DISTRICT HEATING SUBSTATIONS

DESIGN AND INSTALLATION

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Preface

These technical regulations for district heating substations (F:101) are sector-wide regulations for the Swedish district heating sector, describing the design, installation, use and maintenance of substations.

If a district heating substation is to operate in the best possible way, the building's space heating and domestic hot water systems must comply with the requirements in these regulations and with those issued by public authorities.

These regulations also describe aspects that must be considered when substations need to be replaced. The use then of correct values for the building energy requirements ensures that the new substation will be properly matched to its duties.

These regulations are intended for use by:

- those responsible for contacts between the district heating supplier and the customer.
- those who own, operate and/or administer a building or facility that is heated by district heating.
- those who design, manufacture, purchase, test or install substations.

It is recommended that enquiries should refer to the Swedish District Heating Association's technical regulations when specifying requirements. The procurement criteria described in these regulations should be applied when evaluating tenders.

These regulations have been drawn up and confirmed by the District Heating Substation Committee. They are valid with effect from November 2004, and replace the previously published guidelines and instructions for substations.

District Heating Substation Technology

Göte Ekström

Contents

1. Basic rules

These technical regulations, F:101, specify and/or refer to sector requirements, public authority requirements, Swedish and European standards and EU directives.

Technical, commercial and administrative aspects of district heating supplies are regulated in contracts and in model forms of general terms and conditions of contract. These technical regulations, F:101 –"Design and installation of district heating substations", are intended for use as an appendix to such contracts and terms and conditions.

These sector requirements complement public authority regulations, and are therefore applicable to new installations, conversions, replacement and operation of district heating substations[1]. The sector-specific requirements are intended to ensure the correctness and quality of the installation, its performance and its safety. Correct design, sizing / capacity determination and balancing of space heating and domestic hot water systems are a prerequisite of complying with the sector requirements for cooling of the circulating district heating water.

Contracts for the supply of district heating include clauses on interruptions to, and restrictions of, the supply, giving the heat supplier rights in respect of setting limitations in connection with the supply of heat. In order to minimise the effects on heat supply of any such actions, it may be necessary to set priorities for the supply of heat to various functions in the building. The control equipment for the substation should therefore be suitable for connection and/or control of such options, and should also permit them to be remotely controlled.

General terms and conditions of contract for the supply of district heat specify that, for both new installations and for conversions, the property-owner shall provide design data and information to the heat supplier on the required connection arrangement. The heat supplier shall confirm that the intended equipment substation is suitable for use with the district heating system. The heat supplier shall decide the required capacity of the heat meter and shall supply it.

Manufacturers of substations must be able to confirm that their equipment complies with the requirements of F:101 and F:103-3. The final numeral in the test program number indicates the current version of the program. Certification is a confirmation of this ability.

If alterations are planned to the flow requirements, power rating or any other aspect that affects the function of the substation, the heat supplier shall be notified before the conversion works starts. Such alterations may result in changes to the supply contract.

In order to avoid the risk of frost damage to the district heating supply pipes, circulation must always be maintained in them during the winter. It is the responsibility of the property-owner to ensure that the substation and pipes within the property are protected against frost.

1.1. Efficient use of heat

The heat supplier will provide information on production of the heat. Heat should be used efficiently, both in the interests of society and in the interests of efficient use in the building. Both objectives must be observed in areas where district heating is

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1 Hereinafter generally referred to simply as 'substations'.

available, and local authorities may issue directives on how heat shall be used in buildings in respect of such aspects as heat recovery.

Heat recovery is not required in buildings connected to district heating systems where more than 50 % of the heat is based on simultaneous electricity production, on waste heat from industry or on heat production from wood, biofuels or refuse.

The use of energy in buildings can be reduced if heat recovered from ventilation exhaust air is used to preheat the incoming fresh supply air.

1.2. The substation equipment room

The room in which the substation is installed is referred to as the district heating equipment room. It must be available for the heat supplier to inspect and read the heat meter.

The amount of space required shall be determined as needed to ensure good working conditions, and to enable the equipment to be serviced. See Swedish Standards SS 911501, SS 911510, SS 911511 for guidance on the relevant requirements. The district heating equipment room must always have a floor drain.

If a substation has replaced a boiler, the contractor shall ensure that a poppet valve is fitted in the opening to the old chimney in order to ensure controlled ventilation up the chimney. It may also be necessary to install a radiator in the district heating equipment room.

1.3. Contacts with the heat supplier

1.3.1. First-time connections

Contact the heat supplier when a decision has been made to request a supply. Discuss the necessary routing of pipes, the proposed type of substation and the position of the equipment room in the building. District heating pipes within the building must be accessible for examination and inspection by the heat supplier. The pipes must be designed and installed in accordance with the heat supplier's technical regulations. See the Swedish District Heating Association's Technical Regulations no. D: 211.

Notify requests for district heating supplies in good time, in order to give the supplier a reasonable time to arrange and install connections to the building. The supplier may, in turn, have local regulations that apply: An example of such regulations is given in Appendix 1.

1.3.2. Modifications and replacements

Contact the heat supplier when it is necessary to replace a complete substation or part thereof. It is seldom optimum to select new equipment on the basis of the specifications for the equipment to be replaced: changes may have been made in the building, which can affect the demands made upon the proposed replacement equipment. The heat supplier will have operational statistics that can provide valuable information on likely heat requirements.

2. Procurement

Refer to F:101 and F:103-3 when sending out enquiry documents for substations and their associated installation work. The enquiry should give details of the operating data of the district heating system, in order to ensure that components and ancillary systems are designed and installed in such a way as to meet both the public authority regulations and the requirements of these regulations. When evaluating received tenders, check that they have observed the requirements specified in the enquiry.

If requirements are specified for a certified substation, it is advisable to ask for a copy of the test report for evaluation and to assess the equipment on the basis thereof. Test reports can be downloaded from the Swedish District Heating Association web site.

The tender for the substation and its installation must:

- be assessed with regard to the supplier's / contractor's experience, references and technical knowledge,
- be assessed with regard to the supplier's / contractor's resources and organisation,
- be assessed in respect of the quoted prices and weighted life cycle cost, and
- be assessed in respect of its environmental impact.

In addition, the substation and installation must, of course:

- comply with technical and quality requirements as given in F:101 and F:103-3.

It is therefore not only the price of the product or contract that decide the choice of a suitable product. It is also necessary to consider the extra cost of any necessary additional work for the owner's own organisation.

The section entitled 'Procurement of meters' in Technical Specification F:104 for heat meters gives a more detailed description of the entire procurement process, and can be used as a guide for the procurement of substations and their associated systems.

3. Technical data of district heating systems

Traditional high-temperature systems (HT) operate at higher temperatures and pressures than low-temperature systems (LT). Substations that are connected through heat exchangers to HT or LT systems as secondary systems are referred to as secondary-temperature (ST) systems. Table 1 shows rating and design data for the three types of systems.

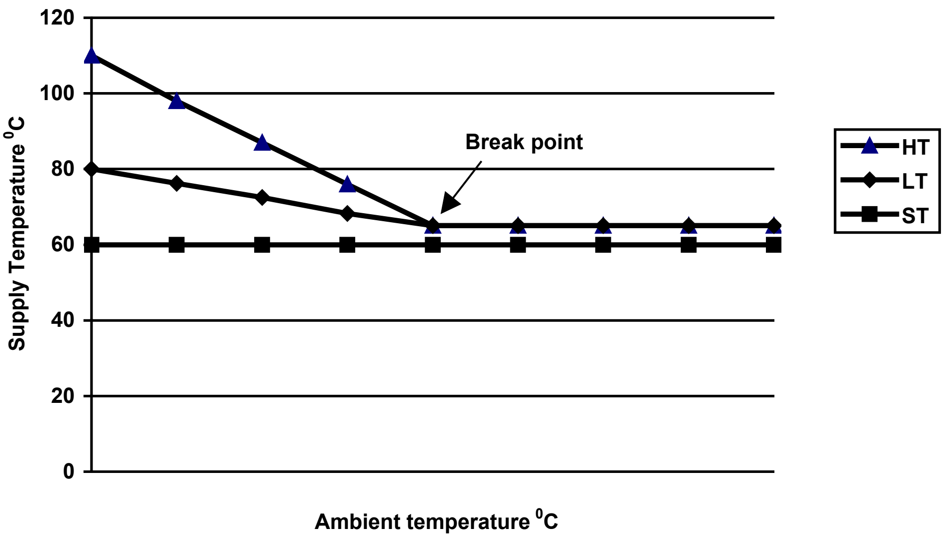
A district heating system must provide good cooling of the return district heating water. This cooling depends on how well the building's heating system and the substation work. If necessary, the heat supplier may install (for example) thermostatically controlled valves in the distribution pipes, so that the supply temperature does not drop below the value shown in Figure 1. This equipment will need to operate only during periods when there is no demand for heat. The quality of the circulating water that carries the heat can affect performance, and so water treatment and control and monitoring of make-up water for the system are important.

3.1. Operating temperatures

The temperature curves in the diagram below show the supply temperatures to substations. It is important that the heat supplier clearly specifies which operating temperature characteristic is employed.

In order to ensure that substations receive a supply at not less than 65 °C at low load, the output temperature of the water from the production plants is about 10 °C higher than this. See Appendix 1, Local Regulations.

Figure 1



Depending on local conditions, the break point can vary over the range -5 °C to +5 °C.

3.2. Rating and design data

Table 1

District heating system	Rating data	Design data
High-temperature system (HT system)	100 °C, 1,6 MPa differential pressure 0,6 – 0,15 MPa	120 °C, 1,6 MPa
Low-temperature system (LT system)	80 °C, 0,6 MPa differential pressure 0,2 – 0,05 MPa	80 °C, 0,6 MPa
Secondary-temperature system (ST)*	< 60 °C, 0,6 MPa differential pressure 0,2 – 0,05 MPa	80 °C, 0,6 MPa

For substations connected via secondary connection.

