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The specifier's guide to selecting pipework systems for heat networks



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Executive Summary

The UK heat network market is entering a period of significant expansion, driven by decarbonisation targets, heat network zoning, government support and growing local authority activity. Modern heat networks that utilise low-carbon renewable energy and waste heat sources are becoming an increasingly important part of the UK's energy infrastructure as the country works towards its target of net-zero carbon emissions by 2050.

The quality of the design, construction and long-term operation of heat networks will be critical to delivering the expected carbon reduction, efficiency and customer benefits.

Pipework is fundamental to the optimal performance of a heat network. Decisions on pipe sizing, insulation, carrier pipe materials, hydraulic design, installation and water quality can all affect system reliability, maintenance requirements, operating costs and the overall lifespan of the network. Pipework material selection and design also play an important role in improving energy efficiency by minimising distribution heat losses.

This becomes particularly important as heat networks move towards lower operating temperatures. Low-carbon heat sources such as heat pumps typically produce lower-grade heat than conventional fossil-fuel systems, meaning that unnecessary distribution losses can have a proportionally greater impact on overall system efficiency. Selecting pipework with appropriate thermal performance is therefore an important part of achieving the required energy and carbon performance.

With the sector moving towards greater technical assurance and regulation, pipework should no longer be treated simply as another construction activity or procured solely on the basis of the lowest capital cost. Early investigation, robust design, competent installation and effective monitoring can help prevent costly failures, delays and disruption later in the network's life.

The latest regulatory standard, TS1, developed by the Government, sets minimum requirements for the design, installation, commissioning and operation of heat networks. It places particular emphasis on issues that can have a detrimental effect on network performance and reliability, including corrosion of steel pipework and leakage from connections between pipe sections. These issues can also affect water quality, making appropriate water treatment, surveillance and testing an important part of long-term network management.

The selection of pipework can play a crucial role in mitigating some of these risks. Polymer-based pipework systems, for example, can be manufactured in long continuous lengths, reducing the number of joints and connections required. Where the system design and operating conditions are suitable, this can simplify installation and reduce potential leak points. Unlike steel, polymer pipework is not susceptible to corrosion, which can help maintain water quality and reduce one potential source of long-term system degradation.

Ultimately, investing in the right pipework solution at the outset is essential to delivering efficient, reliable, cost-effective and genuinely low-carbon heat networks capable of performing successfully throughout their intended service lives.

For specifiers, polymer-based pipework systems can be a credible alternative to traditional steel solutions. In addition to helping address energy efficiency and durability requirements, they can offer potential installation and whole-life cost benefits that should be considered as part of the overall design and procurement decision.

1. Introduction

The growing importance of heat networks

Heat networks are an important part of the UK's future energy infrastructure. Government policy identifies them as a key route to decarbonising heat, particularly in densely populated towns and cities where connecting multiple buildings to a shared network can provide an efficient and cost-effective alternative to individual heating systems.

The scale of the opportunity is significant. Heat networks currently supply around 3% of UK heat[1], but the Government's 2050 vision is for them to provide almost 20% of the country's heat demand[2]. Achieving this level of deployment could require up to £80 billion of investment by 2050[3], creating substantial opportunities across heat generation, district heat networks, energy centres, heat pumps, heat recovery, thermal storage, controls, metering, construction and network operation.

This growth is being driven at both national and local levels. The Government is establishing the policy, funding and regulatory framework needed to create a larger and more investable heat network market. This includes heat network zoning, financial support for development, and the introduction of technical assurance requirements such as HNTAS and the new TS1 standard, expected to be released in early 2027. At the same time, local authorities and devolved administrations are developing their own strategies, targets and projects to decarbonise heat, often linking heat networks with wider regeneration, housing and net-zero objectives.

The result is a market in which national ambition and local delivery are increasingly aligned. Government targets provide long-term direction and investment confidence, while local authorities are helping to identify where networks can work, develop projects and create connections between heat sources and consumers.

Pipework systems as a critical component

The successful delivery of a heat network depends on treating pipework design and installation as a critical part of the overall system rather than another construction activity.

It is important to distinguish between fourth- and fifth-generation heat networks. Fourth-generation networks distribute low-temperature hot water from a central or shared heat source to buildings, so minimising distribution heat losses is important.

Fifth-generation networks are based on a fundamentally different design principle. They typically operate at ambient temperatures of around 20–25°C, with heat pumps located within individual buildings extracting energy from the network and raising it to the temperature required for heating and hot water. Buildings requiring cooling can also reject heat back into the network, allowing this energy to be used by other buildings.

The term 'fifth-generation' therefore describes the network's architecture and method of energy exchange, rather than suggesting it is inherently better than fourth-generation. For designers and specifiers, this distinction is important because the pipework requirements will depend on how the network operates. While traditional heat-loss reduction remains important for fourth-generation systems, fifth-generation networks place greater emphasis on efficient energy exchange, hydraulic performance and low-energy distribution.

Guidance on heat networks has historically been provided through the voluntary CIBSE CP1 (2020) Code of Practice[4], which established principles for technical performance and consumer protection. The code is due to be superseded by the Heat Network Technical Standard (TS1)[5], which supports the Heat Network Technical Assurance Scheme (HNTAS)[6]. This represents a significant shift towards a more formalised and regulated approach to technical assurance across the UK heat network sector.

Design, installation and whole-life performance

The time and cost associated with installing pipework need to be properly recognised at the design and procurement stages. Sufficient time should be allowed to understand existing services, establish practical pipe routes, plan deliveries and storage, and determine how pipework will be transported, positioned and installed.

