	Title: YALE OFFICE OF FACILITIES PROCEDURE MANUAL Chapter: 01 - Yale Design Standard Division: HVAC Standards	Section: 33 61 00 02 Direct Buried Piping and Conduit Systems
		Date: 6/15/16
		Author: Office of Facilities
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PART 1 - INTRODUCTION

1.1 PURPOSE

- A. This section is intended to provide design guidelines for Utility Direct Buried Piping and Conduit Systems.

PART 2 - GENERAL DESIGN REQUIREMENTS

2.1 DIRECT BURIED PIPING AND CONDUIT SYSTEMS


A. GENERAL

- 1. Direct buried piping systems shall be provided when dictated by Yale Utilities.


B. STEAM AND CONDENSATE SYSTEMS

1. Materials

- a. All underground direct buried steam and condensate lines shall be Class A testable, drainable and dryable. The system supplier shall have fabricated systems of the composition described herein for at least three years. All straight sections, fittings, anchors, and other accessories shall be factory prefabricated to job dimensions and designed to minimize the number of field welds. Each system layout shall be computer analyzed by the piping system manufacturer to determine the stresses on the carrier pipe and anticipated thermal movement of the service pipe. The system design shall be in strict conformance with ASME B31.1. The pre-approved conduit system shall include all piping and components to a point as designated on the drawings inside the building, tunnel, or manhole wall. Manufacturers shall be Perma-Pipe (Multi-Therm 500) or Thermacor (Duo-Therm 505).
- b. The system supplier's representative shall be responsible for directing the installation and testing of the conduit system. It shall be certified in writing by the supplier that the representative is technically qualified and experienced in the installation of the systems and has been factory trained to provide field technical assistance. The supplier's representative shall be present during the following work phases:


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- 1) Inspection and unloading
 - 2) Inspection of trench prior to laying of conduit
 - 3) Inspection of expansion loops
 - 4) Inspection of joining of system
 - 5) Hydrostatic Testing (piping)
 - 6) Air test (conduit)
 - 7) Repair of any patchwork
 - 8) Back filling of conduit sections
- c. The contractor shall not perform any of the above stated work in the absence of the system supplier's representative.
 - d. The contractor performing the work shall be responsible for the installation of the pre- approved system and all other components of the underground steam and condensate conduit systems, including the piping equipment in the manholes and buildings. This responsibility shall include all site work and purchase of the pre-approved system from the system supplier.
 - e. General Direct Buried Steam and Condensate System Specifications
 - 1) Service Pipe and Fittings Specifications: Refer to the Part 7 for all System Specifications.
 - f. Service Pipe: Where possible, straight sections shall be supplied in 40 foot random lengths with 6 inches of piping exposed at each end for field joint fabrication. Systems with condensate lines 6 inches and smaller, shall have the trap return and pumped condensate piping contained in a single outer conduit pipe.
 - g. Sub-Assemblies: Gland seals, end seals, and anchors shall be designed by the system manufacturer and factory prefabricated to prevent the ingress of moisture into the system. Gland seals shall be used when thermal expansion is carried through the manhole wall as when an expansion joint is located inside the manhole. When an anchor is direct buried outside of the manhole, end seals shall be used. Make sure end seals and gland seals are called out on the drawings. All sub- assemblies shall be designed to allow for complete draining and drying of the conduit system. Refer to Detail 3-1, Link Seals, End Seals, and Gland Seals.
 - h. Piping Insulation: Piping insulation shall be mineral wool for the service pipe. Split insulation shall be held in place by stainless steel bands installed on not less than 18 inch centers. The insulation shall have passed the most recent boiling test and other requirements specified in the Federal Agency Guidelines. The insulation thickness for mineral wool shall in accordance with Part 11 as stated for fiberglass.
 - i. Outer Conduit: The steel conduit casing shall be airtight, pressure testable,

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smooth wall welded steel conduit. As noted above, with systems having 6 inches or smaller condensate lines, the trap return and pumped condensate service pipes shall share the same outer conduit. The steel conduit shall withstand H-20 loading with a minimum of 24 inches of cover.

