Hull District Heat Network

Connecting to the a heat network

A technical guide for designers of building services

Major Projects, Culture and Place
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1 INTRODUCTION

1.1 Purpose of this guide

This guide is intended to set out:

- The principles for designing heating and hot water systems that will connect to a heat network
- Detailed technical guidance on how these principles should be applied for different building and development types;
- The requirements for 'heat network ready' systems, i.e. systems that have been designed and commissioned for future connection to an existing or planned heat network;
- This guide is intended to supplement the *CIBSE/ADE CP1: Heat Networks: Code of Practice for the UK* and relevant industry standards.
- This guide is intended as information only. Prior to undertaking any design or legal work, or signing any agreements, appropriate engineering, and legal advice should be sought.

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2 KEY DESIGN PRINCIPLES

This guide addresses the design of heating and hot water services within buildings. It is essential that *internal* building services are designed to work with the *external* heat network to optimise the entire system. Once connected, the design and operation of the building's system will affect the operation of the whole network. The following principles are an essential requirement for connection to DH networks:

- Design, commissioning, maintaining and operating systems to comply with the minimum requirements in the CIBSE/ADE *CP1 Heat Networks Code of Practice*, and to aim to deliver best practice;
- Ensure the system is designed, commissioned and operated within the flow and return temperature conditions specified in the connection offer;
- Ensure the difference between flow and return temperatures (Delta T) in the secondary distribution system is maximised;
- Size and specify secondary plant items (such as heat exchangers, pumps, emitters, hot water systems and valves) to operate effectively from maximum load to low load conditions;
- Use flow regulating TRVs or return temperature limiting valves to ensure ease of commissioning and balancing to limit maximum return temperatures;
- Avoid bypasses at the end of circuits unless fully controlled for intelligent 'keep warm' functionality;
- Avoid the use of common headers, which will tend to raise return temperatures unnecessarily;
- Avoid use of 3 port valves; always employ two-port control valves for flow and temperature control;
- Operate circuits with the lowest possible flow and return temperatures and incorporate variable temperature or weather compensation where possible;
- Avoid use of stored hot water in internal coil calorifiers as these increase return temperatures;
- Ensure secondary distribution pipework is designed to minimise length of pipes, minimise pipe diameters and select level of insulation based on calculations of the overall heat loss performance.

The key aim of the above design principles is to ensure consistently low return temperatures. Low return temperatures will:

- Increase efficiency and capacity of the heat network with lower pumping energy and heat losses;

- Provide efficiency savings for interim ‘DH ready’ systems, as low return temperatures will improve the efficiency of condensing gas boilers;
- Avoid the need to oversize boilers, pipework and emitters;
- Allow use of other lower temperature heat generation systems such as heat pumps to facilitate the transition to carbon neutral heat networks.

2.1 Design Parameters

Conventional residential and commercial buildings shall be designed to comply with the typical design parameters.

Typical connection parameters are given as follows:

2.1.1 Operating Flow and Temperature Conditions from Point of Supply

- The supplier will ensure a flow temperature at the point of supply (connections to the secondary side equipment) of 65°C;
- The Building Owner must ensure that the return water at the point of return (secondary side) has a maximum temperature of 40°C;
- The Building Owner is required to provide a variable flow rate between the point of supply and point of return such that the maximum flow rate does not exceed the contracted maximum heat demand for the design temperature difference.

2.1.2 Operating Pressures and Pressure Drop Conditions

- The rated pressure of the supply infrastructure will usually be up to 10bar g at the point of supply on the secondary side;
- The Building Owner is responsible for installation and maintenance of all equipment on the secondary side (e.g. heating pumps, hot water systems, water treatment, expansion and pressure relief systems);
- The typical pressure differential through the secondary side of the supplier's equipment will be 60-80kPa.

