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USACE / NAVFAC / AFCEC **UFGS-33 61 13 (August 2024)**

Preparing Activity: USACE **Superseding**
UFGS-33 61 13 (April 2010)

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated October 2025
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DIVISION 33 - UTILITIES

SECTION 33 61 13

PRE-ENGINEERED UNDERGROUND HEAT DISTRIBUTION SYSTEM

08/24

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SECTION 33 61 13

PRE-ENGINEERED UNDERGROUND HEAT DISTRIBUTION SYSTEM
08/24

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NOTE: This guide specification covers the requirements for an insulated underground heat distribution system (UHDS) and/or condensate return system of the pre-engineered type as covered in UFC 3-430-09 "Exterior Mechanical Utility Distribution", for steam and high temperature hot water up to 230 degrees C 450 degrees F.

Adhere to UFC 1-300-02 Unified Facilities Guide Specifications (UFGS) Format Standard when editing this guide specification or preparing new project specification sections. Edit this guide specification for project specific requirements by adding, deleting, or revising text. For bracketed items, choose applicable item(s) or insert appropriate information.

Remove information and requirements not required in respective project, whether or not brackets are present.

Comments, suggestions and recommended changes for this guide specification are welcome and should be submitted as a Criteria Change Request (CCR).

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PART 1 GENERAL

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NOTE: Notes are to the Government designer or design Architect/Engineer firm and will not be seen by the Contractor or its Subcontractors. The designer will carefully review all Notes; when submitting the "draft" specification for review, Notes will remain intact.

This specification requires coordination with other design disciplines (examples: cathodic protection, trenching and backfill, structural for coordinating

manhole structures). The specified systems are capable of transporting steam, condensate, or high temperature hot water. This specification is for systems operating above 120 degrees C 250 degrees F to a maximum acceptable pressure and temperature of approximately 2.800 Mpa (gage) 408 psig and 230 degrees C 450 degrees F, respectively. It should be noted that not all UHDS are acceptable for all site classifications, temperatures, and pressure ratings.

The Government designer will establish the site, soil and groundwater conditions. The contract drawings will show the size, proposed routing (including construction limits) and estimated length of the system. The contract drawings will establish the elevations and show the profiles of the pipe and the existing and finished earth surfaces. Indicate and identify all obstructions within 8 m 25 feet of the system centerline, including adjacent or crossing utilities.

This guide specification is not for the design of the valve manhole and associated piping and equipment in the valve manhole. Valve manholes and the piping and equipment inside the valve manholes will be designed and detailed on the contract drawings. Section 33 61 13.19 VALVES, PIPING, AND EQUIPMENT IN VALVE MANHOLES will be included as part of this project. Include on the drawings a log of soil conditions along the pipe line right-of-way, at pipe depth, which gives, as a minimum, soil classification, moisture content, soil resistivity and pH, bearing strength and unstable conditions.

Details at building entries will be provided on the contract drawings to show pipe elevation, floor and grade elevation, building wall construction and existing equipment. Include location of valve manhole and/or valve boxes, branch runouts, and isolation valves on the contract drawings. Provide details at manhole entries on the contract drawings to show pipe elevations; floor, top, entrance, and grade elevations; manhole wall construction; anchor location and construction; and existing equipment and piping.

All connections to the UHDS distribution will occur only in manholes.

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1.1 REFERENCES

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NOTE: This paragraph is used to list the publications cited in the text of the guide specification. The publications are referred to in the text by basic designation only and listed in this paragraph by organization, designation, date, and title.

Use the Reference Wizard's Check Reference feature when you add a Reference Identifier (RID) outside of the Section's Reference Article to automatically place the reference in the Reference Article. Also use the Reference Wizard's Check Reference feature to update the issue dates.

References not used in the text will automatically be deleted from this section of the project specification when you choose to reconcile references in the publish print process.

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

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO)

AASHTO M 300	(2003; R 2017) Standard Specification for Inorganic Zinc-Rich Primer

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME B16.9	(2024) Factory-Made Wrought Buttwelding Fittings
ASME B16.11	(2021) Forged Fittings, Socket-Welding and Threaded
ASME B31.1	(2024) Power Piping
ASME B40.100	(2022) Pressure Gauges and Gauge Attachments

ASTM INTERNATIONAL (ASTM)

ASTM A36/A36M	(2019) Standard Specification for Carbon Structural Steel
ASTM A53/A53M	(2024) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM A106/A106M	(2019a) Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service
ASTM A134/A134M	(2019) Standard Specification for Pipe, Steel, Electric-Fusion (Arc)-Welded (Sizes NPS 16 and Over)
ASTM A135/A135M	(2021) Standard Specification for Electric-Resistance-Welded Steel Pipe
ASTM A139/A139M	(2022) Standard Specification for Electric-Fusion (ARC)-Welded Steel Pipe

(NPS 4 and over)

ASTM A234/A234M — (2024) Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service

ASTM A240/A240M — (2025a) Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications

ASTM C177 — (2019; E 2023) Standard Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded-Hot-Plate Apparatus

ASTM C518 — (2021) Standard Test Method for Steady-State Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus

ASTM C533 — (2017; R 2023) Standard Specification for Calcium Silicate Block and Pipe Thermal Insulation

ASTM C547 — (2022a) Standard Specification for Mineral Fiber Pipe Insulation

ASTM C591 — (2022) Standard Specification for Unfaced Preformed Rigid Cellular Polyisocyanurate Thermal Insulation

ASTM C1728 — (2023) Standard Specification for Flexible Insulation

ASTM D1895 — (2017) Standard Test Methods for Apparent Density, Bulk Factor, and Pourability of Plastic Materials

ASTM D2310 — (2006; R 2012) Machine-Made "Fiberglass" (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe

ASTM D2487 — (2017; R 2025) Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)

ASTM D2996 — (2023) Standard Specification for Filament-Wound "Fiberglass" (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe

NACE INTERNATIONAL (NACE)

NACE SP0169 — (2024) Control of External Corrosion on Underground or Submerged Metallic Piping Systems

1.2 DEFINITIONS

The following definitions apply to the work.

1.2.1 Heat Distribution System

A complete pre-engineered, underground [heat distribution] [and] [condensate return] system including all required components such as carrier pipes, [steam pipe,] [hot water supply pipe,] [condensate return pipe,] [hot water return pipe,] and fittings, anchors, pipe supports, insulation, protective casing, and cathodic protection, for the system supplied. The pre-engineered system does not include valve manholes and the piping and equipment inside the valve manholes; use Section 33 61 13.19 VALVES, PIPING, AND EQUIPMENT IN VALVE MANHOLES for pertinent requirements. Include all piping and components to a point at least 150 mm 6 inches inside the building and valve manhole walls. Do not use any part of the building or valve manhole structure as an anchor point.

1.2.2 Direct-Buried

A system which is buried, without the need for a field-fabricated protective enclosure such as a concrete trench or tunnel.

1.2.3 UHDS Types

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N0TE: From the following subparagraphs, select the applicable type of system to be allowed and remove the others.
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1.2.3.1 Drainable-Dryable-Testable (DDT) Direct-Buried

A factory-fabricated system including an air and water-tight outer protective casing, air space and an insulated carrier pipe. Drains and vents are provided at the end plates of the system (in manholes or buildings). The drains are normally capped but the caps can be removed to drain water which can leak into the air space if there is a failure in the casing or the carrier pipe. The vents allow water vapor to escape and provide a tell-tale sign of leakage.

1.2.3.1.1 Piping Design Variation

An available variation of the DDT pre-engineered piping design is characterized by use of a smaller thickness of high-temperature insulation and an annular air space contained within a metallic conduit. The metallic conduit is coated on the outside with lower-temperature insulation and the entire system is encased in a thick, non-metallic exterior jacket. This variation of the DDT system is not recommended for implementation.

1.2.3.2 Water Spread Limiting (WSL) Direct-Buried

A factory fabricated system including an outer protective casing and an insulated carrier pipe. The system is fabricated in sections which are independent from each other; ground water or condensate which leaks from or into one section cannot travel into the next section. Field-assembly of the sections requires no welding as the sections push together and are sealed with a system of couplings and seals.

1.2.3.3 Water Spread Limiting Poured-In-Place Insulation (PIPI)

A field fabricated system consisting of steel carrier pipes and supports encased in the poured-in-place insulation (PIPI). The PIPI consists of chemically modified calcium carbonate powder. The particles cohesively bond with each other to form a closed-cell insulation that thermally insulates the pipes and provides corrosion protection.

1.3 SYSTEM DESCRIPTION

1.3.1 Scope

The work includes the design and fabrication; furnishing; installing, and testing of a direct buried underground [insulated heat-distribution system] [and] [insulated steam pipe,] [insulated high temperature hot water supply pipe,] [insulated steel condensate return pipe,] [insulated high temperature hot water return pipe] consisting of piping as indicated, cathodic protection system (where required by this specification and UFC 3-430-09), together with fittings and appurtenances necessary for a complete and operable system. Gland type end seals will not be permitted. DDT systems with fiberglass casings will not be permitted.

1.3.2 UHDS Design

Submit a Certificate of Satisfactory Operation certifying that at least three systems installed by the UHDS manufacturer within the previous 5 years are operating satisfactorily, not later than [30][40][_____] days after notice to proceed. The UHDS manufacturer is responsible for the complete design of the UHDS, the product to be supplied, fabrication, witnessing installation and testing of the system within the design parameters established by the contract drawings and specifications, and in compliance with the detailed design. The complete design of the UHDS must be sealed by a Professional Engineer in the employ of the UHDS manufacturer.

1.3.3 Cathodic Protection

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NOTE: Cathodic protection system will meet the requirements of UFC 3-570-01 Cathodic Protection.

Cathodic protection system design will include the requirements of UFC 3-430-09.

For Army projects only: these projects require cathodic protection Center of Expertise (CX) review of the proposed design.

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Provide cathodic protection for systems with coated steel casings in accordance with paragraph Cathodic Protection Installation.