3.3. Classification of district heating systems

Swedish district heating systems are generally designed as high-temperature systems with design data of 120 °C and 1,6 MPa. Individual components may have more advanced design data.

District heating systems are classified by an accredited inspection body in accordance with the Swedish Work Environment Authority's Pressure Vessel Regulations. The maximum operating temperature and pressure limits are defined by the classification of the district heating system, and these values must not be exceeded during normal operation. Differing inspection requirements apply, depending on the temperature limit that has been determined.

3.4. The importance of return temperature in district heating systems

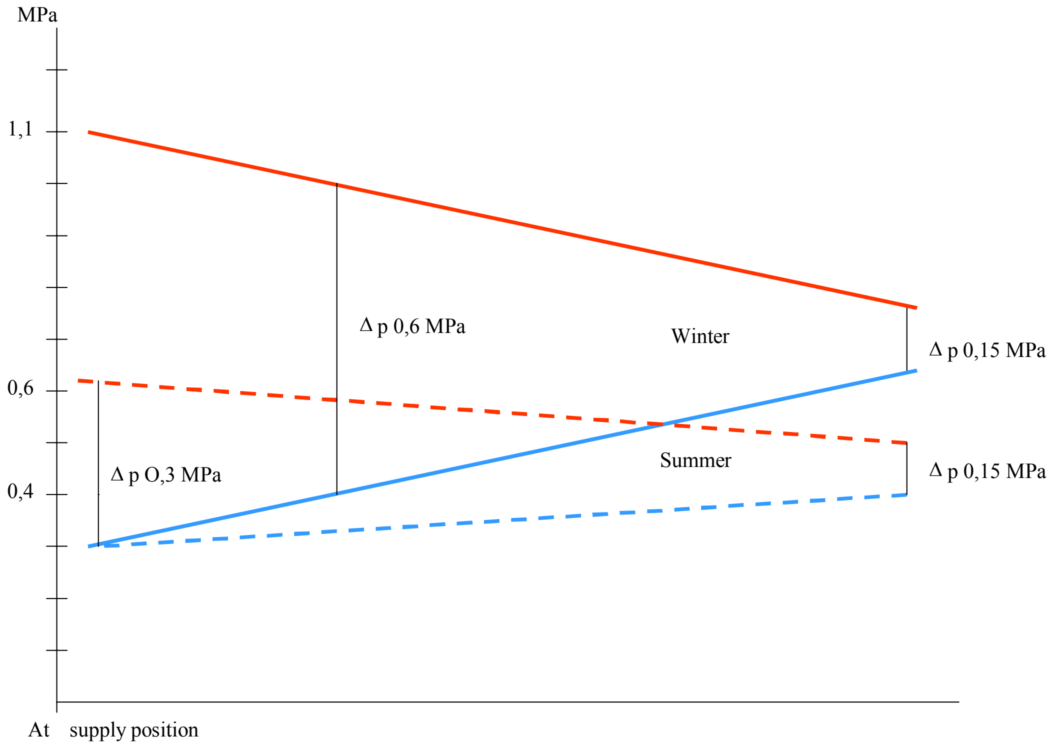
The amount of heat abstracted from the circulating district heating system water depends mainly on the design and adjustment of the building's internal heating systems, and also on the performance and condition of the substation. Good cooling of the return water (i.e. the more heat abstracted) and good performance of the substation are in the interests of both the customer and the heat supplier.

3.5. Differential pressure

The district heating supplier will provide information on the actual minimum and maximum differential pressures, as measured at the service connection isolating valves. This data must be used for determining the necessary sizes and capacities of control valves and heat exchangers. Note that the heat supplier must include the pressure drop across the heat meter in the information provided.

The following diagram shows the ranges over which the differential pressure in a district heating system can vary.

Figure 2.



Substations for HT systems normally operate with a differential pressure in the range 0,15 to 0,8 MPa: the commonest range is 0,15 – 0,6 MPa. See the diagram above. The heat supplier can provide further information on differential pressure.

3.6. Water quality

The Thermal Engineering Research Association has produced a guide entitled 'A handbook of water chemistry for energy plants', publication no. 729, June 2001 edition, which provides further information on water treatment and water quality.

Water quality monitoring and treatment is carried out at the production plants, where the systems are also topped up as necessary.

3.6.1. Classification of various water systems

Table 2

Classification of liquids in the various pipe systems of a district heating substation	
Category 1	Cold water
Category 2	Domestic hot water, water for hygiene purposes
Category 3	Radiator and ventilation heating system water District heating system water

The requirements of the various categories in respect of water qualities are set out in Swedish Standard SS-EN 1717. The standard specifies that water systems must be classified on the basis of their normal use.

SS-EN 1717 (table B1) does not cover the district heating water. However, it does say that the water in heating systems is regarded as Category 3 water, and Item 5.2.3 in the standard, 'Liquids that present some health risk through the presence of several hazardous substances', specifies the requirements for Category 3 water.

District heating water quality is regularly analysed by the heat supplier.

3.6.2. Recommended limit values for district heating water quality

Table 3

	Units	Recommended value
Alkalinity at 25 °C	[pH]	9,5 – 10
Oxygen content	[mg/kg water]	< 0,02
Conductivity at 25 °C	[mS/m]	> 35
Hardness	[°dH]	< 0,1*
Iron content	[mg/kg water]	< 0,1
Chloride content	[mg/kg water]	< 50
Copper content	[mg/kg water]	< 0,02
Fluoride content	[ppm]	0 – 1

*) If there is a heat exchanger between the boiler circuit in the production plant and the distribution mains, a value < 1.0 can be accepted.

Check valves must be fitted in order to prevent reverse flows between the various water systems. The equipment owner is required to ensure that the valves are working correctly.

The standard specifies that substations must be fitted with type EB reverse flow protection devices. However, type EA devices may be fitted, which simplifies checking for correct operation. Chapter 6 (below) gives further details of the requirements applicable to check valves in substations.

4. Design and performance requirements

The substation forms part of the district heating system, and must meet requirements in respect of long-term durability and safety. This means that, regardless of size, substations must be manufactured in accordance with the requirements set out in Tables 2 and 3 in Section 4.2 (CE-marking).

Pipes, valves and fittings in the substation primary circuit must comply with the requirements for pressurised equipment in the Pressure Equipment Directive: see Annex 1 of the directive. Design validation may be performed by the experimental method of five times the design pressure, or by some alternative calculation-based method. See Table 1 for details of district heating system design pressures.

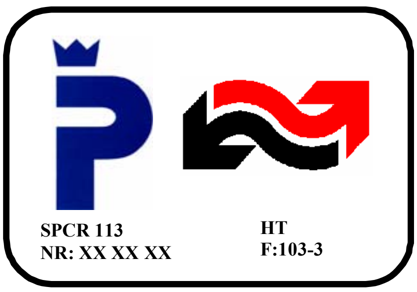
The Act (1999:847) Concerning Building Services Systems makes the owner of the installation responsible for ensuring compliance with the requirements of 2§ of the Act.

4.1. Certification

A certified substation must comply with both the customer's and the heat supplier's requirements. A prerequisite for certification is that the substation must be suited to the district heating system, and must provide the customer with good comfort and reliable operation.

The Swedish District Heating Association has therefore published regulations (F:103-3) for the certification of substations. Substations that fulfil the requirements of F:101 and F:103-3 may be certified, and clearly display the following certification symbol. The certification document is accompanied by a copy of the test report, which sets out the characteristics and features of the substation.

Figure 3.



Example of a certification symbol

The symbol confirms that the substation has been certified by SP Swedish National Testing and Research Institute in accordance with SP's certification rules no. SPCR 113. The accompanying certification certificate gives details of the manufacturer, the type of unit, the test method and the validity of the certificate.

Information on certified substations is available through the Swedish District Heating Association's web site. This shows the validity period of each certificate, test report details and results and any observations noted during the tests. Each test report has an appendix that lists all the components in/on/of the substation tested.

4.2. CE marking

According to the Pressure Equipment Directive (PED), 97/23/EC, prefabricated substations must be CE-marked if they are not covered by Article 3 of the directive. Article 3 is equivalent to 8§ in the Swedish Work Environment Authority's Regulations no. AFS 1999:4. A CE-marked substation must therefore have a declaration of compliance, a copy of which must be delivered by the manufacturer to the heat supplier and to the user of the substation.

Table 4 shows the applicable inspection requirements with which the manufacturer must comply.

Table 4

Heat exchanger		PED / AFS 1999:4				Swedish DHA requirements		
Prim. vol.[l]	Power [kW]	P * V	Category	Module	CE-marked	Cat-egory	Module	CE-marked
< 3.125	< 100	< 50	Art. 3./.8§	Normal practice	No	8§	A1	No
> 3.125	> 100	> 50	I	A	Yes	I	A1	Yes
> 12.5	> 400	> 200	II	A1,D1,E1	Yes	II	*	Yes
> 62.5	> 2000	> 1000	III	B1+D B1+F B+E B+C1 H	Yes	III	*	Yes
> 187.5	> 6000	> 3000	IV	B+D B+F B+E B+C1 H	Yes	IV	*	Yes

* The manufacturer must indicate against which module the unit has been assessed.

The volume and power columns in Table 4 show the requirements for different sizes of heat exchangers.

The columns under the AFS 1999:4 heading are from the Pressure Equipment Directive, and show the procedures required for conformity assessment.

