flow transmitters or switches shall be installed perpendicular to flow.

15. Install flow nozzles in accordance with instrument installation details and only at the location shown on design drawings.

16. Orient the flow nozzle such that the pressure taps are at the top of the installation.

E. Final Control Elements

1. Install control valves and actuators in accordance with the manufacturer’s recommendations and the applicable installation details on design drawings.

2. Pneumatic actuators shall be installed with the diaphragm oriented as shown on installation details.

3. Valve actuators, if electrical, shall be installed as shown in installation details on design drawings.

4. Actuator extension rods shall have little or no side resistance when the valve is not installed, and shall have little or no rotational play when the valve is connected to the actuator rod.

5. Actuators shall be adjusted to provide for full travel of the valve from closed to open as the actuator is operated from closed to open positions.

F. Samplers and Analyzers

1. Samplers shall be installed per applicable instrument installation detail drawings.

2. Install samplers so connections to sample lines are accessible without use of ladders.

3.04 FIELD QUALITY CONTROL

A. Perform the following pretest verifications:

1. Verify that instruments have been properly installed, wired, and piped.

2. Verify that electrical power sources are connected and are the proper voltage as shown on design drawings.

3. Verify that instrument air supply has been connected and adjusted to pressure as specified on design drawings.

4. Verify that field cable checks have been completed.

5. Verify that tubing has been pressure and leak tested.

6. Verify that control valve actuation, position indication, and fail positions are as specified on design drawings.

7. Verify that instrument tags and tubing labels have been installed in accordance with design drawings.

B. Perform Testing

1. Submit test plan for Construction Manager approval before testing.

2. Schedule testing with the Construction Manager.

3. Notify all involved participants of the test schedule.

4. Furnish test equipment which has proof of calibration to a traceable NIST standard.

5. Test equipment calibration must be no older than one year.

6. Perform specific test procedures which are at the end of this section.

7. Report test results in accordance with the instructions of this Section.

8. Submit test reports to the Construction Manager for approval.

C. Manufacturer’s Field Services

1. The supplier of specialty equipment shall make a technical representative available during startup and testing.

2. The Construction Manager shall arrange to have the technical representative on site when needed.

3. In scheduling the representative, the Construction Manager shall consider any site-specific training and access requirements.

END OF SECTION

SECTION 16943

CONSOLES, PANELS, CABINETS AND RACKS INSTALLATION

PART 1 GENERAL

1.01 SUMMARY

This section includes installation of consoles, panels, cabinets, and racks as part of a complete instrumentation and control system. Procurement of materials and hardware necessary for mounting is part of this section, as is fabrication of any mounting brackets or supports required for a completed installation.

1.02 RELATED SECTIONS

A. Section 16120, Building Wire and Cable - 600 V and Below

1.03 SUBMITTALS

A. Submit installation test reports for approval.

1.04 DELIVERY, STORAGE AND HANDLING

A. Inspect consoles, panels, cabinets, and racks for damage.

B. Notify Construction Manager if any damage is found.

C. Replace defective or damaged equipment.

D. Provide a secure and dry location for storing items upon receipt.

E. Store equipment in accordance with manufacturer's recommendations in an area protected from moisture, dirt and chemicals.

F. Store equipment in its original packaging.

G. Do not remove seals or protective coverings until ready for installation.

H. Handle enclosures and equipment in a manner to prevent damage.

PART 2 PRODUCTS

2.01 MATERIALS

A. Mounting stands and brackets

1. Severe environments: 304L stainless steel per Practice “A” of criteria in Table 4 of ASTM A-252; material with unacceptable etch structures per Practice “A” are to conform to Practice “C” nitric acid test with a maximum acceptable corrosion rate of 0.002 inch/month (max.).

2. Outdoor applications: 304 stainless steel.

3. Indoor, non-corrosive applications: carbon steel painted.

PART 3 EXECUTION

3.01 PREPARATION

A. Protect components during brazing, welding and soldering activities.

B. Where damage is possible and the body of component cannot be kept cool to the touch during welding, brazing, or soldering, obtain permission from the Construction Manager to disassemble the component before application of heat.

C. Protect consoles, panels, cabinets, and racks during drilling and filing activities.

D. Do not allow filings and metal or wood shavings to fall onto or within components or into ports or connectors.

3.02 INSTALLATION

A. Handle consoles, panels, cabinets, and racks with appropriate lifting equipment and padding, etc, during transport to the installation site, so as to prevent damage during installation activities.

B. Install consoles, panels, cabinets, and racks at the locations shown on design drawings.

C. Install consoles, panels, cabinets, and racks level and plumb unless otherwise specified.

D. Fabricate mounting brackets in accordance with project design drawings.

E. Attachment Anchors:

1. Use expansion anchors or preset inserts to attach to solid masonry walls.

2. Use self-drilling or expansion anchors to attach to concrete surfaces.

3. Use self-drilling sheet metal screws to attach to metal studs.

4. Do not use piping, ductwork, mechanical equipment, or conduit, as means of support.

3.03 FIELD QUALITY CONTROL

A. Inspect the installation of consoles, panels, cabinets, and racks to ensure they have been installed in accordance with design drawings.