1.3.4 Operating Characteristics

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NOTE: The operating and the rated characteristics must be supplied. Operating characteristics should

be based on the capabilities of the system. The operating characteristics should not exceed the values for the "Rated Characteristics" of the system. Rated characteristics are to be used for calculations for the system design and represent a "worst case". For rated characteristics for DDT systems insert 260 degrees C 500 degrees F and 4.585 MPa gage 665 psig. For rated characteristics for WSL systems, which are only allowed for steam and condensate return systems, insert 208 degrees C 406 degrees F and 1.723 MPa gage 250 psig. For rated characteristics of the PIPI system insert 249 degrees C 480 degrees F and 3.81 MPa gage 551 psig. The design conditions for the condensate and hot water return piping will be the same as for the steam and hot water supply.

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Provide [steam] [high temperature hot water] supply system with an operating temperature of [_____] degrees C[_____] degrees F and an operating pressure of [_____] kPa[_____] psig. [Condensate] [high temperature hot water] return system with an operating temperature of [_____] degrees C[_____] degrees F and an operating pressure of [_____] kPa [_____] psig.

1.3.5 Rated Characteristics

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NOTE: The rated characteristics are to be used in the calculations for the system design and represent a "worst case". The rated conditions for the high temperature hot water return piping will be the same as for the supply. For "Installation Temperature" use the 99 percent Dry Bulb Temperature Winter Design Heating Data from the weather tables in UFC 3-400-02, Engineering Weather Data.

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Provide thermal expansion calculations for the supply and return piping using the following design characteristics and installation temperature. The system design conditions for [steam] [condensate] [high temperature hot water] supply and/or return must be a temperature of 232 degrees C 450 degrees F and a pressure of 4.58 kPa 665 psig. For calculation purposes, ensure the installation temperature is not higher than the ambient temperature at the site: [_____] degrees C F.

1.4 SUBMITTALS

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NOTE: Review submittal description (SD) definitions in Section 01 33 00 SUBMITTAL PROCEDURES and edit the following list, and corresponding submittal items in the text, to reflect only the submittals required for the project. The Guide Specification technical editors have classified those items that require Government approval, due to their complexity or criticality, with a "G." Generally, other submittal items can be reviewed by the Contractor's Quality Control System. Only add a “G” to an item,

if the submittal is sufficiently important or complex in context of the project.

For Army projects, fill in the empty brackets following the "G" classification, with a code of up to three characters to indicate the approving authority. Codes for Army projects using the Resident Management System (RMS) are: "AE" for Architect-Engineer; "DO" for District Office (Engineering Division or other organization in the District Office); "AO" for Area Office; "RO" for Resident Office; and "PO" for Project Office. Codes following the "G" typically are not used for Navy and Air Force projects.

The "S" classification indicates submittals required as proof of compliance for sustainability Guiding Principles Validation or Third Party Certification and as described in Section 01 33 00 SUBMITTAL PROCEDURES.

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Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Submittals not having a "G" or "S" classification are for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Heat Distribution System; G, [_____]

SD-03 Product Data

Interruption of Existing Service; G, [_____]

Work Plan; G, [_____]

Quality Assurance Plan; G, [_____]

UHDS Manufacturer's Representative Reports

Piping, Pipe Fittings, and Insulation

SD-05 Design Data

Pipe-Stress and System-Expansion Calculations; G, [_____]

Design Life Calculations for the Cathodic Protection System; G, [_____]

Manufacturer's Data Sheets; G, [_____]

SD-06 Test Reports

Thermal Performance Test; G, [_____]

Operational Test; G, [_____]

Tests; G, [_____]

Test of WSL Systems for Steam Service; G, [_____]

Test of WSL Systems for Condensate Return Service; G, [_____]

SD-07 Certificates

Manufacturer; G, [_____]

Manufacturer's Representative; G, [_____]

UHDS Design; G, [_____]

Certificate of Compliance; G, [_____]

Testing Firm; G, [_____]

Welding; G, [_____]

SD-10 Operation and Maintenance Data

Heat Distribution System; G, [_____]

1.5 QUALITY ASSURANCE

1.5.1 Manufacturer

The UHDS manufacturer is the company responsible for the design and manufacture of the pre-engineered system. Submit certification of past experience stating that the UHDS manufacturer regularly and currently manufactures direct-buried systems, and that the designs of the system and equipment to be provided for this project conform to specification requirements. Submit an original certification signed by a principal officer of the UHDS manufacturer at least [2 weeks][_____] prior to the start of work; indicate the location, type of system, size of system, point of contact (POC) including phone number, for information verification. The UHDS manufacturer directs the installation of the system and has a representative on the jobsite; submit a Work Plan indicating when various items of work and tests are to be carried out and when its representative will be present at the job site. The Contractor must submit a proposed schedule of activities, no later than [7][_____] days after notice to proceed. The manufacturer must submit a list of characteristics indicating what defects or damage will necessitate replacement. The manufacturer must submit a Quality Assurance Plan not later than [7][_____] days after notice to proceed for fabrication, delivery, storage, installation and testing of the system. The manufacturer must submit manufacturer's data sheets for all coatings and indicating thicknesses of insulation for carrier pipes.

1.5.2 Manufacturer's Representative

Submit a letter from the system manufacturer, at least [2 weeks][_____] prior to the start of work, listing the experience and training of the manufacturer's representative, who must be a person who regularly performs the duties specified, is certified in writing by the UHDS manufacturer to be technically qualified and experienced in the installation of the

system, and authorized by the manufacturer to make and sign the daily reports specified. The UHDS manufacturer's representative must be under the direct employ and supervision of the UHDS manufacturer.

1.5.3 Corrosion Engineer

Corrosion engineer refers to a person who, by knowledge of the physical sciences and the principles of engineering and mathematics acquired by professional education and related practical experience, is qualified to engage in the practice of corrosion control. Such person is permitted to be a licensed professional corrosion engineer or certified as being qualified by the National Association of Corrosion Engineers (NACE), if such licensing or certification includes 3 years experience in corrosion control on underground metallic surfaces of the type under this contract. NACE certification must be technologist, corrosion specialist, or cathodic protection specialist. The corrosion engineer must make at least 3 visits to the project site. The first of these visits must include obtaining soil resistivity data, acknowledging the type of pipeline coatings to be used and reporting to the Contractor the type of cathodic protection required. Once the submittals are approved and the materials delivered, the corrosion engineer must revisit the site to ensure the Contractor understands installation practices and laying out the components. The third visit must involve testing the installed cathodic protection systems and training applicable personnel on proper maintenance techniques. The corrosion engineer must supervise, inspect, and test the installation and performance of the cathodic protection system.

1.5.4 Testing Firm

Submit a Certificate of Qualification from the independent testing firm or firms, not later than [7][_____] days after notice to proceed. The Testing Firm must be able to certify that: weld examination methods and procedures, and the interpretation of radiographic films will be performed in accordance with ASME B31.1; the firm intends to utilize the proper film exposure, techniques, and penetrameter to produce density and geometric sharpness in sufficient clarity to determine presence of defects; and that all radiographic films will be reviewed and interpreted, and reading reports signed, by not less than a Certified American Society for Nondestructive Testing Level III Radiographer.

1.5.5 Contract drawings

The contract drawings accompanying this specification provide information on:

a. The size of carrier pipes, approximate length, and site location of the system.

b. The routing and elevation of the piping along the route.

c. Location and design of manholes.

d. The obstacles that must be avoided along the path.

e. Location of piping anchors.

f. Operating pressure and temperature of system.

1.6 DELIVERY, STORAGE, AND HANDLING

Maintain equipment and material placed on the job in the custody of the Contractor until final acceptance whether or not the Contractor has been reimbursed for the equipment and material by the Government. The Contractor is solely responsible for the protection of the equipment and material against damage from any source while stored or during installation. Protect materials against damage from UV light, and entry of water and mud, by installing watertight protection on open ends at all times. Immediately replace sections of the casing or carrier piping found to have been subjected to full or partial submergence in water (which would allow the insulation to become wet). Cover materials awaiting installation to protect from UV degradation.

1.7 SITE CONDITIONS

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NOTE: A site survey must be made of the proposed routing of the UHDS. It is important that the site survey report include the identification, location, and depth of all existing underground utilities and structures as well as all aboveground utilities, roadways, structures, etc. Classification of the site conditions will be used to determine the type of system to be used: a drainable, dryable, testable (DDT) system should be allowed in severe, bad, and moderate site conditions; a water-spread-limiting (WSL) system should be allowed in bad and moderate site conditions for steam and condensate return systems only. Check with CECW-ETV before including WSL system in a project specification. A PIPI system should be allowed in moderate site conditions. PIPI systems may also be used in bad sites where the water table is expected to never rise above the system. Remove these paragraphs if the survey will be done by the Government.

A soils engineer, familiar with the underground water conditions onsite, should be employed to establish the site classification. Site parameters are defined in the UFC 3-430-09 "Exterior Mechanical Utility Distribution" Chapter 3 Site Classification Criteria Table. If underground water conditions at the site are not available, a detailed site classification survey will be made and the UFC 3-430-09 "Exterior Mechanical Utility Distribution" Chapter 3 Site Classification Criteria Table will be utilized to establish the site classification. This survey should be conducted within the framework of the requirements in UFC 3-430-09.

The results from the completed site survey are to be indicated below.

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Classification of the site conditions for the UHDS are based on ASTM D2487 and the site classification criteria indicated in UFC 3-430-01. The project Site Classification is Class [A-Severe][B-Bad][C-Moderate][D-Mild].

PART 2 PRODUCTS

2.1 STANDARD PRODUCTS

Provide for this project a designed system and equipment which is of current production and that essentially duplicate systems that have been in satisfactory use for at least 5 years prior to bid opening at 3 locations. Provide systems that have been operated under pressure, temperature and site characteristics which are equal to or more severe than the operating conditions in this specification and that have distributed the same medium. Ensure the system is supported by a service organization that can reach the site after a service call within [48][_____] hours. Submit cut sheets for piping, pipe fittings, and insulation to be used in this system.