The right-hand columns show the Swedish district heating industry requirements. They are the same as the requirements in the Directive, with the exception that 8§ heat exchangers must meet the same requirements as Category 1 heat exchangers. This means that units intended for use in detached houses must have a certificate of declaration of compliance. However, under the terms of the Pressure Equipment Directive, they must not be CE-marked. In this respect, the sector requirements are more demanding than those of the Directive, because the unit is intended for use as part of a larger system.

The manufacturer must also show that components, methods of making joints and pipes on the primary side are suitable for use with the static and dynamic loads encountered in the district heating system. Certification in accordance with F:103-3 requires the manufacturer to show that the necessary inspections and tests have been performed.

The Pressure Equipment Directive requires the substation to be CE-marked if it belongs to Categories I, II, III or IV. The values in the table apply for HT systems and are based on heat exchanger design data of pressure = 1,6 MPa, temperature = 120 °C and fluid group 2.

4.3. Risk assessment

The manufacturer's declaration of conformity must show that the substation complies with the technical requirements in F:101.

The plant owner must assess risks affecting care, operation and maintenance of the plant. The Swedish District Heating Association has published a report, no. 2004:2, 'Safety in district heating installations', which is intended to assist this assessment. Design and construction of substations

5. Design of substations

5.1. Substations and building design aspects - general

Substations are designed and built for various purposes. They can be grouped into three categories: for detached houses, for apartment buildings and for other buildings and installations.

Substations are manufactured and supplied as prefabricated units, although some can also be assembled at site. Each is a complete unit, containing heat exchangers, control equipment and safety equipment. It must be possible to perform service and maintenance work safely.

Safety and performance of substations are regulated by public authority requirements, directives and sector requirements.

The Swedish District Heating Association has produced a computer program, 'District Heating Substation Inspection', for determining the required sizes of substations. The program can be downloaded from the Association's web site.

The safety equipment of the primary side of substations in buildings and heated by district heating is installed in the heat supplier's production plant.

The building's or plant's own heating system expansion vessel is intended only to provide a means of accommodating thermal expansion of the water. Its arrangement is simpler than it would be for a building having its own boiler.

It must be possible to connect supervisory and metering equipment to the substation equipment. The communication protocol must be independent of the make of the substation, freely available and of open type. Use should be made of information from sensors on the control equipment and the heat meter in order to optimise system and operational supervision.

5.2. Detached house units

Substations for detached houses are those that have achieved the greatest degree of standardisation, and are supplied as complete, ready-to-install units. They must be certified in accordance with the Swedish District Heating Association's regulations for certification of substations, F:103-3

5.3. Apartment building units

Substations for use in apartment buildings are often similar, which means that they too can be standardised. They supply heat to radiator and domestic hot water systems, and it is only capacity that distinguishes them from each other. Units of this type will also be required to be certified. They are ready-built in the factory, and are supplied as complete units ready for connection to the building's space heating and domestic hot water systems. Manufacturers have already achieved a considerable degree of standardisation.

Standardised modules for various power ranges are described elsewhere in this chapter. The use of modules simplifies the choice of substations. It also enables the manufacturers to produce the best alternative for any given application, and can improve the efficiency of manufacture. The module system also simplifies stock systems for manufacturers, reduces delivery times and simplifies handling.

The performance and function of modules are confirmed by certification.

5.4. Other installations

Other substations are less standardised and more customised to suit their particular applications. This usually requires more detailed information in order to be able to determine the necessary functions and power ratings. The Association's report no. 2004:3, 'Connection principles', describes different ways in which substations may be connected.

5.5. Heat exchanger performance

Manufacturers of heat exchanger must show the heat exchanger performance data. If requested, they must supply a copy of the test report for each type of heat exchanger. Heat exchangers must be tested in accordance with SS-EN 1148, as modified to suit the temperature levels in Swedish district heating systems. See Document F:109, 'Testing Heat Exchangers and Water Heaters' for details of the tests.

Tables 5 and 8 show the temperatures for clean heat exchangers. If the temperature difference between the primary and secondary side return temperatures of the heat exchangers shown in Table 8 increases from +3 °C to +5 °C, the heat exchangers are no longer efficient.

Heat exchangers for domestic hot water are particularly sensitive to clogging if there is lime in the water. Faults in other equipment, such as a leaking control valve or poor regulation, can cause the heat exchanger to overheat and thus build up lime deposits.

5.6. Domestic hot water system

The National Board of Housing, Building and Planning's Building Regulations require a substation to be able to supply domestic hot water at a temperature of at least 50 °C at the taps. In order to ensure compliance with this requirement, it is recommended that, if the water is supplied on demand from a heat exchanger, the temperature of domestic hot water from the substation is not less than 55 °C. Some installations use a hot water storage tank, and in such cases the domestic hot water temperature must be not less than 60 °C. OK

Rate the domestic hot water heat exchanger as needed to meet the appropriate requirements with a minimum water supply temperature as shown in Figure 1. The control equipment and heat exchanger must be matched to each other to ensure good temperature control. If the system incorporates a circulation connection, the temperature in the connection must not be less than 50 °C. See Item 5.6.7, below.

5.6.1. Design temperatures for domestic hot water heat exchangers

Rate the heat exchanger in accordance with the temperatures shown in the following table. These temperatures are for heat exchangers with clean heat transfer surfaces.

Table 5

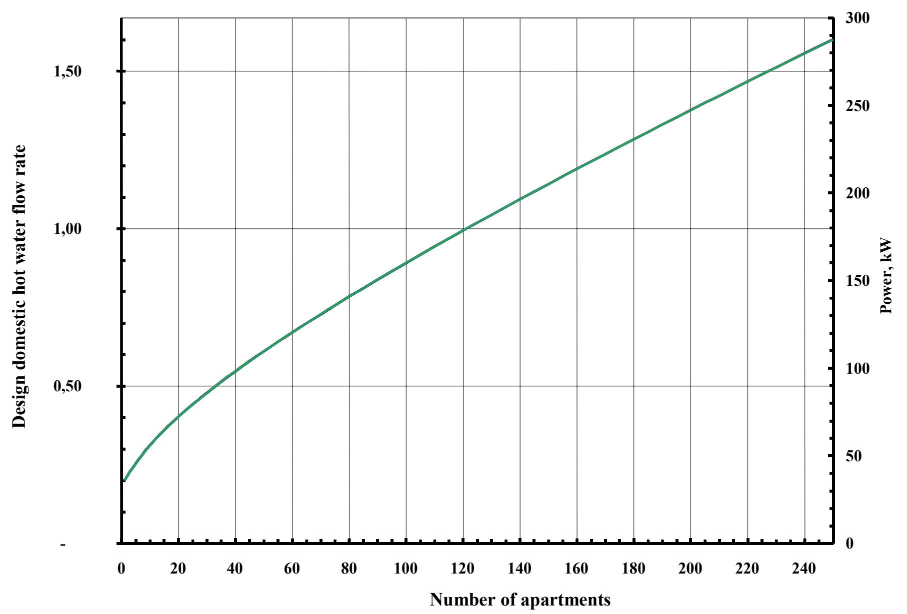
	District heating water temp., supply	District heating water temp., return	Cold water	Domestic hot water	Temp. at taps
Apartment building/ commercial premises	65 °C *	<22 °C	10 °C	55 °C	50 °C
Detached houses/individual apartment units	65 °C *	<25 °C	10 °C	50 °C	50 °C
If supplying storage heaters	65 °C	<25 °C	10 °C	60 °C	50 °C

* 60 °C for ST systems.

5.6.2. Domestic hot water heat exchangers for apartment buildings: powers and flow rates

Determine the required capacities of heat exchangers for apartment buildings on the basis of the following domestic hot water flows. The diagram is valid for apartment buildings with a normal residential mix.

Figure 4



Capacity-determining domestic hot water requirements per apartment

Table 6

No. of apartments	Domestic hot water, l/s	No. of apartments	Domestic hot water, l/s	No. of apartments	Domestic hot water, l/s
1	0,2	80	0,78	170	1,24
5	0,25	90	0,84	180	1,28
10	0,31	100	0,89	190	1,33
20	0,4	110	0,94	200	1,38
30	0,48	120	0,99	210	1,42
40	0,55	130	1,04	220	1,47
50	0,61	140	1,09	230	1,51
60	0,67	150	1,14	240	1,56
70	0,73	160	1,19	250	1,6

The flows in the table have been calculated using the following formula, and are valid for apartment buildings. Use the formula for buildings containing more than 250 apartments.

It must also be pointed out that the formula applies only for determining necessary heat exchanger capacity, and not for determining the necessary capacities of the building's distribution pipes.

$$q = q_m + O(n * Q_m - q_m) + A\sqrt{O * q_m}\sqrt{n * Q_{m} - q_m}$$

q = design flow rate [l/s] for n apartments

n = number of apartments

q_m = 0,15 = aggregated flow per apartment

Q_m = 0,2 = total maximum flow per apartment

O = 0,015 = probability of exceeding q_m

A = 2,1 = probability of exceeding q

A may be increased up to 3,1 for specific purposes:

- apartment buildings with a high demand for domestic hot water, such as student apartments or other types of buildings than apartment buildings

Several conditions must occur simultaneously before a shortage situation occurs:

- a district heating system supply temperature lower than 65 °C
- a lower differential pressure than the design pressure
- a temperature drop higher than 5 °C between the substation and the taps
- a domestic hot water flow rate exceeding q l/s in the above formula over a longer period of time
- the domestic hot water circulation pump has stopped, or some other fault has occurred.

In addition to this, the domestic hot water and circulation connections provide a smoothing effect on the domestic hot water temperature.

Regulations for determining the necessary sizes of domestic hot water pipes in buildings are set out in PR-EN 806-3, Specifications for Installations inside Buildings Conveying Water for Human Consumption - Part 3: Pipe Sizing. This means that the building's piping system must not be based on the selections made for the domestic hot water heat exchanger and associated control valve.