- j. Outer Conduit Insulation and Jacket: Conduit insulation shall be a minimum of 1 inch thick factory applied polyurethane foam, meeting ASTM C591. The outer jacket shall be either:
 - 1) Fiberglass (FRP) and filament wound directly onto the urethane foam insulation, with a minimum thickness of 0.160 inches for 6 inch and above service pipes and a minimum 0.120 inches for service pipes below 6 inches. Field enclosures shall be shrink wrap type per the manufacturer's recommendation.
 - 2) High Density Polyethylene (HDPE) jacket with a minimum wall thickness of 0.175 inches. Field enclosures shall be shrink wrap type per the manufacturer's recommendation.
- k. Pipe Supports: All pipes within the inner casing shall be supported at not more than 10 foot intervals. These supports shall provide support at all sides of the piping and shall be designed to allow for continuous airflow and drainage of the conduit in place. The straight supports shall be designed to occupy not more than 10% of the annular air space. Supports shall be of the type where insulation thermally isolates the carrier pipe from the outer conduit. Supports which directly contact both the carrier pipe and the outer casing shall not be allowed. The surface of the insulation shall be protected at the support by a sleeve not less than 12 inches long, fitted with traverse and where required, rotational arresters.
- l. Expansion Loops and Ells: Prefabricated expansion loops and ells can be utilized during the design and construction of the distribution to provide a layout/proper design in accordance with stress limits indicated by the code for pressure piping ASME B31.1. Loop and ell piping shall be installed in conduit suitable sized to allow for thermal expansion pipe movement. An analysis shall be performed by the Engineer to determine if it is more beneficial to use straight runs with expansion joints in manholes versus using expansion loops and ells. Things to consider in the analysis include construction cost, phasing, and disturbance of grounds.
- m. Field Joints: Insulate, seal, and protect all field joints in accordance with the manufacturer's written instructions and utilizing pipe manufacturer's procedures and field joint kits consisting of insulation, coatings and wrapping materials
- n. Backfill: A 6 inch layer of sand or pea gravel shall be placed and tamped in the


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trench to provide uniform bedding for the conduit. The entire trench shall be evenly backfilled with a similar material as the bedding in 6 inch compacted layers to a minimum height of 6 inches above the top of the insulated piping system. Bedding and backfill materials shall be as approved by the designer and manufacturer. Note that the composition of the backfill and the compaction of the backfill are extremely important due to possibility of settling and having the link seals and/or conduit system being crushed. This causes leaking into the casing and/or manholes and causes major damage. Designers must perform due diligence to verify existing soil conditions and provide a design that minimizes settling.

- o. Provide detectable aluminum foil plastic backed tape or detectable magnetic plastic tape manufactured specifically for warning and identification of buried piping. Tape shall be detectable by an electronic detection instrument. Provide tape in rolls, 6 inches minimum width, color; yellow, with warning and identification imprinted in big black letters continuously and repeatedly over entire tape length. Warning and identification shall read "CAUTION BURIED STEAM SYSTEM DISTRIBUTION PIPING BELOW" or similar wording. Use permanent code and letter coloring unaffected by moisture and other substances contained in trench backfill material.

C. Penetrations

- 1. All penetrations through structure walls (building walls, tunnel walls, and manhole walls, etc.) shall be in accordance to the following requirements:
 - a. All penetrations shall be sealed by utilizing a water tight sleeve by "Link Seal" or approved equal. No dripping of water through the seal is permitted. Refer to Detail 3-1, Link Seals, Ends Seals, and Gland Seals.
 - b. The water tight sleeve shall be installed so it can be accessed from the inside of the structure.
 - c. The pipe alignment to the structure wall shall be as close to perpendicular as possible to provide enough space for the installation of the water tight sleeve.
 - d. The penetration hole shall either be made utilizing a smooth sleeve during the casting of the wall or made utilizing a core drill procedure so that the hole is smooth. (Core drilling is preferred because of the smoothness of the hole, the lack of a need for a sleeve which could be a cause for a leak point if it were to rust, and it removes the risk of accurately locating the sleeve during the construction of the manhole.) The size of the hole shall be coordinated with the water tight sleeve and the outside diameter of the conduit system.
 - e. All space between the back of the water tight sleeve and the exterior face of the structure shall be filled with waterproof foaming polyurethane insulation. In areas below the water table, the space between the back of the water tight

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sleeve and the exterior face of the structure shall be filled with waterproofing grout. The exterior structure waterproofing system (See Part 4.B, Waterproofing Materials and Part 4.C, Waterproofing Methods) shall overlap the foam insulation or grout sealing to the outside of the piping system. If a membrane is used for waterproofing, the membrane shall overlap onto the penetrating pipe and be clamped with a stainless steel band clamp to the penetrating pipe.

