Manual **028**

Alberta Energy Regulator

Buried Geothermal Heat Distribution Pipelines

Best Practices for Planning, Design, Operation, and Closure

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Abbreviations

ABSA	Alberta Boiler Safety Association
AER	Alberta Energy Regulator
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing Materials
EN	European Standard
EPP	environmental protection plan
FRP	fibre-reinforced polymer
HDPE	high-density polyethylene
PE-RT	polyethylene of raised temperature
PEX	cross-linked polyethylene piping
PPI	Plastics Pipe Institute
ROW	right-of-way
RTRP	reinforced thermosetting resin pipe

1 Introduction

1.1 About this Manual

This manual promotes best practices for the safe and reliable design, construction, commissioning, operation, and decommissioning of buried heat distribution pipelines. These best practices support the Alberta Energy Regulator's (AER) mandated outcomes to ensure efficient, safe, orderly, and environmentally responsible development of energy resources over their entire life cycle.

This manual does not provide authorization or procedural direction necessary to construct or operate heat distribution systems.

This manual refers to heat distribution pipelines and heat distribution systems (the latter includes the pipeline and its supporting infrastructure).

1.2 How to Use this Manual

This manual is a guideline and does not include all possible considerations for a geothermal heat distribution pipeline. The manual focuses on the pipeline component of the heat distribution pipeline and its connections. It does not include design specifics of the energy transfer stations, heat exchangers, booster pumps, and other associated infrastructure, nor heat distribution pipelines constructed above grade (surface run).

Owners and operators of heat distribution systems are the intended audience of this guide. As an owner or operator, you are responsible for all site- and project-specific considerations and for performing due diligence in the design of the heat distribution system. This manual can help owners responsibly manage the life cycle of a buried heat distribution system.

This manual is primarily organized based on the life cycle of a heat distribution pipeline. Each section describes the considerations, qualified persons involved, and risks for the specific phase.

The AER will periodically review and update the manual to reflect changes in the industry.

1.3 Heat Distribution System Life-Cycle Outcomes

The expectation is for owners to achieve or exceed the following outcomes over the life cycle of the heat distribution system:

- Design, construct, and operate the system to prevent the loss of carrier fluid and damage to the heat distribution pipeline by other infrastructure and vice versa.
- Safeguard the public and protect the environment from hot carrier fluid releases to the soil and groundwater.

For a list of standards applicable to heat distribution pipelines, see appendix 1.

1.4 Regulatory Framework for Geothermal Resources

The AER is responsible for geothermal resource development below the base of groundwater protection and overseeing heat distribution pipelines relating to geothermal resource development under the *Geothermal Resource Development Act*. Heat distribution pipelines may be associated with a heating plant or geothermal heating operation or can be standalone.

See the *Environmental Protection and Enhancement Act* and the *Activities Designation Regulation* for an overview of the regulatory obligations for heat distribution pipelines. See also *Specified Enactment Direction: Pipeline Conservation and Reclamation Approvals Under the Environmental Protection and Enhancement Act* (publication pending) and *Directive 077: Pipelines – Requirements and Reference Tools*.

Alberta Environment and Protected Areas is responsible for geothermal systems above the base of groundwater protection.

1.4.1 Other Regulatory Considerations

Other regulatory instruments to consider during the life cycle of a heat distribution system include the following:

- *Code of Practice for Pipelines and Telecommunication Lines Crossing a Water Body*
- *Code of Practice for the Temporary Diversion of Water for Hydrostatic Testing of Pipelines*
- Plastics Pipe Institute *TN-46 Guidance for Field Hydrostatic Testing of High-Density Polyethylene Pressure Pipelines*
- *Specified Enactments Direction 002: Application Submission Requirements and Guidance for Reclamation Certificates for Well Sites and Associated Facilities*

1.4.2 Alberta Boiler Safety Association Registration

The Alberta Boiler Safety Association (ABSA; pressure equipment safety authority) is responsible for pressure vessels, plants, and piping systems. For information on pressure equipment, including pressure equipment definitions and their registration, contact ABSA.

2 Heat Distribution Systems

2.1 Definition

A heat distribution system is defined in this manual as a system of pipes (trunk and branch lines, but not service lines), valves, fittings, and appurtenances (including associated pumps and heat exchangers) used to transport heat from a heating plant or a geothermal heating operation to the service connection of an end user for hot water and space heating. Heat distribution systems may be part of a geothermal facility (heating plant and geothermal heating operation) or associated with one. End users are typically commercial or industrial users of geothermal heat.

A heat distribution pipeline transports heat in a carrier fluid from a heat source between two or more heat exchangers (see figure 1).

Heat distribution systems may also be referred to as district heating systems. A system of underground pipes circulates a hot carrier fluid (e.g., water or other fluid) from a centralized source. District heating allows for more efficient use because a centralized plant can manage heat more efficiently than many smaller local heating sources. Because it can use various energy sources, including renewable energy, a district heating system may have lower carbon emissions and fewer environmental effects. Also, using a centralized energy source would make implementing future technologies easier when they become available.