2.2 FACTORY FABRICATED, DIRECT-BURIED DDT SYSTEMS

2.2.1 DDT Steam and High Temperature Hot Water Carrier Pipes

Requirements are in accordance with paragraph HEAT DISTRIBUTION PIPING.

2.2.2 DDT Condensate Carrier Pipes

Provide steel, schedule 80 carrier piping for condensate return systems. Pipe requirements are in accordance with paragraph HEAT DISTRIBUTION PIPING. Do not locate condensate carrier pipes in conduit casings which contain steam pipes or any other piping.

2.2.3 DDT Carrier Pipe Insulation

Provide carrier pipe insulation conforming to minimum thicknesses and type listed in Tables 1 and 2 as required for temperature specified under paragraph Rated Characteristics.

2.2.4 Insulation Banding and Scrim

Use stainless steel bands and clips, at least 13 mm 1/2 inch wide, conforming to ASTM A240/A240M (304 stainless steel), at a maximum spacing of 460 mm 18 inches over the scrim to secure the insulation onto the carrier pipe; use a minimum of two bands for each 1300 mm 4 foot section of insulation. Scrim must be vinyl-coated fiberglass with 18 x 16 mesh (number of filaments per 25 mm 1 inch) and made of 0.335 mm 0.013 inch diameter vinyl-coated fibrous glass yarn.

2.2.5 Casing

Provide casing consisting of smooth-wall steel, electric resistance spiral welded, conforming to ASTM A134/A134M, ASTM A135/A135M, or ASTM A139/A139M and the values tabulated below. Provide eccentric connectors between casing sections as needed to provide drainage of casing section between manholes and between manholes and buildings.

Casing Diameter (mm) (inches)	Minimum Thickness (mm) (inch)
150 - 660 6 - 26	6.35 0.250

Casing Diameter (mm) (inches)	Minimum Thickness (mm) (inch)
675 - 900 27 - 36	6.35 0.250
940 - 1050 37 - 42	6.35 0.250
1170 46	6.35 0.250

2.2.6 Casing End Plates, Vents, and Drains

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NOTE: Designer must accommodate 25 mm 1 inch vent pipe in the design of the manhole.
****

Make end plates of ASTM A36/A36M steel, minimum thickness 13 mm 1/2 inch for conduit pipe sizes above 300 mm 12 inches and 9.5 mm 0.375 inches for conduit pipe sizes 300 mm 12 inches and less. Provide a 25 mm 1 inch ASTM A53/A53M, schedule 40, galvanized vent riser pipe on the end plate, vent opening. Extend vent pipe to top of manhole and terminate 300 mm 12 inches above grade with a 180 degree bend. Provide a 25 mm 1 inch drain at the bottom and vent at the top. Provide brass plugs and half coupling, constructed with welded steel and weld to the end plate; plug drains; do not plug vents.

2.2.7 Air Space

Provide continuous 25 mm 1 inch minimum air space between carrier pipe insulation and casing.

2.2.8 Casing Coating

Coating must be rated for a minimum of 25 years by the manufacturer for continuous service at a temperature of 110 degrees C 230 degrees F. Apply coating in accordance with the coating manufacturer's instructions, factory inspect for holidays and repair as necessary.

2.2.8.1 Fusion-Bonded Epoxy

Use fusion-bonded epoxy casing coating with a minimum thickness of 1 mm 0.04 inches.

2.2.8.2 Urethane Elastomer

Use urethane elastomer coating with a minimum thickness of 1 mm 0.04 inches.

2.2.9 Coating of End Plates and Conduit Extending into Manholes

Coat end plates and conduit extending into manholes with a zinc-rich coating conforming to AASHTO M 300 Type IA, except that volatile organic compounds must not exceed 0.34 kg/L 2.8 pounds/gallon. Apply zinc-rich coating in accordance with the coating manufacturer's requirements including surface preparation. Do not apply additional top coat.

2.2.10 Carrier Pipe Guides

Space carrier pipe guides 3 m 10 feet on centers maximum, no more than 1.5

m 5 feet from pipe ends, with a minimum of three guides per elbow section. Design guides to allow thermal expansion without damage, provide proper pipe guiding, and to allow horizontal movement in two directions as required at expansion loops and bends. Design supports to permit flow of water and air vapor through the support. Extend pipe insulation through the pipe guides and protect by steel sleeves. Design guides to negate metal-to-metal contact between the casing and the carrier pipe. Do not compress insulation or non-metallic material used to ensure no metal-to-metal contact by the weight of the carrier pipe when full of water.

2.2.11 Anchor Plates

Anchor plate must be ASTM A36/A36M steel, welded to carrier pipe and casing, 13 mm 1/2 inch minimum thickness, with passages for air flow and water drainage through the annular air space in the system. Coat exterior surface of the anchor plate with the same coating material as the casing.

2.2.12 Field Connection of Casing Sections

Field connect casing using a compatible steel section, welded to casing sections, coated on all surfaces with UHDS manufacturer's coating field repair compound, and covered with a 1.3 mm 0.05 inch minimum thickness polyethylene shrink sleeve designed for a service temperature exceeding 80 degrees C 176 degrees F.

2.2.13 Manufacturer's Identification

Provide embossed brass or stainless steel tag, hung by brass or stainless steel chain at each end of each conduit or insulated piping in the manholes and buildings. Identify UHDS manufacturer's name, date of installation, Government contract number, and manufacturer's project number.

2.3 FACTORY FABRICATED, DIRECT-BURIED WSL SYSTEM

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NOTE: Contact HQ before allowing this system to be in the contract.
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2.3.1 WSL Steam and Carrier Pipes

Pipe material requirements must be in accordance with paragraph HEAT DISTRIBUTION PIPING. Provide steel pipe with the ends machined and metallized to provide a satisfactory sealing surface for the sealing rings. The metallizing must be a high nickel alloy applied to an excess thickness and then machined to the required OD.

2.3.2 WSL Condensate Carrier Pipes

Carrier piping for condensate return systems must be steel, schedule 80. Pipe requirements must be in accordance with paragraph HEAT DISTRIBUTION PIPING. Do not locate condensate piping in casings which contain any other piping.

2.3.3 Casing for Steam and Condensate

Provide casing consisting of reinforced thermosetting resin pipe (RTRP)

manufactured by the filament winding process. Ensure casing pipe is wound to meet ASTM D2310 classification RTRP and ASTM D2996. Provide a polyester isothalic resin. Coat the outer surface with a pigmented, protected resin containing a paraffinated wax and ultraviolet inhibitors. Casing thickness is as follows:

Carrier Pipe Size (mm) (Inches)	Casing Thickness (mm) (Inches)
50 2	5 0.185
80 3	5 0.185
100 4	5 0.185
150 6	6.5 0.250
200 8	6.5 0.250
250 10	6.5 0.250
300 12	6.5 0.250

2.3.4 Pipe Coupling, Steam

Provide a multi-stage seal coupling designed to accommodate the expansion and contraction of the system in the coupling. Provide coupling consisting of corrosion resistant materials capable of handling the design characteristics of the system listed in paragraph Rated Characteristics. Specifically design the annular seals and carrier pipe ends to protect the seals and resist abrasion due to lateral loads in the system.

2.3.5 Pipe Coupling, Condensate

Provide coupling of a single stage seal design to accommodate the expansion and contraction of the adjacent pipes. Provide coupling consisting of corrosion resistant materials capable of handling the design characteristics of the system listed in paragraph Rated Characteristics. Specifically design the annular seals and carrier pipe ends to protect the seals and resist abrasion due to lateral loads in the system.

2.3.6 WSL Carrier Pipe Insulation

Provide insulation conforming to minimum thicknesses and type listed for WSL systems in Tables 1 and 2 as required for temperature in carrier pipe. Provide insulation consisting of an inner layer of high temperature calcium silicate and an outer layer of polyurethane foam.

2.3.6.1 Calcium Silicate for Steam Systems

Provide calcium silicate insulation consisting of a hydrous material satisfactory for temperatures to 650 degrees C 1200 degrees F. Ensure calcium silicate insulation conforms to ASTM C533. The physical properties are as follows:

a. Density (dry): 208 kg/cubic meter 13 pcf (minimum).

b. Compressive Strength to produce 5 percent compression: 1723 kPa 250 psi (For 37 mm 1.5 inch thick sample).

c. Maximum linear shrinkage after 24 hour soaking period at 650 degrees C 1200 degrees F: 1.1 percent

d. Maximum Thermal Conductivity k: k = W/(meter*K) k = BTU-IN/HR-FT2-DEG.F). Where k varies with temperature as shown:

e.

Mean Temp (degrees C F)	k
38 100	0.04 0.38
93 200	0.04 0.41
149 300	0.04 0.44
204 400	0.04 0.48

2.3.6.2 Polyurethane Foam for Steam and Condensate Systems

Provide polyurethane foam conforming to ASTM C591. Completely fill the annular space between the calcium silicate insulation and the casing for the steam pipe and between the carrier pipe and the casing for condensate return system with the polyurethane foam. Use polyurethane foam insulation that meets the following requirements:

a. Type: Two component urethane.

b. Compressive Strength: 172 kPa 25 psi parallel to rise (minimum at 50 percent compression).

c. Shrinkage: None at -1 to 21 degrees C 30 to 70 degrees F.

d. Free Rise Density: 32 kg/cubic meter 2 pcf.

e. Maximum aged k (32 degrees C 90 degrees F at 90 percent RH for 72 hours): 0.02 W/mK 0.14 (BTU-IN/HR FT2-DEG. F) at 24 degrees C 75 degrees F, when tested in accordance with ASTM C518.

f. Minimum Closed Cell Content: 90 percent

2.3.6.3 Insulation Concentricity

Ensure carrier pipe is concentric in relation to the casing pipe. The allowable maximum deviation from center line of the carrier pipe is plus or minus 6 mm 1/4 inch at the casing center point and plus or minus 1.5 mm 1/16 inch at the end seals.