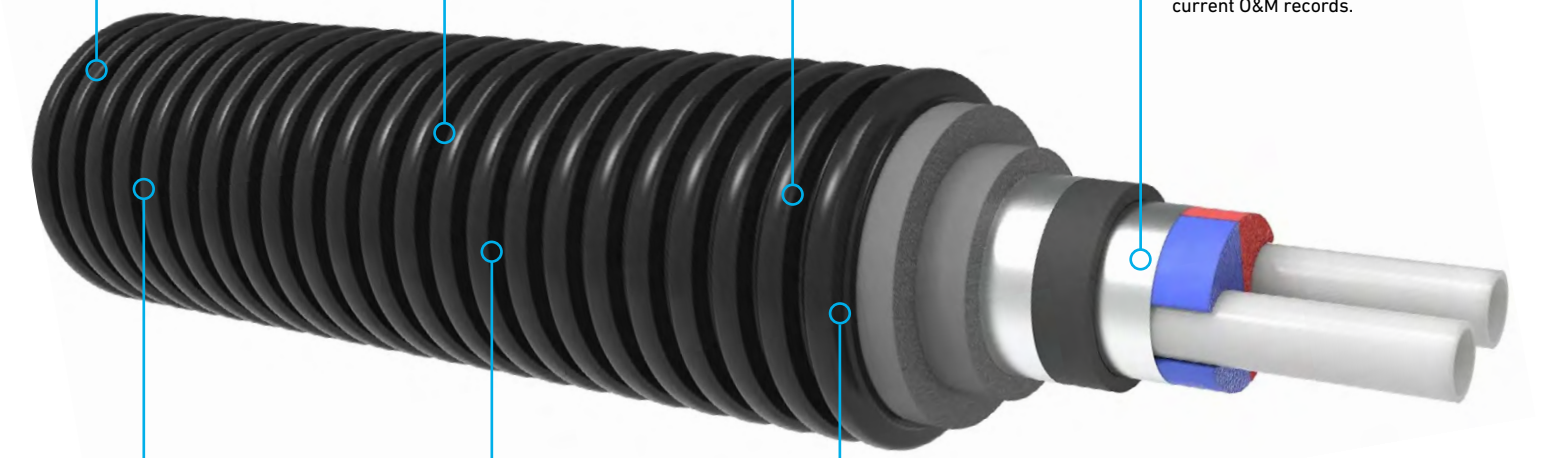
Failure to consider these issues early can result in programme delays, additional excavation, increased material waste and substantially higher costs. Decisions made during the design stage can influence a heat network's energy use, carbon emissions, reliability, maintenance requirements and operating costs for decades.

Getting pipe sizing, insulation, materials, hydraulic design and water quality right from the outset can minimise heat losses and energy consumption while reducing the risk of leaks, corrosion and premature failure. A well-designed, correctly specified and properly installed pipework system is fundamental to network reliability, energy efficiency, customer service, whole-life cost and the long-term delivery of a dependable low-carbon district heat network.

1 https://www.gov.uk/government/publications/warm-homes-plan/warm-homes-plan-html?utm_source=chatgpt.com
2 https://www.gov.uk/government/publications/uk-heat-networks-market-overview/uk-heat-networks-market-overview-accessible-webpage?utm_source=chatgpt.com
3 https://www.gov.uk/government/publications/powering-up-britain/powering-up-britain-net-zero-growth-plan?utm_source=chatgpt.com
4 https://www.cibse.org/knowledge-research/knowledge-portal/cp1-heat-networks-code-of-practice-for-the-uk-2020-pdf
5 https://assets.publishing.service.gov.uk/media/691c938cd140bbbaa59a29b9/heat-network-technical-standard-1-draft.pdf
6 https://www.gov.uk/government/publications/heat-networks-regulation-technical-standards/heat-network-technical-assurance-scheme-hntas

2. Stages of a heat network project

A district heat network project progresses through seven distinct stages, from initial concept and feasibility through design, development, construction and commissioning to long-term operation and maintenance. This structured approach helps manage technical risks, maintain quality and ensure that the completed heat network delivers the efficiency, reliability and longevity expected from the original design.



1 DEFINE
Concept Design

Set heat demand and sources, operating temperatures and pressures, route, initial pipe sizes and insulation. Allow for space and building integration from the outset.

2 COORDINATE
Developed Design

Refine heat demand and plant and equipment sizing. Develop coordinated drawings and schematics showing components, pipework and flow rates.

3 DETAIL
Technical Design

Finalise equipment, plant and pipework sizing, installation requirements and spatial coordination. Include required specialist or subcontractor design so construction can begin.

4 DOCUMENT
Construction Design

Provide the information needed for installation: technical submittals, detailed installation drawings, the O&M manual and records of agreed design changes.

5 BUILD
Installation

Install pipework, equipment and insulation. Fill, flush and pressure test the system, with quality checks focused on joints and other critical work.

6 VERIFY
Commissioning

Commission equipment, complete acceptance tests, check water quality against control limits and assess pipework and equipment condition. Confirm readiness for operation.

7 MAINTAIN
Operation and Maintenance

Protect performance, reliability and condition through planned preventative maintenance, regular inspections, water quality monitoring and current O&M records.

Communal and district networks

Give early priority to space and integration within the building, then coordinate the communal network with other building services and the wider system. District networks are usually less spatially constrained across a whole development.

Installation requirement

Install all heat-network components in line with manufacturers' requirements and the relevant standards and regulations.

2.1 The importance of considering the whole lifecycle

Although these stages can be viewed as a sequence, decisions made during the early stages can have consequences throughout the network's operational life. In particular, choices relating to heat demand, operating temperatures, pipe sizing, insulation, hydraulic design, materials, water quality, controls and future expansion can directly affect capital cost, energy efficiency, carbon emissions, reliability and maintenance requirements.

TS1 supports this approach, stating that verification testing after all stages are complete is a key priority. This helps ensure that the design and installation are correct and that the expected in-service operating costs (OPEX) will be achieved.

> *For this reason, pipework should not be treated as a construction component to be procured at the lowest possible capital cost. Its specification, embodied carbon, operational carbon, installation and long-term performance need to be considered as part of the wider whole-life design of the heat network.*



3. Heat network regulations and guidance

The UK heat network sector is moving towards a more regulated and technically assured approach.

3.1 Heat Network Zoning

Heat network zoning is being introduced by DESNZ to identify areas where heat networks are expected to provide a cost-effective, low-carbon heating solution. By providing greater certainty over future heat demand, zoning is intended to support investment and accelerate network development.

Accurate planning for the medium- and long-term development of a heat network is important. Designing for excessive capacity can result in oversized pipework if the anticipated number of connections or heat demand does not materialise. Larger-than-necessary pipes increase capital costs and can also lead to higher heat losses and pumping requirements, reducing the overall efficiency of the network.

3.2 HNTAS (Heat Network Technical Assurance Scheme)

HNTAS is a mandatory framework being developed under the Energy Act 2023. It will establish minimum technical performance requirements for new and existing heat networks, with assessments covering design, construction and operation.

Under HNTAS, networks are divided into six 'elements' – from the energy centre and distribution networks through to substations, consumer connections and consumer heat systems. Each element must demonstrate compliance with the relevant technical requirements.

3.3 Heat Network Technical Standard (TS1)

TS1 is intended to become the primary technical reference for HNTAS, replacing the previous CIBSE CP1 voluntary Code of Practice. It sets minimum requirements for the design, installation and operation of safe, reliable, efficient and low-carbon heat networks.

The draft standard currently focuses on traditional steel pipe systems and does not fully reflect the range of materials and technologies now available. While it remains in draft form, it may be updated before its official release or in subsequent editions to reflect the full range of options available to designers and specifiers.