3 CONNECTING TO A HEAT NETWORK

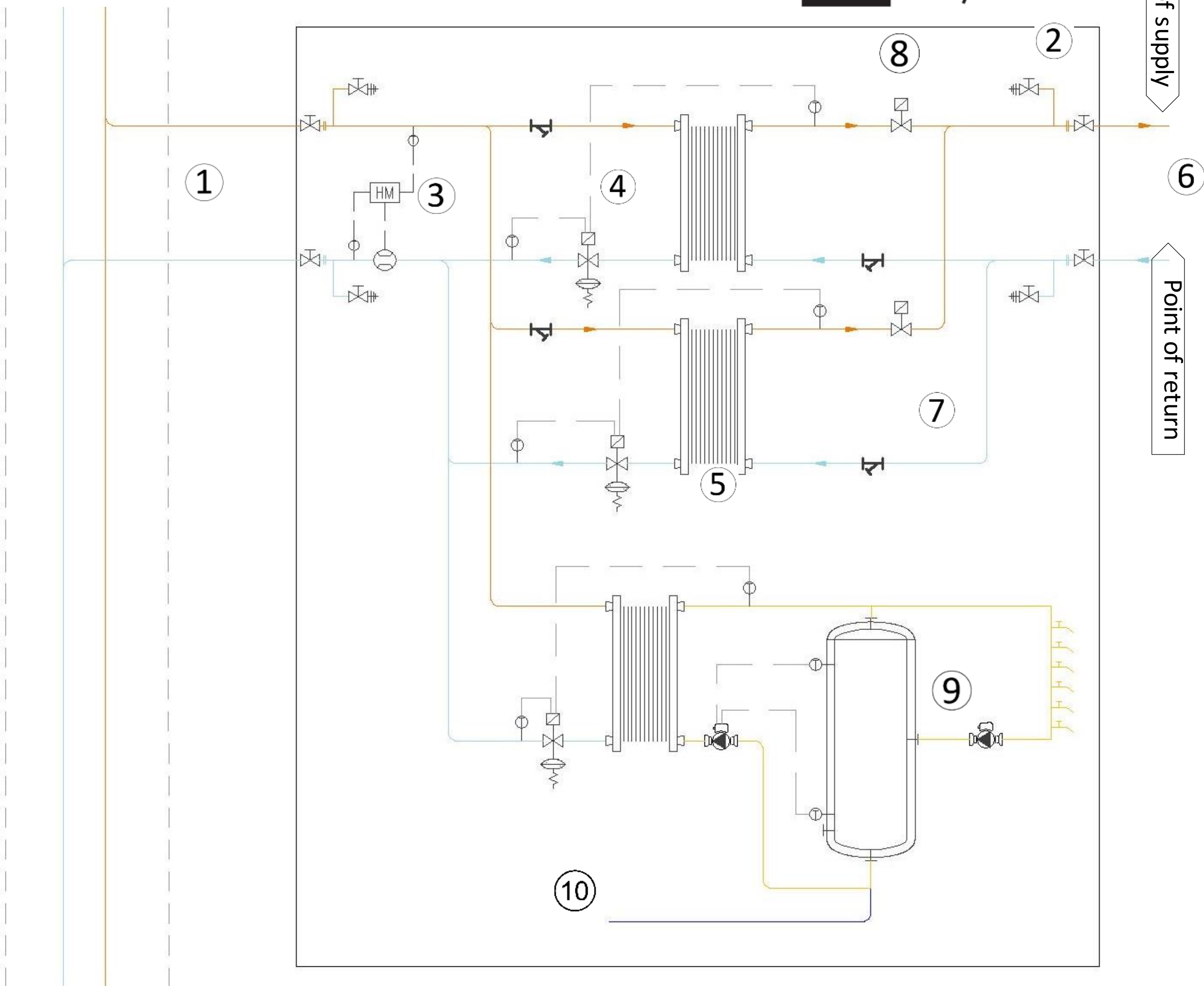
The designer of secondary systems should prioritise the use of low temperature emitter technologies such as underfloor heating, low temperature radiators and low temperature coils or heater batteries within Air handling units.

The district heating system will comprise a substation which is a packaged heat exchanger system that replaces the existing boilers. The substation may be heating only or heating and hot water.

3.1.1 Substation for heat and hot water

The substation or supplier equipment includes heat exchangers, control valves and heat metering that will be maintained by the supplier. The substation can include one or more PHEs (two shown in the schematic below) depending on the size, turn down and redundancy required. Typically, two PHEs in parallel, each installed at 60% of peak load provide a full thermal range, and some redundancy to permit service and maintenance periods. Larger substations may include more than two PHEs. The schematic is for guidance only and final selection of the supplier equipment will be made in agreement with the Building Owner. Only the key functional features are shown in the simplified schematic below.

The delivered package will include: means of flow measurement and test points on both sides for commissioning purposes; filtration to protect the heat exchangers; flushing, filling and draining details; pressure relief, control and instrumentation to allow the supplier control and monitor of the supply of heat.


Point of supply
Point of return
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1. **District heat main** – the heat supply to the substation will be supplied via a district heat main.
2. **Flushing detail** – chemical flushing of all pipework on the secondary side is required before connection of the substation.
3. **Supplier heat meter** – the district heat supplier will meter all heat usage on the primary side of the substation.
4. **Two-port differential pressure control** – provides control of supply flowrate and temperatures across the heat exchanger via two-port control methodology. Control valves can either be a single PICV or a DPCV with a separate two-port control valve.
5. **Plate heat exchanger (PHE**) – the point at which the district heat is transferred to the customer secondary side network. PHEs will be specified with a maximum 3°C approach temperature across the return lines and a maximum 80kPa pressure drop on the secondary side of exchanger.
6. **Heat supply to secondary system** – the point of supply and point of return denote the boundary of the secondary side system and a likely a change in ownership.
7. **Filters** – to protect the plate heat exchangers and valves from fouling.
8. **Secondary control valves –** to allow selection and control of substation
9. **Hot water tank and pump –** to provide efficient delivery of hot water to site
10. **Treated water supply**