2.3.6.4 Insulated Fittings

Provide fittings that are pre-insulated by manufacturer using the same insulation thickness and casing as the straight sections.

2.3.6.5 Coupling Insulation for Steam Systems

Use material composed of refractory composite to lock the bronze coupling

in the casing. Ensure the approximate minimum conductivity of this material is 0.2 W/(m*K) 1.6 (BTU/HR/F/IN DEG.F) at a mean temperature of 1260 degrees C 2300 degrees F.

2.3.6.6 Coupling Insulation for Condensate

Insulate the coupling with polyurethane foam as specified. Use an insulation thickness equal to the carrier pipe insulation. Encase the coupling in the same casing as the pipe.

2.3.7 Manufacturer's Identification

Provide an embossed brass tag hung by a brass chain, or a stainless steel tag hung by a stainless steel chain, at each end of each casing or insulated piping in the manholes and buildings. Identify UHDS manufacturer's name and date of installation.

2.3.8 End Seals

Each preinsulated section of piping must completely seal the insulation, providing a permanent water and vapor seal at each end. Provide preinsulated factory fabricated sections of piping modified in the field with an end seal which is equivalent to the end seals furnished with the preinsulated section of piping. Conduct tests by the UHDS manufacturer to demonstrate that casings, couplings and end seals are capable of resisting penetration of water into the casing and insulation under rated conditions. Perform tests on each type of pre-fabricated system to be furnished, and verify the test results by an independent testing laboratory. Test and certify the steam systems in accordance with paragraph Test of WSL Systems for Steam Service. Test and certify the condensate return system in accordance with paragraph Test of WSL Systems for Condensate Return Service.

2.3.8.1 End Seals for Steam Service

Provide elastomer-ring type end seals designed and dimensioned to fit in the annular space between the casing and the carrier pipe. Use multi-polymer alloy film type tape, which is compatible with synthetic elastomeric tape and suitable for cold application, for covering field repair joints.

2.3.8.2 End Seals for Condensate Return Service

Provide one of the following types of end seals:

a. Carrying the outer casing over tapered pipe insulation ends and extending it to the carrier pipe. Provide sufficient surface bonding area between the casing and the carrier pipe.

b. Using specially designed molded caps made of polyethylene or rubber of standard manufactured thickness. Provide a minimum 40 mm 1-1/2 inch surface bonding area between the cap and both the casing and carrier pipe.

c. Using elastomer-ring end seals designed and dimensioned to fit in the annular space between the casing and the carrier pipe.

d. Using a waterproof mastic seal vapor barrier over the exposed insulation ends.

e. Shrink sleeves.

2.3.9 Test of WSL Systems for Steam Service

Demonstrate that the WSL system will operate successfully for 25 years under typical operating conditions. Conduct tests in both a dry and wet environment. Provide WSL system as described in the manufacturer's brochure. Conduct the testing program described below at the expense of the WSL system manufacturer. Ensure tests are witnessed and verified by an independent testing laboratory. Hydrostatically test the entire pre-insulated test section with water to 2600 kPa 375 psig (1.5 times the rated pressure) before and after temperature cycling. Conduct tests in a dry environment for 60 cycles followed by a test in a wet environment for 60 cycles for a total of 120 cycles. The test in the wet environment demonstrates resistance to ground water infiltration. Conduct all tests on one test section and complete all testing in one time period (approximately 6 weeks) and continue the 120 testing cycles except for weekend time periods.

2.3.9.1 Apparatus

Use a curved bottom test tank at least 3.7 m 12 feet long, 0.8 m 32 inches wide, 0.8 m 32 inches deep. Fit the tank with a gasketed and bolted cover to pressurize the tank to 60 kPa 8.67 psig. Provide a drain at the lowest point and a vent at the highest point. Centrally locate manhole entrance sleeves (i.e. wall sleeves through the ends of the tank to simulate manhole entries in actual field conditions) on each end of the tank. Include the following auxiliary equipment: Steam supply with sufficient capacity to satisfy testing requirements, makeup water tank and pump, and a means for continuously recording temperatures and pressures at needed locations. Use thermocouples to record temperatures at the following points:

a. Carrier pipe at tank inlet (in thermowell).

b. Casing at mid-point in pipe length (on casing).

c. Casing at anchor point (above FRP overwrap on plate).

d. Casing at field joint (repair, on casing).

e. Casing at coupling mid-point (on casing).

f. End seal flange at coupling (on elastomer).

g. Outer edge of new end plate (at steel plate and FRP wrap).

h. Carrier pipe at specimen outlet end (in thermowell).

i. Interface of calcium-silicate and polyurethane insulations.

Ensure surface thermocouples are epoxied to the surface of the casing. Check and record the calibration of the thermocouples prior to installation and record within 0.06 degree C 0.1 degree F resolution. Provide pressure transmitter(s) to record pressure in the test tank and carrier pipe internal pressure, at the inlet to test specimen.

2.3.9.2 Test Section

Provide a 100 mm 4 inch steel carrier pipe test section consisting of 8 m 27 feet of pre-insulated pipe meeting specified materials and design requirements. Encase approximately 3.7 m 12 feet of the test section within the tank as described below. Provide test section within the tank consisting of an expansion coupling, field repair joint, anchor plate, anchor block and end seals. Install the test section (as directed) on at least 280 mm 11 inches of firmly tamped sand. Surround the casing with sand, and ensure the top surface of the sand is no farther than 100 mm 4 inches from the top of the tank. Anchor the test section to the tank wall at one end and the building floor at the other end on the portion of the pipe external to the tank. The expansion coupling must be misaligned by 1.5 degrees in the horizontal plane. Introduce sand (118 mL 4 fluid oz) into the carrier pipe and disburse throughout the test loop at startup.

2.3.9.3 Resistance to Water Damage and Joint Leakage

This test must simulate the operation of the WSL system to assure the system will provide successful service life through its expected life span. Test the system in steam service by cycling for an extended period of time, as described below. Deem system performance successful if there is no joint leakage, deformation of the casing, deterioration of the end seals, or any other deleterious effects.

a. Subject the piping system to 60 cycles of steam introduced into the system while at ambient temperature 38 degrees C 100 degrees F up to a temperature of 207 degrees C 406 degrees F (as measured at the core pipe at the tank inlet and tank outlet) and back to ambient temperature. Hold the system at 207 degrees C 406 degrees F minimum for a minimum of 30 minutes, each cycle. Continue this cycling for 60 cycles in dry sand followed by 60 cycles in a saturated environment. Allow the reduction in temperature to 38 degrees C 100 degrees F to occur naturally with no artificial means of cooling used.

b. Ensure results conform to paragraph Criteria for Satisfactory Results and Reporting.

2.3.9.4 Resistance to Mechanical or Structural Damage

This test must simulate loads induced by truck traffic over pipe, which can occur under actual operating conditions. Conduct this test commencing with the 41st cycle of the resistance to water damage and joint leakage test and continue through the 60th cycle. Continue other aspects of the resistance to water damage and joint leakage test simultaneously with this test.

2.3.9.4.1 Apparatus

Same as for apparatus used in resistance to ground water infiltration test with the addition of a 96 kPa 2000 psf loading device. Use a hydraulic jack to apply the test pressure against a 500 by 500 mm 18 by 18 inch plate bearing on the sand directly over the coupling in the tank.

2.3.9.4.2 Procedure

Apply a steady and constant vertical load of 96 kPa 2000 psf to the plate for 14 days during the test. Install the test section as in the resistance to ground water infiltration test. During the 14 day loading

period, circulate steam through the carrier pipe alternately at ambient and 207 degrees C 406 degrees F as in earlier test.

2.3.9.4.3 Results

Requirements must be in accordance with paragraph Criteria for Satisfactory Results and Reporting.

2.3.9.5 Resistance to Ground Water Infiltration

This test is the wet environment test conducted during the second 3 weeks (61st to 120th cycles) of the test period to show that the WSL system will resist the penetration of ground water into the system.

2.3.9.5.1 Apparatus

Same as for basic apparatus used in Resistance to Water Damage and Joint Leakage phase test, plus the following:

a. One 200 L 50 gallon water reservoir with a 0 to 206 kPa 0 to 30 psig pressure gauge and compressed air connection.

b. Provisions to introduce pressurized red dye into the curved bottom test tank. Mix the water/dye solution to a concentration in accordance with the dye manufacturer's recommendation for maximum detectability.

c. One pressure tank with 0 to 206 kPa 0 to 30 psig static pressure gauge.

2.3.9.5.2 Procedure

Start this phase on the 61st cycle and continue until the 120th cycle. The test section of pipe must be the same test segment used in the previous tests. Bolt the tank cover in place and begin the resistance to ground water infiltration test. Attach the water/dye source to the fill fitting and attach a surge tank to the vent with a tee fitting. Attach a 0 to 206 kPa 0 to 30 psig static pressure gauge to the pressure tank. The other branch of the tee fitting must employ a shut-off valve. With the shut-off valve open, admit the water/dye mixture into the tank through the fill fitting until the tank is full and water/dye runs freely from the open valve. Close the valve and continue filling until the pressure reaches 60 kPa 8.67 psig. Maintain the tank pressure throughout the test period. Circulate steam through the carrier pipe and cycle from ambient to 207 degrees C 406 degrees F as in the previous test. At the end of the test, relieve the pressure by opening the vent valve and drain the water/dye from the tank through the drain fitting.

2.3.9.5.3 Results

Requirements must be in accordance with paragraph Criteria for Satisfactory Results and Reporting.

2.3.9.6 Criteria for Satisfactory Results and Reporting

2.3.9.6.1 Reporting

Record logs of times and temperature to assure compliance with test requirements and procedures. Produce complete photographic documentation of the construction and operation of the test facility, as well as the

piping system components before and after testing. Analyze data to assure complete compliance with test objectives.

2.3.9.6.2 Drawing

Provide a drawing showing details of the test apparatus and test specimen.