3.4 What this means for the industry

Developers, designers and contractors will face a greater requirement to demonstrate technical competence, compliance and whole-life performance.

The heat network must be tested in operation and assessed against the original design criteria.

Correct pipework specification, design and installation will be particularly important in minimising heat losses, improving efficiency, maintaining good water quality and achieving reliable, low-carbon operation.





4. Design principles and considerations

There are several considerations when specifying pipework systems for heat networks.

4.1 Type of heat network

There are two main types of heat network: district heat networks and communal heat networks. While both provide heating and hot water, they differ in scale, design, materials, configuration and how energy is distributed to the point of energy transfer.

4.1.1 District Heat Network

A district heat network (DHN) supplies heating and/or hot water to two or more buildings. Energy is generated or recovered at an energy centre and distributed to connected buildings through a network of insulated pipes. The source of energy will depend on the particular DHN and may include heat pumps, surplus heat from local industry, energy from waste or other low-carbon heat sources.

4.1.2 Communal Heat Network

A communal heat network supplies heating and/or hot water within a single building that is divided into multiple premises, such as apartments. Heat is typically transferred to each dwelling via an HIU or a water-to-water heat pump.

4.2 Operating temperature of heat network

As well as distinguishing between district and communal heat networks, the temperature at which the network operates is important.

Low-temperature networks differ significantly from networks that operate at higher temperatures. For example, an ambient loop serving a communal network within a single building may operate at around 25°C. By comparison, traditional district heat networks operate at much higher temperatures. A fourth-generation district heat network can operate with flow temperatures of up to 75°C, and even higher in older installations.

Fifth-generation heat networks operate at much lower temperatures and typically use a shared low-temperature grid connected to multiple buildings, with network temperatures generally below 35°C. Individual buildings or dwellings can then use heat pumps to raise the temperature to the level required for space heating and domestic hot water.

4.2.1 Why lower temperatures matter

Operating a heat network at a lower temperature can provide several important benefits:

Reduced heat loss: The smaller the temperature difference between the water in the pipes and the surrounding ground or environment, the less heat is lost from the network, improving overall system efficiency.

Reduced overheating risk: Within communal heat networks, heat lost from distribution pipework does not simply disappear. It can cause unwanted heat gains within buildings, contributing to overheating.

Greater compatibility with low-carbon heat sources: Networks operating at lower temperatures are more compatible with a wider range of energy sources. Low-grade heat that would be unsuitable for a conventional higher-temperature network can be captured and upgraded using heat pumps.

4.3 Primary heat source and its location

The primary heat source and its location are fundamental to the design, economics and long-term performance of a heat network. These factors influence operating temperatures and pressures, pipe sizing, insulation, hydraulic design, network routing and building interfaces.

4.3.1 Primary heat source

The heat source determines the network's operating parameters and therefore the requirements for its components. Higher-temperature sources, such as boilers, CHP and some geothermal systems, require pipework and components capable of handling higher temperatures and may involve higher pressures or greater thermal expansion.

Lower-temperature sources help reduce distribution heat losses and allow alternative pipework systems to be specified.

The characteristics of the heat source also influence energy-centre design. Sources that provide relatively constant output may require thermal storage to balance heat generation with fluctuating demand.

4.3.2 Location of the heat source

The distance between the heat source and consumers affects pipework, heat loss, pumping, hydraulic performance and construction costs. Long transmission routes increase heat losses and pressure drops, making pipe insulation, pipe sizing and hydraulic modelling particularly important. Changes in elevation can also require careful pressure management and system design.

Remote heat sources may require complex routes through roads, railways, waterways and areas with congested underground services. These constraints can significantly increase excavation, installation and access costs. Flexible polymer-based pipe systems can provide more cost-effective solutions than traditional steel alternatives.

4.4 Calculation of heat loss

Heat networks require careful design to keep heat losses low. The drive towards better-insulated and more airtight buildings means that heat losses from the network can become a more significant proportion of the total heat supplied. Minimising these losses is essential to control operating costs, reduce carbon emissions and prevent overheating, particularly in residential blocks.

Operating temperatures are central to network efficiency. Low return temperatures reduce flow rates, allowing smaller pipes to be used and reducing heat loss. When the system is designed correctly, they can also reduce pumping energy. Maintaining low return temperatures under part-load conditions requires careful system design and the avoidance of uncontrolled bypass flows.

Flow temperatures should also be optimised for both peak and part-load conditions. Lower flow temperatures can improve the efficiency of heat sources such as heat pumps, while a sufficiently wide ΔT helps reduce pipe sizes. A combination of lower part-load flow temperatures and an appropriate ΔT can therefore improve overall network efficiency.

Other important design considerations include:

+ Twin-pipe systems
Can reduce heat losses by placing flow and return pipes within a single casing.

+ Shorter pipe routes
Reduce capital costs, heat losses and pumping energy.

+ Accurate peak-demand calculations
Avoid unnecessarily oversized pipes and plant.

+ Appropriate pipe sizing
Avoids oversized systems that increase capital costs, heat losses and pumping requirements.

> *When calculating heat loss, specifiers can use free online calculators and obtain design advice and guidance from pipe-system manufacturers such as GF.*

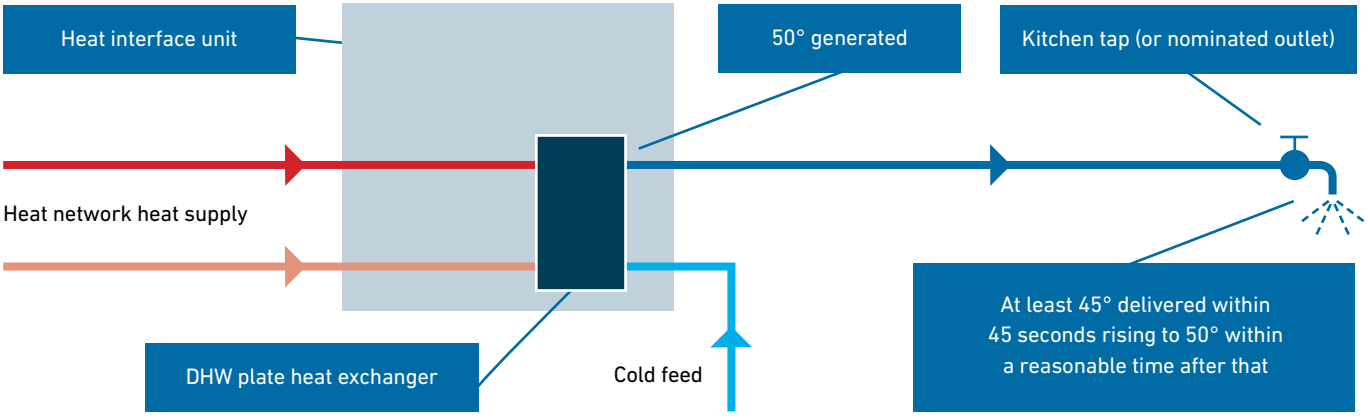
4.5 Guidance from CP1 on heat supplied by HIUs for DHW

In line with the CP1 code of practice, where a new building is connected to a heat network, or undergoes major refurbishment, designers have several options for providing space heating and domestic hot water (DHW). The chosen approach can have a significant impact on both the capital and operating costs of the heat network.

