Preparing Activity: NAVFAC Replacing without change
UFGS-02553 (August 2004)

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated July 2023
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SECTION TABLE OF CONTENTS

DIVISION 33 - UTILITIES

SECTION 33 63 13

EXTERIOR UNDERGROUND STEAM DISTRIBUTION SYSTEM

04/06

PART 1 GENERAL

1.1 REFERENCES
1.2 DEFINITIONS
1.2.1 Pre-engineered System
1.2.2 Direct-Buried
1.2.3 UHDS Types
1.2.3.1 Drainable-Dryable-Testable (DDT) Direct-Buried System
1.2.3.2 Water Spread Limiting (WSL) Direct-Buried System
1.2.4 UHDS Manufacturer Certification
1.2.5 UHDS Manufacturer's Representative
1.2.6 Corrosion Engineer
1.2.7 Pipe-Stress and System Expansion Calculations
1.2.8 Cathodic Protection System Calculations
1.2.9 Manufacturer's Data Sheets
1.2.10 Work Plan
1.2.11 Quality Assurance Plan
1.2.12 Thermal Performance Testing
1.2.13 Certificate of Compliance
1.2.14 Testing Firm Qualification
1.2.15 Welds
1.2.16 Daily Written Report
1.2.17 Heat Distribution System, Data Package 2
1.3 DESCRIPTION
1.3.1 Scope
1.3.2 UHDS Design
1.3.3 Contract Drawings
1.4 SYSTEM REQUIREMENTS
1.4.1 Cathodic Protection
1.4.2 Operating Characteristics
1.4.3 Rated Characteristics
1.4.4 Heat Distribution System design
1.5 STANDARD PRODUCTS
1.6 SUBMITTALS

1.7 SITE CLASSIFICATION

PART 2 PRODUCTS

2.1 FACTORY FABRICATED, DIRECT-BURIED, DRAINABLE, DRYABLE, TESTABLE (DDT) SYSTEMS
2.1.1 DDT Steam and High Temperature Hot Water Carrier Pipes
2.1.2 DDT Condensate Carrier Pipes
2.1.3 DDT Carrier Pipe Insulation
2.1.4 Insulation Banding and Scrim
2.1.5 Casing
2.1.6 Casing End Plates, Vents, and Drains
2.1.7 Air Space
2.1.8 Casing Coating
2.1.9 Coating of End Plates and conduit Sections Extending in Manholes
2.1.10 Carrier Pipe Guides
2.1.11 Anchor Plates
2.1.12 Field Connection of Casing Sections
2.1.13 Manufacturer's Identification
2.2 FACTORY FABRICATED, DIRECT-BURIED, WATER-SPREAD-LIMITING (WSL) SYSTEM
2.2.1 Steam/High Temperature Hot Water Carrier Pipes
2.2.2 Condensate Carrier Pipes
2.2.3 Casing for Steam and Condensate
2.2.4 Pipe Coupling, Steam
2.2.5 Pipe Coupling, Condensate
2.2.6 Carrier Pipe Insulation
2.2.6.1 Calcium Silicate Insulation for Steam Systems
2.2.6.2 Polyurethane Foam Insulation for Steam and Condensate Systems
2.2.6.3 Insulation Concentricity
2.2.6.4 Insulated Fittings
2.2.6.5 Coupling Insulation for Steam Systems
2.2.6.6 Coupling Insulation for Condensate Systems
2.2.7 Manufacturer's Identification
2.2.8 End Seals
2.2.8.1 General
2.2.8.2 End Seals for Steam Service
2.2.8.3 End Seals for Condensate Return Service Types
2.2.9 Assembly Testing of WSL Systems for Steam Service
2.2.9.1 Apparatus
2.2.9.2 Test Section
2.2.9.3 Resistance to Water Damage and Joint Leakage
2.2.9.4 Resistance to Mechanical or Structural Damage
2.2.9.5 Resistance to Ground Water Infiltration
2.2.9.6 Criteria for Satisfactory Results and Reporting
2.2.10 Assembly Test of WSL Systems for Condensate Return Service
2.3 PIPE INSULATION FOR DIRECT BURIED HEAT DISTRIBUTION SYSTEMS
2.3.1 Insulation Thickness
2.4 HEAT DISTRIBUTION PIPING
2.4.1 Steam and High Temperature Hot Water Pipe
2.4.1.1 Condensate Pipe
2.4.1.2 Joints
2.4.2 Fittings
2.4.2.1 Butt-Welded
2.4.2.2 Socket-Welded
2.5 EXPANSION JOINTS, LOOPS AND BENDS

PART 3 EXECUTION

3.1 GENERAL
3.1.1 UHDS Design
3.1.2 Installation, Inspection, and Testing
3.1.3 Job Conditions
3.1.4 Interruption of Existing Service
3.1.5 Connecting to Existing Work
3.1.6 Coordination
3.1.7 Grading
3.1.8 Variations
3.1.9 Storage and Handling
3.2 DEMOLITION
3.2.1 Asbestos Removal
3.3 PIPE, PIPING JOINTS AND FITTINGS
3.3.1 Welded Joints
3.3.2 Fittings
3.4 WELDING
3.4.1 Qualification of Welders
3.4.2 Examining Welders
3.4.3 Examination Results
3.4.4 Beveling
3.4.5 Alignment
3.4.6 Erection
3.4.7 Defective Welds
3.4.8 Electrodes
3.4.9 Radiographic Testing
3.5 HEAT DISTRIBUTION SYSTEM INSTALLATION
3.5.1 Verification of Final Elevations
3.5.2 Excavation, Trenching, and Backfilling
3.5.3 UHDS Manufacturer's Representative Responsibilities
3.5.4 UHDS Manufacturer Representative's Reports
3.5.5 Protection
3.5.6 Defective Material
3.5.7 Cathodic Protection
3.6 TESTS
3.6.1 Holiday Testing of Direct-Buried System Steel Casings
3.6.2 Pneumatic, Hydrostatic and Operational Tests
3.6.2.1 Pneumatic Test
3.6.2.2 Hydrostatic Test
3.6.2.3 Operational Test
3.6.3 Deficiencies
3.7 VALVE MANHOLES
3.8 BURIED UTILITY WARNING AND IDENTIFICATION
3.8.1 Plastic Marking Tape
3.8.2 Markers for Underground Piping
3.9 THERMAL PERFORMANCE TESTING
3.9.1 Equipment
3.9.1.1 Casing Temperature Measurement
3.9.1.2 Carrier Pipe Temperature Measurement
3.9.1.3 Terminals
3.9.2 Initial Thermal Performance Test
3.9.3 Warranty Thermal Performance Test
3.9.4 System Failure

-- End of Section Table of Contents --

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USACE / NAVFAC / AFCEC / NASA **UFGS-33 63 13 (April 2006)**

Preparing Activity: NAVFAC **Replacing without change UFGS-02553 (August 2004)**

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated July 2023

****

SECTION 33 63 13

EXTERIOR UNDERGROUND STEAM DISTRIBUTION SYSTEM
04/06

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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.

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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NOTE: Additional information can be found in UFC 3-430-09, "Exterior Mechanical Utility Distribution."

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PART 1 GENERAL

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NOTE: Remember all design notes are to the government designer or design Architect/Engineer firm and will not be seen by the contractor or their subcontractors. The designer should realize that this specification requires coordination with other design disciplines (examples: cathodic protection, trenching and backfill, structural for coordinating manhole structures). This guide specification

covers the designing, furnishing, installing and testing of a direct buried, insulated UHDS and/or condensate return system of the pre-engineered type. These 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 4.551 Mpa (gage) 660 psig and 260 degrees C 500 degrees F. It should be noted that not all UHDS are acceptable for all site classifications, temperatures, and pressure ratings.

This guide specification provides the requirements necessary for a complete operable system (except for design of the valve manhole and associated piping and equipment in the valve manhole which are covered elsewhere). The manufacturer of the "pre-engineered UHD" (UHDS system manufacturer) will provide a detailed design for the pre-engineered system up to and including the interface with the valve manhole or building wall, terminating their UHDS at least 150 mm six inches inside the valve manhole or building. This includes all designs for pipe anchors and expansion loops, offsets and bends. Valve manholes are not the responsibility of the UHDS manufacturer and will be detailed on the contract drawings.

The UHDS manufacturer shall be responsible for the design, fabrication, and witnessing of the installation and testing of the system within the design parameters established by the contract drawings and specifications. 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 02559, "Valve Manholes and Piping and Equipment in Valve Manholes," will be included as part of this project.

Designer will include a log of soil conditions along the pipe line right-of-way at pipe depth on the drawings which gives, as a minimum, soil classification, moisture content, soil resistivity and pH, bearing strength and unstable conditions.

Designer will provide details at building entries 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.