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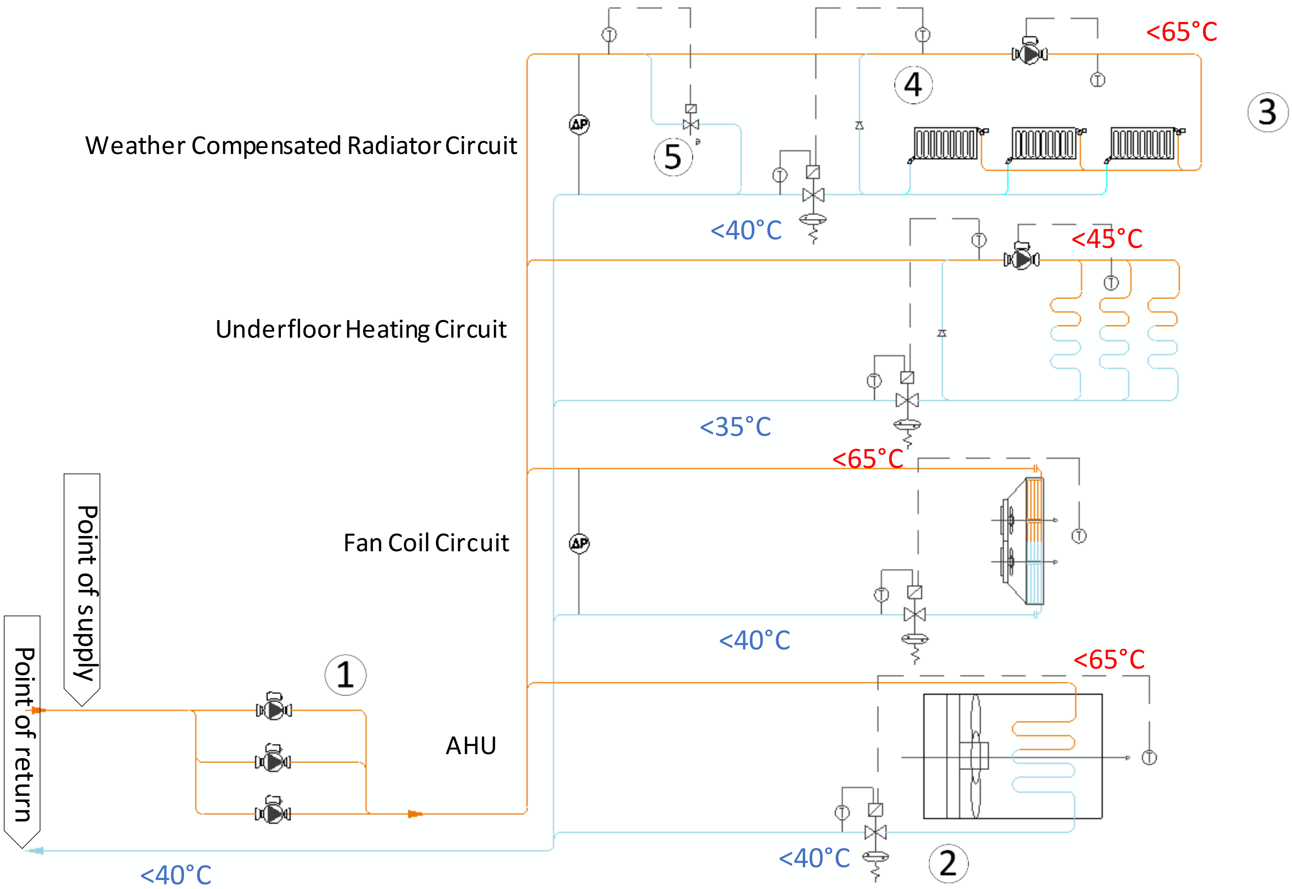
3.2 Access and space requirements

- The developer should provide access to the supplier during the assembly and installation period for delivery, positioning and installation of the equipment. Following completion of the works, the developer should allow the supplier unlimited access to the supplier infrastructure for commissioning, maintenance and operational purposes.
- The developer and supplier shall agree the definition of the site for the purposes of CDM Regulations and define the roles of principal designer and principal contractor accordingly (normally the supplier will act as a subcontractor and follow the site rules of the developer's Principal Contractor for the purposes of the CDM regulations).
- The developer should allow the supplier entry to the plant room. The connecting pipe work will penetrate the plant room; the supplier will provide wall seals to provide a water tight seal with the penetration and the developer must ensure that all other areas of the external plant room walls are water tight.
- Hot works may be required and site permit processes should be followed by the supplier.
- The developer should provide a plant room with a net floor area and access door for delivery, positioning and installation of the supplier heat interface equipment; this will be site specific but some guidance is set out in table below (actual requirements to be determined with the supplier):