5.6.3. Control equipment

Check the settings of the control equipment when the substation is commissioned. The substation must be marked to show what software is installed in it.

The Association's certification testing program, F:103-3, describes how the function tests must be performed. The values of the test settings for certified substations are given in the associated test reports.

The following points must be borne in mind when selecting equipment:

- The district heating system temperature and pressure variations.
- The type of heat exchanger.
- The fact that older equipment at draw-off points (taps) often means that flows will be higher.
- The use of a common domestic hot water heat exchanger for groups of detached houses supplied from a single substation.
- The design and balancing of domestic hot water systems and circulation systems.
- Whether the domestic hot water circulation system also heats towel driers, floor heating circuits or radiators.
- Whether the domestic hot water system has or does not have a circulation connection (detached houses or apartment buildings).
- How frequently the domestic hot water is used.

For best results in systems not having a circulation connection, the equipment should be able to sense both the cold water flow to the heat exchanger and the temperature of the domestic hot water leaving the heat exchanger.

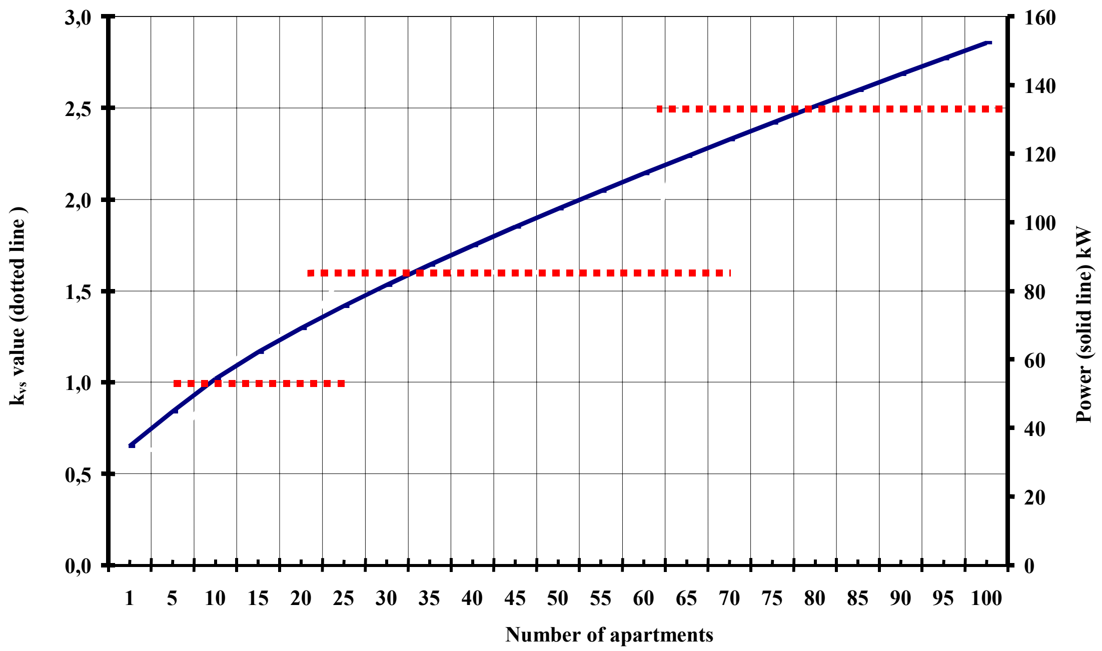
5.6.4. Control valves for domestic hot water

Select control valves so that they properly utilise the available differential pressure, which must be at least 150 kPa across the service connection isolating valves. Select a control valve so that it can provide a pressure drop of at least 100 kPa when fully open, at the design temperature condition of 65 °C, i.e. at the lowest system differential pressure. See Table 1.

Control valves may be regulated either thermo-mechanically or electronically. The most difficult regulation case occurs at the highest supply main temperature and highest differential pressure: the valve must be capable of providing good control under these conditions.

Check the setting values of the various functions when commissioning the substation. For certified substations, suitable setting values are given in the test report, included under the heading 'Component List'.

Figure 5



The diagram shows how control valves with different k_v-values should be matched to heat exchangers. The dotted lines show control valves with k_{vs}-values of 1,0, 1,6 and 2,5. Change to a larger valve where the power curve exceeds the control capacity of a smaller valve.

Such a change will be necessary if the domestic hot water circuit in the building supplies heat loads other than purely domestic hot water, or if the taps can deliver higher flow rates than as specified in current standards.

It may also be necessary to log the draw-off rates that actually occur in operation, and then to re-balance the system or, if necessary, to fit a different control valve. The heat supplier can normally provide assistance in deciding what is required.

The k_v-value in the diagram has been calculated with a differential pressure of 150 kPa and a supply temperature of 65 °C.

5.6.5. Modules for domestic hot water

These technical regulations apply also to the alternative of modular assembly of substations.

Two sizes of modules are considered for domestic hot water to apartment buildings. Table 7 shows the heat exchangers' performances and the control valves that can be fitted in the modules without requiring pipework changes. The modules must meet the performance requirements for both the least and the greatest demands.

By appropriate choice of domestic hot water and radiator circuit modules, substations can be built to suit the needs of different sizes of apartment buildings. As delivered, the modules are fitted with the recommended control valve as shown in the following table. The control valves in Table 7 should all have the same overall body length and connection diameter.

Table 7

Domestic hot water heat exchanger	V 1	V 2
Design temperature	65-22/10-55	65-22/10-55
Heat exchanger power rating kW	80	140
Approx. flows, primary/secondary l/s	0,4 / 0,4	0,7 / 0,7
Max. pressure drop, primary/secondary kPa	< 25 / < 25	< 25 / < 25
Primary control valves k_{vs}*	1,0 - **1,6** - 2,5	1,6 - **2,5**

* The k_{vs} value is the capacity of the fully open valve, with a pressure drop of 0,1 MPa. The valve actuator should be able to vary the valve's kv_s-value.

The temperature of the water leaving the heat exchanger can vary if measured very close to the heat exchanger, but is quickly evened out in the building's piping. The actual temperature performance is shown in the test reports with certified substations. It is suggested that the control valves shown in **bold type** in Table 7 should be used as standard.

It must be possible for modules for apartment buildings to be certified in accordance with the same principles as those for detached houses, in order to provide a guarantee of function and performance.

5.6.6. The domestic hot water system in the building

Both temperature and circulation flow in the domestic hot water system must be controlled in the interests of comfort and of ensuring a correctly operating system to minimise health risks. Note the required parameter values in the operating documents, and check them at intervals in accordance with the instructions. There must not be any cross-connection between the hot and cold water systems in mixer taps, and nor may any equipment that could drop the temperature in the system to below 50 °C be connected to the hot water system. See Item 5.6.7, below.

The building's domestic hot water system consists of pipes from the heat exchanger to the taps, together with circulation connections that return 'unused' domestic hot water to the heat exchanger. This circulation of domestic hot water maintains the temperature of the hot water in the system even when no taps are in use, keeping it at a level appropriate to comfort and environmental requirements.

The domestic hot water system consists of the main distribution pipes, branch pipes and the circulation connections. With the exception of short service connections, which should be left uninsulated in order to avoid the risk of growth of Legionella bacteria, all pipes must be insulated. Adjacent cold water pipes must be protected so that the cold water temperature does not exceed the temperature specified by the National Board of Housing, Building and Planning.

In detached houses, where the distance between heat exchanger and taps is short, a hot water temperature of 50 °C at the heat exchanger is sufficient in order to meet the tap temperature requirement. Circulation connections are not common in detached houses, but can be provided for general convenience.

5.6.7. Environmental requirements in respect of domestic hot water, with particular emphasis on Legionnaires' Disease

Domestic hot water systems must be designed to supply good quality domestic hot water.

Towel driers and floor heating coils connected to domestic hot water systems are risk points. Legionella bacteria can grow in them if they are turned off, and then infect the entire system when they are turned on again. For this reason, towel driers and floor heating coils must OKbe isolated from the domestic hot water system, which must not be used for purposes other than the supply of potable water.

The Swedish District Heating Association's recommendation is that storage of domestic hot water should be avoided. This ensures the best possible hygiene standard for domestic hot water.

A water temperature of 60 °C must be maintained and held in heating tanks and storage tanks for a sufficiently long time to eliminate Legionella bacteria before the water is delivered to taps. The bacteria will not be eliminated by raising the temperature of hot water that has been stored at, say, 40 °C, to 55 °C in a heat exchanger. Such heating occurs very quickly, and does not give sufficient time to kill the bacteria. This is an unsuitable arrangement, and does not meet public health and environment requirements as prescribed in the Building Regulations.