B. Verify that interconnecting wiring has been completed and continuity checked.

C. Verify that tubing has been completed and that pressure/leak testing has been completed.

D. Verify that the specified electrical power is available at the line side of the circuit breaker which supplies the equipment.

E. Do NOT energize the consoles, panels, cabinets or racks.

F. Verify that instrument air supply has been connected, if required, and that the supply pressure is adjusted to the level specified in design drawings.

G. Do not open the block valve which supplies instrument air to the consoles, panels, cabinets, or racks.

H. Schedule testing with Construction Manager.

I. Do not perform testing without Construction Manager’s approval.

J. Notify all involved parties of test schedule.

K. Furnish appropriate test equipment which has proof of calibration to a traceable NIST standard.

L. Calibration certification shall be no older than one year.

M. Perform testing in accordance with manufacturer’s standard calibration tests, loop test procedures, or equipment test procedures as required.

N. Report test results.

O. Submit test reports for approval.

END OF SECTION

SECTION 16960

ELECTRICAL TESTING

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Basic electrical testing requirements necessary for acceptance of electrical equipment and installations.

1.02 PERFORMANCE REQUIREMENTS

A. Acceptance of electrical equipment and cables covered by test procedures is contingent upon proper execution of required tests and acceptable test results. Copies of tests will be distributed to the Construction Manager's Electrical Engineering, Electrical Maintenance, and responsible Operations departments. Original test reports are retained by Construction Manager.

B. Acceptance of electrical equipment is dependent upon equipment satisfactorily performing its intended function as determined by Construction Manager.

C. Construction Manager may, at its discretion, prepare and issue an acceptance report for any accepted piece of equipment or system. Original copy is retained in Construction Manager's file.

PART 2 PRODUCTS

Not used.

PART 3 EXECUTION

3.01 PREPARATION

A. Perform and supervise tests unless otherwise noted. Furnish test equipment required for tests performed. Provide safety measures required for each test.

B. Schedule testing with Construction Manager; perform no testing without Construction Manager's approval.

C. Notify involved parties prior to test advising them of test to be performed and scheduled date and time.

D. Give manufacturers sufficient notice to allow necessary arrangements to be made and to have their engineer or representative present at tests where their presence is required. Where the manufacturer's responsibility includes both electrical and mechanical performance, coordinate tests with others involved.

E. For test instruments to be acceptable for use, they must bear a label documenting the fact that equipment has been calibrated during previous 12 months. Label must show instrument serial number, date of calibration, and name of firm or laboratory performing calibration.

F. Construction Manager will examine test equipment prior to use and may, at his discretion, require equipment be submitted for calibration check. Equipment that fails to be within acceptable limits must be submitted to an approved testing laboratory for proper calibration. After equipment is returned from testing laboratory, submit evidence of proper calibration to Construction Manager.

3.02 TEST REPORTS

A. Construction Manager will ascertain that all tests specified are performed or waived. Test reports or waivers are retained in Construction Manager file.

B. Prepare test reports utilizing the "Electrical Test Report" Form (Attachment A) unless alternate forms are approved by Construction Manager or required by specific test procedures.

1. Complete test report upon completion of each test or series of similar tests.

2. Correct insulation-resistance readings to 20 deg C for final test results.

END OF SECTION

ATTACHMENT A

ELECTRICAL TEST REPORT

THIS TEST REPORT IS TO BE USED FOR POWER CABLE, GROUND GRIDS, ETC., AND ELECTRICAL EQUIPMENT, SUCH AS MOTOR CONTROL CENTERS.

JOB TITLE _________________________________ TEST REPORT NO. ______________
W. O. ______________ BLDG. _____________ PLANT __________ DATE ___________
WEATHER CONDITIONS ___________________ SOIL CONDITIONS ___________________
EQUIPMENT, DESCRIPTION, LOCATION, AND NAMEPLATE DATA ______________________
____
____
SPECIFIC TYPE OF TEST ____
SECTION OF SPECIFICATION DEFINING TEST ____________________ PAGE ___________
ACCEPTABLE VALUE: MIN. ______________________ MAX. _____________________
____
____
____
____
TEST INSTRUMENT ____
MODEL NO. _______________________________ CALIBRATION DATE ______________

TEST PERFORMED BY _______________________ Construction Manager _____________________

TEST SUPERVISED BY _______________________ Construction Manager _____________________

TEST WITNESSED BY _______________________ Construction Manager _____________________

CONSTRUCTION ENGINEER/CONTRACTING OFFICER _______________________________*

____

* SIGNATURE OF CONSTRUCTION ENGINEER OR CONTRACTING OFFICER VERIFIES THAT TEST RESULTS MEET OR EXCEED REQUIREMENTS OF SPECIFICATION.