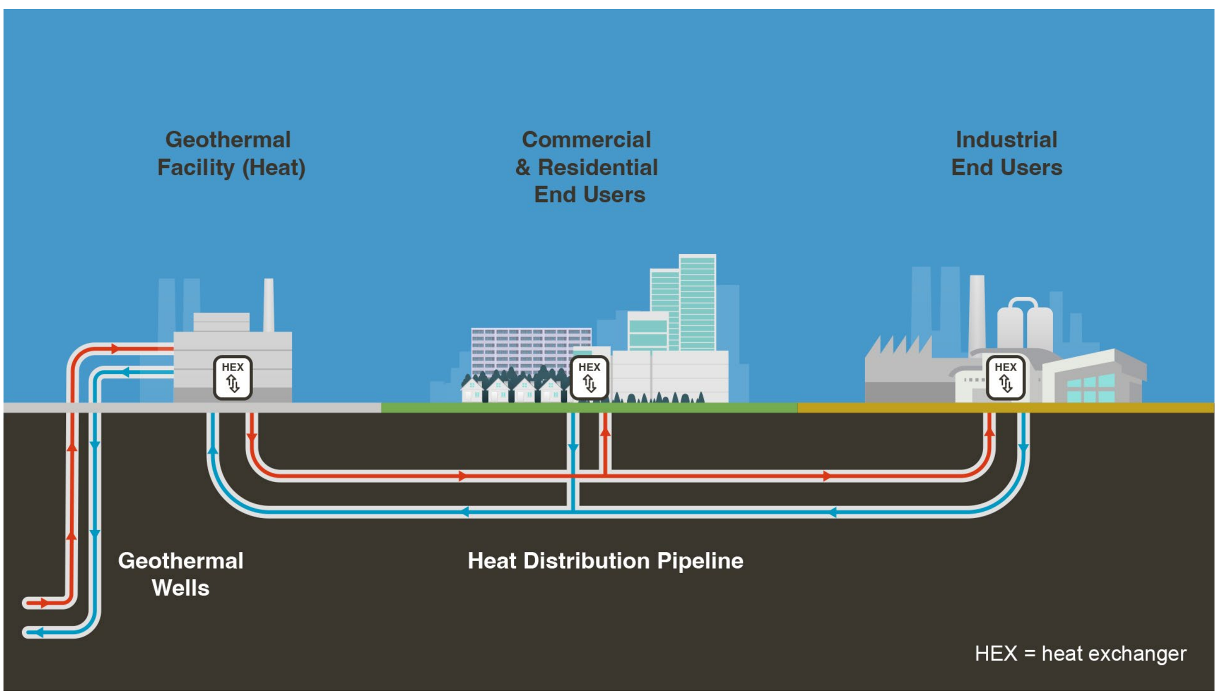

Figure 1. Geothermal heat distribution system

2.2 Life-Cycle Phases

The life cycle of a heat distribution pipeline can be divided into several phases (see figure 2). This manual focuses on the environmental and public safety considerations in these phases.

The life-cycle phases of a heat distribution pipeline are as follows:

- **Concept**: The project input parameters are considered at a high level to determine project viability.
- **Planning**: Technical aspects of the project are considered in greater detail. A high-level environmental and public safety risk analysis is performed. Community engagement and communication plans are developed.
- **Design**: Detailed engineering design is conducted, and a project-specific, detailed environmental and public safety risk analysis is performed. During this phase, consider the effects of climate change on the chosen location so that the project design is resilient to future changes (such as droughts, floods, wildfires, landslides, and extreme temperatures).
- **Construction**: The project is constructed as designed with a focus on safety, quality control, and quality assurance. This phase includes commissioning the pipeline. Soil or vegetation removed or disturbed during this phase should be replaced in accordance with reclamation guidelines and regulations.
- **Operations**: The pipeline operates as designed to deliver heat to the end user. During the operations phase, the pipeline is regularly inspected and maintained.
- **End of life**: Consult with the relevant regulatory agencies to determine how to replace or decommission pipelines safely and in an environmentally responsible manner, including reclamation of the pipeline right-of-way (ROW) and surrounding area (e.g., construction laydown areas, material storage areas, temporary access roads).

Qualified professionals (see section 3) are typically involved in all life-cycle phases of the heat distribution pipeline, helping owners meet desired environmental and public health outcomes throughout the project.

Figure 2. Heat distribution pipeline life-cycle phases

3 Qualified Person

The qualified person has a key role in the responsible management of heat distribution systems by applying best practices.

A qualified person is either a "qualified individual" or a "qualified professional."

A qualified individual is a company-appointed technical person who

- possesses postsecondary education in an applicable discipline (or educational equivalency);
- possesses the technical knowledge, understanding, and experience in the specified area;
- acts within their area of expertise; and
- has the necessary training and certification by an organization or agency to ensure company adherence to policy, standards, and regulatory requirements.

A qualified professional is expected to be a member in good standing of an association regulated by a professions or societies act of Alberta or be certified in Canada, including appropriately trained and experienced members of the following organizations:

- Alberta Institute of Agrologists
- Association of Science & Engineering Technology Professionals of Alberta
- Alberta Society of Professional Biologists
- Association of the Chemical Profession of Alberta
- Association of Professional Engineers and Geoscientists of Alberta
- College of Alberta Professional Foresters
- College of Alberta Professional Forest Technologists

4 Concept and Planning Phases

A thorough assessment of the pipeline route during the concept and planning phases is important to avoid selecting a location with sensitive habitats, high ecological value, or cultural significance. Soil and ground conditions at the site can affect the design requirements and constructability of the pipeline. Assess effects on the environment, involve local experts and communities in the route selection, and prioritize areas with lower ecological and cultural sensitivities to mitigate risk.

Owners that engage a consulting firm or firms specializing in heat distribution systems can ensure they have the necessary disciplines and qualified persons during the concept and planning phases and avoid project risks.

4.1 Concept Phase

The concept phase focuses on considering the heat source (type and temperature), end-user parameters, pipeline length, terrain along the pipeline route, and the overall viability of the heat distribution system.

4.2 Planning Phase

This phase focuses on the high-level planning of the heat distribution pipeline layout, allowing owners to consider their choices before selecting the preferred route in the design phase. Consider the following parameters to help minimize risks and determine the optimal pipeline route:

- **Pipe size**: When determining the pipe size, consider demand, flow, pressure drops, pressure changes due to elevation, and future expansion. Pipe size also affects trenching requirements, pipe material selection, and minimizing pressure drops to maximize heat distribution.
- **Design parameters and temperature**: Temperature determines the pipe material, whereas the temperature differential between supply and return determines piping and equipment sizing. The supply temperature should be high enough to provide sufficient heat transfer but not so high that it leads to excessive heat loss. This parameter will inform design options.
- **Hydraulic analysis**: Conduct a preliminary hydraulic analysis during the planning phase to identify hydraulic routes. This analysis affects pipe selection (sizes, pressure ranges) and pumping capacity (booster station requirements). Hydraulic analysis can ensure a sufficient pressure drop at the end of the system, a minimum return pressure is maintained throughout the pipeline, and the system will not exceed the maximum designed pressure. Detailed hydraulic analysis occurs during the design phase to determine pipe and equipment sizing and during the construction phase to verify input parameters.
- **Stress compensation**: Conduct a stress analysis to select pipe materials and determine stress compensation strategies, including controlling pipe movement because of the temperature differential between the pipe and the ambient ground temperature. Stress compensation strategies are especially important when routing in an area with multiple utilities. Detailed stress analysis is completed during the design phase to identify acceptable stress compensation methods and depth of burial.
- **Maintenance access and isolation**: Vent valves may be required at system high points and can be standalone in a valve box or collocated with isolation values in manholes. Access is important for maintenance and isolation for minimizing pipeline fluids release and related downstream environmental effects in the case of a leak or pipeline failure.
- **System requirements, project constraints, and routing**: Traffic management, existing utilities, natural boundaries, environmentally sensitive areas with rare plants, old growth trees, private property, and rivers and streams can determine project-specific constraints.
- **Risk assessment of site-specific and system-specific hazards**: Conducting a comprehensive, high-level risk assessment during the planning phase helps create a more resilient and sustainable system,

helps protect public safety, and minimizes environmental effects. Further hazard analysis of the selected route may be required during the design phase. Understanding the effects of climate events, such as atmospheric rivers, flooding, and drought, could affect overall project success.

Throughout the life cycle of any pipeline, public safety and environmental protection should be a top priority. Considering all the above is the best practice for minimizing risks and choosing an optimal route when building a heat distribution pipeline.