Size of Heat Connection	**Net Floor area required**	**Access required**	**Approximate floor loading**
Up to 100kW	3m x 2m x 2.5m high	900mm wide x 2.1m high	500kg
< 250kW	3.5m x 2.5m x 2.5m high	900mm wide x 2.1m high	1000kg
< 500kW	4m x 2.8m x 2.5m high	1200mm wide x 2.1m high	1500kg
< 1000kW	4.5m x 3m x 2.5m high	1200mm wide x 2.1m high	2000kg
1500kW	4.8m x 3.5m 2.5m high	1.6m wide x 2.1m high	2200kg
2000kW	6m x 5m x 2.5m high	1.6m wide x 2.1m high	2500kg

3.3 Space heating

This section covers space heating requirements for commercial applications. Space heating requirements should be met using low temperature emitters. It is critical that emitter design allows individual units to be commissioned accurately to ensure flow rates are regulated through each emitter (see Section 3.3.1). Careful design and specification is required to ensure constant low return temperatures are achieved at all rates of thermal demand. There may be rare occurrences where low heat loads require flow rates that are lower than the minimum pump flow rate and it may be necessary to install a bypass. Any bypass will negatively affect the ability to maintain consistent low return temperatures and therefore must be small bore and controlled to open and bypass the minimum flow needed only when the smallest pump is at minimum flow rate. Priority should be given to selecting pumps that have a greater turndown, or even deadhead protection built in.



1. **Multiple staged variable speed pumps with differential pressure control** – secondary system pumps should be controlled to maintain differential pressure across one or more circuit index runs. Using multiple pumps in a parallel arrangement will allow greater range of modulation while maintaining them at their optimum duty point.

2. **Two-port differential pressure control** – control of supply flowrate and temperatures for each heating circuit will be achieved using a two-port control methodology.
3. **Zoning and balancing flowrates** – heat emitter arrays should be suitably zoned and balanced when applying return temperature limiting control.
4. **Variable temperature/weather compensation** – the secondary flow temperature should be varied as ambient temperature conditions increase or heat loads decrease.
5. **'Keep warm' bypasses** – the use of uncontrolled bypasses and/or low loss headers should be avoided. If there are zones that require a 'keep warm' function, then small bore temperature controlled bypasses can be used to maintain a minimum heating set point around the circuit.

3.3.1 Heat emitter flow and temperature control

It is essential that new build secondary side installations are designed with a maximum return temperature of 40°C and a supply flow temperature maximum of 65°C. In many cases radiators will be best sized for 55°C flow and 30°C return, as this will ensure a margin within the target overall return temperature requirements. For smaller emitters to achieve low return temperatures it may be necessary to design for lower flow temperatures than 55°C so that the smaller temperature difference avoids using very low flow rates through emitters.

Emitter arrangements that can be employed to ensure low return temperatures include:

- Controlling each emitter via flow controlled thermostatic valves often known as dynamic valves;
- Using return temperature limit valves.

Return temperature control valves may be used on individual emitters or groups of emitters (such as zones/banks of perimeter radiators) if they are balanced by equally sized emitters in a reverse return arrangement, or if they include individual flow control.

All room or zone controllers should be electronic with a minimum requirement of time, proportional and integral control. A temperature controller for a zone that has TRVs on individual emitters should be used carefully as an overarching zone temperature control that turns off the flow to multiple radiators before the TRVs have started reducing flow rates to the radiators will reduce effectiveness of the TRV control and cause higher heating peaks.