Figure 6

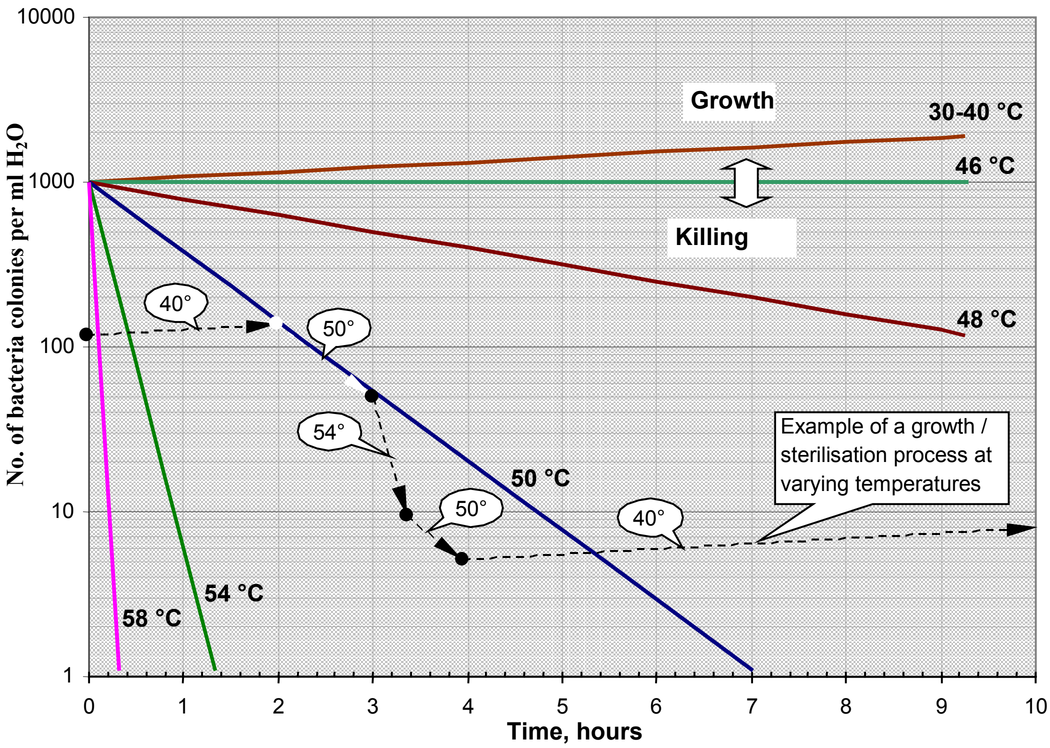


Diagram taken from report no. FoU 2002:75

It can be seen from the above diagram that it is very dangerous temporarily to reduce the temperature in a domestic hot water circulation circuit. Over a ten-hour period, the temperature has been held at 50-54 °C for two hours, and then at 40 °C for the remaining eight hours. These are extreme conditions, and unlikely to be encountered except with a very badly balanced main circulation connection. Nevertheless, despite the unfavourable temperature level, the bacteria have been totally killed. From this perspective, temporary temperature drops to 40-45 °C with very high draw-offs have no practical effect if such draw-offs do not last more than 15-20 minutes and do not occur more than once a day.

The domestic hot water heat exchanger in a substation should be installed in such a way as to permit pressure testing from one side, in order to ensure that there is no leakage from the district heating water to the domestic hot water.

5.6.8. Domestic hot water to fixed shower positions

Fixed shower positions are common in swimming pools, sports facilities and hospitals, supplied with water at 38 °C. The mixing to produce this temperature must occur at the shower positions in order to avoid the growth of Legionella bacteria.

5.6.9. Domestic hot water circulation systems

It is important that the domestic hot water circulation system maintains the prescribed temperature in the distribution pipes and in the circulation pipes. This can be ensured by such means as variable pump capacity, thermostatic valves and balancing valves.

5.7. Space heating system

5.7.1. Determining necessary heat exchanger capacity

Heat exchanger capacity shall be such as to allow the building's heating requirement to be met at the design ambient temperature. In some cases, some operating condition other than the minimum ambient temperature may determine the necessary capacity. Allowance should be made for local climatic conditions that differ from the average conditions in the area. Check calculations should be made at the break-point temperature as shown in Figure 1.

The 'Connection Principles' report, no. 2004:3, describes various ways in which substations may be connected in heating systems.

Select the design and capacity data of the heat exchanger depending on whether the substation is connected to an HT or LT district heating system. If it is connected to an ST system, it is the building's internal requirements that determine the necessary design and capacity ratings.

5.7.2. Capacity determination alternatives for radiator systems

The necessary capacities of radiator systems in buildings already connected to a district heating system can be determined in accordance with Table 8. Other alternatives can be encountered. Note, however, that the primary side return temperature must not be more than 3 °C higher than the secondary side return temperature.

The primary return temperatures are shown in the table below, and apply at the design ambient temperature for the location concerned. When the heat requirement is lower, the district heating system temperatures are also lower, tracking the return temperature in the building heating system.

Table 8

HT-/LT system	District heating system supply temperature	District heating system return temperature	Radiator system supply temperature	Radiator system return temperature
Heating systems in new buildings	100/80 °C	<48 °C <43 °C <33 °C	60 °C 60 °C 70 °C	45 °C 40 °C 30 °C
Ventilation systems in new buildings	100/80 °C	<33 °C	60 °C *)	30 °C
Heating systems in older buildings (1967 Building Regulations. or earlier)	100/80 °C	<63 °C	80 °C	60 °C
After improvements	100/80 °C	<53 °C	70 °C	50 °C

* 55 °C for driers and coil heaters.

The following table shows how various design rating temperatures affect the required radiator surface areas, flow rates etc., relative to a 60/45 reference case.

Table 9

Substat-ion connect-ion principle	Radiator system temper-atur es	Temperature efficiency of the radiator system *	Temper-ature efficiency of the complete substation *	Average annual district heating system temperature	Degree-days percentage **	Radia-tor surface area	Radiator system circulation flow
		%	%	%	%	%	%
Parallel	80/60	79.0	84.1	119.2	107.0	59	84
Parallel	**60/45**	**100.0**	**100.0**	**100.0**	**100.0**	**100**	**100**
Parallel	55/45	100.5	100.4	99.6	99.8	107	165
Parallel	60/40	104.8	103.2	96.1	98.5	115	87
Parallel	70/30	111.7	107.4	91.2	96.6	149	46
2-stage	80/60	78.6	85.5	118.8	106.8	59	84
2-stage	**60/45**	**100.0**	**100.0**	**100.0**	**100.0**	**100**	**100**
2-stage	55/45	100.2	100.2	99.7	99.9	107	165
2-stage	60/40	104.5	102.9	96.5	98.7	115	87
2-stage	70/30	111.3	106.7	92.0	96.8	149	46

***)** The temperature efficiency is a measure of how well the substation cools the return water.

****)** The degree-day percentage is a weighted value for the year of the temperature level in the district heating water passing through the substation. In this case, it reflects only the return temperatures.

Example: An 80/60 °C system has a higher yearly average temperature than a 60/45 °C system has.

When deciding between 60-40 °C or 70-30 °C systems, the factors that particularly need to be considered are the larger necessary radiator surface areas and the lower flow rates, as well as the improved temperature efficiency. Selecting 60-40 °C or 70-30 °C systems improves the efficiency of the district heating system and reduces the return temperatures, but at the price of a somewhat greater radiator surface area.

Regardless of the choice of design temperatures for the radiator circuit, balancing of the system has a decisive effect on operating performance. Over the years, various principles have been applied in order to achieve a good result.

There can be advantages in choosing a low-flow system for the building's heating system. A characteristic of such systems is a relatively high design supply temperature and a low return temperature, which assists the overall performance of the district heating system and reduces costs if charges are based on flow rates.

If a low-flow heating system, providing very low return temperatures, is used, there will not be much further benefit through the use of a two-stage connection in terms of further cooling the return water.

5.7.3. Control valves for space heating systems

Select control valves so that they utilise the available differential pressure, which must be at least 150 kPa across the service connection isolating valves. Select the control valves so that they drop at least 100 kPa across the valve when fully open and under design conditions, i.e. at the lowest differential pressure. See Table 1.

Control valves can be controlled by either electronic and/or thermo-mechanical means. The most difficult control conditions occur at the highest supply main temperature and differential pressure, and it is under these conditions that good control performance is required. It must also be possible to operate the control equipment by hand. A special valve should be used if thermo-mechanical control is used.

Check the setting values of the various functions when commissioning the substation. For certified substations, suitable setting values are given in the test report, included under the heading 'Component List'.

5.7.4. Radiator system modules

A module system can be used for the radiator circuit equipment in the substation in the same way as for the domestic hot water circuit. It, too, may be covered by certification. The following table suggests four modules: the control valves used in modular systems should be easily interchangeable.

Table 10

Radiator heat exchanger	**R 1**	**R 2**	**R 3**	**R 4**
Design temperature	100-63 / 60-80	100-63 / 60-80	100-63 / 60-80	100-63 / 60-80
Heat exchanger rating kW	80	125	230	365
Approx. flows l/s	0,53 / 0,98	0,8 / 1,48	1,46 / 2,71	2,26 / 4,18
Max. pressure drop kPa	< 25 /< 15	< 25 /< 15	< 25 /< 15	< 25 /< 15
Prim. control valve k_{vs} *	1,6	2,5	2,5 - 4	6.3 - 10

* The k_{vs} value is the capacity of the fully open valve, with a pressure drop of 0,1 MPa.
The valve actuator should be able to vary the valve's kv_s-value.

The choice of control valve depends on the actual differential pressure at the installation site. This means that control valves should have the same overall body length and nominal diameter for k_{vs} values from 0,63 – 4,0. This should also apply for larger valves with k_{vs} values in the range 5,0 – 10.0.

6. Substation equipment

6.1. Equipment in the equipment room and in/on the substation

Key: K = must be included
R = inclusion recommended
T = supplied by the heat supplier.

Calculate the required power as the rated power of the radiator / ventilation heat exchanger.
The amount of equipment required can vary from one district heating system to another.