REMEMBER: All connections to the UHDS piping 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	(2018) Factory-Made Wrought Buttwelding Fittings
ASME B16.11	(2022) Forged Fittings, Socket-Welding and Threaded
ASME B31.1	(2022) 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	(2022) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM A106/A106M	(2019a) Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service
ASTM 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 A167	(2011) Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip
ASTM A234/A234M	(2023a) Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service
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 C591	(2022) Standard Specification for Unfaced Preformed Rigid Cellular Polyisocyanurate Thermal Insulation
ASTM D2310	(2006; R 2012) Machine-Made "Fiberglass" (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe
ASTM D2487	(2017; E 2020) Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)

ASTM D2996	(2017) Standard Specification for Filament-Wound "Fiberglass" (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe

INTERNATIONAL SOCIETY OF AUTOMATION (ISA)

ISA MC96.1	(1982) Temperature Measurement Thermocouples

NACE INTERNATIONAL (NACE)

NACE SP0169	(2013) Control of External Corrosion on Underground or Submerged Metallic Piping Systems

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA ICS 4	(2015) Application Guideline for Terminal Blocks

U.S. GENERAL SERVICES ADMINISTRATION (GSA)

FS L-S-125	(Rev B; Notice 1) Screening, Insect, Nonmetallic

1.2 DEFINITIONS

The following definitions are applicable:

1.2.1 Pre-engineered System

A complete underground [heat distribution] [and] [condensate return] system including all required components such as carrier pipes, [steam pipe], [high temperature hot water supply pipe], [condensate return pipe], and [high temperature hot water return pipe], 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; see Section 33 61 13.19 VALVES, PIPING, AND EQUIPMENT IN VALVE MANHOLES. The pre-engineered system shall include all piping and components to a point at least 150 mm six inches inside the building and valve manhole. The UHDS shall 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.

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NOTE: Select from the following two paragraphs as applicable to the type of system to be allowed. See paragraph Site Classification for assistance in selecting system types.

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1.2.3 UHDS Types

1.2.3.1 Drainable-Dryable-Testable (DDT) Direct-Buried System

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 plugged but the plugs can be removed to drain water which may 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.

1.2.3.2 [Water Spread Limiting (WSL) Direct-Buried System

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.

]1.2.4 UHDS Manufacturer Certification

The UHDS manufacturer is the company responsible for the design and manufacture of the pre-engineered system. The UHDS manufacturer directs the installation of their system and has a representative on the job site.Certification includes 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. This certification shall be an original signed by a principal officer of the UHDS manufacturer and shall be submitted at minimum of [2] [_____] weeks prior to start of work.

1.2.5 UHDS Manufacturer's Representative

The UHDS manufacturer's representative shall be a person who regularly performs the duties specified herein, is certified in writing by the UHDS manufacturer to be technically qualified and experienced in the installation of the system, and shall be authorized by the manufacturer to make and sign the daily reports specified herein. The UHDS manufacturer's representative shall be under the direct employ and supervision of the UHDS manufacturer.

1.2.6 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 may 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 shall be technologist, corrosion specialist, or cathodic protection specialist. The corrosion engineer shall make at least 3 visits to the project site. The first of these visits shall 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 shall revisit the site to ensure the Contractor understands installation practices and laying out the components. The third visit shall involve testing the installed cathodic protection systems and training applicable personnel on proper maintenance techniques. The corrosion engineer shall supervise, inspect, and test the installation and performance of the cathodic protection system.

1.2.7 Pipe-Stress and System Expansion Calculations

Pipe-stress and system-expansion calculations for each expansion compensation elbow using a finite element computer generated three-dimensional analysis, not later than [7 days] [_____] after notice to proceed.

Calculations (including heat loss calculations) shall demonstrate that pipe stresses from temperature changes are within the allowable requirements in ASME B31.1 and the anchors and the guides will withstand the resultant forces. Submitted detailed design layout drawings including the location of all anchors and guides. Layout shall also include all analysis node points. As a minimum, the computer analysis results include node stresses, forces, moments and displacements. Calculations shall be approved, certified, stamped and signed by a registered Professional Engineer in the employ of the UHDS manufacturer.

1.2.8 Cathodic Protection System Calculations

Design life calculations for cathodic protection system in accordance with NACE SP0169, not later than [7 days] [_____] after notice to proceed. Calculations shall be stamped and signed by a NACE qualified corrosion engineer.

1.2.9 Manufacturer's Data Sheets

Manufacturer's data sheets on all components of the UHDS and the instrumentation required for thermal performance testing.

Manufacturer's data sheets for all coatings and for carrier pipe insulation, indicate thicknesses not later than [7 days] [_____] after notice to proceed.

1.2.10 Work Plan

A proposed schedule of activities indicating when various items of work and tests are to be carried out and when the representative of the UHDS manufacturer shall be present at job site. The UHDS manufacturer shall submit a list of what characteristics shall be considered damaged or defective materials that must be replaced.

1.2.11 Quality Assurance Plan

Manufacturer's quality assurance plan for fabrication, delivery, storage, installation and testing of system.

1.2.12 Thermal Performance Testing

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 shall 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. The test shall not commence until the procedure has been approved.

1.2.13 Certificate of Compliance

Upon completion of the work, and before final acceptance, a notarized statement signed by a principal officer of both the UHDS manufacturer and the contractor, certifying that the system has been installed satisfactorily and in accordance with the contract drawings, specifications, UHDS manufacturer's detailed design layout drawings and with the UHDS manufacturer's recommendations.

1.2.14 Testing Firm Qualification

A Certificate of the Testing Firm Qualification from the independent testing firm or firms, not later than [_____] days after notice to proceed, certifying 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.

1.2.15 Welds

A Certification of Acceptability of all welds made in the field, upon completion of the project. This certification shall consist 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 acceptability standards specified.

1.2.16 Daily Written Report

A daily written report from the representative of the UHDS manufacturer whenever the representative is required to be on the jobsite. The report shall be checked for accuracy and the original shall be submitted no later than the next working day after the date of the report. One copy shall be forwarded to the UHDS manufacturer's main office. The report shall be signed by the representative. The report shall state whether or not the condition and quality of the materials and methods used and the installation of the system are in accordance with the contract drawings, specifications, and the UHDS manufacturers detailed design layout drawings and requirements. If anything connected with the installation is unsatisfactory, the report shall state what corrective action has been taken or shall contain the UHDS manufacturer's recommendations for corrective action and when the unsatisfactory condition is to be corrected. The daily report will track and report all unsatisfactory conditions and corrective measured being taken. The report shall identify any conditions that could result in an unsatisfactory installation, including such items as open conduit ends left in the trench overnight and improper valve manhole entries and changes required to the UHDS design due to interferences or conflicts, upon realization of interferences or conflicts. On a weekly basis the daily reports shall be reviewed, approved, signed and sealed by the registered Professional Engineer

responsible for the system design and shall be submitted to the Contracting Officer.

1.2.17 Heat Distribution System, Data Package 2

The operation and maintenance manual for the heat distribution system shall list routine maintenance procedures, possible breakdowns and repairs, procedures for recording conduit temperatures biannually, and troubleshooting guides. Manual shall include as-built piping layout of the system including final elevations. Submit in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA.

1.3 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), together with all fittings and appurtenances necessary for a complete and operable system. Gland type end seals shall not be permitted. Drainable, dryable, testable (DDT) systems with fiberglass casings shall not be provided.

1.3.2 UHDS Design

The UHDS manufacturer shall be 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 shall be sealed by a Professional Engineer in the employ of the UHDS manufacturer.A Certificate of Satisfactory Operation shall be submitted certifying that at least 3 systems installed by the UHDS manufacturer within the previous 10 years have and are operating satisfactorily for not less than 5 years, not later than [_____] days after notice to proceed. The certificate shall indicate the location, type of system, size of system, point of contact (POC) including phone number, for information verification. This certificate of satisfactory operation shall be an original signed by a principal officer of the UHDS manufacturer.

1.3.3 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 (anchors will be no closer than one m 3 feet nor further than 1.5 m 5 feet from entrance to manholes and

buildings) at manholes and/or buildings. The UHDS manufacturer shall incorporate any additional anchors as needed for their system.

f. Operating pressure and temperature of system.

1.4 SYSTEM REQUIREMENTS

1.4.1 Cathodic Protection

Cathodic protection shall be provided for systems with coated steel casings.

1.4.2 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 shall 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 and 4.585 MPa (gage) 500 degrees F and 665 psig. For rated characteristics for WSL systems which are only allowed for steam and condensate return systems, insert 208 degrees C and 1.723 MPa (gage) 406 degrees F and 250 psig. The design conditions for the condensate and hot water return piping shall be the same as for the steam and hot water supply.

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The [steam] [high temperature hot water] supply system shall have an operating temperature of [_____] degrees C [_____] degrees F and an operating pressure of [_____] kPa [_____] psig. [[Condensate] [High Temperature hot water] return system shall have an operating temperature of [_____] degrees C [_____] degrees F and an operating pressure of [_____] kPa [_____] psig.]

1.4.3 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 AFM 88-29, TM 5-785, NAVFAC P-89, Engineering Weather Data.

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All thermal expansion calculations shall be computed 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 at a temperature of [260 degrees C 500 degrees F] and a pressure of [4.585 kPa 665 psig.] For

calculation purposes the installation temperature (the ambient temperature at the site) shall be no higher than a temperature of [[_____] degrees C [_____] degrees F].

1.4.4 Heat Distribution System design

A complete description of the Heat Distribution System design and assembly of the system, materials of construction and field installation instructions minimum of [2] [_____] days prior to the start of field measurements. Also submittal shall include sufficient system details required 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, transition point design to aboveground or other type systems. Also, if applicable, type and details of the cathodic protection system to be used. Detailed design layout drawings shall be prepared and approved by a registered Professional Engineer as certified by their stamp.

1.5 STANDARD PRODUCTS

Approval by Contracting Officer is required for products or services of the UHDS manufacturer. The design of the system and equipment provided for this project shall conform to specification requirements, shall be of current production and shall essentially duplicate systems that have been in satisfactory use for at least 5 years, prior to bid opening, at three locations. The systems must have been operated under pressure, temperature and site characteristics that are equal to or more severe than the operating conditions in this specification and must have distributed the same medium. The system shall be supported by a service organization that is, in the opinion of the Contracting Officer, reasonably convenient to the site.