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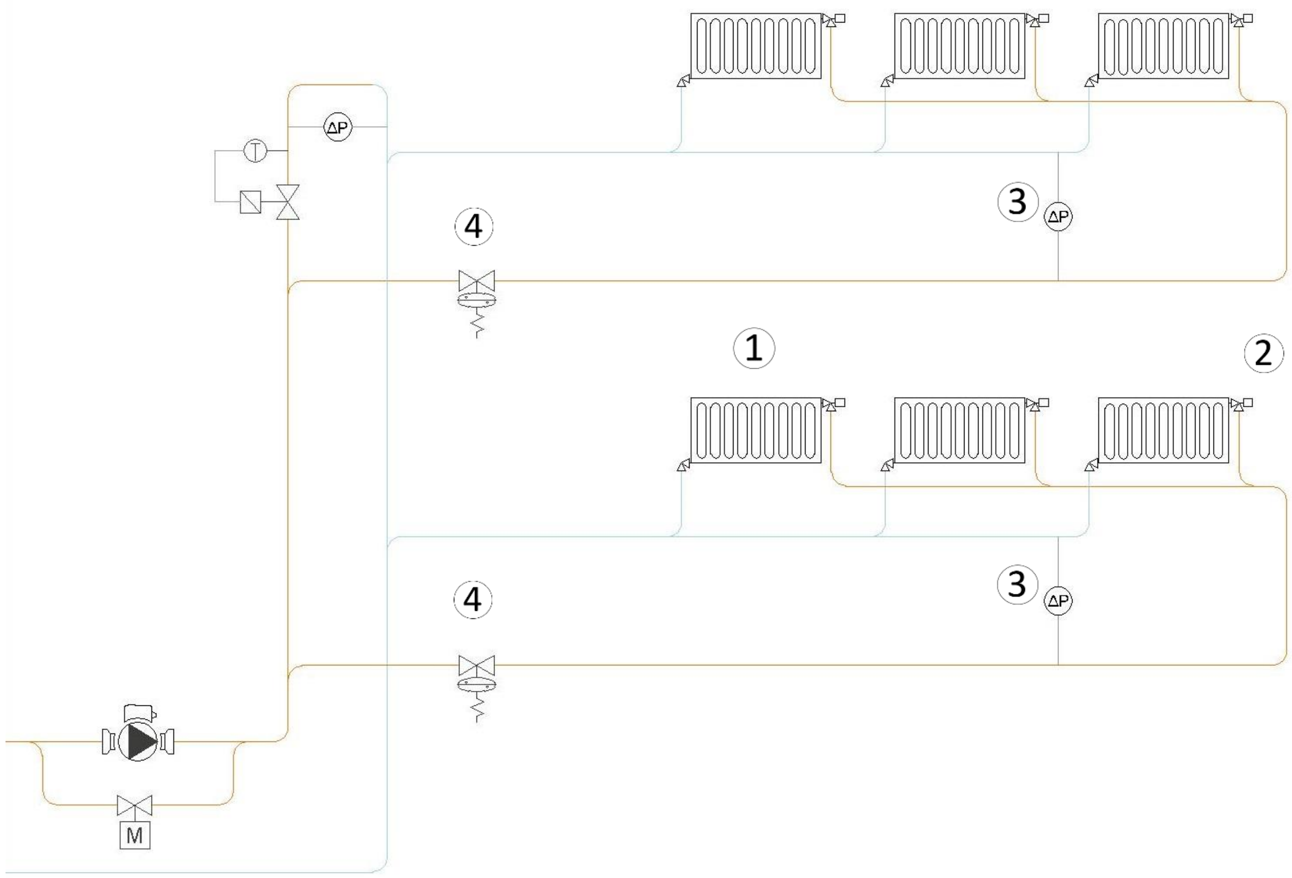
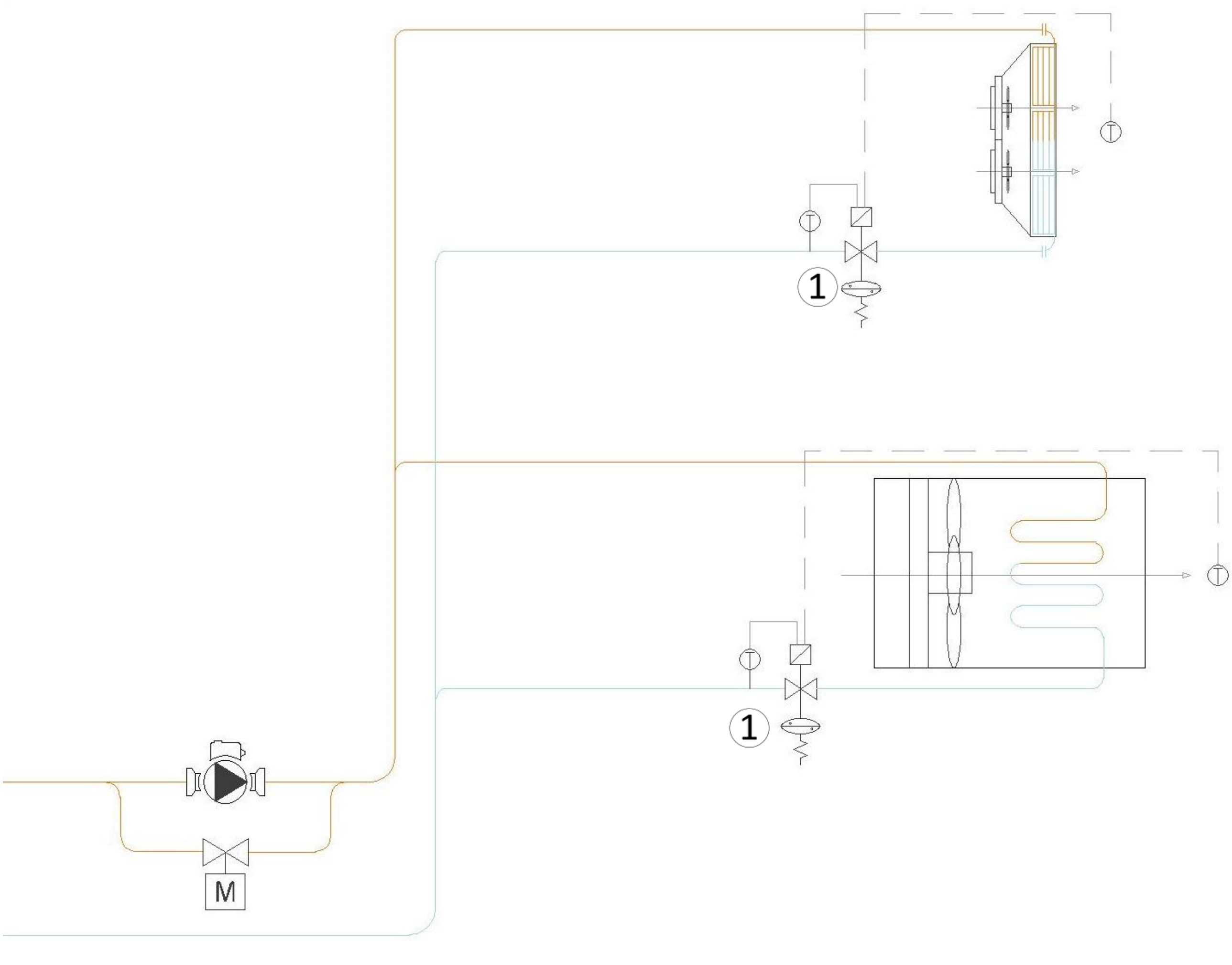