4.3 Pipeline Route Selection

The following considerations for route selection are not exhaustive. They focus on aspects related to public safety and environmental protection. Regardless of the pipeline's length, careful planning during construction helps ensure pipeline safety and integrity.

Owners should conduct preliminary field surveys along the proposed ROW to identify environmental, developmental, and local constraints. If avoiding a constraint is not viable, using these pipeline route best practices can mitigate any negative effects of the chosen route.

Owners can reduce risk by limiting the number of infrastructure crossings (roads, railways) and choosing a route that limits the potential for pipeline strikes, especially from conditions outside of the owner's control. Where possible, use existing utility corridors and ROWs.

Owners can reduce the potential for environmental impacts by minimizing the following:

- the number of tie-ins and selecting pipe lengths to reduce the number of welds, particularly field welds
- the number of encounters with water bodies (including wetlands) and watercourses, the habitat of endangered or threatened species, geohazards, and unstable areas.

Be aware of restricted activity periods for wildlife, including those for migratory birds, waterfowl, amphibians, and fisheries.

From a cultural and heritage perspective, avoid natural areas and parks. Engage with Indigenous communities and avoid any areas of cultural significance.

Communicating with those along the route during pipeline route selection (e.g., rights holders, property owners, occupants, and municipalities) ensures that everyone understands the project details and allows the owner to adapt the route and plan to accommodate any concerns.

4.4 Temperature Considerations

Planning includes understanding the supply temperature for end users and the temperature of the geothermal source. Both temperature parameters influence the complexity and type of piping and heat transfer equipment used in the system.

The differential between the supply and return temperatures can measure the efficacy of a heat distribution system. A greater differential allows for smaller diameter piping, smaller pumps, and lower volumetric flow. The return temperature is less important than the supply temperature when considering material selection, design factors, or piping regulation.

The transmission temperature of the carrier fluid in the heat distribution pipeline is based on the end user needs and the geothermal source temperature. In complex systems with heat pumps, the transmission temperature can be an entirely separate parameter from the end user and geothermal source temperatures. Temperature is one of the key factors in the selection of the heat distribution pipeline material. Higher temperatures reduce the service life expectancy of pipe materials, commonly necessitating steel piping, welding, and pipe insulation. Higher-density materials have more weight and add complexity to the installation process. For more information on pipe materials, see section 5 on design.

This manual identifies three temperature ranges that would result in significant design considerations if exceeded:

- low: less than 45°C
- medium: 45°C–95°C
- high: greater than 95°C

The low range is generally for systems with heat pumps that can lift the transmission temperature to more practical levels for the end user. When considering temperature only, environmental risk and public safety are minimal for low-temperature piping systems.

The medium range offers the broadest variety of applications. Most heat distribution pipelines will be in this temperature range. Temperatures in this range can be effective for space heating and domestic water heating. Transmission temperature can be coordinated with the seasonal reset temperatures of the end user to improve efficiency in off-peak conditions. This temperature range has a higher risk to the public and environment than lower-temperature systems but is considered low risk with adequate precautions, and there is no risk of flashing to steam.

The need for high-temperature systems is lessened by improved system thermal efficiency and greenhouse gas reduction incentives; however, physical limitations will continue to necessitate heat distribution temperatures in the high range (e.g., industrial process, electricity generation, and legacy commercial heating systems). The high-temperature range poses the highest risk to the public and environment as it carries the risk of flashing to steam.

5 Design Phase

During the design phase, a more detailed and in-depth analysis of the site- and system-specific hazards helps owners to understand and mitigate environmental and public safety risks. Risk mitigation plans should be developed where significant environmental or public health risks exist. The owner is responsible for ensuring the system is safe and designed to meet project-specific requirements.

5.1 Qualified Persons

The qualified persons involved during the design phase include the following:

- **Mechanical engineers** ensure that appropriate materials, components, and fittings are chosen and correctly sized and that design considerations such as hydraulics and stress have been properly applied. They may have input into the selection of carrier fluid and determine insulation requirements.
- **Civil engineers** design heat distribution pipeline aspects such as trenching, routing, and managing utility conflicts. They also assess soil and ground conditions along the selected route to determine the required construction methods and insulation requirements (thickness and cover).
- **Geotechnical engineers** assess soil and ground conditions along the pipeline route to determine required construction methods and ensure trench stability.
- **Environmental engineers and biologists** ensure that the design complies with environmental regulations. Depending on project requirements, fisheries, wildlife, and wetland specialists may also be involved.

5.2 Quality Assurance and Quality Control

Quality assurance and quality control plans ensure the reliability and safety of any heat distribution pipeline. Quality assurance involves implementing guidelines, policies, and procedures to prevent issues before they arise. Documenting and sharing lessons learned from past projects is a quality assurance consideration that can help mitigate risk.

Quality control involves processes and checkpoints to identify, assess, document, and address deviations from standards. The owner and engineer should determine the considerations applicable to each project phase.

Quality assurance and quality control considerations vary with each project. For information on quality assurance and quality control considerations specific to the construction and operation phases, see the applicable sections of this manual.

5.3 Carrier Fluid

Consult with the project engineer to select a carrier fluid. Typically, the carrier fluid for heat distribution pipelines is water with low concentrations of additives, such as biocides. Other additives may be required, depending on the conditions of the pipeline location. For example, a 25% to 50% concentration of propylene glycol may be added to prevent carrier fluid freezing. When using a non-water-based carrier fluid or additives to prevent freezing, corrosion, or bacterial growth, it is important to assess the environmental and safety risks of the carrier fluid or additive to mitigate any risks. This manual does not include considerations for non-water-based carrier fluids.

5.4 Project Engineering Design Parameters

5.4.1 Pipe Material

Selecting the correct piping material is paramount for optimal heat distribution system performance. Consider the following design parameters when selecting pipe materials:

- temperature range (low, medium, or high)
- pressure
- application
- joints
- service life
- insulation requirements
- available standards (ASTM, CSA, PPI, EN)

5.4.1.1 Temperature and Pressure

The deciding factors in material selection are typically the temperature and pressure requirements. Design pressure is generally a system constant and is independent of other variables. Pipe pressure ratings are reduced with elevated temperature. Installation conditions may also affect the materials selected. For example, trenchless installations, best suited to plastic piping, can be advantageous in congested areas.

See appendix 1 for a list of standards that apply to the various material types (steel and non-steel, usually plastic). Piping materials currently available for use in heat distribution pipelines include the following:

- carbon steel pipe – ASME standard weight (STD)
- cross-linked polyethylene (PEX)
- fibre-reinforced polymer (FRP) and reinforced thermosetting resin pipe (RTRP)
- high-density polyethylene (HDPE) pipe

- polyethylene of raised temperature (PE-RT)
- pre-insulated steel pipe (see figure 3)

The design temperature for the pipeline should be as close to ambient as practicable. The complexity of the design increases as the temperature differential to the ambient increases. At higher temperatures, conductive energy losses increase, service life expectancy drops, and pipe stress compensation considerations and installation become more complex.

