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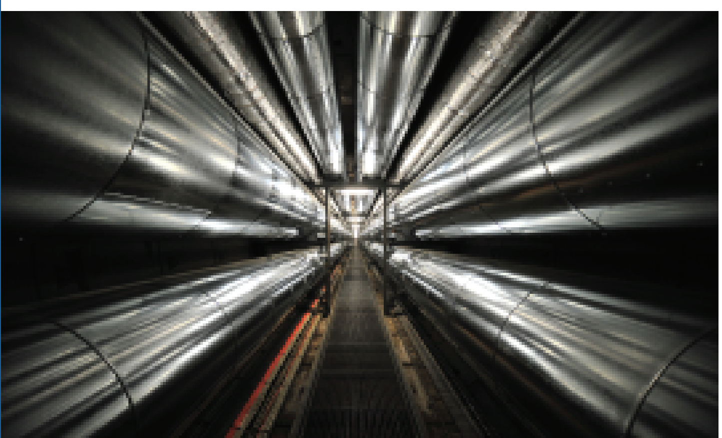

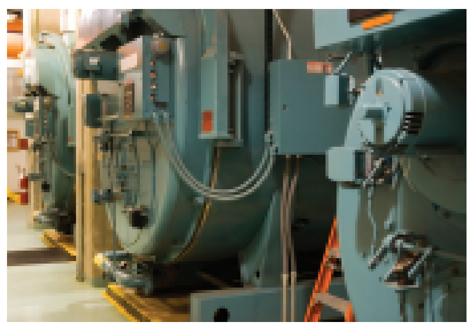

Steam, Heating Hot Water, and Outside Distribution Systems design manual

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Volume 3

Outside Steam and Heating Hot Water DISTRIBUTION SYSTEMS

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DISTRIBUTION SYSTEMS

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1.0 GENERAL:

1.1 Outside heat distribution work includes all heating hot water (HHW), steam supply and steam condensate piping and equipment located underground, in tunnel, or aboveground outside of buildings. Systems located 5 feet outside the building exterior wall are considered site (or outside) distribution.

1.2 Design the outside heat distribution systems to comply with this design manual, and the current editions of VA design guides, VA design and construction procedures, and the VA master specifications. The design shall also comply with the provisions of the current edition of ASME B31.1 Code for Pressure Piping. If state or local codes are more stringent than the above requirements, discuss with the Healthcare Environment and Facilities Programs (HEFP) healthcare engineering staff.

1.3 Show outside heat distribution plot plans on drawings using a minimum scale of 1:250 (1”= 20’). Manhole piping plans and sections shall be drawn with a minimum scale of 1:30 (3/8" = 1').

1.3.1 Existing work shall be identified in a way which easily distinguishes this work from the new work. Points of connection between new and existing work shall be identified.

1.4 Outside steam distribution systems shall be designed to provide the required steam flow and pressure at the point of use. All condensate shall be returned to the boiler plant unless the design of steam-using equipment prevents this, for very small loads, or when it is not economical.

2.0 **CRITERIA UNIQUE TO VA:**

2.1 Outside heat distribution work shall only be indicated on "MS"-series drawings (see VA Design and Construction Procedure, “Drawings”).

2.1.1 “MS"-series drawings shall include symbols and schedules, details, plot plans and profiles with interference from other utilities located and identified, manhole plans and sections, tunnel and trench plans and sections, location of expansion loops and anchors, demolition plans, other work as necessary.

2.1.2 Only symbols and abbreviations shown on VA Standard Details (PG-18-4) division 00 and 23 may be used on the drawings.

2.1.3 Pipe sizes shall be indicated on plot plans and on manhole plans and sections.

2.1.4 Equipment and piping systems shown on the drawings shall be generic and not the configuration of a particular manufacturer.

2.2 Major options and alternatives shall be evaluated utilizing the life cycle cost analysis methods using Department of Energy mandated discount factors.