1. **Top entry / bottom exit –** for low return temperatures a top entry and opposite bottom exit connection is preferred.
2. **Local pressure independent flow control TRVs –** the use of localised pressure independent flow control TRVs ensure maximum flowrates across emitters are not exceeded and assist in setting and balancing low maximum flow rates.
3. **Zone differential pressure and flow control –** the installation of DPCV valves on balanced heating zones is an alternative to individual flow control on each emitter when creating pressure independent circuits.
4. **Return temperature limitation –** the use of return temperature limiters should be considered provided they cannot be easily adjusted by the occupant and that appropriate room temperature control is also provided.



1. **Return temperature limitation** – the use of return temperature limiters should be considered provided they cannot be easily adjusted by the occupant and that appropriate room temperature control is also provided.

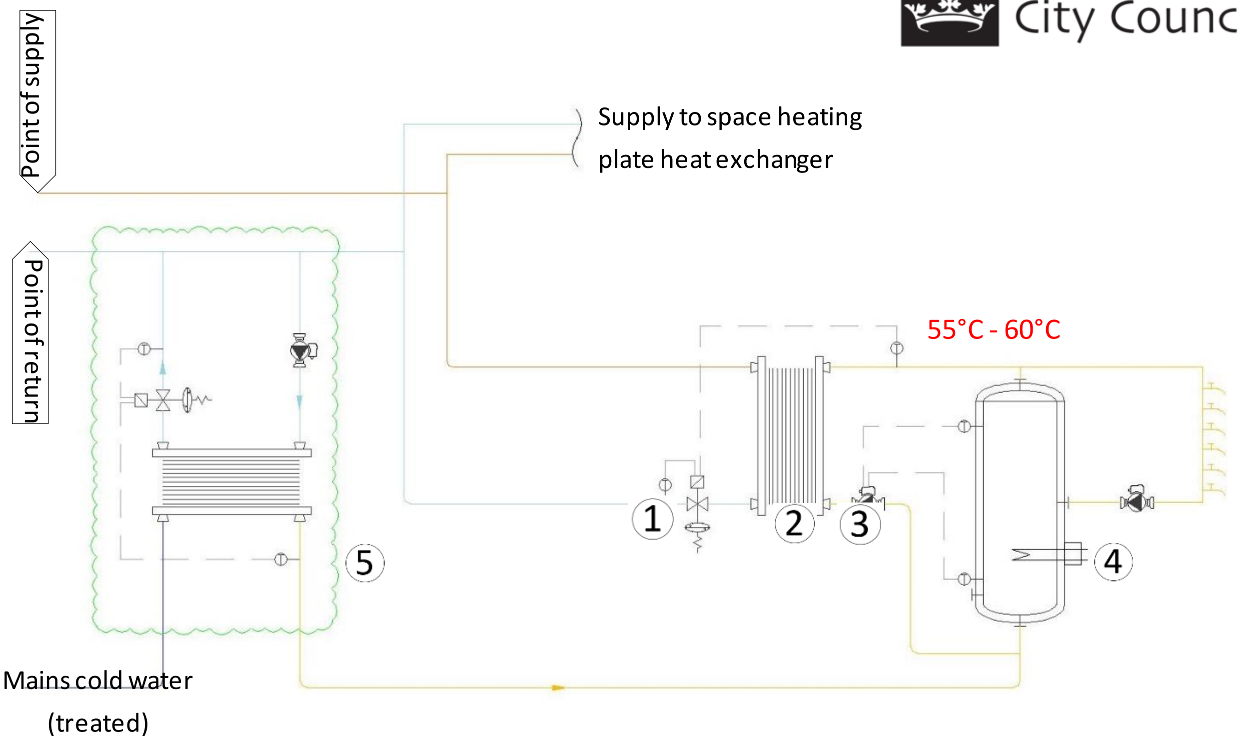
3.4 Hot water systems

Centralised hot water supply for commercial applications should employ instantaneous or semi-instantaneous DHW systems to minimise return temperatures. Calorifiers with internal heating coils should not be used. Oversizing of PHEs is to be avoided to prevent laminar flow through plates, which can result in fouling and reduced performance. Where a pumped return is required to overcome lag in long distribution pipes, a speed controlled pump should be used to minimise circulation rates during low demand. An instantaneous hot water system will eliminate the requirement for standing water, save space and reduce heat losses.

The use of a mains cold water pre-heat plate heat exchanger to recover heat from the heating system return line (also known as 'two stage') is detailed in Section **Error! Reference source not found.**.

Domestic Hot Water operating temperatures should be selected carefully to avoid scaling of the plate heat exchanger. As a guide scale deposits double for every 5°C increase in temperature. The Building Owner shall provide suitable water treatment of the mains incoming water.

The use of uncontrolled bypasses, three port valves or low loss headers should be avoided. If there are long pipe runs before an instantaneous PHE supplies hot water to a non-pumped return hot water circuit then a 'keep warm' function can be incorporated. Fixed bypasses should be avoided.



1. **Two-port differential pressure control** – control of supply flowrate and temperatures for each hot water PHE should use two-port variable volume control.

2. **PHE** – the PHE is to be specified with materials suitable for potable domestic hot water with a maximum secondary return temperature of 25°C when mains cold water is 10°C.

3. **Tank charging pump** – the tank charging pump is controlled in relation to the tank temperature sensors and the status and temperature conditions of the control valve to ensure efficient charging of the tank whilst maintaining low return temperatures.

4. **Electric immersion heater** – to be used for pasteurisation cycles.

5. **Mains cold water preheat** – best practice approach includes a plate heat exchanger to preheat the mains cold water with the DH network return.

4 SECONDARY PIPEWORK AND INSULATION LEVELS

Secondary pipework from the DH substation will require careful and thorough design and installation to minimise heat losses. Calculations for the insulation thicknesses should be carried out with detailed consideration of the diameter and length of the pipework and number of fittings, with the aim of secondary pipework having overall heat losses of less than 10% of heat demand.

Pipe diameters can be minimised by allowing intermittent maximum velocities to exceed conventional limits (many of which are empirical and assume a constant flow rate). Minimising the length of pipework, particularly small bore lateral pipework, will reduce the surface area and associated heat losses. These issues should be concluded before calculating the required insulation materials and thicknesses. Further advice on minimising lengths of risers and laterals design is included in the *HNCoP*.

Traditional sizing and considerations for pipe insulation (such as those described in *BS5422* and the *National Building Specification ECA Y50* enhanced levels) are suitable for heating systems that are only operated for short heating seasons, whereas a DH scheme that is operated for 365 days typically calls for higher levels of insulation. **Therefore**, ***BS 5422*** **and** ***National Building Specification ECA Y50*** **enhanced levels should not be used without full consideration and calculation of overall heat loss performance.**

An example of insulation thicknesses that were calculated for a system design where losses were maintained below 10% is shown below. The table below should not to be used for sizing, but is provided as an illustration of the levels required to achieve best practice (conditions: 60°C pipe work/ambient temperature of 15°C foil faced material).

Pipe Size NB (mm)	Thickness of Insulation (mm)			
	BS5422 level Mineral Wool	**Calculated level Mineral Wool**	**ECA Y50 level Phenolic Foam**	**Calculated level Phenolic Foam**
20	30	50	15	25
25	35	50	20	25
32	35	60	20	30

40	35	60	20	30
50	40	60	20	30
65	40	60	25	35

The design solution should incorporate small diameter risers with short laterals, as this will mean the insulation levels have less impact on the overall losses. As previously stated, the overall design is critical and losses are not solely influenced by insulation.