Medium-Temperature Systems

Most heat distribution pipelines fall into the medium temperature range (45°C–95°C). Piping for medium-temperature systems is mostly insulated steel, often with the lowest pressure and temperature ratings. One example is the European standard *EN 253*, developed for heat distribution systems below 2500 kPa and 120°C. These steel piping systems are lighter than standard-weight steel pipe, come insulated and jacketed (see figure 3), and have custom-made valves and settings.

Plastic pipe such as polyethylene of raised temperature (PE-RT) has an elevated temperature rating and is an option for systems designed for the lower end of the medium temperature range.

Pipe stress compensation for medium- and high-temperature systems requires more consideration than low-temperature systems. Steel piping is more resistant to thermal stresses but is less flexible than plastic. Generally, the stress compensation measures are similar, regardless of the pipe material.

In medium-temperature systems, the temperature can be coordinated with the end users' seasonal reset temperatures, if one exists, to improve transmission efficiency in off-peak conditions.

Courtesy of Kerr Wood Leidal Consulting Engineers

Figure 3. Pre-insulated steel pipe (*EN-253*)

Low-Temperature Systems

In low-temperature systems (<45°C), plastic pipe such as HDPE (see figure 4) can be used. The benefits of plastic include the following:

- Insulating the piping is typically unnecessary unless there is a risk of freezing.
- Piping can be buried without risk of corrosion.
- There is likely no need for stress compensation as the pressure rating is often close to nominal.

Plastic piping has reduced temperature and pressure ratings compared with steel piping materials. PPI *TR-4* lists hydrostatic design basis recommendations for various plastic pipes, including HDPE and PEX.

Courtesy of Kerr Wood Leidal Consulting Engineers

Figure 4. HDPE pipe

High-Temperature Systems

Piping in high-temperature systems (>95°C) is usually insulated steel. Standard *EN 253* indicates a maximum temperature rating of 120°C for insulated steel pipe. Temperatures above 120°C will degrade the insulation and casing materials more rapidly. Above 120°C, standard-weight steel pipe (see figure 5) is commonly used for high-temperature distribution piping in both buried and surface-run applications. Standard-weight pipe has an increased wall thickness, can be designed to much higher temperature and pressure requirements, and is not restricted to water as the heat carrier fluid or to being buried.

Courtesy of Kerr Wood Leidal Consulting Engineers

Figure 5. Coated carbon steel pipe

5.4.1.2 Applicable Standards

Use the standards in appendix 1 to determine the type of pipe needed to meet the pressure requirements of the application. References to codes and standards are to the latest editions.

Piping for heat distribution pipelines is manufactured in compliance with ASME and CSA standards. Pre-insulated carbon steel is included in *EN-253*.

Although *EN-253* and associated European standards are not commonly used in North America, piping manufactured to this standard is considered to comply with *ASME B31.1* and *CSA B51*. A qualified professional must document the owner's acceptance of the use of *EN-253* as an unlisted material in accordance with clause 123.1.2(D) of *ASME B31.1*.

5.4.1.3 Service Life

Service life is another consideration when selecting a pipe material. Service life varies depending on the service parameters of the pipeline. (For example, where in the temperature range it falls).

- HDPE can have a service life of 50 to 100 years.
- Pre-insulated carbon steel has a minimum service life of 30 years. Its service life would be at least 50 years when continuously operated at temperatures below 115°C.
- The service life of ASME standard-weight carbon steel pipe varies due to the variety of applications under the standard and is limited by the degradation of the insulation and jacketing.
- The minimum service life for PEX pipe is 50 years (see figure 6).
- The service life of FRP is 20 to 50 years. Its service life would be at least 50 years when used in a water-based heat distribution system.

- The service life of RTRP is specific to the grade of RTRP.

Courtesy of Kerr Wood Leidal Consulting Engineers

Figure 6. PEX pipe

5.4.2 Stress Compensation Methods

Stress compensation requirements and methods depend on

- the type of pipe material used,
- the temperature range of the system, and
- the pipe diameter and layout.

Stress compensation is important to ensure the heat distribution pipeline can be operated safely. Stresses that are not addressed can cause the pipe to deform, leak, or fail with limited cycling. ASME and CSA design standards dictate the allowable limits for pressure piping.

HDPE or FRP piping may not require stress compensation due to lower temperatures. Stress compensation helps prevent unwanted stresses by absorbing the expansion or contraction of the piping due to temperature changes. Stress compensation methods typically used for buried steel heat distribution pipelines include the following:

- **Directional changes**: Using elbows to change the pipe direction provides flexibility in pipe alignment.
- **Expansion loops**: Use elbows to form a U shape, allowing piping to flex in congested areas to change elevation or direction to get around utilities.
- **Expansion joints**: Using expansion joints allows for movement in specific directions.

- **Heat prestressing (hot water)**: Circulating hot water through the system maintains a more consistent temperature in the pipes.
- **Heat prestressing (electric)**: This method requires an electricity source.
- **Flexible connectors**: Flexible connectors between pipes can be used for aboveground piping but are not feasible for buried steel piping.
- **Anchors, guides, limit stops, and hold downs**: Use these supports to control the movement, expansion, and contraction of interior building piping.

Heat prestressing (hot water and electric) allows for longer straight lengths of pipes with no loops or joints. However, the method requires that the entire trench remains open until the heat distribution system is installed and operational, which may not be ideal for all projects.

The preceding list is not exhaustive. A complete stress analysis for both exterior buried and interior aboveground piping is necessary to ensure that the heat distribution system is designed to be safe and reliable. Stress analysis should include various stress load cases, including sustained load cases, expansion load cases, occasional load cases, and operating load cases.

5.4.3 Insulation Requirements

Insulation protects pipes from freezing, reduces heat loss to meet the demands of the end users, and, in some cases, provides cathodic protection to the piping material. It is important to protect a heat distribution pipeline routed above the frost line from freezing. Qualified persons, such as mechanical and civil engineers, can determine the insulation thickness required to avoid freezing on a case-by-case basis.

During the design phase, identify areas of potential groundwater infiltration and select insulation with a waterproof cover. Moisture in insulation can cause damage that can potentially lead to leaks.

Insulation may negate the need for cathodic protection, which protects against corrosion. With buried steel piping, the outer insulation jacket provides corrosion protection. However, if the insulation jacket is compromised and allows water to enter, the pipe can fail prematurely.

Several manufacturers provide insulated and jacketed pipe and fittings for various installation applications and temperatures for both buried and surface-run piping.

5.4.4 Pipeline Route and Alignment (Present and Future)

Consider future configurations of the pipeline route and alignment during the concept and planning phases. Account for these potential configurations during the design phase when choosing a pipeline route to avoid limiting build-out capacity or system expansion.