1.6 SUBMITTALS

****

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, Air Force, and NASA 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.

Choose the first bracketed item for Navy, Air Force, and NASA projects, or choose the second bracketed item for Army projects.

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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.][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 design; G[, [_____]]

SD-03 Product Data

Pipe; G[, [_____]]

Insulation; G[, [_____]]

Fittings; G[, [_____]]

Cathodic protection; G[, [_____]]

Anchors; G[, [_____]]

Expansion joints; G[, [_____]]

Coatings; G[, [_____]]

Conduit; G[, [_____]]

Field Connection of Casing Sections; G[, [_____]]

SD-05 Design Data

Pipe-stress and system expansion calculations; G[, [_____]]

Cathodic protection system calculations; G[, [_____]]

Manufacturer's data sheets; G[, [_____]]

SD-06 Test Reports

WSL system tests; G[, [_____]]

SD-07 Certificates

Work plan; G[, [_____]]

Quality assurance; G[, [_____]]

Thermal performance testing; G[, [_____]]

UHDS manufacturer certification; G[, [_____]]

UHDS design; G[, [_____]]

Certificate of compliance; G[, [_____]]

Testing firm qualification; G[, [_____]]

Welds; G[, [_____]]

SD-10 Operation and Maintenance Data

Heat distribution system, Data Package 2; ; G[, [_____]]

Submit operation and maintenance data in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA.

SD-11 Closeout Submittals

Daily written report

1.7 SITE CLASSIFICATION

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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. 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 TABLE A. If underground water conditions at the site are not available, a detailed site classification survey will be made and TABLE B will be utilized to establish the site classification. This survey should be conducted within the framework of the following guidelines:

1. The survey will be made after the general layout of the system has been determined and should cover

the entire length of the proposed system.

2. The survey should be conducted during the time of the year when the water table is at its highest point. If this is not possible, water table measurements should be corrected to indicate conditions likely to exist at the time of year when the water table is at its highest point.

3. Information on groundwater conditions, soil types, terrain, and soil moisture content in the area of the system will be collected. Information on terrain, precipitation rates and irrigation practices will be obtained if not available from records at the installation.

4. Required information will be obtained through boring, test pits, or other suitable exploratory means. Generally, a boring or test pit should be made at least every 30 m (100 feet) along the line of the proposed system, and each exploratory hole should extend to a level at least 1.5 m (5 feet) below the anticipated elevation of the bottom of the system.

5. Underground and aboveground utilities and obstructions will be located.

The load-bearing qualities of the soil in which the system will be installed will be investigated by an experienced soils engineer (preferably the same engineer responsible for other soils engineering work), and the location and nature of potential soil problems will be identified.

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Classification of the site conditions for the UHDS was based on ASTM D2487 and the following criteria: [_____].

TABLE A - SITE CLASSIFICATION DEFINITION BASED ON KNOWN UNDERGROUND WATER CONDITIONS	
Site Classification	General Conditions for Classification
Severe	The water table is expected to be frequently above the bottom of the system and surface water is expected to accumulate and remain for long periods in the soil surrounding the system.
	OR
	The water table is expected to be occasionally above the bottom of the system and surface water is expected to accumulate and remain for long periods in the soil surrounding the system.
Bad	The water table is expected to be occasionally above the bottom of the system and surface water is expected to accumulate and remain for short periods (or not at all) in the soil surrounding the system.
	OR
	The water table is expected never to be above the bottom of the system but surface water is expected to accumulate and remain for short periods in the soil surrounding the system.
Moderate	The water table is expected never to be above the bottom of the system but surface water is expected to accumulate and remain for short periods (or not at all) in the soil surrounding the system.
	OR
	The water table is expected never to be above the bottom of the system but surface water is expected to accumulate and remain for brief or occasional periods in the soil surrounding the system.
	OR
	The water table is expected never to be above the bottom of the system and surface water is not expected to accumulate or remain in the soil surrounding the system.

TABLE B - SITE CLASSIFICATION CRITERIA BASED ON SUBSURFACE SOIL INVESTIGATION				
Site Classification	Water Table Level	Soil Types	Terrain	Precipitation Rates or Irrigation Pratices in Area
SEVERE	Water table within 300 mm of bottom or system	Any	Any	Any
	OR			
	Water table within 1500 mm of bottom of system	GC, SC CL, CH OH	Any	Any
BAD	Water table within 1500 mm of bottom of system	GW, GP SW, SP	Any	Any
	OR			
	No groundwater encountered	GC, SC, SW, CH, OH	Any	Equivalent to 75 mm or more in any one month or 500 mm or more in one year.

TABLE B - SITE CLASSIFICATION CRITERIA BASED ON SUBSURFACE SOIL INVESTIGATION				
Site Classification	Water Table Level	Soil Types	Terrain	Precipitation Rates or Irrigation Pratices in Area
MODERATE	No groundwater encountered	GM, SM, ML, OL, MH	Any	Equivalent to 75 mm or more in any one month or 500 mm or more in one year.
	OR			
	No groundwater encountered	GC, SC, SL, CH, OH	Any except low areas	Equivalent to 75 mm or more in any one month or 500 mm or more in one year.
	OR			
	No groundwater encountered	GW, GP, SW, SP	Any	Any
	OR			
	No groundwater encountered	GM, SM, ML, SM	Any	Equivalent to 75 mm or more in any one month or 500 mm or more in one year.

TABLE B - SITE CLASSIFICATION CRITERIA BASED ON SUBSURFACE SOIL INVESTIGATION				
Site Classification	Water Table Level	Soil Types	Terrain	Precipitation Rates or Irrigation Pratices in Area
SEVERE	Water table within 1 foot of bottom or system	Any	Any	Any
	OR			
	Water table within 5 feet of bottom of system	GC, SC CL, CH OH	Any	Any
BAD	Water table within 5 feet of bottom of system	GW, GP SW, SP	Any	Any
	OR			
	No groundwater encountered	GC, SC, SW, CH, OH	Any	Equivalent to 3 inches or more in any one month or 20 inches or more in one year.

TABLE B - SITE CLASSIFICATION CRITERIA BASED ON SUBSURFACE SOIL INVESTIGATION				
Site Classification	Water Table Level	Soil Types	Terrain	Precipitation Rates or Irrigation Pratices in Area
MODERATE	No groundwater encountered	GM, SM, ML, OL, MH	Any	Equivalent to 3 inches or more in any one month or 20 inches or more in one year.
	OR			
	No groundwater encountered	GC, SC, SL, CH, OH	Any except low areas	Equivalent to 3 inches or more in any one month or 20 inches or more in one year.
	OR			
	No groundwater encountered	GW, GP, SW, SP	Any	Any
	OR			
	No groundwater encountered	GM, SM, ML, SM	Any	Equivalent to 3 inches or more in any one month or 20 inches or more in one year.

PART 2 PRODUCTS

2.1 FACTORY FABRICATED, DIRECT-BURIED, DRAINABLE, DRYABLE, TESTABLE (DDT) SYSTEMS

2.1.1 DDT Steam and High Temperature Hot Water Carrier Pipes

Requirements shall be in accordance with the "Heat Distribution Piping" paragraph.

2.1.2 DDT Condensate Carrier Pipes

Carrier piping for condensate return systems shall be steel, schedule 80. Pipe requirements shall be in accordance with the "Heat Distribution Piping" paragraph.

Do not locate condensate pipes in conduit casings which contain steam pipes or any other piping.

2.1.3 DDT Carrier Pipe Insulation

Carrier pipe insulation shall conform to minimum thicknesses and type listed in Tables 1 and 2 as required for temperature in carrier pipe specified under the "Rated Conditions" paragraph.

2.1.4 Insulation Banding and Scrim

Stainless steel bands and clips, at least 13 mm 0.5 inches wide, ASTM A167 (304 stainless steel), maximum spacing 460 mm 18 inches shall be used over the scrim to secure the insulation onto the carrier pipe. A minimum of two bands are required for each 1300 mm 4 foot section of insulation. Vinyl-coated fiberglass scrim, FS L-S-125, Type II, Class 2, with 18 by 16 mesh (number of filaments per mm inch) and made of 0.335 mm 0.013 inch diameter vinyl-coated fibrous glass yarn. Bands are used over the scrim to secure the insulation onto the carrier pipe.

2.1.5 Casing

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 as necessary between casing sections to provide drainage of casing section between manholes and between manholes and buildings.

Casing Diameter (mm)	Minimum Thickness (mm)
150 - 660	6.35
675 - 900	6.35
940 - 1050	6.35
1170	6.35

Casing Diameter (inches)	Minimum Thickness (inches)
6 - 26	0.250
27 - 36	0.250
37 - 42	0.250
46	0.250

2.1.6 Casing End Plates, Vents, and Drains

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

End plates shall be made of ASTM A36/A36M steel, minimum thickness 13 mm 0.5 inches 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 25 mm 1 inch ASTM A53/A53M, Schedule 40, galvanized vent riser pipe on end plate vent opening. Vent pipe shall extend to top of manhole and terminate 300 mm 12 inches above grade with a 180 degree bend. Provide 25 mm one inch drain at the bottom and vent at the top. Construct with welded steel half coupling welded to the end plate, and brass plugs. Plug drains, do not plug vents.

