DISTRICT HEATING SUBSTATIONS

DESIGN AND INSTALLATION

Technical regulations | F:101 | February 2016

ENERGI FÖRETAGEN

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PREFACE

These technical regulations for district heating substations are sector-wide regulations for the Swedish district heating sector. They describe how a building must be designed and/or altered to suit connection to a district heating system, and also specify the requirements for district heating substations in respect of determination of capacity, design, installation, operation and maintenance. They constitute an appendix to the contract between the property-owner and the district heating service supplier. Local regulations, of which Appendix 2 is an example, indicate whether the operating conditions or requirements of a particular district heating supplier differ from those in this specification due to local conditions.

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. In its design and choice of components, the district heating substation must fulfil the requirements in respect of function and security of supply specified by the district heating supplier and public authorities.

This version of F:101 applies from January 2014, replacing the previous edition from 2008. New points in this edition include:

- a detailed review and updating of all requirements and recommendations in the regulations,
- changes to the content and order of chapters, intended to make this version easier to read and more pedagogic,
- updating of some pictures and diagrams.

F:101 is intended for use by:

- those responsible for contact 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 district heating substations.

These regulations have been updated by the Swedish District Heating Association’s Substations Group, whose members are:

Hans Dahlbäck, Mälarenergi AB
Hans Engström, Luleå Energi AB
Martin Ek, Tekniska verken i Linköping AB
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Jan Baldefors, Swedish District Heating Association AB

The proposed regulations have been circulated for consultation and comment to HEAS, Fjärrvärmebyrån, Värmek and the Swedish District Heating Association’s member companies.

The Swedish District Heating Association's Technical Group has ratified these Technical Regulations.

Swedish District Heating Association
Jan Baldefors

INNEHÅLL

1 INTRODUCTION — A NEW FUTURE FOR DISTRICT HEATING

District heating is firmly established in today's Sweden. 90 % of all apartment buildings, for example, are heated by it, but this means that district heating cannot continue to expand at the same rate as has been the case up to now. In fact, when the effect of energy conservation measures in the country's existing building stock is taken into account, it is likely that future demand for district heating is likely to decline rather than to increase. This is a new situation for the district heating sector, which makes it necessary to look for new application areas for district heating.

With increasing proportions of combined heat and power production (CHP) from refuse incineration and industrial waste heat, many district heating systems will have considerable quantities of surplus heat in the summer. If this can be utilised in some way, such as in absorption cooling, it will mean that the energy will not be wasted. The use of low-temperature systems (4GDH) will also be important, as this improves the production proportion between electricity and heat in CHP plants.

Residential buildings in future will be designed for heating at steadily decreasing supply temperatures. Although today's detached house developments have low energy demands for space heating, their power demand for domestic hot water production is at least as high as has historically been the case, and is the rating-determining factor for the entire house system.

The requirement of an EU directive that can have a considerable effect on district heating in the future is that of individual metering and billing at apartment level in apartment buildings. This can have a considerable effect on the design of future district heating substations..

1.1 New applications for district heating

In future, district heating suppliers will have to be able to offer alternative arrangements for the supply of district heating to their customers, as competition for alternative forms of heating has increased over the last few years. The following are new potential applications for district heating.

- **Low-temperature supply or the use of return water for residential buildings and ground heating**
  One alternative way of supplying low-tem heat is to restrict the customer's supply temperature to a particular maximum value, while another is to use the system's return water as the supply water for applications suitably designed to utilise such low-temperature heat. In both cases, domestic hot water would be heated by the ordinary district heating supply–side water.

- **Ground and lobby heating**
  There are many customers who could benefit from ground heating. In addition to ordinary street heating, which has been in existence for decades for some roads, pedestrian areas, etc., there are also potential applications in hotel and restaurant entrances, offices, shops of various kinds, football fields, health care centres and hospitals, service centres and care homes. Using return water and appropriate pricing can create a demand for an environmentally beneficial and low-cost way of ground heating and heating of entrances, while at the same time improving urban conditions.

- **District heating in conjunction with external heat sources**
  There are model forms of circuits and systems for operating external heat sources in conjunction with district heating systems: see Appendix 1. Examples of such external heat sources include solar heat, heat pumps, pellet-fired boilers and heat stores.

- **Overflow or temporary premises for schools, child day-care centres, libraries and building sites**
  These are areas that require no special technology, but rather flexibility to accommodate different conditions. A temporary structure or site building must have a waterborne heating system: today, these are transportable units that are often electrically heated. However, they can remain on the same site for many years, which means that there is considerable potential for the possible supply of district heating.