5.4.5 Leak Detection Methods

Leak detection should be part of the engineering design and operation. A pipeline leak or rupture can affect the environment, have human health implications, and affect the owner's reputation. Leak detection does not prevent a leak from occurring but is important in minimizing the effects of a leak.

If the carrier fluid is not water or contains additives, it may result in an incident response and environmental remediation. The type of response and remediation depends on the environmental protection requirements related to the location of the heat distribution pipeline. Consider all environmental risks associated with leaks and develop mitigation plans where the risk from a leak is significant.

Leak detection systems can detect when a leak occurs in the system, alert the operator and, ideally, detect its location. Early detection of leaks should minimize heat loss and, where the heat carrier fluid contains additives, any environmental effects and public safety risks.

The three main categories of leak detection are as follows:

- **External**: Leak detection occurs external to the pipeline (for example, acoustic sensors, fibre optics, or conductivity wires).
- **Visual inspection**: Leak detection occurs during the inspection of the pipeline and ROW. A leak may occur during the period between inspections.
- **Internal or computational**: Leak detection is triggered based on monitoring parameters within the pipe (pressure or flow) or by monitoring the fluid make-up volumes.

Leak detection may be built into the specific pipe. *EN 253* piping systems have built-in leak detection systems that can be continuously monitored to identify the leak location.

6 Construction Phase

Improper construction practices can result in habitat destruction, soil erosion, and pollution from construction activities. To mitigate these risks, implement erosion control measures, adhere to construction best practices, and ensure proper waste management to prevent soil and water contamination. Take care when filling, flushing, and draining systems, especially if using a carrier fluid that can harm the environment.

6.1 Qualified Persons

Qualified persons typically required during the construction phase include the following:

- Civil engineers will manage the construction of the heat distribution pipeline, including trenching, routing, and any utility conflicts.

- Construction managers will oversee construction to ensure system delivery as per the schedule. Owners may have the mechanical or civil engineer act as the construction manager or have a dedicated construction manager.
- Engineering inspectors will conduct regular on-site inspections of the construction and review construction documentation (e.g., shop drawings, construction logs, leak detection reports).
- Environmental engineers and biologists will ensure construction is compliant with environmental regulations.
- Fusion technicians will fuse pipe using techniques applicable to the pipe material and standards. The technicians receive manufacturer-specific training in heat fusion and electrofusion equipment and techniques for the pipe material and standards.
- Geotechnical engineers will confirm assessed soil and ground conditions along the pipeline as per the design to confirm construction methods and ensure trench stability.
- Mechanical engineers will ensure construction occurs as designed and confirm the hydraulic analysis for any significant construction-related changes.
- Project engineers will manage the overall system design and project implementation.
- Semiskilled labourers can install leak detection systems, insulation, and joint kits: Some material types (e.g., *EN 253*) require labourers to be trained in these things.
- Welders will weld pipe in accordance with welding quality standards. Welders are licensed by the province to weld pressure piping and possess valid welder performance qualification records for the specific welding procedures being conducted.
- Welding inspectors are independent, third-party personnel, qualified and certified for each examination method being conducted in accordance with the requirements of the pressure piping design standard being applied.

6.2 Quality Assurance and Quality Control Considerations

Consider the following best practices in quality assurance and quality control during construction:

- Consider implementing the following with the project engineers:
  - Review mill test reports for all piping and fittings to ensure materials comply with specifications. (construction).
  - Decide on inspection hold points during construction. For example, if foam expansion pads are required, inspect them to ensure they have been installed correctly before backfilling.
- Consider implementing the following measures with the contractor and engineer:

  - Document measures taken to protect the pipe and fittings from oxidation throughout the construction process as identified in the project specifications.
  - Maintain proper control and traceability documents to verify compliance with codes and standards of product specifications.
  - Free access by the owner and project engineer to the contractor's fabrication shop and site during fabrication and construction.
  - Before tying into an existing system and before commissioning, test the existing leak detection system to ensure there are no faults with either system.
  - Maintain accurate, daily reports of all personnel and on-site equipment, material deliveries, construction progress reports, problems encountered, weather conditions, and other pertinent information. These reports should be available to the owner and the engineer.
  - For piping with leak detection systems (i.e., *EN 253* piping with leak detection installed per *EN 14419*), keep daily field reports of all continuity ohmic resistance and insulation resistance for each pipe component after it is added. The contractor will submit the reports regularly to the engineer, who reviews them to ensure there are no concerns with the leak detection readings.
  - Verify joints are free of moisture before completing joint installation.
- Consider implementing the following with the pipe installer and field inspector:
  - Ensure documentation for all welding and jointing are completed per applicable codes and standards, including inspections.
  - Provide all weld inspections, weld maps, and quality control documentation to the engineer for review before commissioning.
  - Conduct radiographic testing to protect the public and workers.
  - Field inspectors document the site progress, discussions, and field issues for every field visit.
  - Complete compaction testing at regular, short intervals to ensure that trenches are adequately backfilled and compacted.
  - If insulation is deemed necessary, ensure it is installed properly around joints and that care is taken to avoid damaging the insulation. Extend insulation and casing over completed joints and seal.

6.3 Environmental Measures During Construction

Develop and implement an environmental protection plan (EPP) for the pipeline describing the measures to be taken during construction. The EPP is a standalone document describing the environmental protection measures to be implemented and site-specific information used by pipeline construction and regulatory personnel.

The goal of the EPP is to prevent environmental effects and habitat disruption that may occur during pipeline construction. It serves as a summary and reference document that describes or provides a map of all environment-related processes and documents. It should summarize and refer to the environmental management elements of the management system that apply to the activity. The EPP does not describe all details of the environmental elements of the owner's management system.

The EPP should include the following:

- soil salvage depths and alternative soil handling
- watercourse and wetland crossing methods
- sensitive wildlife or vegetation features (e.g., surveys and sweeps)
- land use
- soil inspection locations

6.4 Conservation of Materials During Construction

Reclamation of land in the pipeline ROW helps ensure sustainable construction practices and meeting environmental regulations while managing and mitigating environmental risk. See *Specified Enactment Direction: Pipeline Conservation and Reclamation Approvals Under the Environmental Protection and Enhancement Act* (publication pending) for construction and reclamation guidance applicable to heat distribution pipelines.

6.5 Pipe Joining Methods

Depending on the type of piping selected, there are many methods for joining. It is crucial that pipes are joined properly to ensure a tight seal and prevent the pipeline from leaking. Use the right qualified persons to complete and oversee this work.

The methods for joining HDPE piping and fittings include heat fusion and electrofusion. ASTM standards apply to both methods.