3.0 TYPES OF SYSTEMS:

3.1 Pre-engineered, factory-fabricated, direct buried distribution systems: These are systems of various manufacturers which include the carrier pipes, pipe insulation, protective enclosures, and accessories. The systems may be "drainable-dryable-testable" or "water-spread-limiting" as defined in the VA master specification. The "drainable-dryable-testable" system specified is an enhancement of the standard products of manufacturers. The enhancements include thicker casings, type and thickness of insulation, superior coating, thicker end plates, and cathodic protection. These enhancements are based on studies and recommendations made under the auspices of the federal agency committee on underground heat distribution systems. The "water-spread-limiting" system specified is one which, before acceptance on VA projects, must have passed tests required by the current Unified Facilities guide specification, UF 02546. Currently, no system has passed these tests.

Caution: ***The design of direct buried systems shall adhere strictly to the VA Master Specification, Section 33 63 00. Numerous failures of manufacturer's standard systems have been experienced.***

3.2 Concrete Shallow Trench Distribution Systems: These are either precast or field-built systems designed specifically for each project. The tops of the trench covers are slightly below or at grade and the trenches are sized only for pipe, insulation, and pipe supports with no provision for personnel access other than the removable covers. These systems can be applied only where site conditions (such as water table below maximum trench depth, lack of surface water, level or continuous grades) permit. Refer to Master Specification Section 33 63 00, Appendix I for acceptable conditions for application of shallow trenches.

3.3 Concrete Tunnel Systems: These are either precast or field-built systems designed specifically for each project and are sized to permit personnel walk-thru. They can often be justified on the basis of life cycle costs when other utilities, such as chilled water, share the tunnel.

4.0 SELECTION OF TYPE OF SYSTEM:

4.1 The design engineer shall select the type of system primarily based on a comparison of the life cycle costs of the types of systems.

4.2 The analysis shall also include an environmental impact (potentially NEPA) as applicable to the past work on the site. Life cycle cost analysis shall include removal of any portion of an existing system that may pose an environmental hazard if left abandoned in place.

4.3 In making the selection, the engineer shall also consider the service record of existing types of systems at the site. Consideration shall be given to the extent of the new systems, the ability to combine various utility services into one trench or tunnel, and maintenance requirements.

5.0 SYSTEM DESIGN

5.1 Steam and HHW load calculations:

5.1.1 Loads may include HVAC, domestic hot water, kitchen, laundry, sterilizers, other process loads, and line losses.

5.1.2 Load profiles shall include diversity factors and credits for heat recovery systems which are in operation during the peak load conditions.

5.1.3 Existing loads should be determined by reviewing boiler steam flow rate data for winter periods when the outside temperature approaches ASHRAE design conditions. Loads may be apportioned among separate buildings by analysis of major steam-using equipment and comparing building floor areas, whichever is most accurate.

5.1.4 Consider future loads for new construction projects which are programmed.

5.2 Steam distribution pressure:

5.2.1 Distribution shall be the same as the boiler plant header pressure unless existing conditions make this impractical.

5.2.2 It is recommended that operational steam pressure not be increased on existing distribution systems. Pressures on existing systems may be increased only if a complete engineering analysis of the system is performed and stamped by a registered engineer and is deemed appropriate to increased thermal expansion, increased pressures in fittings, valves and joints as well as temperatures.

5.3 Connecting to existing steam distribution systems:

5.3.1 Calculate steam flows and pressure drops on the portions of the existing system which are affected by the new steam loads. The new steam loads shall not impose excessive pressure drops or velocities on the existing systems.

5.4 Sloping and dripping of steam lines:

5.4.1 Steam lines shall pitch down 50 mm in 12 meters [two inches in 40 feet] in the direction of flow. Provide drip pockets and steam traps at all risers and immediately ahead of all isolation valves that would collect condensate if the valves are closed. Distance between drip pockets shall not exceed 150 meters [500 feet] and should be less if possible. Locate all drip pockets and steam traps in manholes or buildings. Provide oversized drip pockets (refer to standard detail). Steam drip traps shall discharge into a drip return line which is separate from other types of condensate return lines such as pumped returns and vacuum returns.