- **Interruptible district heating for large customers**
  This is an arrangement whereby, depending on various conditions (such as days of the week or perhaps ambient temperature), the customer can either himself, or via a third party, temporarily disconnect his district heating substation from the external district heating network.

  The arrangement is simple and involves no significant additional costs. The supply can be interrupted by a valve that simply closes the customer's connection on the primary side; generally the main shut-off valve. The supply can be interrupted or restored either by programmed conditions in the substation's local control equipment, or from a remote control point. Circulation in interrupted circuits is maintained by thermally controlled circulation pumps.

- **District heating for laundry equipment in utility rooms**
  This arrangement, supplying heat to washing machines, etc., is already in use. It has considerable potential for application both in new buildings, and in existing properties.

- **Floor heating, e.g. bathroom floors, and towel driers**
  As has now been the case for several years, future heating systems will incorporate heated bathroom floor and towel driers. These comfort-enhancing features are very suitable for supply from the radiator circuit.

  Floor heating is suitable for a low-temperature supply, and in turn delivers a low return water temperature. At design ambient temperature, maintaining a comfortable room temperature of 21 °C requires a supply temperature of only about 37 °C. Heated floors, laundry appliances and towel driers can easily be included in future district heating-supplied buildings, to the benefit of the environment and with a reduction in costs.

See Appendix 1 for more detail on these applications.

2 WORKING WITH THE DISTRICT HEATING SUPPLIER

These technical regulations, F:101, cover sector requirements, references to public authority requirements, Swedish and European standards and EU directives. There may be local regula-tions or requirements, so it is essential always to contact the local district heating supplier for specific information. Technical, commercial and administrative aspects of district heating supplies are regulated in contracts and in general terms and conditions of contract. These technical regulations, F:101 –"Design and installation of district heating substations", are stand alone, or can constitute an appendix to contracts and general terms and conditions.

In accordance with the general terms and conditions for the supply of district heating, the property-owner shall provide details of design rating data and proposed connection arrangements to the heat supplier. This applies for both new installations and for conversions of properties. On the basis of the documents provided, the heat supplier shall confirm that the proposed district heating substation is suitable for use on the supplier's system. The heat supplier will decide the necessary capacity of the heat meter, and will supply the meter.

These technical regulations, F:101 complement public authority regulations, and are therefore applicable to new installations, conversions, replacement and operation of district heating substations. The sector-specific requirements are intended to ensure the correctness and quality of the installation, its performance and its safety in a pressurised system.

If the design rules and rating determination principles as set out in these regulations are followed, and if space heating and domestic hot water systems are correctly set up, the technical requirements in respect of cooling of return water will be fulfilled. Cooperation and liaison between the customer and the district heating supplier also benefit system efficiency of the customer's system.

If changes are planned to the property that could affect the function or performance of the substation, the heat supplier must be notified before the conversion works starts. If the heat supplier requires new documentation, material relating to the proposed substation must be submitted for inspection and approved.

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.

Manufacturers of small house substations must be able to confirm that their equipment complies with the requirements of F:101 and F:103-8. Certification is a confirmation of this compliance. This applies mainly to small house substations.

A proposed Standard for larger substation units was completed in 2015. The name of this workshop agreement is CWA 16975 (Eco-Efficient Substations EES).

EES should be certified, and marked according to certification given according to testing result and environmental ranking. Only EES with a capacity of up to 500 kW per heat exchanger for heating and domestic hot water respectively can be certified.

2.1 Efficient use of energy

The local district heating supplier can provide information on how the district heating is produced and distributed, and on its environmental impact. Requirements relating to the use of heat in both new and renovated buildings are set out in the National Board of Housing, Building and Planning's current Building Regulations.

2.2 The district heating substation equipment room

The room in which the substation is installed is referred to as the district heating equipment room. It must be accessible for the heat supplier to inspect it, to read the heat meter, and to inspect the main isolating valves.

Determine the space requirement as needed in order to ensure good working conditions, and to enable the equipment to be serviced.

The district heating substation must always be positioned so that it is easily accessed in terms of distance from walls and at reasonable heights. The Swedish Work Environment Authority's regulations AFS 1998:1 specify that it is the responsibility of the owner to ensure that equipment does not cause health hazards or unnecessarily tiring demands or physical loadings in connection with installation, normal use, maintenance or other commonly encountered use or handling.

Lighting in substation equipment rooms must always be of sufficient quality for service work. In addition, the rooms must have a floor drain and a cold water supply.

If a substation replaces a boiler, the old flue duct and chimney must be mechanically ventilated, and a cowl fitted over the top of the chimney. It may also be necessary to install a radiator in the district heating equipment room.