For pre-insulated carbon steel (*EN 253*), joints are welded in accordance with EN, ASME, and CSA standards. For quality assurance and quality control purposes, it is important to have qualified persons perform and oversee the welding. Specialized welder performance qualification records identified in the standard may be required depending on the grade of steel and the pipe dimensions selected for the heat distribution pipeline. The insulation and casing must extend over completed joints and be sealed. Fittings and procedures for sealing joints must comply with applicable standards. If measuring wires (leak, tracer) are specified, ensure they are tested and connected before insulating and sealing the joint.

For ASME standard-weight carbon steel, joints are welded in accordance with the design standard being applied (e.g., ASME or CSA).

PEX pipe joints are typically made with compression-style fittings. However, joints should not be buried, creating a known point of potential failure that is inaccessible, as there is no method to confirm proper fitting installation. Fitting performance requirements are defined in the standard specifications. As PEX is often supplied coiled in continuous lengths up to hundreds of feet, the need for buried joints should be eliminated with proper planning and procurement.

6.6 Installation Methods for Buried Pipe

Heat distribution pipelines are usually buried.

6.6.1 Safety Considerations

When considering trenching methods, focus on protecting pipeline integrity (damage prevention), the environment, and public safety from trench integrity issues.

Before fully backfilling the trench, place some highly visible materials (such as warning tape or strips of orange plastic snow fencing) along the trench above the pipeline to mark the presence of the pipeline. This material will warn future excavators that they are nearing a buried pipeline and will help prevent contact damage and improve public safety.

It is important to hand excavate or hydrovac when excavating near existing utilities to prevent damage to the infrastructure or contact damage with the pipeline. Furthermore, using these excavation methods will reduce the risk of a release and environmental effects.

6.6.2 Open Trench

Trenching involves excavating an open trench along the entire length of the pipeline route, bedding the trench, placing the pipe, and laying backfill. Bedding the trench and laying backfill helps ensure pipeline integrity, preventing pipeline failure and protecting the environment. The owner and project engineer are responsible for ensuring adequate sand bedding is used for the installation(e.g., meeting sand bedding requirements is EN standards when using pre-insulated carbon steel [EN 253] pipe). Using incorrect bedding material with HDPE pipe may result in leaks.

Backfill materials can be either conventional or modern. Conventional backfill materials can be pure materials (such as cementitious materials or sand-soil backfill) or mixed materials (mixtures of bentonite, crushed concrete, and water) and are primarily used in dry soils. Modern backfill materials consist of acid and shape-stabilized phase change materials. It is recommended to use native backfill material or recycled concrete where possible for sustainability.

6.6.3 Trenchless Methods

Some heat distribution pipelines can be installed using trenchless methods instead of open excavation. Trenchless methods of pipe installation involve digging localized pits (launching and receiving pits) at either end of a straight pipeline segment and tunnelling or drilling the pipe from one pit to the other. Trenchless methods include ploughing, tunnelling, micro-tunnelling, horizontal directional drilling, and pipe jacking. Trenchless methods are more suited to plastic piping. The benefits of trenchless methods include reduced environmental effects and shorter installation times.

A qualified person should determine the installation method and technology suitable to the pipe material and site conditions along the pipeline route.

6.6.4 Other Considerations

Compressible soil, such as muskeg, is prone to excessive displacement and needs to be minimized during construction to protect pipe integrity. The geotechnical engineer can define the soil conditions and help determine an adequate trench design to minimize disturbance.

It is best to install a pipeline in warm, dry conditions. In wet conditions, significant amounts of groundwater can lead to a trench collapse. If installing in wet conditions, plan for increased groundwater volumes and ensure adequate dewatering measures and trench shoring are in place.

6.7 Damage Prevention

As a best practice to minimize ground disturbance and prevent damage to existing and new pipelines, the contractor should take the following actions:

- Contact Utility Safety Partners (formerly Alberta One-Call), locate utilities, and complete four-way sweeps before excavating.
- Establish appropriate zones for proximity of work, hand exposure, and mechanical excavation.
- Conduct all excavation in compliance with local regulations.

CSA Z247 outlines processes for preventing damage to underground infrastructure and applies to ground disturbance near existing and abandoned infrastructure.

6.8 Pipeline Crossings

Pipeline crossings include crossing other pipelines, water bodies or watercourses, or heavy equipment crossing over existing pipelines.

If the pipeline route crosses an existing pipeline, execute a crossing agreement with the owner of the other pipeline. The agreement includes the details of the proposed pipeline and design information for the proposed crossing location. The owner of the other pipeline or their representative must be present in the field during the construction of your pipeline.

The crossing clearance between heat distribution pipelines and other utilities or bedrock within a common trench should be at least 300 mm vertically and 1000 mm horizontally. If the pipeline cannot accommodate these clearances, owners should install high-load closed-cell extruded polystyrene foam (e.g., Styrofoam) between the piping and the utility or bedrock. Other required clearances may vary and should be considered on a case-by-case basis.

Installing a heat distribution pipeline below a water crossing requires site-specific plans that address all environmental and workplace safety concerns. Retain appropriate qualified persons (such as environmental engineers or biologists) to ensure minimal effects on fish, fish habitat, other aquatic life, and downstream users.

6.9 Depth of Cover to Ground Surface

Providing an adequate depth of cover helps ensure the pipeline operates safely and minimizes risk to public safety. Pipelines should have at least 0.8 to 1.2 metres of coverage in any space. Within road or highway ROWs, increase the depth of cover.

Detailed design based on loading may require specific depths. As part of quality control, ensure that engineering design parameters are followed for depth of cover.

6.10 Pipeline Inspections and Testing

Inspections and testing help ensure pipeline integrity and protect the environment and safety of the public. Required inspections are detailed in the design standards and are specific to each installation. During installation, inspectors can verify that the installed pipe complies with the standards and whether or not any corrective action is required. Local building codes, bylaws, and other legislation may have additional inspection requirements. Manufacturers may document inspection requirements and best practices specific to their products to promote better quality assurance and quality control or to maintain a warranty.

The owner and qualified persons (including field engineers and weld inspectors) should ensure the project specifications include all required and recommended inspections. Consider documenting all inspection requirements in a checklist or shop travel document, which can be circulated with the contractor and engineers to identify project hold points. Hold points indicate where formal inspections will be conducted, passed, and recorded in the document before work proceeds on the project. This documentation forms part of the project quality assurance and quality control records and is retained for future reference.

Inspecting heat distribution pipelines during installation is recommended because, once buried, it is difficult to access them for inspection during operations. During installation inspections, owners should pay close attention to potential failure points, such as joints. The welding inspector will ensure the welded joints in steel piping are completed in accordance with the corresponding standards (including *ASME B31.1*). For fused joints in plastic piping that cannot be tested nondestructively, owners should have a dedicated weld inspector witness the fusion of each joint. The project engineer may recommend additional testing above what is outlined in the standards or by the manufacturer based on project-specific parameters.