2.3.9.6.3 Resistance to Water Damage and Joint Leakage Test

Remove joints and end seals for examination, immediately upon completion of all test cycles. Successful results must show that steam has not leaked out of the carrier pipe and that the components show no signs of deterioration.

2.3.9.6.4 Resistance to Mechanical or Structural Damage Test

At the end of testing, inspect the casing for damage or deformation which would impair the functionality of the system. Successful test results consist of no ruptures in the casing, the casing has not deformed more than 25 mm 1 inch in any direction, and no separation has occurred between the casing and the pipe anchor interface.

2.3.9.6.5 Resistance to Ground Water Infiltration Test

Determine no water/dye solution has penetrated the insulation. This test is determined by removing and inspecting all joints and seals for dye penetration at the end of the test. Results will be deemed successful if no dye solution is evident in the insulation.

2.3.9.6.6 Evidence of Test Results

After completion of all tests, dismantle the test apparatus for visual inspection of all critical components subjected to the heat cycling, water infiltration and loading tests. All parts will be examined thoroughly for any detrimental affects. Conduct identified examinations. Keep log sheets, test data and color photographs on file and make available as required to document and substantiate compliance to the test requirements.

2.3.9.6.7 Report

Submit a report from the independent testing agency. The report must include the laboratory analysis of the condition of the test section and attest that the testing conditions were followed.

2.3.10 Test of WSL Systems for Condensate Return Service

Submit test reports in booklet form showing all factory and field tests performed to prove compliance with the specified performance criteria, upon completion and testing of the installed system. Use testing and certification procedures by an independent testing laboratory to demonstrate that casings and end seals are capable of resisting penetration of water into the casing and insulation. Perform the test on the type of prefabricated system to be furnished. If more than one type of prefabricated system is to be used, perform the tests on each type. Perform test consisting of hot and cold cycle testing followed by immersion in a water filled chamber with a head pressure. The hot and cold cycle testing must consist of 14 days of temperature cycling.

a. Circulate a fluid with a temperature of 5 degrees C 40 degrees F

through the carrier pipe, alternating every 24 hours with a fluid with a temperature of 95 degrees C 200 degrees F circulating through the carrier pipe for a low temperature hot water or dual temperature service, or 24 degrees C 75 degrees F for a chilled water service.

b. While the hot and cold cycle test is being performed, either bury or encase the test sample in dry bedding sand with a minimum of 300 mm 12 inches of sand all around the test sample. Ensure the carrier pipe size of the test sample is 75 mm 3 inches in diameter and restrain during the test period. The insulation thickness must not exceed the maximum thickness provided for the piping in the project.

c. Transition time for temperature cycle testing must not exceed 15 minutes in going from cold to hot and 30 minutes in going from hot to cold. The fluid in the carrier pipe may be water, oil or heat transfer fluid. Following the hot and cold cycling test, immerse the test sample in a water filled chamber. The pressure on the highest point of the test sample must not be less than 60 kPa 20 feet of water head pressure subjected over the entire length of the 2.4 m 8 foot test sample of prefabricated pipe.

d. Use water containing a dye penetrant to check for end seal leakage. Hold the pressure in the chamber for no less than 48 hours. Upon completion of this pressure test, cut open the test sample. With the use of a light that will readily show the presence of the dye that was in the water, inspect the test sample. Evidence of the dye inside the test sample indicates that the end seal is not acceptable and cannot be certified.

2.4 WATER SPREAD LIMITING POURED-IN-PLACE INSULATION (PIPI) SYSTEM

2.4.1 PIPI Steam and High Temperature Hot Water Carrier Pipes

Requirements must be in accordance with paragraph HEAT DISTRIBUTION PIPING.

2.4.2 PIPI Condensate Carrier Pipes

Provide steel, schedule 80 carrier piping for condensate return systems. Ensure pipe requirements are in accordance with paragraph HEAT DISTRIBUTION PIPING.

2.4.3 PIPI Carrier Pipe Insulation

Provide carrier pipe PIPI conforming to minimum thickness and type listed in Tables 1, 1A, 2, and 2A as required for temperature specified under paragraph Rated Characteristics.

2.4.4 Poured-in-Place Insulation - Physical Properties

Provide poured-in-place insulation consisting of calcium carbonate powder chemically modified to be hydrophobic with no particles exceeding 1 mm in any dimension. The installed density must fall in the range of 960 to 992 kg/cubic meter 40 to 62 lb/cubic foot when tested in accordance with ASTM D1895. Perform additional product testing at the identified installed density in accordance with ASTM C177.

2.4.5 Poured-in-Place Insulation - Thermal Properties

The thermal conductivity of the PIPI must not exceed 0.083 W/mK 0.58

Btu-in/hr-square foot-degree F at 37.8 degrees C 100 degrees F, and 0.099 W/mK 0.68 Btu-in/hr-square foot-degree F at 149 degrees C 300 degrees F, when tested in accordance with ASTM C177.

2.4.6 Poured-in-Place Insulation - Electrical Properties

Ensure the electrical resistivity of the PIPI is not less than 1 by 10 to the 12th power ohm-cm.

2.4.7 PIPI System Piping Anchors, Supports, and Guides

Ensure the design and location of pipe anchors, pipe supports, pipe guides, and expansion cushions are in compliance with the most recent design manual available from the PIPI manufacturer.

2.4.8 PIPI Envelope Penetrations

Design penetrations through the PIPI envelope in compliance with the most recent design manual available from the PIPI manufacturer. Coat all pipe anchors, pipe supports, pipe guides and manhole walls that come in contact with the PIPI with a mastic compound. For pipe service temperatures up to 204 degrees C 400 degrees F, use a mastic compound consisting of bitumastic coal tar. For pipe service temperatures in excess of 204 degrees C 400 degrees F, use silicone grease.

2.5 PIPE INSULATION TYPE AND MINIMUM THICKNESS

****
NOTE: Delete inapplicable columns in Tables 1 and 2.
****

Comply with EPA requirements in accordance with Section 01 33 29 SUSTAINABILITY REQUIREMENTS AND REPORTING. Materials containing asbestos will not be permitted. The minimum thickness of insulation for the heat distribution system must be in accordance with Tables 1, 1A, 2, and 2A in which the insulations listed have passed the 96 hour boiling water test. If PIPI Manufacturer has installation requirements which exceed minimum thickness of material within Tables 1A and Table 2A. Comply with the Manufacturers installation requirements.

TABLE 1
MINIMUM PIPE INSULATION THICKNESS (mm) (Inches)

For Steam (100 to 2,800 kPa (gage)) (16 to 408 psig) and High Temperature Hot Water Supply and Return (120 to 230 degrees C) (250 to 450 degrees F)

	INSULATIONS for Drainable/Dryable Systems		INSULATIONS for Other Pre-Engineered Systems	
Nominal Pipe Diameter (mm) (inches)	Aerogel ASTM C1728 Type III Grade 1A	Mineral Wool ASTM C547 Type III Grade A	Calcium Silicate	WSL Polyurethane
25 1.0	25 1.0	75 3.0	N/A	N/A
40 1.5	35 1.5	75 3.0	N/A	N/A
50 2.0	35 1.5	75 3.0	N/A	N/A
65 2.5	35 1.5	75 3.0	N/A	N/A
80 3.0	35 1.5	75 3.0	35 1.5	+31 +1.23
100 4.0	50 2.0	85 3.5	35 1.5	+31 +1.23
125 5.0	50 2.0	85 3.5	N/A	N/A
150 6.0	50 2.0	85 3.5	35 1.5	+34 +1.34
200 8.0	50 2.0	85 3.5	50 2.0	+30 +1.21
250 10.0	50 2.0	100 4.0	65 2.5	+33 +1.31
300 12.0	50 2.0	100 4.0	50 2.0	+32 +1.29
350 14.0	50 2.0	100 4.0	N/A	N/A
400 16.0	50 2.0	100 4.0	N/A	N/A
450 18.0	50 2.0	100 4.0	N/A	N/A

TABLE 1A
MINIMUM PIPI THICKNESS (mm) (Inches)

For Steam (100 to 2,800 kPa (gage)) (16 to 408 psig) and High Temperature Hot Water Supply and Return (120 to 230 degrees C) (250 to 450 degrees F)

Nominal Pipe Diameter (mm) (inches)	Sides and Bottom	Between Pipes	Above Pipes
25 1.0	100 4.0	50 2.0	200 8.0
40 1.5	100 4.0	50 2.0	210 8.5
50 2.0	100 4.0	50 2.0	210 8.5
65 2.5	100 4.0	50 2.0	225 9.0
80 3.0	100 4.0	50 2.0	225 9.0
100 4.0	125 5.0	50 2.0	275 11.0
125 5.0	125 5.0	75 3.0	275 11.0
150 6.0	150 6.0	75 3.0	340 13.5
200 8.0	150 6.0	100 4.0	350 14.0
250 10.0	150 6.0	100 4.0	360 14.5
300 12.0	175 7.0	100 4.0	425 17.0
350 14.0	175 7.0	100 4.0	425 17.0
400 16.0	200 8.0	125 5.0	490 19.5
450 18.0	200 8.0	125 5.0	490 19.5

TABLE 2 MINIMUM PIPE INSULATION THICKNESS (mm) (Inches) CONDENSATE RETURN			
	INSULATIONS for Drainable/Dryable Systems		INSULATIONS for Other Pre-Engineered Systems
Nominal Pipe Diameter (mm) (inches)	Aerogel ASTM C1728 Type III Grade 1A	Mineral Wool ASTM C547 Type III Grade A	Polyurethane
25 1.0	25 1.0	35 1.5	N/A
40 1.5	25 1.0	35 1.5	N/A
50 2.0	25 1.0	35 1.5	19 0.77
65 2.5	25 1.0	35 1.5	N/A
80 3.0	25 1.0	50 2.0	26 1.05
100 4.0	25 1.0	50 2.0	26 1.05
125 5.0	25 1.0	50 2.0	N/A
150 6.0	25 1.0	63 2.5	30 1.32
200 8.0	25 1.0	63 2.5	N/A
250 10.0	25 1.0	76 3.0	N/A
300 12.0	25 1.0	76 3.0	N/A
350 14.0	25 1.0	76 3.0	N/A
400 16.0	25 1.0	76 3.0	N/A
450 18.0	25 1.0	76 3.0	N/A