2.1.7 Air Space

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

2.1.8 Casing Coating

Fusion-bonded epoxy, minimum thickness 1.0 mm 0.040 inches. Rated by coating manufacturer for continuous service for at least 25 years at temperatures of 110 degrees C 230 degrees F and having a coefficient of expansion similar to that of steel. Coating shall be applied in accordance with the coating manufacturer's instructions. Factory-inspect for holidays and make repairs as necessary.

2.1.9 Coating of End Plates and conduit Sections Extending in Manholes

Zinc-rich coating that conforms to AASHTO M 300, Type IA except that volatile organic compounds shall not exceed 0.34 kg per liter 2.8 pounds per gallon. The zinc rich coating shall be applied in accordance with the coating manufacturer's requirements including surface preparation. No additional top coat shall be applied.

2.1.10 Carrier Pipe Guides

Maximum spacing 3 m 10 feet on centers, no more than 1500 mm 5 feet from pipe ends, minimum of three guides per elbow section. Guides shall be designed 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 of supports shall permit flow of water and air vapor through the support. Pipe insulation shall extend thru the pipe guides and be protected by steel sleeves. Design of guides shall be such that no metal to metal contact exists between the casing and the carrier pipe. Insulation or non-metallic material used to ensure no metal to metal contact shall be designed to not be compressed by the weight of the carrier pipe when full of water.

2.1.11 Anchor Plates

Anchor plate shall be ASTM A36/A36M steel, welded to carrier pipe and casing, 13 mm 0.5 inches minimum thickness and shall include, passages for air flow and water drainage through the annular air space in the system. Exterior surface of the anchor plate shall be coated with the same coating material as the casing.

2.1.12 Field Connection of Casing Sections

Steel section conforming to casing specification, 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 260 degrees C 500 degrees F.

2.1.13 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. The tag shall identify UHDS manufacturer's name, date of installation, Government contract, and manufacturer's project number.

2.2 FACTORY FABRICATED, DIRECT-BURIED, WATER-SPREAD-LIMITING (WSL) SYSTEM

2.2.1 Steam/High Temperature Hot Water Carrier Pipes

Refer to Paragraph, HEAT DISTRIBUTION PIPING for pipe material requirements. The pipe shall be steel with the ends machined and metallized to provide a satisfactory sealing surface for the sealing rings. The metallizing shall be a high nickel alloy applied to an excess thickness and then machined to the required OD.

2.2.2 Condensate Carrier Pipes

Carrier piping for condensate return systems shall be steel, Schedule 80. Refer to paragraph entitled "HEAT DISTRIBUTION PIPING" for pipe requirements. Condensate piping shall not be located in casings which contain steam piping or any other piping.

2.2.3 Casing for Steam and Condensate

The casing shall be reinforced thermosetting resin plastic pipe (RTRP) manufactured by the filament winding process. The casing pipe shall be wound to meet ASTM D2310 classification RTRP and ASTM D2996. The resin shall be a polyester isothalic resin. The outer surface shall be coated with a pigmented, protected resin containing a paraffinated wax and ultraviolet inhibitors. Casing thickness shall be as follows:

Carrier Pipe Size, mm	Casing Thickness, mm
50	5
80	5
100	5
150	6.5
200	6.5
250	6.5
300	6.5

Carrier Pipe Size, inches	Casing Thickness, inches
2	0.185
3	0.185
4	0.185
6	0.250
8	0.250
10	0.250
12	0.250

2.2.4 Pipe Coupling, Steam

Coupling shall be of a multi-stage seal designed to accommodate the expansion and contraction of the system in the coupling. Couplings shall be of corrosion resistant materials capable of handling the design characteristics of the system listed in paragraph entitled "Rated Characteristics". The annular seals and carrier pipe ends shall be specifically designed to protect the seals and resist abrasion due to lateral loads in the system.

2.2.5 Pipe Coupling, Condensate

Coupling shall be a single stage seal design to accommodate the expansion and contraction of the adjacent pipes. Coupling shall be of corrosion resistance materials capable of handling the design characteristics of the system listed in paragraph entitled "Rated Characteristics." The annular seals and carrier pipe ends shall be specifically designed to protect the seals and resist abrasion due to lateral loads in the system.

2.2.6 Carrier Pipe Insulation

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

2.2.6.1 Calcium Silicate Insulation for Steam Systems

The calcium silicate insulation shall be a hydrous material satisfactory for temperatures to 650 degrees C 1200 degrees F. Calcium Silicate insulation shall conform to ASTM C533. The physical properties shall be as follows:

Density (dry) 208 kg/cubic meter 13 lbs./cu. ft. (minimum)
Compressive Strength to produce 5 percent compression: 1723 kPa 250 psi (For 37 mm 1.5 inch thick sample)

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

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

Mean Temp	100	200	300	400
k	0.38	0.41	0.44	0.48
k(metric	0.04	0.04	0.04	0.04

2.2.6.2 Polyurethane Foam Insulation for Steam and Condensate Systems

Polyurethane foam shall be in accordance with ASTM C591. The polyurethane foam shall 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.

Polyurethane foam insulation shall also meet 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 one to 21 degrees C 30 to 70 degrees F.

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

e. Maximum aged k (32 degrees C 90 degrees F/90 percent RH for 72 hours):

.02 W/mK 0.14 (BTU-IN/HR FT-2-DEG. F) at 24 degrees C 75 degrees F, when tested in accordance with ASTM C518.

f. Minimum Closed Cell Content: 90 percent

2.2.6.3 Insulation Concentricity

Carrier pipe shall be concentric in relation to the casing pipe. The allowable maximum deviation from center line of the carrier pipe shall be plus or minus 6 mm 0.25 inch at the casing center point and plus or minus 1.5 mm 0.06 inch at the end seals.

2.2.6.4 Insulated Fittings

Fittings shall be pre-insulated by manufacturer using the same insulation thickness and casing as the straight sections.

2.2.6.5 Coupling Insulation for Steam Systems

The material which locks the bronze coupling in the casing shall be composed of refractory composite. The approximate minimum conductivity of this material shall be .2 W/(meter*K) 1.6 (BTU/HR/F/IN DEG.F) at a mean temperature of 1260 degrees C 2300degrees F.

2.2.6.6 Coupling Insulation for Condensate Systems

The coupling shall be insulated with polyurethane foam per requirements

herein. The insulation thickness shall be equal to the carrier pipe insulation. The coupling shall be encased in the same casing as the pipe.

2.2.7 Manufacturer's Identification

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

2.2.8 End Seals

2.2.8.1 General

Each preinsulated section of piping shall completely seal the insulation providing a permanent water and vapor seal at each end of the preinsulated section of piping. Preinsulated factory fabricated sections of piping modified in the field shall be provided with an end seal which is equivalent to the end seals furnished with the preinsulated section of piping. Tests shall be conducted 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. The WSL System Tests shall be performed on each type of pre-fabricated system to be furnished, and the test results shall be verified by an independent testing laboratory. The steam system shall be tested and certified in accordance with paragraph entitled Assembly Testing of WSL systems for Steam Service. The Condensate Return system shall be tested and certified in accordance with paragraph entitled "Assembly ASSM Testing of WSL systems for Condensate Return Service". Test reports in booklet form showing all field tests performed to prove compliance with the specified performance criteria, upon completion and testing of the installed system.

2.2.8.2 End Seals for Steam Service

End seals shall be elastomer-ring type designed and dimensioned to fit in the annular space between the casing and the carrier pipe. Tape used for covering field repair joints shall be multi polymer alloy film type and shall be compatible with synthetic elastomeric tape, suitable for cold application.

2.2.8.3 End Seals for Condensate Return Service Types

End seals provided shall be one of the following types:

a. Carrying the outer casing over tapered pipe insulation ends and extending it to the carrier pipe. Sufficient surface bonding area shall be provided between the casing and the carrier pipe.

b. Using specially designed molded caps made of polyethylene or rubber of standard manufactured thickness. A minimum 40 mm 1 1/2 inch surface bonding area shall be provided 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.

2.2.9 Assembly Testing of WSL Systems for Steam Service

The tests shall demonstrate that the WSL system will operate successfully for 25 years under typical operating conditions. The tests shall be conducted in both a dry and wet environment. The WSL system shall be as described in the manufacturer's brochure. The testing program described below shall be conducted at the expense of the WSL system manufacturer. Tests shall be witnessed and verified by an independent testing laboratory. The entire pre-insulated test section shall be hydrostatically tested, with water, to 2600 kPa 375 psig (1/5 times the rated pressure) before and after temperature cycling. The tests shall be conducted in a dry environment which followed by a test in a wet environment for 60 cycles which demonstrates resistance to ground water infiltration. All tests shall be conducted on one test section and all testing shall be completed in 1 time period (approximately 6 weeks) and the 120 testing cycles shall be continuous except for weekend time periods.

2.2.9.1 Apparatus

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 shall be used. The tank shall be fitted with a gasketed and bolted cover to pressurize the tank to 60 kPa 8.67 psig. The tank shall have a drain at the lowest point and a vent at the highest point. Manhole entrance sleeves (i.e. wall sleeves through the ends of the tank to simulate manhole entries in actual field conditions) shall be centrally located on each end of the tank. Auxiliary equipment shall include: 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. Thermocouples shall be used 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 FRRP 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.

j. Carrier pipe internal pressure, at inlet to test specimen.