For instantaneous hot water systems, such as HIUs, the DHW outlet temperature should normally be set to 50°C at the plate heat exchanger outlet, unless a higher temperature is specifically required. This is acceptable where the water volume is small (less than 15 litres) and the risk of Legionella can be appropriately controlled. HIU heat losses of less than 0.7 kWh/day should be specified.

The hot-water system within a dwelling should also be designed to deliver at least 45°C at the kitchen tap within 45 seconds of the tap being fully opened, but it must ultimately achieve 50°C, as illustrated in Figure 1. This is a customer service requirement. In non-domestic buildings without a kitchen, the designer should identify a representative tap to which the requirement will apply. Usually, the outlet furthest from the heat source would be nominated as the sentinel point.

Where flushing bypasses are not incorporated within the HIU, they should be provided at each HIU connection to protect sensitive equipment during network flushing. The bypass arrangement should comply with the HIU manufacturer's requirements.



4.6 Demand-side considerations when specifying heat network pipework

Understanding the heat demand, temperature requirements and operating profile of connected buildings helps ensure that the network is correctly sized and avoids unnecessary capital and operating costs. Early collaboration with pipe manufacturers is vital: they can assist in calculating expected demand and determining the most appropriate material specifications to meet the project's performance requirements.

4.6.1 Peak heat demand and diversity considerations

+ Peak load
Size the network for the maximum coincident thermal demand, taking appropriate account of diversity.

+ Diversity
Apply realistic diversity factors across multiple buildings rather than assuming every consumer will reach peak demand simultaneously.

+ Avoid oversizing
Excessively large pipes increase capital costs, heat losses and pumping requirements.

+ Low-flow conditions
Oversized pipes can reduce flow velocities, increasing the risk of sediment accumulation and poor system performance.

4.6.2 Temperature regimes and ΔT considerations

+ Low return temperatures
Keep building return temperatures as low as practicable.

+ Maximise ΔT
A wider difference between flow and return temperatures reduces the volume of water that needs to be circulated.

+ Smaller pipework
Lower flow rates can allow smaller pipe diameters, reducing capital cost and heat loss.

+ Lower pumping energy
Optimised flow rates and correctly sized pipes can reduce pumping energy.

4.6.3 Building interfaces and control considerations

+ Substation design
Select an appropriate direct or indirect connection, depending on the network and building requirements.

+ Hydraulic separation
Indirect systems can separate network pressures and water quality from the building's internal system.

+ Control valves
Pressure-independent control valves (PICVs) can help maintain the required flow under varying system conditions.

+ Avoid unnecessary bypasses
Uncontrolled bypass flows can increase return temperatures and reduce network efficiency.

+ Variable-speed pumping
Pumps should respond to actual demand rather than operating continuously at full output.

4.6.4 Consumer load profiles and future demand considerations

+ Domestic hot water
Consider whether DHW is generated instantaneously or through storage, as this affects peak demand.

+ Space heating
Assess the building's actual heating profile, including continuous background heating and intermittent peak demand.

+ Future demand
Consider improvements to building fabric and energy efficiency that could reduce heat demand over the network's lifetime.

+ Cooling
Where future cooling is anticipated, consider whether a lower-temperature network or ambient loop could provide greater flexibility.

4.7 Hydraulic optimisation of heat network pipework

Hydraulic design should be considered alongside pipe sizing, operating temperatures, ΔT, controls and network topology rather than as an isolated calculation. Optimising these elements can reduce pipework capital costs, pump energy and heat losses while improving the network's reliability and capacity to accommodate changing demand.

In large district heat networks, the objective is to balance pipe size against pressure drop. Larger pipes cost more to install but require less pumping energy, while smaller pipes reduce capital costs but increase pressure losses and pumping requirements. Designers should therefore seek the combination that delivers the optimal balance for the network as a whole. GF has dedicated design teams who can provide advice based on an individual heat network's needs.

4.7.1 Pipe diameter sizing

Traditional designs often use fixed velocity or pressure-drop limits, such as 200–300 Pa/m, to determine pipe sizes. More advanced optimisation methods can assess the network as a whole and select from commercially available pipe diameters based on factors including flow rates, pressure losses and capital costs.

The design should account for local pressure losses at fittings such as bends, elbows, valves and T-junctions, using the correct zeta values or equivalent length measures rather than considering only friction losses along straight pipework.

4.7.2 Dynamic differential-pressure management

Instead of operating pumps at a permanently high pressure to satisfy the most hydraulically remote consumer, variable-speed pumps and local control valves can be coordinated to respond to actual demand.

Dynamic differential-pressure control can reduce unnecessary pumping energy, particularly where demand varies significantly throughout the day. Pressure sensors and network monitoring can further support optimisation by providing real-time information on system conditions.



4.7.3 Network topology and hydraulic balancing

Communal heat networks, particularly those with multiple heat sources or interconnected loops, require careful hydraulic balancing. Loop-control valves, differential-pressure controls and, where appropriate, dedicated pumps can help distribute flow effectively across the network.

This prevents poorly served or 'starved' areas, maintains adequate flow to consumers and avoids excessive pumping elsewhere in the system.



4.8 Hydraulic separation in heat networks

Hydraulic separation isolates the primary heat-generation circuit from the secondary building distribution circuits, allowing each side to operate at its own required flow rate and pressure without adversely affecting the other.

This is important in heat networks because the flow requirements of the central heat source or primary network rarely match the constantly changing demand within individual buildings. Effective hydraulic separation accommodates these variations, helping to maintain stable system operation, efficient heat transfer and reliable performance across the network.

4.8.1 The importance of hydraulic separation in lower-temperature heat networks

In fourth- and fifth-generation lower-temperature heat networks, lower supply temperatures make effective hydraulic separation between the primary network and secondary building circuits increasingly important. As operating temperatures fall, maintaining the required heat output can require higher water flow rates, particularly where the available ΔT is reduced.