TABLE 2A MINIMUM PIPI THICKNESS (mm) (Inches) CONDENSATE RETURN		
Nominal Pipe Diameter (mm) (inches)	Sides and Bottom	Above
25 1.0	75 3.0	160 6.5
40 1.5	75 3.0	160 6.5

TABLE 2A
MINIMUM PIPI THICKNESS (mm) (Inches)
CONDENSATE RETURN

Nominal Pipe Diameter (mm) (inches)	Sides and Bottom	Above
50 2.0	75 3.0	160 6.5
65 2.5	100 4.0	175 7.0
80 3.0	100 4.0	175 7.0
100 4.0	100 4.0	225 9.0
125 5.0	100 4.0	240 9.5
150 6.0	100 4.0	240 9.5
200 8.0	125 5.0	300 12.0
250 10.0	150 6.0	310 12.5
300 12.0	150 6.0	360 14.5
350 14.0	175 7.0	375 15.0
400 16.0	175 7.0	375 15.0
450 18.0	175 7.0	440 17.5

2.6 HEAT DISTRIBUTION PIPING

2.6.1 Steam and High Temperature Hot Water Pipe

Pipe material must be steel; seamless ASTM A53/A53M, Grade B or ASTM A106/A106M, Grade B; or electric resistance welded ASTM A53/A53M, Grade B; Schedule 40. Standard weight will be permitted for pipe sizes 300 mm 12 inches and above. ASTM A53/A53M, Type F furnace butt welded pipe will not be allowed. Joints will not be allowed in factory fabricated straight section of carrier pipes. Provide factory fabricated piping sections, as part of an expansion loop or bend, with all welded joints 100 percent radiographically inspected in accordance with ASME B31.1. Ensure radiographs are reviewed and interpreted by a Certified American Society for Nondestructive Testing (ASNT) Level III radiographer, employed by the testing firm, who will sign the reading report.

2.6.2 Condensate Pipe

Pipe must be steel; seamless ASTM A53/A53M, Grade B or ASTM A106/A106M, Grade B, schedule 80; electric resistance welded ASTM A53/A53M, Grade B; Schedule 80. ASTM A53/A53M, Type F furnace butt welded pipe will not be allowed. Joints will not be allowed in the factory fabricated straight section of the carrier pipe. Provide factory fabricated piping sections, as part of an expansion loop or bend with all welded joints 100 percent radiographically inspected in accordance with ASME B31.1. Ensure radiographs are reviewed and interpreted by an ASNT Certified Level III

radiographer, employed by the testing firm, who will sign the reading report.

2.6.3 Joints

Provide butt-weld joints except socket-weld joints are permitted for pipe sizes 50 mm 2 inches and smaller. Dye penetrant may be used in place of 100 percent radiographic inspection for pipe sizes 50 mm 2 inches and below. Indicate location and elevation of all field joints on detailed design layout drawings. Split-ring welding rings may be used.

2.6.4 Fittings

Radiographically inspect welds in factory fittings. Ensure radiographs are reviewed and interpreted by a Certified ASNT Level III radiographer, employed by the testing firm, who will sign the reading report. The Contracting Officer may review all inspection records, and if any welds inspected are found unacceptable in accordance with ASME B31.1, remove, replace, and radiographically reexamine the fitting at no cost to the Government.

2.6.4.1 Butt-Welded

Fittings must be steel; ASTM A234/A234M, Grade B or ASME B16.9, same schedule as adjoining pipe. Provide long radius elbows unless otherwise indicated. Provide full size or reducing tees as required, with interior surfaces smoothly contoured. Split-ring welding rings may be used.

2.6.4.2 Socket-Welded

Use forged steel ASME B16.11; 13,800 kPa 2000 pound class fittings for pipe sizes 50 mm 2 inch and below. Dye penetrant inspection may be used in lieu of radiographic inspection of welded fittings for pipe sizes 50 mm 2 inches and below.

2.7 EXPANSION LOOPS AND BENDS

Ensure stresses are less than the maximum allowable stress from the Power Piping Code (ASME B31.1). Submit pipe-stress and system-expansion calculations for each expansion compensation elbow using a finite element computer generated 3 dimensional analysis, no later than [7 days] after notice to proceed. Demonstrate with calculations that pipe stresses from temperature changes are within the allowable requirements in ASME B31.1 and that the anchors and the guides will withstand the resultant forces. Include all analysis node points in the detailed design layout drawings. As a minimum, include node stresses, forces, moments and displacements in computer analysis results. Ensure calculations are stamped by a registered Professional Engineer in the employ of the UHDS manufacturer. Provide detailed design layout drawings and stress and anchor force calculations for all loops and bends. Show locations of all anchors, guides and supports. Base calculations on design characteristics (pressures and temperatures) specified for both the supply and return lines.

PART 3 EXECUTION

3.1 PREPARATION

3.1.1 Job Conditions

Phasing of [demolition and construction] [construction] must be as shown on contract drawings.

3.1.2 Interruption of Existing Service

Submit schedule of proposed outages and interruptions of existing services, [14 days][_____] in advance. Arrange, phase and perform work and provide temporary facilities, materials, equipment, and connections to utilities, to ensure adequate heat distribution service for existing installations at all times. Only necessary interruptions required for making connections will be permitted, and only at times when approval is obtained from the Contracting Officer. All interruptions are to be scheduled with and approved by the Contracting Officer.

3.1.3 Grading

Unless otherwise shown on the contract drawings or the detailed design layout drawings, grade steam/condensate and high temperature hot water supply/return lines uniformly downward no less than 25.4 mm in 6.10 meters 1.0 inches in 20 feet to the lower point of entry between manholes and/or building entries.

3.1.4 Connecting to Existing Work

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NOTE: Any connections to the UHDS distribution will only occur in manholes. Designer must ensure that a thorough survey of the aboveground and underground conditions is performed. The contract drawings must identify all potential interferences or conflicts.

****

Submit changes required to the UHDS design due to interferences or conflicts, upon realization of interferences or conflicts. Connect new work to existing work to complete piping connections that enable pressure tests with successful outcomes per the requirements of this specification. Make connections only in manholes. Where an existing structure must be cut or existing utilities interfere, bypass, remove, replace or relocate, restore and repair such obstructions. Obtain approval from the UHDS designer and the Contracting Officer for any changes required to the UHDS design as a result of interferences or conflicts. Restore disturbed or damaged work to its prior condition.

3.1.5 Coordination

Coordinate the location of all items of equipment and work of all trades. Maintain operability and maintainability of the equipment and systems.

3.1.6 Variations

Submit any variations from the approved detailed design layout drawings to the Contracting Officer for approval. Ensure variations are signed and sealed by the UHDS manufacturers' professional engineer responsible for

the complete design of the UHDS.

3.2 DEMOLITION

****
NOTE: Ensure that Section 02 41 00 DEMOLITION AND DECONSTRUCTION is included in project specifications. Demolition work should be well defined in the drawings and specifications; photographs should be included in the contract package, if available.
****

3.2.1 Demolition Procedures

Perform work in accordance with requirements for phasing. Remove pipe, valves, fittings, insulation, and hangers, including the connection to the structure and any fastenings. Seal openings in manhole or building walls after removal of piping. Material and equipment removed is the property of the Contractor and will be removed from the Government property within 1 week and do not store in operating areas. Perform flame cutting with adequate fire protection facilities available as required by safety codes and Contracting Officer.

3.2.2 Asbestos Removal

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NOTE: Existing systems may include asbestos containing materials. Provisions must be made for an asbestos survey to be performed and abatement measures to be included in project specification if necessary.
****

Remove asbestos in conformance with Section 02 82 00 ASBESTOS REMEDIATION.

3.3 PIPE, PIPING JOINTS AND FITTINGS

3.3.1 Joint Preparation

Clean pipe and fittings inside and outside before and after assembly. Remove dirt, scale, and other foreign matter from inside the piping by use of a pipe swab or pipe pig before connecting pipe sections, valves, equipment or fittings. Use eccentric connectors as needed between casing sections to provide drainage of casing section between manholes and between manholes and buildings.

3.3.2 Direction Changes

Make changes in direction with factory-built reinforced fittings. Field-fabricated fittings and miters are not permitted.

3.4 WELDING

Submit Certification of Acceptability of all welds made in the field, upon completion of the project. This certification consists of a letter, signed by an official of the independent testing firm or firms examining welds, stating that all provisions of this specification have been complied with, and that all welds inspected radiographically have met the

specified acceptability standards. The Contractor will be responsible for welding quality and must:

a. Conduct tests of the welding procedures used in the work, determine the suitability of the procedures used, determine that the welds made will meet the required tests, and determine that the welding operators have the ability to make sound welds under standard conditions.

b. Comply with ASME B31.1.

c. Perform all welding operations required for construction and installation of the heat distribution system.

3.4.1 Qualification of Welders

Rules of procedure for qualification of all welders and general requirements for fusion welding must conform with the applicable portions of ASME B31.1, and as outlined below.

3.4.2 Examining Welders

Examine each welder to determine the ability of the welder to meet the required qualifications. Test welders for welds in all positions, including welds with the axis horizontal (not rolled) and with the axis vertical. Each welder must:

a. Weld only in positions in which they have qualified.

b. Identify welds with the specific code marking signifying name and number assigned.

3.4.3 Examination Results

Provide a list of welder's names and corresponding code markings. Retest welders who fail to meet the prescribed welding qualifications. Welders who fail the second test sre disqualified for work on this project.

3.4.4 Beveling

Make field and shop bevels by mechanical means or by flame cutting. Where beveling is done by flame cutting, thoroughly clean surfaces of scale and oxidation just prior to welding.