Small substation units, as used for detached houses, can be installed outside the house, in a cubicle in the wall of the building. These cubicles must be of an appropriate size and design to suit them for use in the extreme ambient temperature of the site.

2.3 Contact with the heat supplier

2.3.1 Changed heat requirements and replacement of substations.

Contact the heat supplier when it is necessary to replace a complete substation or part of it.

Changes may have been made in the building. The heat supplier may have operational statistics that can provide valuable information on likely heat requirements; it is not suitable to select new equipment on the basis of the specifications for the equipment that is to be replaced.

FC-kontroll is the (Swedish) name of a design program for determining design ratings of substations, that can be downloaded from the Association's website, *www.svenskfjarrvarme.se*.

2.3.2 New connections

Contact the heat supplier to request a heat supply. Discuss the routing of pipes, the proposed type of substation and its position in the building. Notify requests for district heating supplies in good time, in order to give the supplier reasonable time to arrange and install connections to the building.

District heating pipes within the building must be accessible for examination and inspection by the heat supplier.

2.3.3 Plastic pipe systems on the secondary side

The heat supplier must be contacted in connection with any planned new construction, rebuilding or renovation work involving installation of plastic piping in space heating and domestic hot water systems.

A guideline from the National Board of Housing, Building and Planning advises; 'Plastic pipes for domestic hot water systems should be designed and specified to withstand a static pressure of 1 MPa at 70°C.' Protection against overtemperature and overpressure must still be installed even when this advice is followed. Note that all secondary systems must be designed in accordance with their respective temperature ratings.

3 TECHNICAL REQUIREMENTS OF DISTRICT HEATING SYSTEMS

3.1 District heating substations: general

District heating substations are designed for different purposes, such as for detached houses, apartment buildings, and other buildings and premises. They are usually manufactured and delivered as prefabricated units, but can also be built at site. Each substation is a complete unit, comprising heat exchangers, control equipment, safety equipment, etc.

Traditional high-temperature systems operate at higher temperatures and pressures than the secondary systems. Table 1 below shows the rating and design data of the different systems.

3.2 Rated temperature and operating temperature

The district heating supplier specifies the design temperatures for the system. The operating temperature at the production plant is somewhat higher than the substation's heat exchangers' design temperatures in order to ensure that the design temperature of the customer's substation unit is maintained.

The district heating system supply temperature is normally highest when the ambient temperature is lowest. As the ambient temperature rises, so the supply temperature falls linearly with it. The supply temperature is then maintained constant against rising ambient temperature above the knee point in the ambient temperature curve, in order to maintain a sufficiently high temperature to meet domestic hot water heating requirements. In low-temperature systems, the supply temperature is constant year-round.

The supply temperature can, however, be considerably higher than the design rating curve temperature due to system-related requirements and/or for production optimisation. The figure below shows an example of how the operating temperature at a substation can vary.

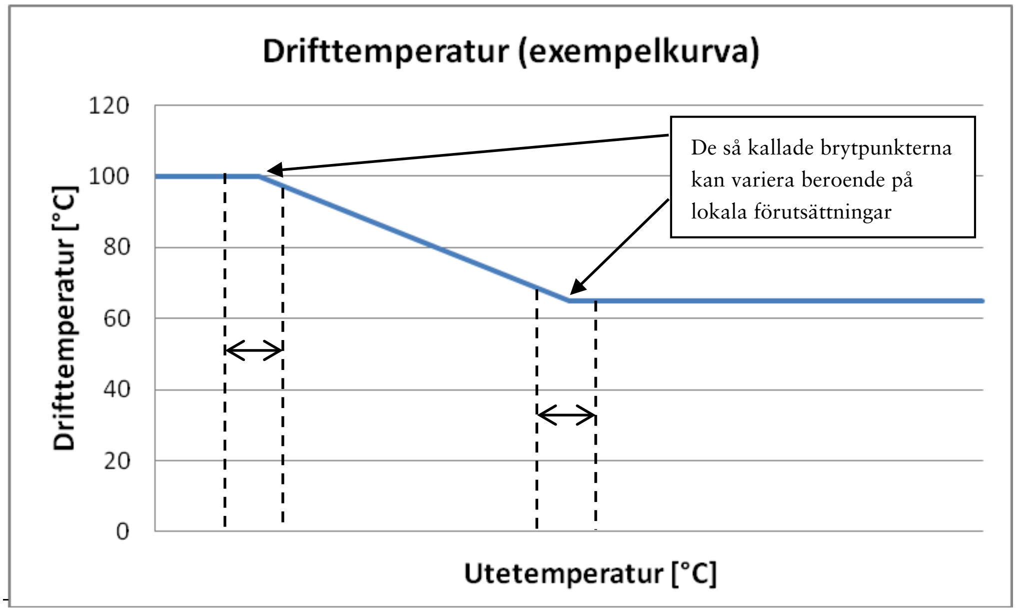


Figure 1. An example of a temperature curve showing the district heating system's operating temperature as a function of the ambient temperature.