Surface thermocouples shall be epoxied to the surface of the casing. The calibration of the thermocouples shall be checked and recorded prior to installation and the recorder shall record within 0.06 degrees C 0.1 degrees F resolution. A pressure transmitter shall be used to record pressure in the test tank.

2.2.9.2 Test Section

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 shall be provided. Approximately 3.7 m 12 feet of the test section shall be encased within the tank as described below. The test section within the tank shall consist of an expansion coupling, field repair joint, anchor plate, anchor block and end seals. The test section shall be installed (as directed) on at least 280 mm 11 inches of firmly tamped sand. Sand shall not be any lower than 100 mm 4 inches from the top of the tank. The test section shall be anchored 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 shall be misaligned by 1.5 degrees in the horizontal plane. Sand (118 mL 4 fluid oz.) shall be introduced into the carrier pipe and disbursed throughout the test loop at startup.

2.2.9.3 Resistance to Water Damage and Joint Leakage

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

a. The piping system shall be subjected to 60 cycles of admitting steam into the system while at an ambient temperature of less than 38 degrees C 100 degrees F, heating the system up to a temperature of 207 degrees C 406 degrees F (as measured at the core pipe at the tank inlet and tank outlet), stopping the steam admission and allowing the system to cool back to ambient temperature. The system shall be held at 207 degrees C 406 degrees F minimum for a minimum of 30 minutes, each cycle. This cycling shall continue for 60 cycles in dry sand followed by 60 cycles in a saturated environment. The reduction in temperature to less than 38 degrees C 100 degrees F shall occur naturally with no artificial means of cooling used.

b. Results shall conform to paragraph Criteria for Satisfactory Results and Reporting.

2.2.9.4 Resistance to Mechanical or Structural Damage

This test shall simulate loads induced by truck traffic over pipe, which may occur under actual operating conditions. This test shall be conducted commencing with the 18th cycle of the Resistance to Water Damage and Joint Leakage test and continue through the 60th cycle. Other aspects of the Resistance to Water Damage and Joint Leakage test shall continue simultaneously with this test.

a. Apparatus: Same as for apparatus used in Resistance to water damage and joint leakage test loading device, with the addition of a 96 kPa 2000 psf. A hydraulic jack shall be used 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.

b. Procedure: A steady and constant vertical load of 96 kPa 2000 psf shall be applied to the plate for 14 days during the test. The test section shall be installed as in the Resistance to water damage and

joint leakage test. During the 14 day loading period, steam shall be circulated through the carrier pipe alternately at ambient and 207 degrees C 406 degrees F as in earlier test.

c. Results: Requirements shall be in accordance with paragraph Criteria for Satisfactory Results and Reporting.

2.2.9.5 Resistance to Ground Water Infiltration

This test shall be 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.

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

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

(2) Provisions to introduce pressurized red dye into the curved bottom test tank. The water/dye solution shall be mixed to a concentration in accordance with the dye manufacturer's recommendation for maximum detectability.

(3) One pressure tank with 0 to 206 kPa 0 to 30 psig static pressure gauge.

b. Procedure: This phase shall start on the 61st cycle and continue until the 120th cycle. The test section of pipe shall be the same test segment used in the previous tests. The tank cover shall be bolted in place and the Resistance to Ground Water Infiltration test shall begin. The water/dye source shall be attached to the fill fitting and a surge tank shall be attached to the vent with a tee fitting. The pressure tank shall have 0 to 206 kPa 0 to 30 psig static pressure gauge attached. The other branch of the tee fitting shall employ a shut-off valve. With the shut-off valve open, the water/dye mixture shall be admitted into the tank through the fill fitting until the tank is full and water/dye runs freely from the open valve. The valve shall be closed and the filling shall continue until the pressure reaches 60 kPa 8.67 psig. The tank pressure shall be maintained throughout the test period. Steam shall be circulated through the carrier pipe and cycled from ambient to 207 degrees C 406 degrees F as in the previous test. At the end of the test, the pressure shall be relieved by opening the vent valve and the water/dye shall be drained from the tank through the drain fitting.

c. Results: Requirements shall be in accordance with paragraph criteria for Satisfactory Results and Reporting.

2.2.9.6 Criteria for Satisfactory Results and Reporting

a. Reporting: Logs of times and temperature shall be recorded to assure compliance with test requirements and procedures. Complete photographic documentation of the construction and operation of the test facility, as well as the piping system components before and after testing, shall be produced. Data shall be analyzed to assure complete compliance with test objectives.

b. Drawing: A drawing showing details of the test apparatus and test

specimen shall be provided.

c. For the Resistance to Water Damage and Joint Leakage test: Joints and end seals shall be removed for examination, immediately upon completion of all test cycles. Successful results shall show that steam has not leaked out of the carrier pipe and that the components show no signs of deterioration.

d. For the Resistance to Mechanical or Structural Damage test: The loading shall not have been sufficient to cause the casing to be damaged or deformed enough to impair functioning of the system. The casing shall not be ruptured or deformed more than 25 mm one inch in any direction. Casing sections with pipe anchors shall not fail.

e. For the Resistance to Ground Water Infiltration test: Determine whether or not the water/dye solution has entered the insulation. This shall be observed 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.

f. Evidence of Test Results: After completion of all tests, the test apparatus shall be dismantled 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. Examinations specified shall be conducted. Log sheets, test data and color photographs shall be kept on file and made available as required to document and substantiate compliance to the test requirements.

g. Report: A report from the independent testing agency shall be submitted. The report shall include the laboratory analysis of the condition of the test section and shall attest that the testing conditions were followed.

2.2.10 Assembly Test of WSL Systems for Condensate Return Service

Testing and certification procedures by an independent testing laboratory shall demonstrate that casings and end seals are capable of resisting penetration of ground water or condensate into the casing and insulation. The test shall be performed on the type of prefabricated system to be furnished. If more than 1 type of prefabricated system is to be used, the tests shall be performed on each type. The test shall consist of hot and cold cycle testing followed by immersion in a water filled chamber with a head pressure. The hot and cold cycle testing shall consist of a minimum of 120 cycles, of temperature cycling. A fluid with a temperature of 5 degrees C 40 degrees F shall circulate through the carrier pipe alternating every 3 hours with a fluid with a temperature of 120 degrees C 250 degrees F circulating through the carrier pipe. While the hot and cold cycle test is being performed, the test sample shall be either buried or encased in dry bedding sand with a minimum of 300 mm 12 inches of sand all around the test sample. The carrier pipe size of the test sample shall be 75 mm 3 inches in diameter and shall be restrained during the test period. The insulation thickness shall not exceed the maximum thickness provided for the piping in the project. Transition time for temperature cycle testing shall 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 shall be water, or steam. Following the hot and cold cycling test, the test sample shall be immersed in a water filled chamber. The pressure on the highest point of the test sample shall 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. The water shall contain a dye penetrant, which shall be used to check for end seal leakage. The pressure in the chamber shall be held for not less than 48 hours. Upon completion of this pressure test, the test sample shall be cut open. With the use of a light that will readily show the presence of the dye that was in the water, the test sample shall be inspected. Evidence of the dye inside the test sample shall indicate that the end seal is not acceptable and cannot be certified.

2.3 PIPE INSULATION FOR DIRECT BURIED HEAT DISTRIBUTION SYSTEMS

Materials containing asbestos are not permitted.

2.3.1 Insulation Thickness

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

The minimum thickness of insulation for the heat distribution system shall be in accordance with Tables 1 and 2 in which the insulations listed have passed the 96 hour boiling water test.

TABLE 1 - MINIMUM PIPE INSULATION THICKNESS (mm)					
For Steam (100 to 2.800 kPa (gage)) and High Temperature Hot Water Supply and Return (120 to 230 degrees C).					
INSULATIONS For Drainable/Dryable Systems				INSULATIONS For other Pre-Engineered Systems	
Nominal Pipe Diameter (mm)	Paroc	Epitherm Delta	kaylo-10 Thermo-12 Super Caltemp	WSL	
				Calcium Silicate	Polyurethane
25	50	63	100	N/A	N/A
40	50	63	100	N/A	N/A
50	63	85	110	N/A	N/A
65	63	85	110	N/A	N/A
80	75	100	125	25	+31
100	75	100	125	25	+31
125	75	100	125	N/A	N/A
150	85	110	135	35	+34
200	85	110	135	50	+30

TABLE 1 - MINIMUM PIPE INSULATION THICKNESS (mm)					
For Steam (100 to 2.800 kPa (gage)) and High Temperature Hot Water Supply and Return (120 to 230 degrees C).					
INSULATIONS For Drainable/Dryable Systems				INSULATIONS For other Pre-Engineered Systems	
Nominal Pipe Diameter (mm)	Paroc	Epitherm Delta	kaylo-10 Thermo-12 Super Caltemp	WSL	
				Calcium Silicate	Polyurethane
250	100	125	150	63	+33
300	100	125	150	50	+32
350	100	125	150	N/A	N/A
400	100	125	150	N/A	N/A
450	100	125	150	N/A	N/A

TABLE 1 - MINIMUM PIPE INSULATION THICKNESS (inches)					
For Steam (16 to 408 psig) and High Temperature Hot Water Supply and Return (250 to 450 degrees F).					
INSULATIONS For Drainable/Dryable Systems				INSULATIONS For other Pre-Engineered Systems	
Nominal Pipe Diameter (inches)	Paroc	Epitherm Delta	kaylo-10 Thermo-12 Super Caltemp	WSL	
				Calcium Silicate	Polyurethane
1.0	2.0	2.5	4.0	N/A	N/A
1.5	2.0	2.5	4.0	N/A	N/A
2.0	2.5	3.5	4.5	N/A	N/A
2.5	2.5	3.5	4.5	N/A	N/A
3.0	3.0	4.0	5.0	1.0	+1.23
4.0	3.0	4.0	5.0	1.0	+1.22
5.0	3.0	4.0	5.0	N/A	N/A
6.0	3.5	4.5	5.5	1.5	+1.34