6.11 Precommissioning Activities

6.11.1 Flushing and Cleaning

Flushing, cleaning, and passivation procedures (i.e., application of corrosion prevention to stainless steel pipe) should be submitted by the contractor and reviewed by the project engineer before completing these activities.

It is important that all pipes undergo flushing, cleaning, and conditioning/passivation. Owners should also vent any trapped air from the heat distribution system. Flushing removes debris, scale, and rust from the pipeline. Use chemical cleaners to remove grease, petroleum products, and iron oxide from the pipe interior.

Owners should install temporary equipment and bypasses in branches to ensure all sections are flushed adequately. Bypass heat exchangers, equipment, and instrumentation to prevent them from damage during flushing and cleaning. Have the project engineer witness the flush velocity to ensure that sufficient velocities are reached for the required test duration.

The contractor should obtain any permits required for the draining and disposal of flushing and cleaning fluids and comply with these permits to mitigate environmental concerns. If the system is not immediately commissioned, the project engineer may recommend keeping the pipe full of water and circulating it regularly.

6.11.2 Pressure Testing

Before commissioning the heat distribution system, pressure test each pipeline to ensure it is ready for service and is free of accumulations of metal or other contaminants.

As part of quality assurance and quality control, conduct pressure testing on the heat distribution pipeline before commissioning to verify its ability to withstand the required operating pressure without leakage or failure. Testing should be conducted in accordance with the applied design standard. Pressure testing will verify there are no leaks in the pipeline. Typically, pressure tests are performed at 1.5 times the design pressure.

The contractor should submit the pressure testing procedure to the project engineer for review before testing. The engineer should witness the testing. Each witness to the testing should submit a signed report at the end of the testing to the owner and project engineer.

While pressure testing is taking place, it is important to provide signage to notify the public and site personnel that the test is occurring.

6.12 As-Built Survey Plans

Owners should retain as-built survey plans for the life of the system that include the starting point, the route, and the end points of the heat distribution pipeline, including associated pipeline equipment. The end point is where heat transfer occurs between the pipeline and the end user and often consists of a heat transfer station or heat exchanger.

The plans should represent the actual pipeline route from both a plan view and a cross-section view (pipeline elevation and terrain). They should also include the main trunk and branch lines but not necessarily the service lines, except for the location of the end-user service connection.

As-built surveys are important as confirmation that the pipeline was constructed as per the design and for activities after construction. Knowing the location of the installed pipeline is crucial for access by the owner or others and for monitoring or performing repairs during operations.

6.13 Construction Reclamation

Reclamation of the land and natural habitat of the pipeline ROW helps ensure sustainable construction practices and meeting environmental regulations. Taking the following steps during construction will help with reclamation:

- Minimize the pipeline corridor to reduce the construction footprint.
- Install geotextiles.
- Construct the pipeline during winter or late fall when plants are dormant.
- Replace topsoil at the beginning of the growing season.

Once pipeline installation is complete, clean up and reclaim the land used for construction. Restoring the land to its original condition should include the following:

- Replacing stockpiled subsoil and topsoil.
- Recontouring to re-establish proper drainage.

- Removing construction debris.
- Reseeding of vegetation.
- Re-establishing slopes.

The pipeline ROW should be monitored for at least two growing seasons to ensure successful reclamation.

7 Operations Phase

Owners should consider pipeline operations and maintenance during the planning and design phases. Operations and maintenance plans vary depending on the site conditions, geographic location, piping materials, accessibility, and environmental sensitivity. Leaks or spills from pipeline operations can contribute to air and water pollution, affecting local ecosystems and air quality. Steps to take to mitigate risk include the following:

- leak detection systems
- regular maintenance
- isolation valves to minimize the risk of leaks
- promptly addressing any issues

Inadequate maintenance practices can lead to pipeline corrosion and material degradation, increasing the risk of leaks or pipeline failures. If the system becomes inoperable due to a failure, the heat supply to the end users could be interrupted. Conduct regular inspections, use corrosion prevention measures (e.g., corrosion inhibitors), and prioritize repairs to maintain pipeline integrity to reduce risk.

Be prepared for to respond to emergencies like leaks, natural disasters, or third-party damage.

7.1 Qualified Persons

Qualified persons required during operations and for maintenance include the following:

- **Maintenance technicians**: Responsible for regular inspections, repairs, and upkeep of the heat distribution pipeline.
- **Operations managers**: Oversee operations, monitor performance, and manage issues that arise.
- **Health and safety personnel**: Ensure that all aspects of the heat distribution pipeline comply with safety regulations and take precautions to ensure the public are protected.

7.2 Quality Assurance and Quality Control Considerations

Consider the following quality assurance and quality control measures during the operations phase:

- Develop a maintenance plan for all equipment to ensure it is maintained as per supplier and manufacturer recommendations.
- Develop comprehensive emergency response plans and collaborate with local authorities to ensure an effective response and timely resolution.
- Register the heat distribution pipeline with Utility Safety Partners (formerly Alberta One-Call).

7.3 Metering and Monitoring

Proper metering and monitoring of the heat distribution pipeline help ensure efficient and reliable system operation and mitigate risk by detecting issues that arise during operation.

Key components of a metering and monitoring system include flow meters (electromagnetic and ultrasonic), pressure sensors, leak detection systems, alarms, and, in some cases, energy meters (as per CSA standards).

Owners can use remote monitoring and remote control. Remote monitoring provides the operator with real-time system monitoring from a remote location to address issues quickly. Remote control allows the operator to remotely control isolation valves and other equipment to ensure efficient operation and maintenance and a quick response to leaks or other issues, minimizing the downstream environmental effects.

Data analysis and trending historical data can provide valuable insights into safe system operations and preventive maintenance planning.

7.4 Leak Detection Systems

Using leak detection systems helps to prevent energy loss and reduce potential environmental effects. Leak detection systems identify leaks and, depending on the method, the location. Alternatives to built-in leak detection systems include

- using operational data from flow meters (a volumetric balance),
- using make-up water data trends, or
- pressure monitoring of hot outbound lines and cold-water returns. Sudden and unexplained pressure drops may indicate an issue with the distribution piping, including a potential leak.

When a leak is suspected, make a visual inspection to look for signs of the leak and identify the location. It is possible to use thermal imaging from thermal-imaging drones in the area where the leak is suspected. Inspections of the ROW may assist in determining where leaks have occurred.

For piping systems that do not have a built-in leak detection system, it may be advantageous to design additional isolation points, which will help isolate the leak to minimize environmental effects and assist in repair work.

7.5 Utility Safety Partners Registration

Registration with the Utility Safety Partners (USP) is recommended to ensure heat distribution pipes can be easily located and line strikes avoided. The USP promotes “call before you dig” and helps to find underground utilities and infrastructure to prevent damage.

All heat distribution pipelines should be registered and their data updated, regardless of the operational status. Registration of a new heat distribution pipeline should be before the pipeline is operational.