Without effective separation or carefully considered compensatory measures, variations in building-side demand can affect the primary network, causing unstable flow, unacceptable differential pressures, higher return temperatures and increased pumping energy. These effects can reduce overall network efficiency and negatively affect the performance and coefficient of performance (COP) of connected heat pumps.

4.8.2 How material choice affects hydraulic separation

Material selection plays an important role in the performance and durability of hydraulic separation within heat networks. Hydraulic separation, typically achieved using a low-loss header (hydraulic separator) or a plate heat exchanger (PHE), isolates the primary heat-generation circuit from the secondary distribution system. The chosen material affects thermal performance, corrosion resistance and long-term reliability.

4.8.2.1 Thermal performance

+ Carbon steel
Is commonly used for larger hydraulic separators because it is robust and cost-effective. It is available with epoxy coatings for corrosion protection and magnetic systems to remove sludge.

+ Stainless steel
Is widely used in compact separators and plate heat exchangers, where its strength permits thinner walls and provides corrosion resistance.

+ Copper
Offers excellent thermal conductivity but is generally limited to smaller heat exchangers because of its cost and lower durability compared with stainless steel.

+ Thermally conductive polymers
Utilise composite polymers blended with conductive fillers, such as graphite, boron nitride or carbon nanotubes, to increase thermal conductivity. They are typically reserved for highly aggressive environments where metals fail, such as geothermal heat networks.



4.8.2.2 Corrosion and water quality

+ Mixing dissimilar metals
Can lead to galvanic corrosion unless the materials are properly isolated. In water systems, flow should generally proceed from the less noble metal to the more noble metal; however, this is difficult to achieve in a circulating system.

+ Carbon steel systems
Can generate magnetite over time, making effective filtration and dirt separation important to protect downstream valves and controls.

+ Stainless steel
Offers greater resistance to corrosion and erosion where water chemistry or flow conditions are more demanding.

+ High-performance polymers
Such as glass-filled polyamide/nylon or PPS, are widely used in small commercial and residential low-loss headers and eliminate the risk of oxygen ingress, rust or galvanic corrosion.

4.8.2.3 Hydraulic performance

+ Smooth internal surfaces
Reduce friction and pressure loss through the separator or heat exchanger.

+ Stainless steel and copper
Generally retain smoother surfaces over time than untreated steel, helping to reduce pumping energy and maintain hydraulic balance. Corrosion from untreated steel can block the system or downstream valves.

+ Flexible polymer pipework
Has a smooth internal surface and is immune to internal corrosion.

4.8.2.4 Thermal expansion and durability

+ Insulation
Good external insulation is also essential, regardless of the separator material, to limit heat loss and preserve the temperature conditions needed for effective hydraulic separation. The use of pre-insulated pipework offers advantages by speeding up installation because the pipes do not need to be manually insulated on site. Where flexible pre-insulated pipes are specified, they can easily bend around obstacles on site, minimising the width and depth of required trenches and the number of connections required.

4.9 Layout of pipework system

As most district heat pipework is buried, poor layout decisions can be extremely costly and disruptive to correct after construction. Getting the design right before construction is critical to the network's long-term performance, efficiency and commercial viability.

A well-planned layout can deliver:

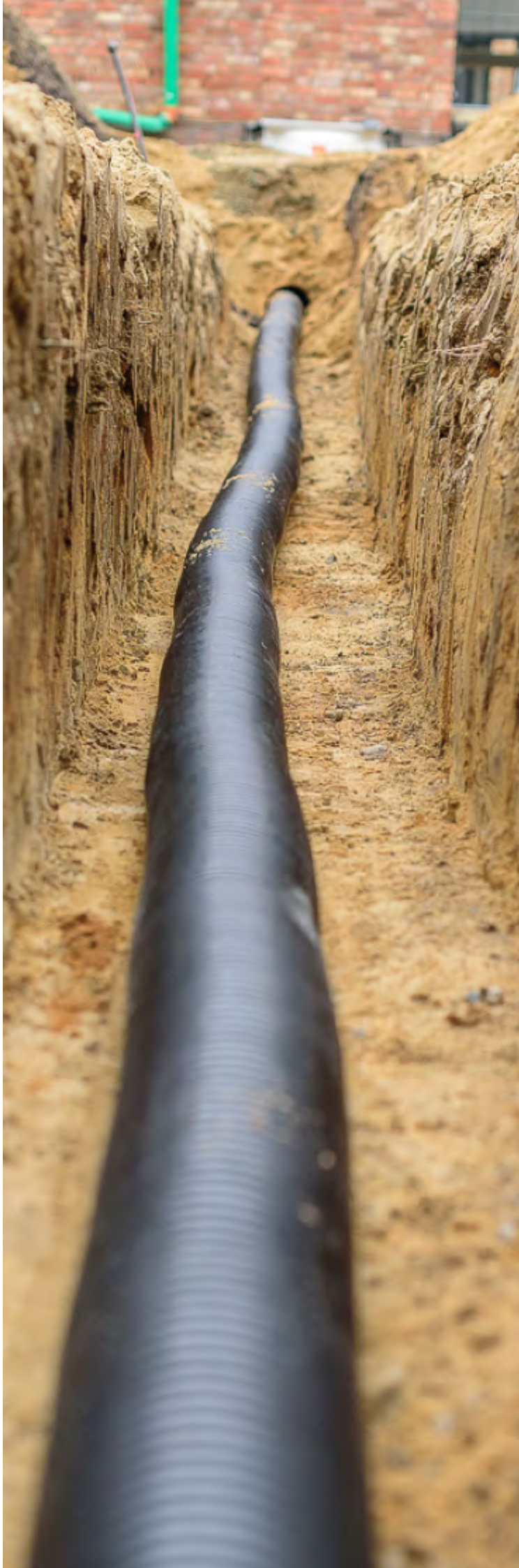
+ Reduced heat losses
Short, direct routes minimise pipe length and the surface area through which heat can be lost. Appropriate pipe sizing also reduces the volume of water held within the network and associated standing losses.

+ Lower capital and construction costs
Routing flexible polymer pipework through verges, soft ground and other accessible areas can reduce excavation and reinstatement costs. Flexible polymer pipework can simplify routes, reduce the need for bends, tees and joints, and limit material and installation costs as well as potential failure points.

+ Improved hydraulic performance
Careful routing and pipe sizing help control pressure losses, maintain adequate flow to all consumers and reduce the electrical energy required for pumping. Changes in elevation must also be considered to manage pressure zones and avoid problems such as airlocks.

+ Greater resilience and flexibility
The network configuration affects security of supply and future expansion. Radial or spine networks can offer lower initial costs, while ring or loop arrangements can provide alternative flow paths and greater resilience if part of the network fails.