D. Testing and Cleaning

1. Service Pipe

- a. General: For most cases encountered for Yale's direct buried utilities, radiography and magnetic particle testing are not required per ASME B31.1. The requirements are specified to get the Contractor to use good welders. Leaks in piping in direct buried systems are difficult to find, can significantly hurt the construction schedule, and can cause other problems.
- b. Examine 100% all factory butt welds (typically 2-1/2" NPS and greater) per radiography examination requirements in accordance with Part 9, Pipe System Testing and Cleaning. The Engineer shall specify a number of field welds to be tested via radiography examination - this shall be a hard number, not a percentage of welds so that the actual scope can be determined and tracked. The Engineer shall estimate the number of field welds and shall require testing of at least 20% of the estimated field welds. The Engineer shall specify that when there is a radiography examination that does not pass, the repair weld of the failed weld shall be tested and an additional weld (located by the Engineer) shall be tested at no cost to Yale. If a welder has three failed welds, he must be removed from the project.
- c. Examine 100% of factory socket and fillet welds (typically 2" NPS and under) per magnetic particle method examination in accordance with Part 9, Pipe System Testing and Cleaning. The Engineer shall specify a number of field welds to be tested via magnetic particle examination - this shall be a hard number, not a percentage of welds so that the actual scope can be determined and tracked. The Engineer shall estimate the number of field welds and shall require testing of at least 20% of the estimated field welds. The Engineer shall specify that when there is a magnetic examination that does not pass, the repair weld of the failed weld shall be tested and an additional weld (located by the Engineer) shall be tested at no cost to Yale. If a welder has three failed welds, he must be removed from the project.
- d. Cleaning shall be in accordance with Part 9, Pipe System Testing and Cleaning.


2. Steel Conduit casing shall be air tested at 8 psig. The test pressure shall be held for not less than one hour.

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E. CHILLED WATER SYSTEMS

1. Materials


- a. The complete underground direct buried chilled water distribution piping system shall include all required components such as carrier pipes, fittings, anchors, pipe supports, and insulation. The underground distribution piping systems shall not include valve manholes and the piping and equipment inside the manholes. The underground distribution piping systems shall include all piping and components to a point 12 inches inside the building, tunnel walls, or manhole walls. The underground piping distribution system shall be rated for 250 PSIG at fluid temperatures from 34 degrees Fahrenheit up to 140 degrees Fahrenheit. Each underground piping system shall be pre-engineered by the piping system manufacturer. All straight pipe sections, fittings, anchors, and other accessories shall be provided as required by the underground piping system manufacturer. The underground piping system shall be designed in accordance with the ASME B31.1. System shall be carbon steel pipe with fiberglass or HDPE jacketed. Acceptable products are POLYTHERM preinsulated piping system manufactured by PERMA-PIPE and CHILL-THERM preinsulated piping system manufactured by Thermacore Process, L.P.
- b. The system supplier's representative shall be responsible for directing the installation and testing of the conduit system. It shall be certified in writing by the supplier that the representative is technically qualified and experienced in the installation of the system. The supplier's representative shall be present during the following work phases:
 - 1) Inspection and unloading
 - 2) Inspection of trench prior to laying of conduit
 - 3) Inspection of expansion loops
 - 4) Inspection of joining of system components
 - 5) Hydrostatic Testing (piping)
 - 6) Repair of any patchwork
 - 7) Back filling of conduit sections
- c. The contractor shall not perform any of the above stated work in the absence of the system supplier's representative.
- d. The contractor performing the work shall be responsible for the installation of the piping system and all other components of the underground conduit system, including the manholes and the piping equipment in the manholes. This responsibility shall include all site work and purchase of the piping system from the system supplier.
- e. General Direct Buried Chilled Water System Specifications

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- 1) Service Pipe and Fittings Specifications: Refer to the Part 7 for all System Specifications.
- 2) Protective Jacket: Conduit surfaces, inside and outside, shall be cleaned and made free of all loose debris. Protective jacket shall be:
 - a) Fiberglass (FRP) and filament wound directly onto the urethane foam insulation. Field enclosures shall be shrink wrap type per the manufacturer's recommendation.
 - b) High Density Polyethylene (HDPE) jacket with a minimum wall thickness of 0.150 inches. Field enclosures shall be shrink wrap type per the manufacturer's recommendation.
- f. Expansion Loops and Ells: Expansion loops and ells are the preferred method in all installations. The design shall be of proper design in accordance with stress limits indicated by the code for pressure piping ASME B31.1.
- g. End Seals: Terminal ends of conduits inside building, tunnels, or manholes shall be equipped with factory furnished end seals. Terminate all conduits 12" beyond the inside face of manhole or building walls to protect any exposed piping insulation from damp-wall condensation.
- h. All fittings shall be factory prefabricated, insulated and jacketed
- i. Insulation: Polyurethane Foam insulation, meeting ASTM C591 with the following insulation thickness:

Nominal Pipe Size (IN)	Insulation Thickness
1"	1"
1-1/2" to 3"	1-1/2"
4" to 6"	2"
8" to 14"	2-1/2"
16" to 20"	3"
22" and up	3-1/2"

- j. A written certification from the underground distribution piping system manufacturer verifying that the conduit system contains no voids in the insulation prior to shipment to the job site shall be required. All insulation shall be factory tested for voids prior to application of the protective jacket by infrared inspection over the entire length or x-ray over the entire length.
- k. Anchors: Anchors shall be designed by the manufacturer and factory prefabricated to prevent the ingress of moisture into the system.
- l. Field Joints: Insulate, seal and protect all field joints in accordance with the manufacturer's written instructions and utilizing pipe manufacturer's procedures

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- and field joint kits consisting of insulation, coatings and wrapping materials.
- m. Backfill: A 6 inch layer of sand or pea gravel shall be placed and tamped in the trench to provide uniform bedding for the conduit. The entire trench shall be evenly backfilled with a similar material as the bedding in 6 inch compacted layers to a minimum height of 6 inches above the top of the insulated piping system. Bedding and backfill materials shall be as approved by the designer and manufacturer. Note that the composition of the backfill and the compaction of the backfill are extremely important due to possibility of settling and having the link seals and/or conduit system being crushed. This causes leaking into the casing and/or manholes and causes major damage. Designers must perform due diligence to verify existing soil conditions and provide a design that minimizes settling.
- n. Buried Utility Warning and Identification Tape: Provide detectable aluminum foil plastic backed tape or detectable magnetic plastic tape manufactured specifically for warning and identification of buried piping. Tape shall be detectable by an electronic detection instrument. Provide tape in rolls, 6 inches minimum width, color; yellow, with warning and identification imprinted in big black letters continuously and repeatedly over entire tape length. Warning and identification shall read "CAUTION BURIED CHILLED WATER DISTRIBUTION PIPING BELOW" or similar wording. Use permanent code and letter coloring unaffected by moisture and other substances contained in trench backfill material.


F. Penetrations

- 1. Refer to Part 3.B.2, Penetrations.

G. Testing and Cleaning

1. Service Pipe

- a. Examine 100% all factory butt welds (typically 2-1/2" NPS and greater) per radiography examination requirements in accordance with Part 9, Pipe System Testing and Cleaning. The Engineer shall specify a number of field welds to be tested via radiography examination - this shall be a hard number, not a percentage of welds so that the actual scope can be determined and tracked. The Engineer shall estimate the number of field welds and shall require testing of at least 10% of the estimated field welds. The Engineer shall specify that when there is a radiography examination that does not pass, the repair weld of the failed weld shall be tested and an additional weld (located by the Engineer) shall be tested at no cost to Yale. If a welder has three failed welds, he must be removed from the project.

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- b. Examine of 100% of factory socket and fillet welds (typically 2" NPS and under) per magnetic particle method examination in accordance with Part 9, Pipe System Testing and Cleaning. The Engineer shall specify a number of field welds to be tested via magnetic particle examination - this shall be a hard number, not a percentage of welds so that the actual scope can be determined and tracked. The Engineer shall estimate the number of field welds and shall require testing of at least 10% of the estimated field welds. The Engineer shall specify that when there is a magnetic examination that does not pass, the repair weld of the failed weld shall be tested and an additional weld (located by the Engineer) shall be tested at no cost to Yale. If a welder has three failed welds, he must be removed from the project.
- c. Cleaning shall be in accordance with Part 9, Pipe System Testing and Cleaning.

2.2 CONDUIT SYSTEM

A. Materials

1. All underground direct buried conduits shall be rigid galvanized steel and UL listed for use in wet locations. The conduit exterior and interior shall be hot-dipped galvanized in accordance with ANSI C80.1. The conduit threads shall be hot-dipped galvanized after fabrication. The conduit shall be provided with a corrosion protective coating. Conduit shall be NRTL-listed and labeled under UL 6. Manufacturers shall be Allied Tube and Conduit, Wheatland Tube Company, or Western Tube & Conduit Corporation.
2. All conduit elbows, couplings, and fittings shall be rigid galvanized steel and UL listed for use in wet locations. Elbows, couplings, and fittings shall be hot-dipped galvanized and also have a corrosion protective coating. All conduit accessories shall be NRTL and UL listed.
3. Direct buried conduit shall be installed to meet the minimum cover requirements stated in NEC Table 300.5.
4. The contractor performing the work shall be responsible for the installation of the conduit system. This responsibility shall include the purchase of the conduit and accessories.

B. Penetrations

1. Refer to Part 3.B.2, Penetrations.