Table 11

	ST system	HT system/LT system	
	<100 kW	<100 kW	>100 kW
The equipment room:			
Lighting	K	K	K
Electricity metering	K	K	K
Meter position	K	K	K
Floor drain	K	K	K
Domestic hot water and cold water taps available	R	K	K
District heating circuit (primary side)			
Service connection isolating valves	T	T	T
Filter	R	K	K
Pressure gauge		R	R
Pressure measurement point			K
Temperature display	R	R	R
Radiator / ventilation heat exchanger	R	K	K
Domestic hot water heat exchanger	K	K	K
Control valve, radiators / ventilation	K	K	K
Control valve, domestic hot water	K	K	K
Metering equipment	R	T	T
Drain valve	R	R	K
Heating circuit (secondary side)			
Circulation pump	K	K	K
Expansion vessel	K	K	K
Temperature display	R	R	R
Pressure gauge	K	K	K
Safety valve	K	K	K
Filling valve	K	K	K
Check valve in filling connection *	K	K	K
Filter	R	R	K
Domestic hot water system			
Safety valve	K	K	K
Circulation pump	R	R	K
Temperature display	K	K	K
Drain valve	R	R	R
Filter, incoming cold water	R	R	R
Check valve, incoming cold water to heat exchanger *	K	K	K
Bypass, shut-off and check valve *		R	R

* Type EB check valve acc. to SS-EN 1717. Type EA is also acceptable.

Complete substations are delivered with all necessary heat exchangers, control valves and control units. They may also be connected to higher-level supervisory and control systems for the building as a whole. In either case, the substation control system must comply with the heat supplier's requirements and meet the heating needs of the building.

The Swedish District Heating Association's certification testing specification F:103-3 describes the function requirements for the domestic hot water and space heating control equipment in more detail.

6.1.1. Pipes, valves and fittings etc.

District heating pipes from the service connection isolating valves and within the substation must comply with the same requirements as for other district heating piping, as set out in the Swedish District Heating Association's Technical Regulations for distribution pipes. The Regulations also specify requirements in respect of materials, methods of jointing, connections, sealing materials and valves and fittings. It must be possible to check, and further tighten if necessary, connections that incorporate gaskets as the seal.

Control valves, actuators and other piping fittings must be suitable for use with the static and dynamic loads that can occur in the primary system. See Chapter 3. Valves must be clearly marked with identification of their type, design and capacity. Noise, such as from cavitation, must be minimised. See requirements in respect of noise levels in the National Board of Housing, Building and Planning's regulations concerning noise protection.

Valves, fittings etc. that may need to be replaced must have flanged joints or connectors fitted with gasket seals.

The quality of seals, gaskets and sealing surfaces etc. in joints must be suitable for use in HT systems. Seals etc. must be centred in relation to the sealing surface by and after tightening the joint. Sealing surfaces must be rated for the system design pressure.

Connections up to and including size G1½ may be of threaded type. All threaded components shall have a marked position to which an opposing force may be applied to prevent the component from turning when the thread is being tightened. This size OK limitation does not apply for threaded connections to heat exchangers.

6.1.2. Service connection isolating valves

The service connection isolating valves are supplied by, and are the property of, the heat supplier, and must be connected to the district heating system by means of welding or brazing. Take care when making any welded or brazed joints in the vicinity of the service valves, in order to prevent damage to the seals in the valves.

Service connection isolating valves must be easily accessible, and clearly marked, so that they can be quickly found in an emergency situation.

Service connection isolating valves having a manual operating lever must be installed in such a position that the valve will not be accidentally opened if a person or object falls against it. Where possible, valves should be opened by moving the lever upwards.

6.1.3. Potential equalisation

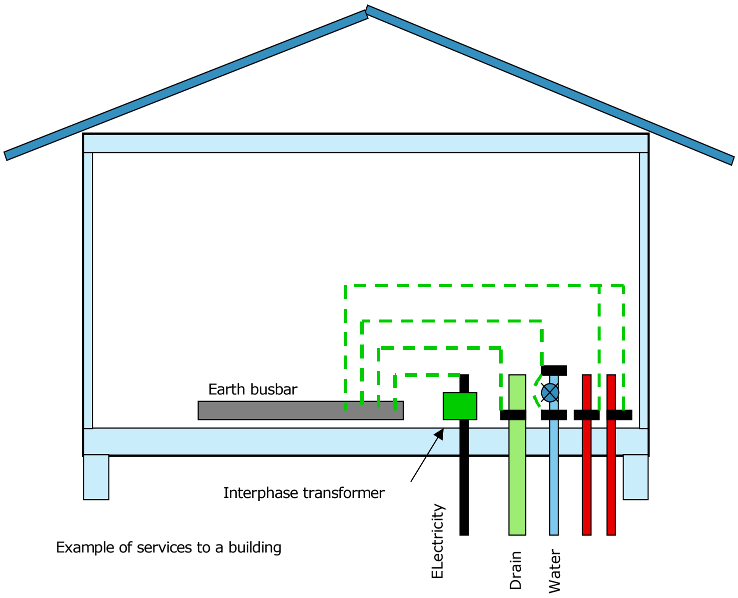
Electric fields and stray currents are an electrical problem, and must be solved using methods as described in the Heavy Current Regulations (FS 1999:5) and the Swedish Electrotechnical Commission's guide no. 413, 'Potential Equalisation in Buildings'. If the building already incorporates potential equalisation bonding, the district heating pipes must be bonded to the system.

Most buildings have three-phase four-wire supplies. The fourth wire serves two purposes: as the neutral conductor and as a protective earth conductor (also known as an earth continuity conductor). This means that everything connected to the earth wire can also carry neutral currents. It is the neutral currents that appear as stray currents, and generate mains-frequency magnetic fields. One way of solving this problem is to provide a fifth conductor, so that the earth continuity conductor and the neutral conductor are separated.

The diagram below shows how the use of an interphase transformer and interconnection bonding, not only of the district heating pipes, but of all other services, avoids stray currents.

Stray currents are caused by the design of the electrical installation, and must be dealt with by an authorised electrician.

Figure 7



6.1.4. Filter

The filter mesh size must be 0.6 mm. It must be possible to clean the filter without having to dismantle or remove it. Connections must be flanged or welded. The maximum permitted size for threaded connection is G1½". The filter must be positioned so that there is no risk of water damaging electronic equipment when the filter is being cleaned.

6.1.5. Pressure sensors

Pressure sensors read the static pressure and the differential pressure in the substation, and must display between zero and the lowest test pressure. They may be either analogue or electronic: if they are of analogue type, the isolating valve in the connection to the sensor must be open only when reading.

Electronic sensors must meet the relevant requirements applicable to the district heating system (see Chapter 3). The signal from the sensors is combined with other measurement equipment, such that the integrator may be the instrument that provides local indication and transfers static pressure in the supply and return connections, as well as transferring the differential pressure signal to the overall control system.

6.1.6. Temperature display

Temperature may be displayed directly by means of thermometers or by means of sensors connected to supervisory equipment. Measurement ranges must cover at least the maximum temperature variation.

Pockets for temperature sensors must not be covered by insulation. It must be possible to see whether a sensor is fitted in a pocket.

6.1.7. Space heating and ventilation heat exchangers

The materials in heat exchangers must withstand the liquids in both sides of the system. Advice must be obtained from the manufacturer before carrying out chemical cleaning

6.1.8. Heating and ventilation control system

The system consists of a control valve, a valve actuator, sensors and a controller. The controller must provide a menu function for selecting the required software. It must be possible manually to control the valve.

Note and record the values after adjusting/setting the control parameters in the regulator. Position sensors as close to the heat exchanger as possible.

6.1.9. Domestic hot water heat exchanger

The material on the district heating side of this heat exchanger must withstand the treated water in the district heating system. On the secondary side, it must withstand oxygenated water. Advice must be obtained from the manufacturer before carrying out chemical cleaning. It must be possible to test the integrity of the heat exchanger after it has been installed.

6.1.10. Domestic hot water control system

The system consists of a control valve, a valve actuator, sensors and a controller, although thermo-mechanical valves may also be used in detached house substations. The equipment must be capable of meeting the temperature performance requirements for domestic hot water as specified by the National Board of Housing, Building and Planning.

It must be possible to check, by means of the menu function in the controller, which control software program is being used.

Note and record the control setting values after adjusting/setting them in the regulator: appropriate settings are noted in the test certificates supplied with certified substations. Position sensors as close to the heat exchanger as possible in order to ensure best performance of the regulator.

6.1.11. Heat meter

The heat meter will be supplied by, and is the property of, the heat supplier. Its design and function must comply with SFS 1994:99, the Ordinance Concerning Electricity, Water and Heat Meters. The heat supplier must be able to connect the metering equipment to a communication system for remote meter reading.

6.1.12. Meter position

The meter position must be arranged as shown in Figure 8. It incorporates a filter and temperature sensor in the supply connection, and a flow sensor and temperature sensor in the return connection. In addition, space for an integrating meter and power supply must be provided. The temperature reading from the integrator is normally used to check district heating water the supply and return temperatures.

The vent connections may be omitted if the system is vented in some other way.

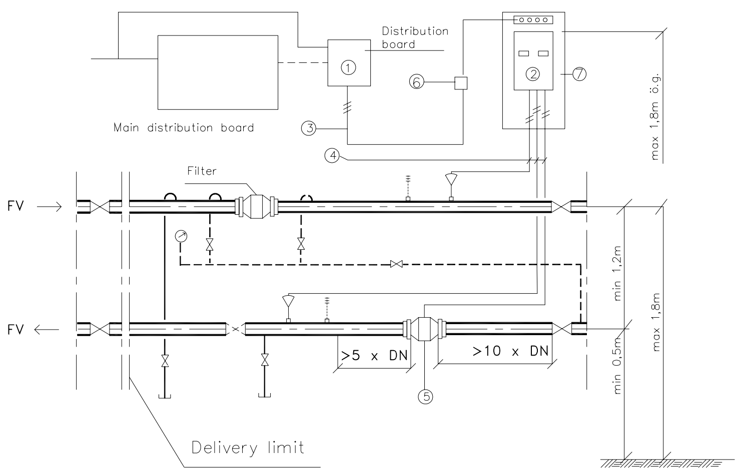
If the meter position is not in the substation equipment room, shut-off valves must be fitted on each side of flow sensors. There must not be any connections or valves in the straight pipe length upstream of flow sensors.