+ Effective management of thermal movement
Pipework must accommodate expansion and contraction caused by temperature changes. Strategic bends, loops and anchors can help manage thermal stresses and protect joints and connections from excessive loading.



4.10 Calculation of pipe sizing

Initial pipe sizing should be undertaken early to establish the primary network costs and should balance capital cost, heat loss and pumping energy to achieve the lowest whole-life cost.

Most pumps in modern heat networks can be switched or configured to operate in either variable or constant mode. As peak flow rates and velocities occur infrequently, smaller pipe diameters and higher flow velocities can be more economically viable. However, higher flow rates can cause 'erosion corrosion' by constantly stripping the oxidised layer from steel pipes. Polymer pipes are not susceptible to this phenomenon and can provide more reliable long-term system performance.

Pipe sizing should be based on realistic, diversified heating and hot-water demand, rather than applying maximum theoretical loads. The design should also accurately determine the expected return temperature and ΔT (flow temperature minus return temperature) under peak conditions for each building or dwelling. This ensures that pipework is appropriately sized for actual network conditions while avoiding unnecessary oversizing.

When designing a heat network in accordance with TS1, two different calculation approaches are used depending on whether the objective is to determine the instantaneous peak domestic hot water (DHW) demand or to size the central plant and main distribution network.

4.10.1 Velocity-based pipe dimensioning

Velocity-based pipe sizing determines the required pipe diameter by controlling the water velocity within the network. The aim is to balance hydraulic performance, pumping energy, noise, erosion and installation costs.

Typical design velocities for communal heat networks broadly fall within the following ranges:

+ Minimum velocity
Around 0.5 m/s to help prevent sediment accumulation and thermal stratification.

+ Normal operating range
Approximately 0.8–1.5 m/s, providing a balance between pressure loss and pumping energy.

+ Maximum velocity
Around 2.5–3.0 m/s to limit excessive pressure loss, noise, water hammer and pipe wear.

Pipe sizing should not be based on velocity alone. The peak mass flow rate and allowable pressure drop should also be assessed. A pipe may meet the required pressure-drop criterion but still have an excessive velocity, in which case a larger diameter may be necessary.

4.10.2 Pressure-gradient-based pipe dimensioning

Pressure-gradient-based pipe sizing is a fundamental method for designing district heating and cooling networks. It determines pipe diameter by limiting the frictional pressure loss per metre of pipe (R, expressed in Pa/m) while aiming to select the smallest practical pipe diameter that meets the required hydraulic performance.

The method is based primarily on two design constraints:

+ Pressure gradient (R)
Sets the allowable pressure drop along the pipe and helps control pumping energy. Keeping the pressure gradient within an appropriate range prevents excessive hydraulic losses and provides a standardised method that avoids unnecessarily large pipe diameters.

+ Flow velocity (v)
Provides an additional safety and performance check. If a pipe is undersized, excessive velocity can increase erosion, turbulence and local pressure losses. It can also increase noise, which may be an issue for residents in communal networks.

The two criteria therefore work together. The pressure gradient controls hydraulic efficiency, while velocity limits protect the pipework and maintain acceptable operating conditions.



4.11 System design to minimise health risks from Legionella

For communal heat networks, guidance focuses on controlling water temperatures and preventing heat transfer between heating and cold-water systems to minimise Legionella risk.

Key design considerations include:

- Insulate cold-water and potable-water pipework where it is exposed to adjacent heat network pipes.
- Where complete separation of pipes is not possible, maintain adequate spacing between hot and cold services.
- During installation, run cold-water services below heated-water services to prevent convective heat transfer from the heated pipework, which can increase the risk of Legionella growth.
- Set instantaneous domestic hot-water systems using HIUs to achieve 50°C at the plate heat exchanger outlet, unless a higher temperature is specifically required.
- Use the 50°C instantaneous hot-water approach only where the volume of water is small (less than 15 litres) and the Legionella risk is appropriately controlled.
- Where domestic hot water is stored, maintain it at 60°C for Legionella control.

4.12 Factors affecting the balance between CAPEX and OPEX

When designing and engineering a district heat network, balancing capital expenditure (CAPEX) against operational expenditure (OPEX) is critical to the network's whole-life economic performance and the cost of heat to consumers.

Although capital costs can dominate the initial investment, reducing upfront costs through a lower-quality specification or under-designed components can result in higher energy consumption, increased maintenance, greater heat losses and reduced reliability over the network's lifetime.

Installation costs should also be considered as part of the overall CAPEX. For example, polymer pipework systems can simplify groundworks and accelerate installation, potentially reducing the overall installation cost. These factors should be considered alongside the purchase price of the pipe itself when comparing alternative materials.

The lowest initial cost is therefore not necessarily the lowest whole-life cost. Decisions on pipe sizing, insulation, materials, pumps, controls and system design should take account of both capital cost and the long-term impact on network performance.

The operational outcomes for connected residents and buildings must also be considered. Avoiding system outages is critical, as failures can disrupt heating and hot water supplies and reduce customer satisfaction. Short-term cost savings can therefore result in higher whole-life costs and poorer customer outcomes. For example, steel pipework may offer initial CAPEX benefits, but subsequent corrosion or leakage can lead to costly repairs, disruption and system outages.

4.12.1 Pipe sizing

Oversizing pipes results in higher capital costs and greater heat losses because of their larger surface area, thereby increasing OPEX. Undersizing can reduce CAPEX; however, it increases hydraulic resistance, causing circulation pumps to use more energy and increasing OPEX.

Pipe sizing should be carried out to minimise lifecycle cost, taking account of pump capital costs, energy costs and the cost of heat loss, as depicted in Figure 2.

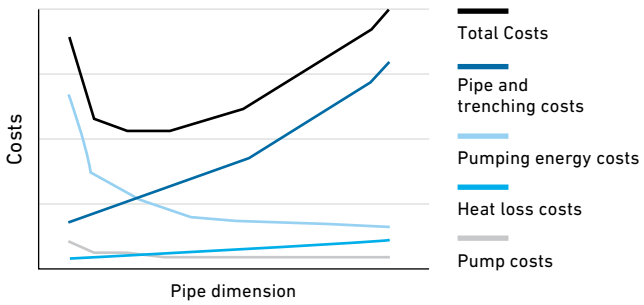


Figure 2: Typical optimisation of pipe sizes on a lifecycle cost basis

Graph taken from CIBSE's CP1 Heat networks: Code of Practice for the UK

4.12.2 Operating temperature

High-temperature networks often use steel pipes; however, lower-temperature fourth- and fifth-generation networks can use flexible polymer (PE-X) pipes, reducing CAPEX through faster installation and lower excavation costs.