Caution: ***Water hammer is dangerous and must be prevented. It can occur when condensate is not properly removed from steam lines. Steam lines shall be properly sloped and drained.***

5.4.2 Steam traps for steam line drip service shall handle normal steady state radiation and convection heat loss condensate and also high levels of condensate and air flow when the steam line is being warmed-up. The preferred trap type is the inverted bucket type with thermal vent (for air release on warm-up) in the bucket. This type is resistant to water hammer and wire drawing of the valve and seat. Caution must be exercised when sizing the traps because oversized traps can "blow-through" (fail open) and lose their prime.

5.4.3 Trap monitoring shall be supplied in critical locations on all mains and major traps.

5.4.4 Provide adequate access to all traps and other appurtenances for maintenance and inspection. See also para 5.11.11

Caution: ***Fixed orifice steam traps with no operating mechanism shall not be applied on steam line drip service. VA experience is that the small diameter orifices become plugged with dirt and the trap fails closed. This will cause build-up of condensate in the steam main and dangerous water hammer may occur.***

5.5 Condensate Return:

5.5.1 Generally, all condensate should be collected at condensate return pump sets and then be pumped to the boiler plant. Exceptions include existing systems being replaced which have other types of condensate returns such as vacuum or gravity. Also drip returns from the steam line drip traps may be returned directly to the boiler plant if practical.

5.6 Installation of HHW Lines

5.6.1 Indicate piping slopes on drawings. Piping shall be installed free of sags and bends. Design for fittings for changes in direction and branch connections. Design and installation of piping shall allow application of insulation. Groups of pipes shall be parallel to each other, spaced to permit applying insulation and servicing of valves.

5.6.2 Reduce pipe sizes using eccentric reducer fitting installed with level side up.

5.6.3 Indicate branch connections to mains using tee fittings in main pipe, with the branch connected to the bottom of the main pipe. For up-feed risers, connect the branch to the top of the main pipe.

5.6.4 Show shutoff valve immediately upstream of each dielectric fitting.

5.6.5 Indicate sleeves and/or seals for piping penetrations of concrete walls and slabs with specific detail as to design and construction requirements.

5.7 Thermal Expansion:

5.7.1 Locate and design the anchors and the expansion joints, bends and loops so that piping will not be overstressed. The locations shall be shown on drawings. Sizes of bends and loops need not be shown on direct buried systems because the system manufacturer is responsible for loop and bend sizing. Expansion loops shall be used instead of expansion joints unless not physically possible. The use of expansion joints shall be approved by HEFP if absolutely required to accommodate the installation.

5.7.2 Pipe anchors shall be provided within 0.6 to 1.5 m [two to five feet] outside of manhole and building walls to minimize pipe movement through the manhole and/or Building. For piping passing through the manhole, do not anchor on both sides of the manhole unless the piping within the manhole has sufficient offset to avoid overstress. Thermal expansion stress calculations shall be conducted to ensure proper anchor locations throughout the system. Those calculations shall also account for the pipe expansion in the manholes.

5.7.3 All anchoring and expansion joints, bends and loops shall be completely designed including the civil structural component and specified in the contract documents except for anchors and expansion loops and bends being furnished as part of a direct buried system. These are the responsibility of the manufacturer of the direct buried system to design.

5.7.4 Design steam piping system for a minimum steam pressure of 1,034 kPa, 188 C [150 psi, 370 F] or the maximum boiler safety valve setting and associated temperature whichever is greater. The condensate/return system shall also be designed for 1,034 kPa, 121 C [150 psi, 250F] or pump dead head whichever is greater. Pipe stresses shall not exceed allowable stresses calculated in accordance with ASME B31.1, ASME Code for Pressure Piping, Power Piping.