Flow sensors, temperature sensors and integrators must be installed so that they are easy to read and to replace.

Differential pressure measurement can be arranged by fitting a pressure gauge to a prepared measurement point. The valves should be suitable for fitting of pressure gauges for check purposes. Pressure may also be measured by differential pressure sensors, communicating with the existing communication system and fitted in the prepared measured points.

A more detailed description of heat meters is given in the Swedish District Heating Association's Technical Regulations no. F:104.

Figure 8



Schematic diagram of the meter position connections and arrangements

Key:

1 Electrical distribution board, with fuses. Can be sealed with lead seal.
2 Integrator.
3 Supply from distribution board, 1,5 mm²
4 Connections between the parts of the meter, 0,75 mm².
Use 1,5 mm² conductors if the distance exceeds 7,5 m.
See SS-EN 1434, Part 2, page 10 for further details.
5 Flow sensor. DN = sensor connection size.
6 Isolator, with lock-out facility and/or lead seal. Must be fitted if the meter position and the fuse are not in the same room.
7 Meter board.

Figure 8 shows schematic details of required meter positions, maximum distances between components etc. The integrator must be mounted within 2 m cable length from the flow sensor.

Heat meters in detached houses may be battery-powered.

6.1.13. Vent valve

This valve, together with its discharge connection, must be fitted to the highest point of the district heating pipes for manual venting of air in the system. The discharge pipe must be fitted with an end plug.

6.1.14. Drain valve

The drain valve, together with its discharge connection, must be fitted to the lowest point of the pipes. The drain pipe must be fitted with an end plug.

6.2. Equipment for the radiator and ventilation circuit

6.2.1. Circulation pump

The pump must be suitable for use with the pressure class for which the radiator and ventilation system is designed, and must also be capable of generating a suitable head and flow rate. Speed control of the pump is recommended.

6.2.2. Expansion vessel

The expansion vessel in non-directly heated secondary heating systems must be able to accommodate normal volume variations, and must be suitable for use with the pressure class of the radiator and ventilation system. Sealed expansion vessels should be connected to the return pipe to the heat exchanger. Safety equipment for the primary side of the system is installed in the heat supplier's plant.

6.2.3. Temperature display

Temperature may be displayed directly by means of thermometers, or by means of sensors connected to supervisory equipment or to the control unit. Measurement ranges must cover at least the maximum temperature variation. For safety reasons, pockets for temperature sensors having threaded connections must not be covered by insulation.

6.2.4. Pressure gauge

The pressure gauge is intended for manual reading of the pressure in the radiator/ventilation circuits. It must be graduated between zero and not less than the test pressure, and must also be marked to show the pressure at which the system safety valve operates.

6.2.5. Safety valve

The safety valve can most suitably be fitted to the incoming connection to the heat exchanger. No shut-off valves are allowed between the safety valve and the heat exchanger. A safety valve is not required for open expansion systems.

6.2.6. Filling valve and check valve

This valve is used for filling the radiator and ventilation system with hot water to obtain the correct working pressure. The equipment consists of a shut-off valve and type EB check valve in accordance with SS-EN 1717. Filling is performed manually and under supervision. This valve is closed during normal operation of the system.

6.2.7. Filter

The filter mesh size must not exceed 0,6 mm. It must be possible to clean the filter without having to dismantle or remove it.

6.3. Equipment for the domestic hot water circuit

6.3.1. Safety valve and check valve

Fit the safety valve in the cold water connection to the heat exchanger. No shut-off valves are allowed between the safety valve and the heat exchanger. The check valve must be a type EB valve in accordance with SS-EN 1717.

6.3.2. Domestic hot water circulation pump

Pump capacity must be such that good performance is obtained throughout the domestic hot water circulation system.

6.3.3. Emergency connection

The emergency connection is a pipe that is intended, in the event of an emergency or repairs to the system, to keep the domestic hot water system pressurised. The connection is normally closed, and is fitted with a shut-off valve and type EB check valve in accordance with SS-EN 1717.

6.3.4. Temperature display

Temperature may be displayed directly by means of thermometers, or by means of sensors connected to supervisory equipment. The thermometer must have a measurement range covering at least the maximum temperature variation.

6.3.5. Drain valve

This valve must fitted at the lowest point of the pipework, and must be fitted with a plug. This is a safety requirement.

7. Quality assurance

7.1. Installation

7.1.1. Initial design

Contact the heat supplier for information on connection to the district heating system and on choice of suitable substations. The necessary power requirement for the substation should be discussed with the supplier. Obtain energy statistics for the building when converting an existing substation or building. See also Chapter 1, 'Basic rules'.

Certification and CE marking of substations confirm the function, quality and performance of the units as a whole and of the components in them.

CE-marked substations must always be accompanied by a printed declaration of conformity.

Attach a risk analysis, for which the heat supplier can provide information. See Chapter 4.

7.1.2. Selection and installation of piping

The Association's technical regulations for district heating piping must be complied with in connection with the selection and installation of piping materials and supplies.

7.1.3. Selection of components and pipe parts

Components, piping parts and joint/sealing materials must be made of approved materials, and be of at least the pressure rating as required by the system concerned. Piping and components must be capable of withstanding the dynamic pressure variations that can occur in district heating systems. Suitable materials are steel, steel castings and dezincification-resistant brass.

All components must be installed in such a manner that they can be easily serviced and/or replaced.

7.1.4. Selection of heat exchangers

Heat exchangers and water heaters must fulfil the requirements of, and must have been manufactured and tested in accordance with, Swedish Standard SS-EN 1148. Manufacturers must be able to prove this. The Swedish District Heating Association's Technical Regulations no. F:109 describe the test procedure.

Inspection also includes checking to ensure that the performance of the manufactured products is in accordance with the results of the manufacturer's computer design/rating program(s).

7.1.5. Welding and brazing

Welding and brazing on HT systems must comply with the working and inspection requirements in the Swedish District Heating Association's instructions for district heating pipes.

There are no regulatory requirements for welding or brazing of pipes in LT or ST systems, or for welders to have a welding licence. Nevertheless, it is recommended that, in order to assure quality, corresponding requirements are applied in respect of welding and brazing work carried out on such systems.

Equipment installed in the substation or system may include materials that can be damaged by high temperatures, and allowance must be made for this when deciding on the type of welding method to be used.

7.1.6. Inspection and testing at site

On conclusion of the work, its quality must be inspected by leak testing of the system in accordance with the Swedish HVAC AMA codes. If welding work has required the use of licensed welders, sample welded joints must be radiographically tested. The heat supplier can require welded and brazed or OK soldered joints to be inspected.

7.1.7. Inspection and testing

The Swedish Work Environment Authority's regulations specify the inspections that must be performed, and who may perform them. See Item 3.3 above.

The heat supplier will always inspect the substation and the installation to ensure that they fulfil the requirements of F:101. This inspection includes pressure-testing of the primary side of the substation, and of the connections between it and the district heating system. This pressure testing will be carried out using cold water over a period of at least one hour, at a pressure of 1.43 x the design pressure. This water must be drained off before filling the primary side with district heating water.

7.2. Commissioning

7.2.1. System balancing

Balance the space heating and domestic hot water systems, including any circulation system that may be included, in order to ensure a properly operating system. Record the results.

Balancing involves:

- Checking and, if necessary, adjusting the P-band and I-time of the control equipment.

  Appropriate setting values for the domestic hot water system are given in the test record form supplied with certified substations.

- Balance the building's heating system so that the required temperature drop in the system is obtained.
- Adjust the domestic hot water circulation system flow rate and thermostatic valves to give the required water temperature at taps and in the circulation connection.

7.2.2. Function checking

When installation is concluded, and the system has been properly set up and balanced, the property-owner should carry out a function inspection, with measurement of temperatures, in order to confirm that the promised performance has been achieved. For domestic hot water systems, this should be done by logging the domestic hot water temperature in the pipe from the heat exchanger, close to the heat exchanger.

If any non-compliances are found in the domestic hot water system, start by looking for causes in the checks described above in Item 5.6.5.

The following should be checked:

- Data of the components in the system.
- Positions of sensors.
- Domestic hot water temperature at the heat exchanger *
- Domestic hot water temperature at a tap **
- The performance of the heat exchanger at specified loads. The heat exchanger manufacturer should supply information as needed for assessing the performance under specified load conditions. Note the district heating system supply temperature.
- That pipes are correctly marked.
- That all installation documentation and operation and care instructions have been supplied, and are correct.

* Measure the temperature after the water temperature has stabilised.

** The same conditions as above apply for measurement at the taps. Note that the mixed water temperature must be 50 °C

7.2.3. Actions in the event of non-compliances

The first response in the event of a non-compliance is to correct the situation. If this is not realistic, the non-compliances should be evaluated and a suitable response should be agreed.

7.2.4. Recurrent surveillance inspection of a district heating system installation

A surveillance inspection programme, in accordance with the requirements of the Swedish Work Environment Authority, must be applied for inspection of the substation and its associated primary connections. This inspection programme must be based on the results of the risk assessment carried out by the installation owner/user for the installation. It is therefore in the interests of the installation owner/user to inspect, at least once a year, the substation in accordance with the inspection programme. The results of inspections should be documented, together with details of any defects found and work carried out.

The heat supplier can provide advice on suitable procedures. The Swedish District Heating Association has also produced a report, 'Safety in District Heating Installations', no. 2004:2.