3.4.5 Alignment

Use split welding rings for field joints on carrier pipes above 50 mm 2 inches to assure proper alignment, complete weld penetration, and prevention of weld spatter reaching the interior of the pipe. Make field joints 50 mm 2 inches and smaller with welding sockets.

3.4.6 Erection

Do not split, bend, flatten, or otherwise damage piping before, during, or after installation. Where the pipe temperature falls to 0 degrees C 32 degrees F or lower, heat the pipe to approximately 38 degrees C 100 degrees F for a distance of 300 mm 1 foot on each side of the weld before welding, and finish the weld before the pipe cools to 0 degrees C 32 degrees F.

3.4.7 Defective Welds

Replace and reinspect defective welds in accordance with ASME B31.1. Repairing defective welds by adding weld material over the defect or by peening is not permitted. Ensure welders responsible for defective welds are tested for qualification.

3.4.8 Electrodes

Store electrodes in a dry, heated area, and keep free of moisture and dampness during fabrication operations. Do not use electrodes that have lost part of their coating.

3.4.9 Radiographic Testing

An approved independent testing firm regularly engaged in radiographic testing must perform radiographic examination of 100 percent of the field welds in the carrier piping of direct-buried systems in accordance with ASME B31.1. Provide the following: a set of films showing each weld inspected, a reading report evaluating the quality of each weld, and a location plan showing the physical location where each weld is to be found in the completed project, prior to installing casing field joints, backfilling and hydrostatic testing. Ensure all radiographs are reviewed and interpreted by a Certified American Society for Nondestructive Testing Level III radiographer, employed by the testing firm, who will sign the reading report. The Contracting Officer may review all inspection records, and if any welds inspected are found unacceptable, the Contractor must remove, reweld, and radiographically reexamine welds at no cost to the Government.

3.5 HEAT DISTRIBUTION SYSTEM INSTALLATION

Submit a complete description of the design and assembly of the system, materials of construction and field installation instructions, not later than [21 days][_____] prior to the start of field measurements. Include sufficient system details to show that the specified minimum insulation thickness has been met. A detailed design layout of the system (plan and elevation views) showing size, type, elevations and location of each component to be used in the system, the design and location of anchors, pipe guides, pipe supports, expansion loops, Z-bends, L-bends, end seals, leak plates, joint locations, pipe and insulation thickness and sizes, types, and movements, connection to manhole and building wall penetrations, and including, if applicable, details of transition point to aboveground or other type systems. Also, if applicable, type and details of the cathodic protection system to be used. Ensure detailed design layout drawings are stamped by a registered Professional Engineer. The UHDS manufacturer's representative will oversee the delivery, storage, installation and testing of the system. Perform work in accordance with the requirements specified and with the printed instructions of the manufacturer. These specifications take precedence over the printed instructions if conflicts arise. Submit printed instructions to the Contracting Officer prior to system installation. Submit operation and maintenance manual listing routine maintenance procedures, possible breakdowns and repairs, procedures for recording conduit temperatures biannually, and troubleshooting guides, before completion of work. Include in the Manual as-built piping layout of the system with final elevations. Submit in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA.

3.5.1 Verification of Final Elevations

After all temporary supports have been removed and prior to covering the top of the pipe with [backfill] [PIPI] material, measure and record the elevation of the top of each pipe at each field joint, 1/3 points along each pipe section, and the top of each elbow. Check these measurements against the contract drawings and confirm that the conduit system has been installed to the elevations shown on the contract drawings. Ensure slope is uniform to within 0.1 percent. Record these measurements, include in the UHDS manufacturer's representative daily report, and give to the Contracting Officer prior to covering the casing with backfill material.

3.5.2 Excavation, Trenching, and Backfilling

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NOTE: The designer must coordinate the type of sand to be used with Section 31 00 00 EARTHWORK. Do not allow beach sand or any sand with large amounts of chlorides to be specified.

****

Perform excavation, trenching, and backfilling as required by the UHDS manufacturer's design and as specified in Section 31 00 00 EARTHWORK. Lay pipe on a 305 mm 12 inch minimum sand bed and backfill with sand on all sides to a minimum of 150 mm 6 inches as measured from outside of casing. This sand bedding requirement does not apply to the PIPI system. Provide a firm and stable foundation for the system. Ensure foundation and backfill is free from rocks or substances which could damage the system coating. Install concrete anchor and thrust blocks in undisturbed earth. Do not commence backfilling until system has been satisfactorily pressure tested (both hydrostatic test of carrier and air test of casing). Minimum depth of burial to the top of the casing (or PIPI envelope) is 1 m 39 inches or depth required for piping to be below the frost line, whichever is greater. Maximum depth of burial to the top of the casing (or PIPI envelope) must be 3 m 10 feet.

3.5.3 UHDS Manufacturer's Representative Responsibilities

The UHDS Manufacturer's representative must be present at the job site and witness when the following types of work are being performed:

a. Inspection, unloading and storage (not applicable to PIPI).

b. Inspection of trench prior to commencing installation of system.

c. Inspection of concrete anchors and thrust blocks.

d. Pneumatic and Hydrostatic testing.

e. Field joint closure work (not applicable to PIPI).

f. Air test of casing (not applicable to all WSL systems).

g. Holiday test of conduit coating (not applicable to all WSL systems).

h. Repair of any coating (not applicable to all WSL systems).

i. Installation of cathodic protection system (not applicable to all WSL systems).

j. Initial backfill up to 254 mm 10 inches above the top of the casing.

k. Verification of final elevations. Elevation readings must be witnessed and recorded.

l. Testing of cathodic protection system (not applicable to all WSL systems).

m. Startup and operational tests.

n. Radiographic weld examination.

Notify the Contractor immediately of any problems. Notify the Contracting Officer of problems requiring immediate action; otherwise, note any problems encountered and indicate the corrective actions taken in the daily reports.

3.5.4 UHDS Manufacturer's Representative Reports

The UHDS manufacturer's representative must: prepare and sign a written daily report; present the original daily report to the Contracting Officer no later than one working day after it is prepared; and forward 1 copy to the manufacturer's main office. State whether or not the condition and quality of the materials used and the delivery, storage, installation and testing of the system are in accordance with the drawings, specifications, and manufacturer's printed instructions and are satisfactory in all respects. When any work connected with the installation is unsatisfactory, state what corrective action has been taken or list the UHDS manufacturer's recommendations for corrective action. Identify any condition that could result in an unsatisfactory installation, including such items as open conduit ends left in the trench overnight and improper manhole entries. Ensure daily reports are reviewed, signed and sealed, on a weekly basis, by the registered engineer responsible for the system design. Submit signed and sealed copies of the daily reports with the payment request. Requests for payment will be denied if the weekly review is not accomplished. Upon completion of the work and before final acceptance, submit a notarized Certificate of Compliance, signed by a principal officer of both the manufacturing and the contracting firms, stating that the installation is satisfactory and in accordance with drawings, specifications, and manufacturer's instructions to the Contracting Officer. Retain a copy of all daily reports and the Certificate of Compliance for 5 years after final acceptance of the system by the Government.

3.5.5 Protection

Protect casing coating from damage during unloading, storage, rigging and installation. Protect casing and carrier pipe ends from water intrusion during unloading, storage, rigging and installation. Protect piping and accessories from damage due to exposure to UV light.

3.5.6 Defective Material

The UHDS manufacturer's representative must take prompt action to remove from the site all damaged or defective material, subject to rejection in accordance with the quality assurance provisions included in the manufacturer's submittals and printed instructions, and must order prompt replacement of such material.

3.5.7 Cathodic Protection Installation

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NOTE: Designer must indicate on the contract drawings that dielectric separation is shown where UHDS enter buildings or above transition from underground to aboveground piping.
****

Provide cathodic protection for all steel casing systems and all buried exposed metal. Assume that 25 percent of the exterior of the UHDS is exposed metal. Submit design life calculations for the cathodic protection system in accordance with NACE SP0169, not later than [7 days][_____] after notice to proceed. Ensure calculations are stamped by an NACE qualified corrosion engineer. Provide cathodic protection systems with a minimum design life of 25 years and conforming to [Section 26 42 13 GALVANIC (SACRIFICIAL) ANODE CATHODIC PROTECTION (GACP) SYSTEM] [or] [Section 26 42 17 IMPRESSED CURRENT CATHODIC PROTECTION (ICCP) SYSTEM]. Provide dielectric pipe flanges and waterways, and isolation devices at all points necessary. Provide test stations at grade on each section of the piping system. Provide dielectric waterways with temperature and pressure rating equal to or greater than that specified for the connecting piping. Provide waterways with metal connections on both ends suited to match the connecting piping. Line dielectric waterways internally with an insulator specifically designed to prevent current flow between dissimilar metals. Provide dielectric flanges meeting the performance requirements described herein for dielectric waterways.

3.6 TESTS

Submit a proposed test procedure and proposed samples of test data sheets for each required test, 30 days prior to the proposed test date. The procedure must contain a complete description of the proposed test with calibration curves or test results furnished by an independent testing laboratory of each instrument, meter, gauge, and thermometer to be used in the tests. Do not commence test until the procedure has been approved. Perform pressure tests (hydrostatic, pneumatic) and operational tests to demonstrate leak-tightness of all piping systems. Pressure test heat distribution system in conformance with specified requirements and printed instructions for the system supplied; include carrier piping and casing. Test the carrier pipe hydrostatically. Test casings of DDT systems pneumatically. Test casing and end seals of WSL system for intrusion of water into the casing and insulation. Do not use mercury in thermometers required for the tests.

3.6.1 Holiday Testing of Direct-buried System Steel Casings

Test entire exterior surface of the casing, including the bottom exterior surface, for faults in coating after installation in trench, prior to backfilling, using test method and voltage recommended by coating manufacturer. If any holidays are found, repair them and retest the coating. Do not backfill the system until all holidays are eliminated.

3.6.2 Pneumatic, Hydrostatic and Operational Tests

Before conducting heat distribution system tests, flush lines with high pressure water until [discharge shows no foreign matter] [the Contracting Officer, after examining the discharge, stops the flush].