TABLE 1 - MINIMUM PIPE INSULATION THICKNESS (inches)					
For Steam (16 to 408 psig) and High Temperature Hot Water Supply and Return (250 to 450 degrees F).					
INSULATIONS For Drainable/Dryable Systems				INSULATIONS For other Pre-Engineered Systems	
Nominal Pipe Diameter (inches)	Paroc	Epitherm Delta	kaylo-10 Thermo-12 Super Caltemp	WSL	
				Calcium Silicate	Polyurethane
8.0	3.5	4.5	5.5	2.0	+1.21
10.0	4.0	5.0	6.0	2.5	+1.31
12.0	4.0	5.0	6.0	2.0	+1.29
14.0	4.0	5.0	6.0	N/A	N/A
16.0	4.0	5.0	6.0	N/A	N/A
18.0	4.0	5.0	6.0	N/A	N/A

TABLE 2 - MINIMUM PIPE INSULATION THICKNESS (mm) CONDENSATE RETURN HIGH TEMPERATURE HOT WATER RETURN SYSTEM				
Nominal Pipe Diameter (mm)	Paroc	Epitherm Delta	kaylo-10 Thermo-12 Super Caltemp	Polyurethane
25	35	50	75	N/A
40	35	50	75	N/A
50	35	50	75	19
65	35	50	75	N/A
80	50	63	85	26
100	50	63	85	26
125	50	63	85	N/A
150	63	76	110	30
200	63	76	110	N/A
250	76	100	125	N/A

TABLE 2 - MINIMUM PIPE INSULATION THICKNESS (mm) CONDENSATE RETURN HIGH TEMPERATURE HOT WATER RETURN SYSTEM				
Nominal Pipe Diameter (mm)	Paroc	Epitherm Delta	kaylo-10 Thermo-12 Super Caltemp	Polyurethane
25	35	50	75	N/A
40	35	50	75	N/A
300	76	100	125	N/A
350	76	100	125	N/A
400	76	100	125	N/A
450	76	100	125	N/A

TABLE 2 - MINIMUM PIPE INSULATION THICKNESS (inches) CONDENSATE RETURN HIGH TEMPERATURE HOT WATER RETURN SYSTEM				
Nominal Pipe Diameter (inches)	Paroc	Epitherm Delta	kaylo-10 Thermo-12 Super Caltemp	Polyurethane
1.0	1.5	2.0	3.0	N/A
1.5	1.5	2.0	3.0	N/A
2.0	1.5	2.0	3.0	0.77
2.5	1.5	2.0	3.0	N/A
3.0	2.0	2.5	3.5	1.05
4.0	2.0	2.5	3.5	1.05
5.0	2.0	2.5	3.5	N/A
6.0	2.5	3.0	4.5	1.32
8.0	2.5	3.0	4.5	N/A
10.0	3.0	4.0	5.0	N/A
12.0	3.0	4.0	5.0	N/A
14.0	3.0	4.0	5.0	N/A

TABLE 2 - MINIMUM PIPE INSULATION THICKNESS (inches) CONDENSATE RETURN HIGH TEMPERATURE HOT WATER RETURN SYSTEM				
Nominal Pipe Diameter (inches)	Paroc	Epitherm Delta	kaylo-10 Thermo-12 Super Caltemp	Polyurethane
1.0	1.5	2.0	3.0	N/A
1.5	1.5	2.0	3.0	N/A
16.0	3.0	4.0	5.0	N/A
18.0	3.0	4.0	5.0	N/A

2.4 HEAT DISTRIBUTION PIPING

2.4.1 Steam and High Temperature Hot Water Pipe

Pipe material shall 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 permitted for pipe sizes 300 mm 12 inches and above. ASTM A53/A53M, Type F furnace butt welded pipe is not allowed. No joints shall be allowed in the factory fabricated straight section of the carrier pipe. Factory fabricated piping sections as part of an expansion loop or bend shall have all welded joints 100 percent radiographed inspected in accordance with ASME B31.1. Radiographs shall be reviewed and interpreted by a Certified American Society for Nondestructive Testing (ASNT) Level III radiographer, employed by the testing firm, who shall sign the reading report.

2.4.1.1 Condensate Pipe

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 is not allowed. No joints shall be allowed in the factory fabricated straight section of the carrier pipe. Factory fabricated piping sections as part of an expansion loop or bend shall have all welded joints 100 percent radiographed inspected in accordance with ASME B31.1. Radiographs shall be reviewed and interpreted by an ASNT Certified Level II radiographer, employed by the testing firm, who shall sign the reading report.

2.4.1.2 Joints

Joints shall be butt-weld except socket-weld joints are permitted for pipe sizes 50 mm 2 inches and smaller. Dye penetrant inspection 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.

2.4.2 Fittings

All welds in factory fittings shall be 100 percent radiographic inspected. All radiographs shall be reviewed and interpreted by a Certified ASNT Level III radiographer, employed by the testing firm, who

shall sign the reading report. The Contracting Officer reserves the right to review all inspection records, and if any welds inspected are found unacceptable in accordance with ASME B31.1, the fitting shall be removed, replaced, and radiographically reexamined at no cost to the government.

2.4.2.1 Butt-Welded

Steel, ASTM A234/A234M, Grade B, ASME B16.9, same schedule as adjoining pipe. All elbows shall be long radius unless otherwise indicated. Tees shall be full size or reducing as required, having interior surfaces smoothly contoured. Split-ring welding rings may be used.

2.4.2.2 Socket-Welded

Forged steel, ASME B16.11, 13,800 kPa 2000 pound class will be used for pipe sizes 50 mm 2 inch and below. Dye penetrant inspection may be used in place of 100 percent radiographic inspection of welded fittings for pipe sizes 50 mm 2 inch and below.

2.5 EXPANSION JOINTS, LOOPS AND BENDS

Stresses shall be less than the maximum allowable stress from the Power Piping Code (ASME B31.1). Submit detailed design layout drawings and stress and anchor force calculations for all loops and bends. Show locations of all anchors, guides and supports. Base the calculations on rated characteristics (pressures and temperatures), specified herein, for both the supply and return lines.

PART 3 EXECUTION

3.1 GENERAL

3.1.1 UHDS Design

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 shall be prepared, signed, and sealed by a Professional Engineer in the employ of the UHDS manufacturer.

3.1.2 Installation, Inspection, and Testing

The pre-engineered system shall be installed, inspected, and tested in accordance with the contract drawings and specifications, the UHDS manufacturer's standard procedures, detailed design layout drawings and any directions given by the UHDS manufacturer's representative. All work described in paragraph "UHDS Manufacturer's Representative's Responsibilities" shall be performed in the presence of the UHDS manufacturer's representative.

3.1.3 [Job Conditions

Phasing of [demolition and construction] [construction] shall be in accordance with the provisions of Section 01 11 00 SUMMARY OF WORK, and as shown on contract drawings.

]3.1.4 Interruption of Existing Service

The contractor shall arrange, phase and perform work and provide temporary facilities, materials, equipment, and connections to utilities, to assure adequate heat distribution service for existing installations at all times. Only such absolutely necessary interruptions as may be required for making connections shall be permitted, and only at such times when approval is obtained from the Contracting Officer. Interruptions to heat distribution service shall be only with prior approval, and be the minimum possible duration. All interruptions shall be [between the hours of [_____] thru [_____]] [as scheduled under paragraph "PHASING" of Section 01 11 00 SUMMARY OF WORK] [as approved by the Contracting Officer].

3.1.5 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.

****

Connect new work to existing work in a neat and workmanlike manner. Connection shall be made only in manholes. Where an existing structure must be cut or existing utilities interfere, such obstruction shall be bypassed, removed, replaced or relocated, restored and repaired. Any changes required to the UHDS design as a result of interferences or conflicts must be approve by the UHDS designer and the Contracting Officer. Work disturbed or damaged shall be replaced to its prior condition, as required by Section 01 11 00 SUMMARY OF WORK.

3.1.6 Coordination

Coordinate the location of all items of equipment and work of all trades. Maintain operability and maintainability of the equipment and systems. Any relocation of equipment or systems to comply with the requirement of operability and maintainability shall be performed by the contractor at his cost.

3.1.7 Grading

Unless otherwise shown on the contract drawings or the detailed design layout drawings, steam/condensate and high temperature hot water supply/return lines shall be graded uniformly downward not less than 40 mm in 10 meters 5.0 inches in 100 feet to the lower point of entry between manholes and/or building entries.

3.1.8 Variations

Any variations from the approved detailed design layout drawings must be submitted to the Contracting Officer for approval. Variations must be signed and sealed by the UHDS manufacturers' professional engineer responsible for the complete design of the UHDS.

3.1.9 Storage and Handling

Equipment and material placed on the job shall remain 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. Protect all materials against entry of water and mud by installing watertight protection on open ends at all times. 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) shall be immediately replaced. Protect materials at all times while stored or during installation from damage from UV light. Materials awaiting installation shall be completely covered to protect from UV degradation.

Place all damaged items in new operating condition or replace damaged items as determined and directed by the Contracting Officer, at no additional cost to the Government.