5.8 Fiberglas Reinforced Plastic (FRP) Pipe for Condensate:

5.8.1 This prohibited.

5.9 Pipe Material

5.9.1 The following table reflects acceptable carrier pipe material. Outside HHW distribution, including distribution in tunnels and/or shallow trenches shall be all welded construction. Alternate systems may be considered based on specific needs and characteristics of a given site, but will require prior approval by HEFP:

Utility	Minimum Size	Material
Steam / HHW	≥ 150 mm (6 inches)	Seamless carbon steel schedule 40, butt weld
Steam / HHW	< 150 mm (6 inches)	Carbon Steel Schedule 40, socket weld joint 2” and smaller, butt weld larger
Condensate	< 150 mm (6 inches)	Seamless carbon Steel Schedule 80, socket welded 2” and smaller, butt weld larger
High Pressure Drip	N/A	Seamless Carbon Steel schedule 80, Socket weld 2” and smaller, butt weld larger.

5.10 Insulation:
Comply with EPA and VA specification requirements.

5.10.1 Factory Applied Insulation:
Prefabricated pipe and fittings shall be insulated in the factory. Foam insulation for prefabricated insulated pipe and fittings shall be polyurethane (polyisocyanurate) foam meeting the requirements of ASTM C591 having a density not less than 2 pounds per cubic foot (pcf). The polyurethane (polyisocyanurate) foam shall completely fill the annular space between the carrier pipe and the casing. Insulation thickness shall be a minimum of 1” inch. The insulation thermal conductivity factor shall not exceed the numerical value of 0.15 Btu-inch/square foot-degree F-hour at 75 degrees F, when tested in accordance with ASTM C518. Manufacturer shall certify that the insulated pipe is free of insulation voids.

5.10.2 Field Applied Insulation:
Steam Systems: Field applied insulation for fittings, and field casing closures, if required, and other piping system accessories shall be polyurethane (polyisocyanurate) matching the pipe insulation. Thickness shall match adjacent piping insulation thickness. Buried fittings and accessories shall have field applied polyurethane (polyisocyanurate) insulation to match adjacent piping and shall be protected with a covering matching the pipe casing. Shrink sleeves with a minimum thickness of 50 mils shall be provided over casing connection joints.
HHW Systems: Field applied insulation shall follow the requirements of VA specifications Section 23 07 11 “HVAC and Boiler Plant Insulation”. Tunnel piping insulation shall adhere to this specification requirement for “above ground insulation”. Shallow trench and underground piping insulation shall adhere to the requirements “for Exterior Locations”.

5.11 Underground warning tape:

Design for the provision of underground warning tape to be buried above the piping during the trench backfilling and shall be buried approximately 30.5 cm [12 inches] below grade. Tape shall be polyethylene tape with metallic core. Tape shall be 15 cm [6 inches] wide and be printed with repetitive caution warnings along its length. Tape shall be yellow in color with black letters. Tape color and lettering shall not be affected by moisture or other substances contained in the backfill material.

5.12 Manholes:

5.12.1 In direct buried systems and in concrete trench systems all devices requiring access for operation and maintenance shall be located in manholes. These devices include valves, steam traps, expansion joints, flanged and threaded joints, unions.

5.12.2 Manholes shall be cast-in-place reinforced concrete. Prefabricated manholes are prohibited due to difficulty of properly locating underground pipe openings in the manhole walls. Concrete floor slabs shall be of sufficient weight to prevent floatation in high water table areas.

5.12.3 Do not locate manholes in roads or parking areas because of access and ventilation problems.

5.12.4 Manhole structure and mechanical layout shall be completely designed by the A/E. Allow adequate working access and headroom.

5.12.5 Provide a minimum of two separate entrances from grade with full-size manhole covers dependent on safety/operational requirements. One shall be for access with grab-bars or ladder set in the manhole wall, the other shall be for ventilation while working in the manhole. Locate the ventilation access directly above the sump.

5.12.6 Provide 760 mm (30 inch) square (minimum) by 915 mm (36 inch) deep sump in floor and slope manhole floor to the sump. Provide duplex submersible sump pumps when electricity is available otherwise a drop-down pump shall be used. Where feasible, provide gravity drainage to a storm sewer.