4.12.3 Insulation thickness

Increasing the insulation thickness on pre-insulated pipework, such as GF's Ecoflex VIP for district heat networks, may raise pipe procurement costs but reduce system heat loss, thereby lowering OPEX.

4.12.4 Heat Interface Units

Low-cost, direct-acting HIUs can reduce the initial residential connection cost and lower CAPEX. However, a cheaper HIU can result in higher OPEX if it does not control return temperatures effectively. Poor return-temperature performance reduces the network ΔT, requiring higher water flow rates to deliver the same amount of heat. This increases pumping energy, pump wear and maintenance requirements, while raising return temperatures and reducing overall network efficiency.

5. Pipework material selection

Pipework materials range from traditional steel to modern polymers, and each can offer benefits in heat network applications.

5.1 The advantages of PE-X for heat networks

PE-X (cross-linked polyethylene) pipework offers flexibility, corrosion resistance and good thermal performance, making it well suited to modern low- and medium-temperature heat networks.

Flexibility and ease of installation

+ Fewer joints
PE-X pipework can be supplied in long coils, reducing the number of underground joints and potential leak points.

+ Flexible routing
Its flexibility allows pipework to follow complex routes and navigate existing utilities and other site constraints without requiring numerous fittings.

+ Faster installation
Unlike steel pipework, PE-X does not require on-site welding, helping to simplify installation and reduce the time and specialist equipment required.

Efficiency and design flexibility

+ Reduced need for expansion measures
The flexibility of PE-X allows it to accommodate thermal movement, reducing the need for the expansion loops and additional space often required with rigid steel pipework.

+ Low heat losses
When used as part of a pre-insulated system, PE-X can provide effective thermal insulation for low-temperature heat distribution.

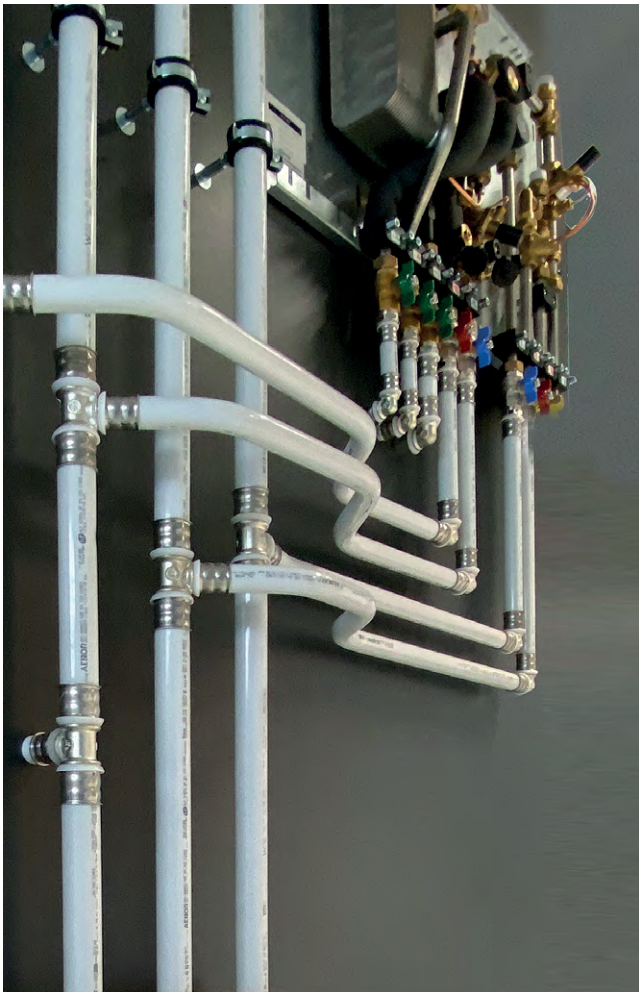
+ Smooth internal surface
The smooth bore helps to minimise friction and reduce the potential for deposits and corrosion, supporting efficient hydraulic performance.

Durability and longevity

+ Corrosion resistance
PE-X does not corrode in the same way as steel, reducing the risk of corrosion-related degradation and its potential impact on water quality.

+ Long service life
When correctly designed, installed and operated within the manufacturer's specified temperature and pressure limits, PE-X systems can provide a long service life suitable for many heat network applications.

+ Reduced maintenance
The combination of fewer joints, corrosion resistance and flexible installation can reduce potential maintenance requirements and contribute to reliable long-term network operation.



5.2 The benefits of pre-insulated pipes for heat networks

Pre-insulated pipe systems for use in district energy networks combine the carrier pipe, insulation and protective outer jacket into a single factory-manufactured assembly, making them particularly suitable for buried district heating and cooling networks. Their high-performance insulation reduces heat losses, helping improve overall network efficiency and supporting the operation of modern low-temperature and low-carbon heat networks. Different insulation thicknesses can also be specified to balance upfront cost against long-term energy savings.

Traditional materials such as insulated steel pipework can present a number of challenges that may affect the long-term performance, reliability and maintenance of the network. Steel systems typically require numerous joints and connections, creating additional potential leak points and making leak detection and monitoring an important consideration.

A leak in a metal pipe system is considered a major failure. Repair may require the system to be taken out of service for an extended period, affecting all customers connected to the network.

Internal corrosion can also affect water quality, making regular water treatment, surveillance and testing an important part of managing the system in line with the requirements of TS1.

The installation of steel pipework can also require heavy lifting equipment and more extensive groundworks. Its rigid nature can place greater constraints on pipe routing, potentially making it more difficult to achieve the shortest and most efficient pipe runs.

Flexible polymer-based pipework systems offer an alternative approach. They can be supplied in long continuous lengths, reducing the number of joints and potential leak points and simplifying installation. GF can supply pipework in batches to reduce excess material and offer on-site training for installers.



Polymer pipework is also resistant to corrosion, helping to maintain water quality and reduce one potential source of system degradation. Its flexibility allows pipe routes to follow the optimum path around site constraints, while installation can be faster and require less equipment and less extensive groundworks than traditional steel systems.

Pre-insulated pipework that uses VIP technology offers exceptional thermal performance and space-saving advantages. The flexible design and small diameter of VIP pipes help to reduce installation time by up to 20% compared with hard-foam-insulated flexible pipes and by more than twice that amount compared with steel pipes.

The initial CAPEX of different pipework systems may vary; however, the overall assessment should consider the whole-life cost. Faster installation, reduced maintenance requirements, a lower risk of leakage and corrosion, and improved reliability can all contribute to lower OPEX over the network's service life.