3.2 DEMOLITION

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NOTE: Ensure that Demolition specification is included in project specifications.

****

Perform work in accordance with requirements for phasing. Completely remove all pipe, valves, fittings, insulation, and all hangers including the connection to the structure and any fastenings. Seal all openings in manhole or building walls after removal of piping. All material and equipment removed shall become the property of the Contractor and shall be removed from Government property within one week and shall not be stored in operating areas. All flame cutting shall be performed with adequate fire protection facilities available as required by safety codes and Contracting Officer.

3.2.1 Asbestos Removal

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NOTE: Existing systems may contain 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.

****

Conform to Section 02 82 00 ASBESTOS REMEDIATION.

3.3 PIPE, PIPING JOINTS AND FITTINGS

3.3.1 Welded Joints

Clean pipe and fittings inside and outside before and after assembly. Remove all 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 necessary between casing sections to provide drainage of casing section between manholes and between manholes and buildings.

3.3.2 Fittings

All changes in direction shall be made with factory-built reinforced

fittings. Field-fabricated fittings and miters are not permitted.

3.4 WELDING

The Contractor is entirely responsible for the quality of the welding and shall:

a. Conduct tests of the welding procedures used by his organization, determine the suitability of the procedures used, determine that the welds made shall meet the required tests, and also 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 shall conform with the applicable portions of ASME B31.1 and also as outlined below.

3.4.2 Examining Welders

The contractor shall examine each welder to determine the ability of the welder to meet the qualifications required. Test welders for piping for all positions, including welds with the axis horizontal (not rolled) and with the axis vertical. Each welder shall:

a. Weld only in positions in which he/she has qualified.

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

3.4.3 Examination Results

Provide the Contracting Officer with a list of names and corresponding code markings. Retest welders which fail to meet the prescribed welding qualifications. Disqualify welders who fail the second test, for work on the project.

3.4.4 Beveling

Field bevels and shop bevels shall be done by mechanical means or by flame cutting. Where beveling is done by flame cutting, surfaces shall be thoroughly cleaned of scale and oxidation just prior to welding. Conform to specified standards.

3.4.5 Alignment

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

3.4.6 Erection

Piping shall not be split, bent, flattened, or otherwise damaged either before, during, or after installation. Where the pipe temperature falls to 0 degrees C 32 degrees F or lower, the pipe shall be heated to approximately 38 degrees C 100 degrees F for a distance of 300 mm one foot on each side of the weld before welding, and the weld shall be finished 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 shall not be permitted. Welders responsible for defective welds must be requalified.

3.4.8 Electrodes

Electrodes shall be stored in a dry heated area, and be kept free of moisture and dampness during fabrication operations. Discard electrodes that have lost part of their coating.

3.4.9 Radiographic Testing

An approved independent testing firm regularly engaged in radiographic testing shall perform radiographic examination of 100 percent of the field welds in the carrier piping of direct-buried systems in accordance with ASME B31.1. Furnish 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. All radiographs shall be reviewed and interpreted by a Certified American Society for Nondestructive Testing Level III radiographer, employed by the testing firm, who shall sign the reading report. The Contracting Officer reserves the right to review all inspection records, and if any welds inspected are found unacceptable they shall be removed, rewelded, and radiographically reexamined at no cost to the Government.

3.5 HEAT DISTRIBUTION SYSTEM INSTALLATION

The UHDS manufacturer's representative shall oversee the delivery, storage, and witness the installation and testing of the system. All work shall be in strict accordance with the requirements specified herein and with the printed instructions of the manufacturer. These specifications shall take precedence over the printed instructions, if conflicts arise. Printed instructions shall be submitted to the Contracting Officer prior to system installation.

3.5.1 Verification of Final Elevations

Prior to covering the top of the casing with backfill material, but after all temporary supports have been removed and initial backfilling of the conduit system has been accomplished, the Contractor shall measure and record the elevation of the top of the casing in the trench. Elevations shall be taken at every completed field joint, 1/3 points along each pipe section and top of elbows. This measurement shall be checked against the contract drawings. These measurements shall confirm that the conduit system has been installed to the elevations shown on the contract

drawings. Slope shall be uniform to within 0.1 percent. These measurements shall be recorded by the Contractor, included in the UHDS manufacturer's representative daily report, and given 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 all excavation, trenching, and backfilling as required by the UHDS manufacturer's design and as specified in Section 31 00 00 EARTHWORK. Pipe shall lay on a 305 mm 12 inch minimum sand bed and backfilled with sand on all sides to a minimum of 150 mm 6 inches as measured from outside of casing. Foundation for system must be firm and stable. Foundation and backfill must be free from rocks or substances which could damage the system coating. Concrete anchor and thrust blocks must be installed in undisturbed earth. Backfilling must not commence until system has been satisfactorily pressure tested (both hydrostatic test of carrier and, for DDT systems, pneumatic test of casing. Minimum depth of burial to the top of the casing is600 mm 24 inches. Maximum depth of burial to the top of the casing is 3 meters 10 feet.

3.5.3 UHDS Manufacturer's Representative Responsibilities

This shall be a person who regularly performs the duties listed below, is certified in writing by the UHDS manufacturer to be technically qualified and experienced in the installation of the system, and shall be authorized by the manufacturer to make and sign the daily reports specified herein. The UHDS Manufacturer's representative shall be present at the job site and witness when the following types of work are being performed:

a. Inspection and unloading.

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

c. Inspection of concrete anchors and thrust blocks.

d. Hydrostatic testing of carrier piping.

e. Field joint closure work.

f. Pneumatic testing of DDT system casing.

g. Holiday test of conduit coating.

h. Repair of any coating.

i. Installation of cathodic protection system.

j. Initial backfill up to 250 mm 10 inches above the top of the casing.

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

l. Testing of cathodic protection system.

m. Operational tests

The UHDS manufacturer's representative is to notify the contractor immediately of any problems. If necessary, the UHDS manufacturer's representative will notify the Contracting Officer of problems requiring immediate action, otherwise the daily reports will note any problems encountered and indicate the corrective actions taken.

3.5.4 UHDS Manufacturer Representative's Reports

The UHDS manufacturer representative shall 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 one copy to the manufacturer's main office. The report shall 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 plans, specifications, and manufacturer's printed instructions and is satisfactory in all respects. When any work connected with the installation is unsatisfactory, the report shall state what corrective action has been taken or shall contain the UHDS manufacturer's recommendations for corrective action. The report shall identify any conditions that could result in an unsatisfactory installation, including such items as open conduit ends left in the trench overnight and improper manhole entries. The daily reports are to be reviewed, signed and sealed, on a weekly basis, by the registered engineer responsible for the system design. Signed and sealed copies of the daily reports shall be submitted with the payment request. Requests for payment shall be denied if the weekly review is not accomplished.

Upon completion of the work and before final acceptance, deliver to the Contracting Officer a notarized Certificate of Compliance signed by a principal officer of both the manufacturing and the contracting firm, stating that the installation is satisfactory and in accordance with plans, specifications, and manufacturer's instructions.

The UHDS manufacturer will 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 all accessories from damage due to exposure to UV light.

3.5.6 Defective Material

The UHDS Manufacturer's Representative shall 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 shall order prompt replacement of such material.

3.5.7 Cathodic Protection

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NOTE: Designer must indicate on the contract drawings that dielectric separation is shown where UHDS enter buildings or at 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. Cathodic protection systems shall have a minimum design life of 25 years and shall conform to [Section 26 42 13 GALVANIC (SACRIFICIAL) ANODE CATHODIC PROTECTION (GACP) SYSTEM][Section 26 42 17 IMPRESSED CURRENT CATHODIC PROTECTION (ICCP) SYSTEM]. Provide dielectric pipe flanges and unions and isolation devices at all points necessary. Provide test stations at grade on each section of the piping system. Isolation flanges and unions shall be rated for the service temperature and pressure.

3.6 TESTS

Demonstrate leak-tightness of all piping systems by performing pressure tests (hydrostatic, pneumatic) and operational tests. Pressure test heat distribution system in conformance with requirements stated in this specification and in printed instructions for the system supplied. Tests shall include carrier piping and casing. The carrier pipe shall be hydrostatically tested. Casings of DDT systems shall be pneumatically tested. Casing and end seals of WSL system will be tested for intrusion of water into the casing and insulation.

3.6.1 Holiday Testing of Direct-Buried System Steel Casings

Test entire exterior surface of the casing including the bottom exterior surface of the casing for faults in coating after installation in trench prior to backfilling. Use test method and voltage recommended by coating manufacturer. Repair any holidays found and retest. System shall not be backfilled 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 and are deemed clean to the satisfaction of the Contracting Officer.

3.6.2.1 Pneumatic Test

The casing of DDT systems shall be pneumatically tested after welding and before field coating using air as the test medium. The test pressure shall be 103 kPa 15 psig. Persons not working on the test operations shall be kept out of the testing area while testing is proceeding. The test shall be made on the system as a whole or on sections that can be isolated. Joints in sections shall be tested prior to backfilling when trenches must be backfilled before the completion of other pipeline sections. The test shall continue for 24 hours from the time of the initial readings to the final readings of pressure and temperature. The initial test readings of the instrument shall not be made for at least 1 hour after the casing has been subjected to the full test pressure, and neither the initial nor final readings shall be made at times of rapid changes in atmospheric conditions. There shall 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. Pressure shall be measured with a mercury manometer, inclined manometer(slope gauge), or an equivalent device so calibrated as to be read in increments of not greater than one kPa 0.1 psi. [Pressure shall be measured 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 shall be at least 114 mm 4.5 inches with a measurable range of 0 to 103 kPa 0 to 15 psig and graduations of not greater than 0.5 kPa 0.1 psig.] During the test, the entire system shall be completely isolated from all compressors and other sources of air pressure. Each joint shall be tested while under test pressure by means of soap and water or an equivalent nonflammable solution prior to backfilling or concealing any work. The testing instruments shall be approved by the Contracting Officer. All labor, materials and equipment for conducting the tests shall be furnished by the Contractor and shall be subject to inspection at all times during the tests. The Contractor shall maintain proper safety precautions for air pressure testing at all times during the tests.