5.12.7 The designer shall review the “confined space” regulations of the facility and design the manholes to allow maximum possible access convenience. The designs shall be reviewed and approved by the appropriate facility officials regarding these regulations. A possible design feature to ease the “confined space” limitations may be the use of sidewalk-type access doors instead of manhole covers.

5.12.8 Show all pipe supports on drawing. Completely design all pipe anchors to withstand the applied forces.

5.12.9 Place waterproof membranes in or below the concrete bottom slabs and continue them up the outer sides to the top of the sidewalls.

5.12.10 Provide ventilation pipes through the top of the manhole. Terminate one, 31 cm [12 inches] above grade and the other 31 cm [12 inches] below the bottom of ceiling slab. Both pipes shall terminate 46 cm [18 inches] above finish grade in a gooseneck configuration.

5.12.11 All piping, fittings, valves, etc., in the valve manholes shall be insulated. Insulation shall be pre-molded, precut, or job fabricated to fit and shall be removable and reusable. Thickness of insulation shall be in accordance with VA specifications Section 23 07 11 “HVAC and Boiler Plant Insulation”. Insulation jackets shall be provided for all pipe and fittings insulation. Insulation for all piping, fittings, and valves shall be molded calcium silicate conforming to ASTM C533, type I, or molded mineral fiber insulation conforming to ASTM C547, Class 2, or cellular glass insulation conforming to ASTM C552. All insulation shall be asbestos free. Laminated construction shall not be used unless the thickness exceeds 11 cm [4 inches]. Flanges, couplings, unions, valves, fittings, and other pipe accessories, unless otherwise shown or approved, shall be insulated with removable and reusable factory pre-molded, prefabricated, or field fabricated insulation. For accessories in valve manholes, aluminum sheet shall be applied over the insulation.

5.12.12 Site Investigations:

5.12.13 The designer shall determine the most economical and practical locations for the system and accessories. In addition, the determination of soil conditions is necessary when direct buried systems are selected.

5.12.14 The designer shall perform the following:

5.12.14.1 Land surveys to determine routing, grades, and location of any interference.

5.12.14.2 Testing to determine water table depth

5.12.14.3 Soil corrosiveness, soil type, moisture content, and pH if direct buried systems are to be used. This shall be performed by a licensed professional geotechnical engineer. Test samples shall be taken every 30 m (100 feet) (minimum) along the routes of the systems.

5.12.14.4 Review "as-built" drawings and interview VAMC maintenance personnel to locate underground interferences. When sufficient information is not available, acquire services to perform utility locating in addition to local utilities, to determine location and depth of existing underground systems in the area.

5.12.15 Field work by the A/E or their consultant shall be administered under the terms of the contract between VA and the A/E.

5.13 Design of Direct Buried Systems:

5.13.1 The manufacturer is responsible for the design of the system within the parameters of the VA specification. This responsibility includes insulation types, pipe guides and anchors, end seals, corrosion protection, expansion bends and loops, and carrier pipes. The designer is responsible for all other aspects of the design including manhole structure and piping, system locations, profiles, pipe type and sizing and anchor locations. The contract drawings should include no details of the elements of the system for which the manufacturer is responsible.

5.13.2 The condensate return piping shall not be included in the same conduit as the steam piping. This will prevent condensate piping failures from affecting the steam piping.

Typically, condensate pipes have a much higher failure rate than the steam pipes due to the acidic and corrosive content that can occur if water treatment is not properly applied.

5.13.3 Depth of burial of the systems shall be 0.6 to 1.5 m [two to five feet] to top of conduit casing.

5.13.4 The designer shall be completely responsible for the manhole design including manhole structure, ventilation, and piping.

5.13.5 Provide cathodic protection for all steel casing systems and all buried exposed metal. Assume that a minimum of 25 percent of the exterior of the system is exposed metal. Submit design life calculations for the cathodic protection system, stamped by a qualified corrosion engineer. Cathodic protection systems shall have a minimum design life of 25 years. Dielectric pipe flanges and waterways, and isolation devices shall be provided at all points as necessary. Test stations at grade shall be provided on each section of the piping system. Dielectric waterways shall have temperature and pressure rating equal to or greater than that specified for the connecting piping. Waterways shall have metal connections on both ends suited to match the connecting piping. Dielectric waterways shall be internally lined with an insulator specifically designed to prevent current flow between dissimilar metals.