7.3. Operation and maintenance of the substation

It is important to prepare and keep operation and maintenance reports in order to ensure correct operation of the substation and of the building's heating systems. The Association's report no. 2004:1, entitled 'Your District Heating Substation', gives advice on this.

7.3.1. Checking for leaks

A common method of finding leaks in district heating systems is to use pyranine die as a tracer. The die is injected into the district heating water by the heat supplier, after having received permission to do so from the local authority environmental department and having notified the public. The method is described in the Thermal Engineering Research Association's report no. 343, 'Dies for leak tracing in district heating systems'.

Contact the manufacturer of the heat exchanger for advice on suitable cleaning agents and working methods before cleaning heat exchangers and associated systems. The heat supplier should also be informed of planned cleaning.

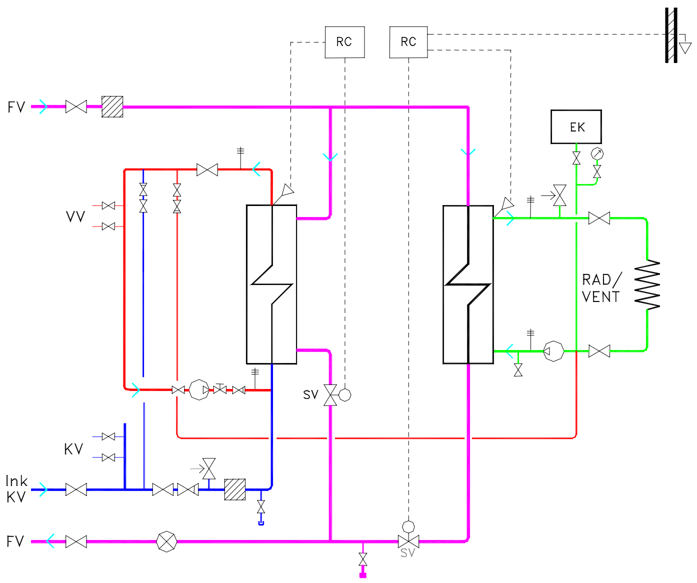
8. Connection principles

Various connection arrangements are possible, depending on the building's heat requirements and the design of its heating system.

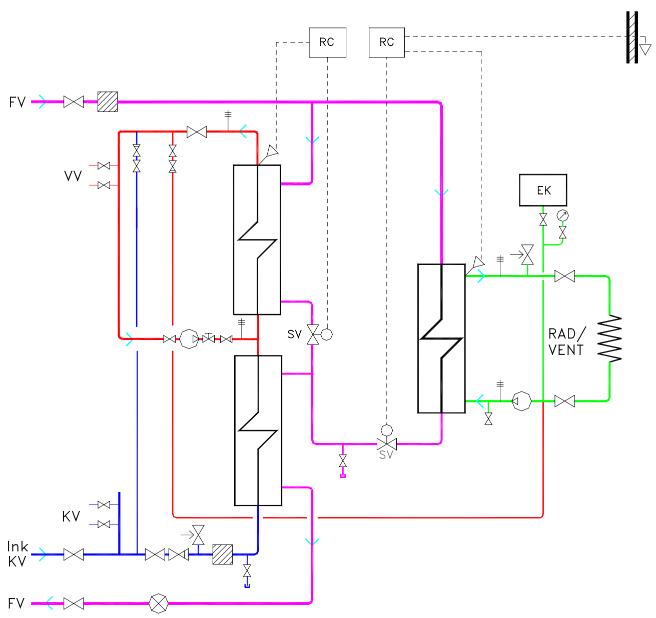
The Swedish District Heating Association has published a report, no. 2004:3, entitled 'Substations - Connection Principles', which describes different arrangements and their characteristics.

The two commonest principles are shown in the diagrams below: of them, parallel connection is recommended first and foremost:

Parallel connection



Two-stage connection



9. Appendices

1. Examples of local regulations
2. Checking substation functions
3. Information on determining substation capacity

Appendix 1

Examples of local regulations

HT system design temperature

Under certain conditions, the supply temperature may exceed the ……..^{o}C operating temperature. Installations must therefore be designed so that they can withstand a maximum temperature of 120 °C and pressure of 1.6 MPa.

Classification of district heating systems

The district heating system is classified for a maximum temperature of …………. and pressure of ……….

Diagram of the district heating system supply temperature as a function of ambient temperature in accordance with the classification.

Documents to be sent to the heat supplier

- site plan
- layout drawing for the district heating connections to the equipment room
- plan of the equipment room, the substation and the position of the heat meter
- schematic diagram of the substation and the building's heating system
- parts and labour description for installation of the substation
- for installations less than 100 kW in size, only the schematic diagram and parts/materials description are required
- capacity/rating-determining material: see Appendix 3.

Information from the heat supplier

- type of system: LT/HT
- classification temperature of the system
- delivery limits
- differential pressure at the supply point
- suggestion for suitable connection arrangement
- date/time for supply of district heating
- operating data from existing installation (for conversion of an existing unit)
- valuation of reduced return temperature from the substation.

The heat supplier will supply the following equipment, as needed:

All equipment to be installed by the customer's pipework contractor:

- filter, primary side
- pressure gauge
- spacer section for flow sensor
- instrumentation pockets for temperature sensors.

Heat recovery

The following general exceptions in respect of heat recovery apply for buildings connected to the .... district heating system:

Procedures during/after installation

Installation drawings that have been examined by the heat supplier shall, on request, be shown to the heat supplier's inspector at the installation site.

When installation work has started, it is recommended that a representative of the heat supplier is present to check the erection work.

Before the installation is started up, the district heating circuit must be tested in the presence of the heat supplier's representative.

On completion of installation, the customer or his representative shall notify the heat supplier of readiness for final inspection.

The heat supplier's representative shall be present when the installation is commissioned.

Appendix 2

Function checking of the substation

Installation no.:	
Date:	Performed by:
Customer / company:	Routine visit / Notified fault:

DISTRICT HEATING

Meter readings:

1 Volume	m^3
2 Energy	MWh

Pressure:

3 Supply, before filter	kPa
4 Supply, after filter	kPa
5 Pressure, return	kPa

Temperature in district heating pipes

6 Temperature, supply	ºC
7 Temperature, return	ºC
8 Temperature, after radiator heat exchanger	ºC

Other meter readings:

13 Cold water	m^3
14 Domestic hot water	m^3

BUILDING HEATING SYSTEM

Radiators:		Ventilation:
9 Temperature, supply	ºC	ºC
10 Temperature, return	ºC	ºC
11 Domestic hot water, supply	ºC	
12 Domestic hot water circulation, return	ºC	

Other:

15 Ambient temperature at time of visit	ºC

Pos	System / Component	pos	Fault description / Comments Status: 1=Urgent 2=Requires attention 3=Information 4=Corrected by inspector	Item	Cost estimate
1	Components in district heating mains				
1.1	Service connection isolating valves				
1.2	Filter				
1.3	Pressure gauge				
1.4	Thermometer				
1.5	Flow sensor				
1.6	Integrator				
1.7	Temperature sensors				
1.8	Other				
2	Radiator/vent. circuit				
2.1	Heat exchanger				
2.2	Filter				
2.3	Sensor				
2.4	Control unit				
2.5	Control valve				
2.6	Thermometer				
2.7	Pumps				
2.8	Exp. vessel / Safety valve				
2.9	Valves				
2.10	Filling and check valve				
2.11	Other				
3	Domestic hot water circuit				
3.1	Heat exchanger				
3.2	Filter				
3.3	Control unit				
3.4	Control valve				
3.5	Sensor				
3.6	Thermometer				
3.7	Circulation pump				
3.8	Valves				
3.9	Check valves				
3.10	Other				
4	Other				

Appendix 3

Rating and capacity data

<u>Enter the rating and capacity data on the unit's flow diagram</u>

Heated floor area ....m^2 Address ....…
No. of apartments ....…
Flow (domestic hot water) ....l/s
Transmission.................. kW at design ambient temp. .... °C
Transmission.................. kW at $T_{ambient}$............................ °C break point
Ventilation...................... kW at design ambient temp. .... °C

<u>Heat recovery</u>

Heat pumps .....………....... kW with waste heat source …………….......….
Other ....………… ...... kW with heat source ....…………….........….

Heat exchanger Make:	Domestic hot water	Radiators	Floor heating	Ventilation	Other
Type / no. of plates					
Type of district heating system					
Design flow, m^3/h					
Pressure drop, kPa					
Design temp., °C					
Type of system in the building					
Design flow, m^3/h					
Pressure drop, kPa					
Design temp., °C					

Control valves / actuators Make:	Domestic hot water		Radiators	Floor	Vent-ilation	
Type of control unit/program version						
Type of control valve						
Flow, m^3/h						
Pressure drop, kPa						
Valve diameter, k_{vs} value						
Valve diameter, k_{vs} value						
Actuator run times, O/C, C/O						

Technical regulations

District heating substations Design and installation	**F:101**
District heating substations Design and installation	**F:102**
Certification of district heating substations Test and inspection programme	**F:103-3**
Heat meters Technical requirements and advice on meter installations	**F:104**
Testing heat exchangers and water heaters	**F:109**
Heat meters Dynamic function testing of heat meters for detached houses	**F:111**

Reports

Your district heating substation A handbook for caretakers	**2004:1**
Safety of district heating installations Rules and advice for risk assessment	**2004:2**
District heating substations Connection principles	**2004:3**
Magnetic-inductive flow meters	**1993**
Ultrasonic flow meters	**1994**
Maintenance systems for district heating substations Performance specification for procurement	**1998:5**
Remote communication for energy utilities	**1997:3**

Publications

Publications can be ordered from the District Heating Association's Publishing Service on telephone +46 26-24 90 00 or fax +46 26-24 90 10. A current list of publications in print is also available on the Association's web site.

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