In some cases, heat loss calculations will indicate required insulation thicknesses need to be greater than is conventional; in these cases pipework and equipment spacing within the risers and laterals should include additional separation. This will not result in increased space requirements for risers and laterals, as the designer will be working with greater temperature differentials and an aim to reduce losses, and therefore smaller diameter pipework will be specified.

- Cladding with ID bands and directional arrows should be fitted to all internal insulated pipework and pipe supports should be installed over rigid insulation inserts to avoid thermal bridging. All valves should be provided with valve covers secured with Velcro or drawstrings suitable for easy removal and replacement.

5 DEFINITIONS

AHU – acronym for an 'air handling unit', a device used to regulate and circulate air as part of a heating, ventilating, and air-conditioning system.

Building Owner –owner of an existing building considering connecting to the heat network.

Delta T - the difference between flow and return temperatures

Demarcation point of supply / return – the point of supply and point of return denote the boundary of the secondary side system and a likely a change in ownership of heating equipment.

Developer – owner of the development building and/or land (or owner of an existing building considering connecting to the heat network).

DH – acronym for 'district heat', the provision of heat to a group of buildings, a district or a whole city, usually in the form of piped hot water from one or more centralised heat sources. Also known as a heat network.

DH network – a district heat network, made up of the flow and return pipes that distribute the heat from the energy centre to the customers. The pipes are frequently buried but may be above ground or within buildings. This may also be referred to as simply 'heat networks' or 'district energy networks'.

DH ready – district heat ready. A DH ready building has the infrastructure in place for a new development to connect to the district heat network in line with the requirements in this document.

DHW – acronym for 'domestic hot water' - the potable hot water used in any type of building, for domestic purposes.

Direct connection – direct connection refers to a system **without** a hydraulic break between the water flowing in the district heat main and the water within the property's heating system.

DPCV – acronym for 'differential pressure control valve', a self-acting valve that contains a diaphragm which enables the valve to absorb unwanted head pressure. The DPCV is used to maintain a constant differential pressure between two points in a heating system.

FCU – acronym for 'fan coil unit', a device used to regulate the temperature of an indoor space through means of a heat exchanger and a fan.

HIU – acronym for 'heat interface unit', an integrated solution for delivering and recording the heat consumed by an individual dwelling or building served by a district heating scheme. The HIU consists of a pre-fabricated assembly of components that form the interface between the heat network and the dwelling's heating system. It may include a Plate Heat Exchanger for the production of hot water and a further plate heat exchanger to separate the DH circuit from the building's heating circuit, together with control valves and a heat meter.

HNCoP – acronym for 'Heat Networks: Code of Practice', ADE/CIBSE document CP1 that defines the minimum requirements of a heat network project from feasibility through to operation, as well as best practice approaches.

Indirect connection – indirect connection refers to a system **with** a hydraulic break between the water flowing in the district heat main and the water within the property's heating system.

Instantaneous hot water – a domestic hot water system with no stored hot water. All the hot water in an instantaneous system is generated instantaneously when there is demand. These systems contain a Plate Heat Exchanger.

Keep warm – the function for ensuring that supply pipework and/or domestic hot water plate heat exchanger is kept at a minimum "standby" temperature, to ensure a fast response after a period of no use.

Kv – the factor that specifies the water flow in m^3 through a valve in one hour at a pressure drop across the valve of 1 Bar.

PICV – acronym for 'pressure independent control valve'. A PICV combines a Differential Pressure Control Valve and two-port control valves into a single body.

PHE – acronym for 'plate heat exchanger', a device in which heat is transferred from one fluid stream to another without mixing. It comprises a number of stainless steel plates which are brazed or bolted together.

Primary side – this is the suppliers network circuit which connects the energy centre to the building or site. The primary side connects to the secondary side via the substation.

PWM controlled pump – pulse width modulation control pumps for domestic and small commercial applications, which are able modulate flow rate from peak conditions to a fully closed circuit.

Secondary side – this is the circuit that is after hydraulically separate from the primary heat network circuit, usually in the ownership of the developer (unless supplier adopts or installs equipment for the distribution and supply of heat)

Semi-instantaneous hot water – a domestic hot water system with some stored hot water. The hot water in a semi-instantaneous system is generated via a plate heat exchanger, which is external to the hot water storage.

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Substation – The interface between the district heating network and the developers secondary systems. Similar to a HIU it will contain heat exchangers, heat meters and control valves.

Supplier – the supplier of heat via a district heating scheme.

TRV – acronym for ‘thermostatic radiator valve’, a self-regulating valve fitted to radiators that adjusts flowrate through the radiator to control room temperature.

Variable speed pumps – a water circulation pump combined with a frequency inverter to allow motor speed to vary and thus vary flow rate and the pump head produced.

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