5.14 Design of Concrete Shallow Trench Systems:

5.14.1 The designer shall be completely responsible for the entire design including concrete trenches, pipe anchors, sizing of expansion loops and bends, sizes of expansion joints, pipe supports and guides, manhole structure and piping, system locations, profiles and pipe sizing and insulation. Provide access points (Manholes or handholes) every 105 m [350 feet] and/or change of trench direction and point of connection to buildings where main valves are to be located. Pipe insulation shall conform to the requirements of para 5.9.2.

5.15 Design of Concrete Tunnel Systems:

5.15.1 The designer shall be completely responsible for the entire design including concrete tunnel, pipe anchors, sizing of expansion loops and bends, sizes of expansion joints, pipe supports and guides, tunnel structure and piping, system locations, profiles and pipe sizing and insulation. Insulation shall conform to the requirements of para 5.9.2.

5.15.2 The tunnel shall include ample walking space with height for persons to stand erect, and drain system to handle ground water and piping leaks.

5.15.3 Tunnel access shall be provided every 105 m [350 feet] of tunnel length and every change of direction. Provide a minimum of two separate entrances from grade and at least one every 105 m [350 feet] of tunnel with full-size manhole covers. Access entrance shall have grab-bars or ladder set in the tunnel wall.

5.15.4 Provide ample lighting and electrical receptacles designed for high temperatures per OSHA 1926.56 and NFPA 101. Lights must be connected to Life Safety branch of the EES, if it is practical or feasible (or have 1-1/2 hour-emergency power packs integral with the lights. The power packs will require periodic maintenance/testing per code).

5.15.5 Provide ventilation systems to allow personnel to work safely. A minimum 6 air changes per hour (ACH) are recommended or as required by IBC/IMC, whichever is more stringent for tunnel ventilation. Provide ventilation (exhaust) fans every 213 m [700ft]. For shorter tunnels one fan shall be provided by the end with the fresh air intake at the opposite end.

5.16 Design Details:

5.16.1 Provide pressure gages at the outlet side of all main steam valves so that personnel can observe the gages while warming-up the steam line.

5.16.2 Provide steam drip traps and manual drains on steam lines at all low points and upstream of all valves and pressure reducing stations. Spacing shall not exceed 150 m (500 feet).

5.16.3 Provide HHW air vents, vacuum breakers and drains to allow the system to be purged of air and drained if required. The vents and vacuum breakers shall be placed at all high points and sized to accommodate the calculated drain rate and anticipated air entrainment. Drains shall be located at all low points and trapped areas to ensure that the system can be drained.

5.16.4 Provide isolation valves (gate valves) on all branch connections to the main piping runs.

5.16.5 Provide gravity drainage along the length of the tunnel and to the storm sewer in the vicinity. When not possible to drain by gravity provide 760 mm (30 inches) square (minimum) by 915 mm (36 inches) deep sump in floor and slop Tunnel floor to the sump. Provide duplex submersible sump(s) in number and location as required by the tunnel layout and elevation.

5.16.6 The designer shall furnish thermal expansion calculations for the supply and return piping using the following design characteristics and installation temperature. The system design conditions shall be 1,034 kPa, 188 C [150 psi, 370 F] or the maximum boiler safety valve setting and associated temperature whichever is higher. The condensate/return shall be designed for 1,034 kPa, 121 C [150 psi, 250 F] or pump dead head whichever is greater.

5.16.7 Assure that proper chemical treatment for the site distribution system is provided and included with the design of systems and equipment in the Heating Power Plant (refer to Chapters 1 and 2 of this manual). If not, make provisions for a chemical feeder connection to the piping system for such service and in close proximity to the Heating Power Plant.