3.6.2.2 Hydrostatic Test

Carrier piping shall be tested hydrostatically before insulation is applied at field joints and shall be proved tight at a pressure 1.5 times the heat distribution supply pressure of [_____] kPa [_____] psig for 2 hours. There shall be no indication of reduction of pressure during the test. Pressure shall be measured with a device calibrated as to be read in increments of not greater than one kPa 5.0 psi.

3.6.2.3 Operational Test

Prior to acceptance of the installation, Contractor shall subject system to operating tests simulating actual operating conditions to demonstrate satisfactory functional and operating efficiency. These operating tests shall cover a period of not less than six hours for each portion of system tested. Conduct tests at times as the Contracting Officer may direct.

a. The contractor shall provide calibrated instruments, equipment, facilities and labor, at no additional cost to the Government.

b. When failures occur, repair problems then repeat test.

3.6.3 Deficiencies

Deficiencies discovered shall be corrected at the Contractor's expense, to the satisfaction of the Contracting Officer. Major deficiencies or failure to correct deficiencies, to the satisfaction of the Contracting Officer, may be considered cause for rejecting the entire installation.

****

NOTE: Include Section 02559 VALVE MANHOLES AND PIPING AND EQUIPMENT IN VALVE MANHOLES as part of the contract specifications for this job when there are manhole or steam pits. Include sealing of pipe penetrations through manhole walls in the design of the manhole.

****

3.7 VALVE MANHOLES

Valve manholes, piping, and equipment in valve manholes shall be 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

Polyethylene plastic tape manufactured specifically for warning and identifying buried utility lines shall be supplied and installed. Tape shall be buried above the pipe during the trench backfilling operation and shall be buried approximately 300 mm 12 inches below grade. Tape shall be [0.1 mm 0.004 inch thick polyethylene] [polyethylene with a metallic core]. Tape shall be acid and alkali-resistant and shall have a minimum strength of 12 MPa 1750 psi lengthwise and 10.3 MPa 1500 psi crosswise with an elongation factor of 350 percent. [The tape shall be manufactured with integral wires, foil backing or other means to enable detection by a metal detector when the tape is buried up to one meter 3 feet deep. The metallic core of the tape shall be encased in a protective jacket or provided with other means to protect it from corrosion.] The tape shall be of a type specifically manufactured for marking and locating metallic underground utilities. Tape shall be 150 mm 6 inches wide and printed with a caution and identification of the piping system over the entire tape length. Tape shall be yellow with bold black letters. Tape color and lettering shall 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

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Markers for underground piping shall be located along the distribution and service lines. Markers shall be placed as indicated approximately 600 mm 2 feet to the right of the distribution system when facing in direction of flow in the supply line. The marker shall be concrete 150 mm 6 inch square or round section [600] [900] mm [2] [3] feet long. The top edge of the marker shall have a minimum 13 mm 1/2 inch chamfer all around. The letters [STEAM] [HTHW] [CONDENSATE] shall be impressed or cast on the top, and on one side of the markers to indicate the type of system that is being identified. Each letter shall be formed with a V-shaped groove and shall have a width of stroke at least 6 mm 1/4 inch at the top and depth of 6 mm 1/4 inch. The top of the marker shall protrude not more than [25] [50] [75] [100] mm [1] [2] [3] [4] inch(es) above finished grade.

3.9 THERMAL PERFORMANCE TESTING

The purpose of this section is to provide a basis for assuring the thermal performance of a heat distribution system procured under this specification. The equipment and procedures specified herein shall assure acceptable thermal performance upon installation. All materials and procedures described for this test shall be included as deliverables of the construction contract for the system unless otherwise noted. The

methods used for the prescribed thermal performance measurements have been verified by several successful field studies. This work has clearly demonstrated that methods based on temperature measurements at the soil/casing interface are accurate, reliable, and repeatable.

3.9.1 Equipment

3.9.1.1 Casing Temperature Measurement

Before backfilling, temperature sensors shall be installed by adhesion with epoxy (epoxy used to adhere to exterior of casing shall be suitable to 260 degrees C 500 degrees F) to the exterior of every other field closure after welding, once the field coating has been applied and cured. A sensor shall be adhered with epoxy to the coated casing at the midpoint of every other pipe section between field joints, but no closer than 1.5 m 5 feet to any guide on the interior of the casing. After the sensors have been adhered to the casing, two complete wraps of duct tape shall be used to secure and protect the sensor. In all cases the radial position of the sensor shall be at 45 degrees from the top of the conduit at either the 1:30 or 10:30 position. The position chosen shall be the position facing away from the adjacent heat distribution system pipe, if present. All sensors shall be type T thermocouples in accordance with ISA MC96.1, copper constantan 20 gauge thermocouples, made from special limits grade thermocouple wire (accuracy plus or minus 0.40 degrees C 0.75 degrees F), with each conductor insulated and an overall jacket on all conductors. Insulation on the thermocouple wires shall be suitable for service at temperature of carrier pipe. No splicing or other connections will be allowed in the thermocouple wire between sensor location and termination point. Each sensor shall be shown with a special symbol on the detailed design layout drawings and shall be identified by a number and/or letter code, starting from the upstream manhole.

3.9.1.2 Carrier Pipe Temperature Measurement

Carrier pipe temperature shall be measured within the manhole where the terminal equipment will be located. Carrier pipe temperature shall be measured by a sensor adhered with epoxy, suitable to 260 degrees C 500 degrees F directly to the exterior of the carrier pipe. Sensors shall be type T thermocouples in accordance with ISA MC96.1, copper constantan 20 gauge thermocouples, made from special limits grade thermocouple wire (accuracy plus or minus 0.40 degrees C 0.75 degrees F), with each conductor insulated and an overall jacket on all conductors. Insulation on the thermocouple wires shall be suitable for service at temperature of carrier pipe. No splicing or other connections will be allowed in the thermocouple wire between sensor location and termination point. The location of this sensor shall be at either the 1:30 or 10:30 position. At the location of the sensor the carrier pipe shall be insulated with an approved calcium silicate insulation of 125 mm 5 inches minimum thickness. This insulation shall extend at least 150 mm 6 inches on each side of the actual sensor location and shall be clad with an aluminum jacket.

3.9.1.3 Terminals

The wires from each casing or carrier pipe temperature sensor shall be extended into the nearest manhole and terminated in a NEMA ICS 4 type 4 waterproof enclosure, of suitable size, mounted near the top of the manhole at a location near the manhole entrance so as to be accessible without entrance into the manhole, where possible. The termination of the

sensor wires shall be with a connector type OMEGA Miniature Jack Panel (MJP-*-*-T) or exact equal. The thermocouple jack panel shall be mounted to the back plate of the NEMA ICS 4 type 4 enclosure. The temperature sensors shall be labeled at their termination within the NEMA ICS 4 type 4 enclosure; a drawing showing the location of each temperature sensor shall be laminated and attached to the inside of the NEMA ICS 4 type 4 enclosure. The manufacturer's operating casing temperature factors for each temperature sensor location shall be laminated to a card attached to the inside of the NEMA ICS 4 type 4 enclosure. All temperature sensors shall be verified as operational by an independent laboratory, hired by the Contractor, after backfilling is complete but before the system is accepted.

3.9.2 Initial Thermal Performance Test

After the system construction is complete, including all backfilling, and the system has reached operating condition for not less than 48 hours nor more than 168 hours, all of the temperature sensors shall be read by an independent laboratory with experience and equipment appropriate for the sensors used. For each temperature sensor location the initial casing temperature shall be recorded. All of the temperature values of the temperature sensors shall be tabulated and submitted in accordance with requirements herein.

3.9.3 Warranty Thermal Performance Test

After not less than 9 months nor more than 11 months of continuous operation, all of the temperature values of the temperature sensors shall be read by an independent laboratory with experience and equipment appropriate for the sensors used. The temperature shall be tabulated and submitted in accordance with requirements herein.

3.9.4 System Failure

System shall be deemed a failure when the conduit surface temperature exceeds values in Table 3, that portion shall be repaired and temperatures again measured and recorded.

TABLE 3

Carrier pipe Temperature TP (degrees C)	Acceptable Casing Temperature TC (degrees C)
121	43
135	47
149	50
163	54
177	58
204	65

TABLE 3	
Carrier pipe Temperature TP (degrees C)	Acceptable Casing Temperature TC (degrees C)
218	68
232	72

TABLE 3	
Carrier pipe Temperature TP (degrees F)	Acceptable Casing Temperature TC (degrees F)
250	110
275	116
300	123
325	129
350	136
400	149
425	155
450	162

The following equations were used to calculate the above values:

TC, </=[(0.261) X (TP) + 11.5] TC, </=[(0.261) X (TP) + 44.3]

-- End of Section --