3.6.2.1 Pneumatic Test

Pneumatically test the casing of DDT systems after welding and before field coating using air as the test medium. Use a test pressure of 103 kPa 15 psig. Keep persons not working on the test operations out of the testing area while testing is proceeding. Make the test on the system as a whole or on sections that can be isolated. Test joints in sections prior to backfilling when trenches must be backfilled before the completion of other pipeline sections. Continue the test for 24 hours from the time of the initial readings to the final readings of pressure and temperature. Do not make the initial test readings of the instrument for at least 1 hour after the casing has been subjected to the full test pressure, and make neither the initial nor final readings at times of rapid changes in atmospheric conditions. There must be no indication of reduction of pressure during the test after corrections have been made for changes in atmospheric conditions in conformity with the relationship T(1)P(2) = T(2)P(1), in which T and P denote absolute temperature and pressure, respectively, and the numbers denote initial (1) and final (2) readings. Measure pressure with a pressure gauge conforming to ASME B40.100. A throttling type needle valve or a pulsation dampener and shutoff valve may be included. The diameter of the face must be at least 114 mm 4.5 inches with a measurable range of 0 to 103 kPa 0 to 15 psig and graduations of at least 0.5 kPa 0.1 psig. During the test, isolate the entire system from all compressors and other sources of air pressure. Test each joint while under test pressure by means of soap and water or an equivalent nonflammable solution prior to backfilling or concealing any work. All labor, materials and equipment for conducting the tests must be furnished by the Contractor and are subject to inspection at all times during the tests. Maintain proper safety precautions for air pressure testing at all times during the tests.

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NOTE: Input the heat distribution design pressure for the supply line. Design pressure to equal or exceed the operating pressure of the system.

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3.6.2.2 Hydrostatic Test

Test carrier piping hydrostatically before insulation is applied at field joints and prove tight at a pressure 1.5 times the heat distribution supply design pressure of [_____] kPa [_____] psig for 2 hours. There must be no indication of reduction of pressure during the test. Measure pressure with a device calibrated to be read in increments not greater than 1 kPa 0.1 psi.

3.6.2.3 Operational Test

Prior to acceptance of the installation, subject system to operating tests simulating actual operating conditions to demonstrate satisfactory functional and operating efficiency. Cover a period of no less than 6 hours for each portion of system tested. Submit for approval a schedule of the tests to be performed [14 days][_____] in advance. Provide calibrated instruments, equipment, facilities and labor, at no additional cost to the Government. When failures occur, repair problems and repeat test.

3.6.3 Deficiencies

Correct deficiencies discovered at the Contractor's expense. Major deficiencies, or failure to correct deficiencies, can be considered cause for rejecting the entire installation.

3.7 VALVE MANHOLES

****
NOTE: Include Section 33 61 13.19 VALVES, PIPING, AND EQUIPMENT IN VALVE MANHOLES as part of the contract specifications for this job. Include sealing of pipe penetrations through manhole walls in the design of the manhole.
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Provide valve manholes, piping, and equipment in valve manholes in accordance with the contract drawings and Section 33 61 13.19 VALVES,PIPING, AND EQUIPMENT IN VALVE MANHOLES.

3.8 BURIED UTILITY WARNING AND IDENTIFICATION

3.8.1 Plastic Marking Tape

Supply and install polyethylene plastic tape manufactured specifically for warning and identifying buried utility lines. Bury tape above the pipe during the trench backfilling operation and bury approximately 300 mm 12 inches below grade. Tape must be [0.1 mm 0.004 inch thick polyethylene] [polyethylene with a metallic core]. Use tape that is acid- and alkali-resistant with a minimum strength of 12 MPa 1750 psi lengthwise and 10.3 MPa 1500 psi crosswise with an elongation factor of 350 percent. Ensure tape is manufactured with integral wires, foil backing or other means to enable detection by a metal detector when the tape is buried up to 1 m 3 feet deep. Encase the metallic core of the tape in a protective jacket or provide with other means to protect it from corrosion. Ensure tape is a type specifically manufactured for marking and locating metallic underground utilities. Provide tape that is 150 mm 6 inches wide and printed with a caution and identification of the piping system over the entire tape length. Tape must be yellow with bold black letters. Tape color and lettering must be unaffected by moisture and other substances contained in the backfill material.

3.8.2 Markers for Underground Piping

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NOTE: Indicate the location of the markers on the contract drawings for projects that require markers. Delete the paragraph if not needed in the project.
****

Locate markers for underground piping along the distribution and service lines. Place markers as indicated approximately 600 mm 2 feet to the right of the distribution system when facing in direction of flow in the supply line. Provide concrete marker that is 150 mm 6 inch square or round section [600] [900] mm [2] [3] feet long. The top edge of the marker must have a minimum 13 mm 1/2 inch chamfer all around. Impress or cast the letters [STEAM] [HTHW] [CONDENSATE] on the top, and on one side of the markers to indicate the type of system that is being identified.

Form each letter with a V-shaped groove and with a width of stroke at least 6 mm 1/4 inch at the top and depth of 6 mm 1/4 inch. Do not allow the top of the marker to protrude more than [25] [50] [75] [100] mm [1] [2] [3] [4] inches above finished grade.

3.9 THERMAL PERFORMANCE TESTING

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NOTE: The temperatures in Table 3 are based on calculations that assume 85 percent of the thermal resistance of a new properly functioning system is in the insulation and that a degradation of up to 50 percent of the original thermal resistance will be allowed. A soil temperature of 15 degrees C 60 degrees F was also assumed in the calculations.

****

Use the equipment and procedures specified to ensure acceptable thermal performance of the installed system. Submit manufacturer's data sheets on all UHDS components and the instrumentation required for thermal performance testing, [7][_____] days after notice to proceed. Because of its geometry, the PIPI system is exempt from the thermal performance test requirement; submit the test results for approval. Include all materials and procedures described for this test as deliverables of the construction contract for the system, unless otherwise noted. Due to its geometry, the PIPI system is exempt from this requirement.

3.9.1 Equipment

3.9.1.1 Casing Temperature Measurement

Before backfilling, and after field joint closures have been welded to the casing and the coating has been applied and cured, attach temperature sensors to the exterior of every other field joint closure. Attach the sensors with epoxy suitable for use at 260 degrees C 500 degrees F. adhere a sensor with epoxy to the coated casing near the midpoint of every other pipe section between field joints. Do not locate the sensor closer than 1.5 m 5 feet from any guide in the interior of the casing. After the sensors have been adhered to the casing, use two complete wraps of duct tape to secure and protect the sensor. Locate the radial position of the sensors 45 degrees from the top center of the casing, at either the 1:30 or 10:30 position, away from the adjacent heat distribution system pipe if present. Ensure all sensors are type T copper constantan 20 gauge thermocouples, made from special limits grade thermocouple wire, 0.5 degrees C 0.9 degrees F or 0.4 percent maximum error, with each conductor insulated and an overall jacket on both conductors. Use insulation on the thermocouple wires suitable for service at 260 degrees C 500 degrees F. Ensure the thermocouple wire between sensor location and termination point is continuous with no splicing or other connections. Show each sensor with a special symbol on the detailed design layout drawings and identify by a number and/or letter code, starting from the upstream manhole.

3.9.1.2 Carrier Pipe Temperature Measurement

Measure carrier pipe temperature within the manhole where the panel box is located. Measure carrier pipe temperature by a sensor adhered with epoxy directly to the exterior of the carrier pipe. Ensure all sensors are type T copper constantan 20 gauge thermocouples, made from special limits grade thermocouple wire, 0.5 degrees C or 0.4 percent maximum error, with each

conductor insulated and an overall jacket on both conductors. Use insulation on the thermocouple wires suitable for service at 260 degrees C 500 degrees F. Ensure the thermocouple wire between sensor location and termination point is continuous with no splicing or other connections. Locate this sensor at either the 1:30 or 10:30 position. At the location of the sensor, insulate the carrier pipe with calcium silicate insulation at least 125 mm 5 inches thick. Extend this insulation at least 150 mm 6 inches on each side of the actual sensor location and must be clad with an aluminum jacket.

3.9.1.3 Terminals

Extend the wires from each casing or carrier pipe temperature sensor into the nearest manhole and terminate in a panel box. The panel box must be a NEMA Type 4 waterproof enclosure, of suitable size, mounted near the top of the manhole at a location near the manhole entrance, accessible without entrance into the manhole, where possible. Terminate the sensor wires with an approved connector of type [OMEGA Miniature Jack Panel (MJP-*-*-T)]. Mount the thermocouple jack panel to the back plate of the panel box. Label the temperature sensors at their termination within the panel box; laminate and attach a drawing showing the location of each temperature sensor to the inside of the panel box. Ensure all temperature sensors are verified as operational by an independent laboratory, hired by the Contractor, after backfilling is complete but before the system is accepted.

3.9.2 Thermal Performance Test

After the system construction is complete, including backfilling, and the system has reached operating condition for at least 30 days, all of the temperature sensors must be read by an independent laboratory with experience and equipment appropriate for the sensors used. Record the temperature for each sensor. Tabulate and submit the temperatures in accordance with specified requirements. If temperatures exceed values in Table 3, repair that portion and measure and record temperatures again.

TABLE 3

Carrier Pipe Temperature - TP (degrees C F)	Acceptable Casing Temperature - TC (degrees C F)
121 250	43 110
135 275	47 116
149 300	50 123
163 325	54 129
177 350	58 136
204 400	65 149
218 425	68 155
232 450	72 162

TABLE 3	
Carrier Pipe Temperature - TP (degrees C F)	Acceptable Casing Temperature - TC (degrees C F)
The following equations were used to calculate the above values:	
TC, <(0.261) X (TP) + 11.5 TC <(0.261) X (TP) + 44.3	
For carrier pipe temperatures between those given in Table 3, the maximum acceptable casing temperature may be either interpolated from the values in Table 3 or calculated using the equations above.	

-- End of Section --