5.3 Using BIM and EPDs when specifying materials for pipework systems

BIM (Building Information Modelling) and EPDs (Environmental Product Declarations) can be combined to support more sustainable pipework selection by allowing engineers to assess embodied carbon alongside technical and operational requirements during the design stage. BIM provides accurate information on pipe routes, lengths, diameters, fittings and quantities, while EPDs provide independently verified lifecycle environmental impact data for specific products.

The process involves creating an accurate BIM model of the network, including its operating temperatures, pressures and material quantities, and then matching the specified products to EPDs that comply with EN 15804[7]. Global Warming Potential (GWP) data across relevant lifecycle stages can then be used to calculate the embodied carbon associated with the pipework, insulation and fittings.

Different materials can be assessed against their intended application. Steel may be appropriate for high-temperature, high-pressure and large-diameter networks, while polymer or PE-X systems can be advantageous in lower-temperature networks where flexibility and lower embodied impacts are important. Insulation materials should also be assessed because their embodied carbon needs to be balanced against the operational carbon savings achieved through reduced heat loss.

By linking EPD data with BIM quantities, designers can compare different pipework configurations and material options during the design process. This enables embodied carbon to become a measurable design consideration rather than an assumption, helping optimise pipework for technical performance, energy efficiency, cost and whole-life carbon.

7 https://knowledge.bsigroup.com/products/sustainability-of-construction-works-environmental-product-declarations-core-rules-for-the-product-category-of-construction-products

6. Installation and maintenance considerations

Correct installation of pipe systems and their ongoing maintenance are important factors in delivering the performance and long-term reliability expected of a heat network.

6.1 Installation stage

The installation stage typically overlaps with both construction design and commissioning, as different sections of the heat network are designed, installed and commissioned at different times. Consequently, installation activities may be completed before all construction design work is finished or may continue after commissioning activities have already begun elsewhere on the network.

Before installation begins, there should be sufficient technical documentation and defined installation methodologies for the relevant sections of the network. This information may originate from the technical design or construction design stages and should provide installers with clear requirements for carrying out the work correctly.

By the end of the installation stage, all pipework, equipment and insulation should have been installed to an appropriate standard of workmanship and in accordance with manufacturers' guidelines. Manufacturers such as GF can provide on-site training to help achieve this. The network should also have been filled, pressure tested and flushed, with suitable water treatment or conditioning undertaken where required. Relevant quality assurance activities, including non-destructive testing (NDT) of welds, which are a common source of failure, should also have been completed.

Good workmanship means that construction, installation and commissioning activities result in a system that is functional, safe, durable and compliant with the design intent, applicable standards and relevant legal or project requirements. It represents the level of workmanship expected from competent and appropriately skilled contractors within the relevant trade or industry.





6.2 Maintenance of pipe systems

Maintaining pipe systems in heat networks requires continuous monitoring, effective water-quality management and proactive maintenance to prevent heat loss, corrosion, scaling and leaks. Polymer-based pipe systems avoid many of the pipework maintenance requirements associated with corrosion-related water-quality problems and leak detection. Water quality must still be checked to ensure that additives remain at the correct concentrations. This allows maintenance to focus more on ensuring that mechanical and electrical systems operate as expected and meet customer needs.

Water quality in steel pipe systems should be monitored regularly and controlled to limit corrosion and deposits. In both steel and polymer systems, water additives should be checked by monitoring parameters such as gaseous and dissolved oxygen levels and the depletion of chemical treatments.

Operational data can help identify abnormal heat losses or changes in network performance that may indicate developing faults.

Where a leak-detection system indicates an issue, locating and repairing the leak is a top maintenance priority because it may already have caused system problems and could result in significant downtime for customers.

Regular flushing and cleaning can remove sediment and mineral deposits that restrict flow and reduce heat transfer efficiency. Where conventional flushing is insufficient, specialist cleaning techniques may be considered. Insulation should also be inspected and maintained, particularly around joints, valves and other vulnerable areas, to prevent deterioration and unnecessary heat loss.

7. About GF

Georg Fischer (GF) Piping Systems provides a range of pre-insulated pipework and engineered solutions for district energy applications. GF systems combine factory-applied insulation with plastic pipework and electrofusion jointing, offering potential benefits including reduced heat loss, corrosion resistance and faster installation compared with conventional metal systems.

For district heating applications, GF's pre-insulated systems are designed for buried and above-ground installations, with factory-applied insulation helping to provide consistent thermal performance and reduce the risks associated with site-applied insulation.

7.1 GF Products for heat networks

GF provides engineered, pre-insulated systems optimised for transporting heated or chilled water over long distances with minimal thermal dissipation.

GF Uponor Ecoflex VIP

Following GF's strategic integration of Uponor, this cutting-edge solution features advanced vacuum insulation panel (VIP) technology. It reduces heat loss by up to 60% compared with standard soft-foam pre-insulated pipes, while its flexible format cuts on-site installation times by up to 50%.

GF COOL-FIT Series

While widely recognised for industrial cooling and chilled-water distribution, products such as GF COOL-FIT 2.0 Pipe and COOL-FIT 4.0 are vital to modern low-temperature fourth- and fifth-generation district heating and cooling (5GDHC) networks. These systems feature a robust high-density polyethylene (HDPE) outer jacket and a 100% corrosion-free plastic structure that offers 30% greater energy efficiency than post-insulated metal systems.

7.2 GF Services

GF offers comprehensive support throughout the project lifecycle, with BIM files, Environmental Product Declarations (EPDs) and experienced project teams available to help ensure specifications meet the latest standards and project requirements.

Calculation tools

GF offers two specialised online calculation tools that evaluate pipework heat loss and system energy efficiency:

GF Hot Water Energy Calculator

This tool identifies the amount of heat lost during the generation, distribution and storage of domestic hot water in buildings. It calculates annual energy consumption, carbon emissions and potential cost savings from optimisation measures.

GF COOLING Toolbox

Specifically designed for chilled-water and cooling systems, this tool calculates critical pipework metrics, including heat gain and loss, temperature drop, pressure loss and pipe contraction.

On-site training

GF provides customised, on-site training, with application specialists able to deliver practical training directly at a project site or facility. Training programmes can be tailored to the specific requirements of the project, including the piping systems and installation methods being used.

The training combines technical theory with practical, hands-on jointing instruction, while a standardised training approach helps maintain consistent quality and installation practices across projects worldwide.

Tool calibration

GF can arrange for the tools used with GF products on site to be calibrated to maintain consistency and quality of the installation process.

Technical information and literature

Our extensive know-how is documented in detail in our Download Centre. This includes BIM files, EPDs, product catalogues, system specifications and brochures. The information can be searched using either a specific term or the available filters.

If you are working on a heat network project and would like to find out more about our range of GF products and services, please contact us today, and our expert team will be happy to help.

Excellence in Flow

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