For more information, see the Utility Safety Partners website.

7.6 Pipeline Inspection

Owners should inspect pipelines after construction and throughout their life cycle. Furthermore, owners should be proactive in making inspections when opportunities arise because access to buried pipelines is limited, and they are in constant operation. For example, if sections of a pipeline need to be shut down, partially drained, and exhumed to make a new connection, have an inspection strategy in place to document the condition of the exposed section, take measurements, and visually inspect the bore of the drained segment with a fibre-optic camera.

Inspecting the ROW is important to ensure that reclamation has been achieved, confirm the visual presence of a leak, monitor encroachment, and monitor geohazards (such as slope stability, slumping, erosion, or physical integrity of restoration measures). The inspection should look for weeds, dying vegetation, surface deformation (subsidence or sinkholes), and unauthorized activity within the ROW. Where any are present, owners should immediately act to rectify the issue before it worsens and affects pipeline integrity. Owners should maintain historical records for the ROW, including photographs (time stamped). After construction, owners should conduct a pipeline ROW survey at regular intervals (e.g., annually).

8 End-of-Life Phase

At the end of the operations phase, the heat distribution pipeline enters the end-of-life phase. Owners are responsible for decommissioning their pipeline in a safe, environmentally responsible manner and in adherence to all relevant regulations.

8.1 Pipeline Abandonment and Decommissioning

When a pipeline reaches its end of life, it is important to decommission and abandon it properly. Improper decommissioning can lead to soil and water contamination, pollution, and waste management challenges.

Develop a decommissioning plan that includes

- proper removal of equipment,
- abandonment (includes purging and cutting and capping if steel removal of cathodic protection) of the pipeline within the ROW and pipelines within a plant site should be removed,
- mitigation of potential contamination risk,
- prioritization of reuse and recycling, and
- safe disposal of materials and waste.

8.2 Reclamation Certification

Under Alberta's *Environmental Protection and Enhancement Act*, owners must conserve and reclaim specified land and obtain a reclamation certificate for the conservation and reclamation. Specified land refers to land used for pipeline construction, including access roads and temporary workspaces.

Appendix 1 Code Compliance and References

The applicable codes and standards will vary depending on the project-specific requirements. It is imperative that the owner and their qualified persons adhere to applicable codes and standards. The following is not an exhaustive list of the codes and standards that may apply to a project. Not all of the following codes and standards are referenced in this manual. References to codes and standards are to the latest editions.

Alberta Pressure Equipment Safety Regulation

ASME B31.1: Power Piping

ASME B36.10: Welded and Seamless Wrought Steel Pipe

ASME NM.1: Thermoplastic Piping Systems

ASME NM.2: Glass-Fiber-Reinforced Thermosetting-Resin Piping Systems

ASTM A53: Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless

ASTM A106: Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service

ASTM F412: Standard Terminology Relating to Plastic Piping Systems

ASTM F714: Standard Specification for Polyethylene (PE) Plastic Pipe (DR-PR) Based on Outside Diameter

ASTM F876: Standard Specification for Crosslinked Polyethylene (PEX) Tubing

ASTM F2164: Standard Practice for Field Leak Testing of Polyethylene (PE) and Crosslinked Polyethylene (PEX) Pressure Piping Systems Using Hydrostatic Pressure

ASTM F2620: Standard Practice for Heat Fusion Joining of Polyethylene Pipe and Fittings

ASTM F2623: Standard Specification for Polyethylene of Raised Temperature (PE-RT) Systems for Non-Potable Water Applications

ASTM F2829: Standard Specification for Metric- and Inch-Sized Fittings for Crosslinked Polyethylene (PEX) Pipe

ASTM D2774: Standard Practice for Underground Installation of Thermoplastic Pressure Piping

ASTM D2837: Standard Test Method for Obtaining Hydrostatic Design Basis for Thermoplastic Pipe Materials or Pressure Design Basis for Thermoplastic Pipe Products

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

ASTM D3350: Standard Specification for Polyethylene Plastics Pipe and Fittings Materials

CSA B51: Boiler, Pressure Vessel, and Pressure Piping Code

CSA B137.1: Polyethylene (PE) Pipe, Tubing, and Fittings for Cold-Water Pressure Services

CSA B137.5: Crosslinked Polyethylene (PEX) Tubing Systems for Pressure Applications

CSA B137.18: Polyethylene of Raised Temperature Resistance (PE-RT) Tubing Systems for Pressure Applications

CSA C900.1: Heat Meters – Part 1: General Requirements

CSA Z247: Damage Prevention for the Protection of Underground Infrastructure

CSA Z662: Oil and Gas Pipeline Systems

EN 253: District Heating Pipes – Bonded Single Pipe Systems for Directly Buried Hot Water Networks – Factory Made Pipe Assembly of Steel Service Pipe, Polyurethane Thermal Insulation and a Casing of Polyethylene

EN 448: District Heating Pipes – Bonded Single Pipe Systems for Directly Buried Hot Water Networks – Factory Made Fitting Assemblies of Steel Service Pipe, Polyurethane Thermal Insulation and a Casing of Polyethylene

EN 488: District Heating Pipes – Bonded Single Pipe Systems for Directly Buried Hot Water Networks – Factory Made Steel Valve Assembly for Steel Service Pipes, Polyurethane Thermal Insulation and a Casing of Polyethylene

EN 489-1: District Heating Pipes – Bonded Single and Twin Pipe Systems for Directly Buried Hot Water Networks – Part 1: Joint Casing Assemblies and Thermal Insulation for Hot Water Networks in Accordance with EN 13941-1

EN 10028: Flat Products Made of Steels for Pressure Purposes

EN 10216: Seamless Steel Tubes for Pressure Purposes. Technical Delivery Conditions

EN 10217: Welded Steel Tubes for Pressure Purposes. Technical Delivery Conditions

EN 13941: District Heating Pipes – Design and Installation of Thermal Insulated Bonded Single and Twin Pipe Systems for Directly Buried Hot Water Networks

EN 14419: District Heating Pipes – Bonded Single and Twin Pipe Systems for Buried Hot Water Networks – Surveillance Systems

ISO 12162: Thermoplastics Materials for Pipes and Fittings for Pressure Applications –Classification, Designation and Design Coefficient

PPI TN-42: Recommended Minimum Training Guidelines for PE Pipe Butt Fusion Joining Operators

PPI TN-46: Guidance for Field Hydrostatic Testing of High Density Polyethylene Pressure Pipelines

PPI TR-4: PPI Listing of Hydrostatic Design Basis (HDB), Hydrostatic Design Stress (HDS), Strength Design Basis (SDB), Pressure Design Basis (PDB) and Minimum Required Strength (MRS) Ratings For Thermoplastic Piping Materials or Pipe

PPI Handbook of Polyethylene Pipe