3.3 Rating and design data

Swedish district heating systems are generally designed as high-temperature systems.

District heating system	Rating data	Design data
Conventional system Primary system	≤100 °C, 1.6 MPa diff. pressure 0.1 –0.6 MPa**	120 °C, 1.6 MPa
Low-temperature system Primary system	≤80 °C, 1.6 MPa diff. pressure 0.1 – 0.6 MPa	120 °C, 1.6 MPa
Secondary system *	≤80°C, 0.60–1.0 MPa diff. pressure 0.1 – 0.2 MPa	≤80°C, 0.6 -1.0 MPa

Table 1. Rating and design data for district heating systems.

* For 'secondary-connected' substations.

** Higher differential pressures can be encountered, so the functionality of control valves cannot be guaranteed at all differential pressures.

In order to determine applicable inspection requirements, 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 determined by the classification of the district heating system, and these values must not be exceeded during normal operation. Inspection requirements can vary, depending on the applicable temperature and pressure limits.

3.4 The importance of return temperature in district heating systems

In addition to benefiting the environment, good cooling of the return water is also in the interests of both the customer and the heat supplier. Good cooling is dependent on the design and adjustment of the building's heating systems, as well as on the capacity rating, performance and function and condition of the substation, as described in Regulations F:103 and F:109. The test report of a certified district heating substation shows the documented performance.

3.5 Differential pressure

The district heating supplier will provide information on the actual minimum and maximum differential pressures, as measured at the delivery boundary. This data must be used when designing the substation unit and for determining the necessary sizes and capacities of control valves. The control valves must be suitable for use with the local differential pressure in order to be able to provide optimum control. If the differential pressure is changed, it may be necessary to replace the control valves in order to maintain full capacity.

Note that allowance must be made for the pressure drop across the heat meter when determining the necessary control valve rating and capacity. The pressure drop across the meter can vary, depending on the type of meter.

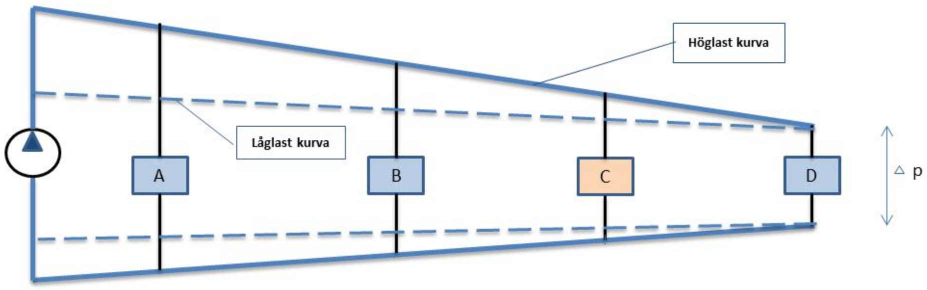


Figure 2. An example of the ranges over which the differential pressure in a district heating system can vary. The distance in the x-plane represents the distance from the system circulation pumps.

District heating substations **A, B, C** and **D** supply loads ranging from 0 to 100 %, which means that the flows through them vary. The distribution system's pump controls the pressure as needed to maintain the pressure at the substation where the differential pressure is lowest: it must not be less than 0.1 MPa. Other production units and distribution pumps can be connected to the network at various points and be taken into use as needed to meet demand. This means that, in principle, substation units can be exposed to differential pressures ranging from 0.1 MPa up to the highest pressure given by the heat supplier.

The maximum differential pressure across a substation should not exceed 0.6 MPa, although higher differential pressures can occur in some cases. Noise problems can arise, and require attention, with differential pressures as low as 0.4 MPa. If necessary, differential pressure regulators can be installed on an area basis in order to reduce the highest differential pressures and thus facilitate better control.

The local district heating supplier can provide information on differential pressures.

4 DESIGN AND PERFORMANCE REQUIREMENTS

The substation forms part of the district heating system, and must meet the requirements for long term durability and safety. This means that, regardless of size, substations must be manufactured in accordance with the requirements set out in Table 2 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 destructive testing (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.

4.1 Certification

A certified substation must comply with both the customer's and the heat supplier's requirements for an energyefficient system, be suited to the district heating system, and must provide the customer with good comfort and high operational reliability.

The Swedish District Heating Association has published regulations (F:103) for the certification of substations. Substations that fulfil the requirements of F:103 can be certified, and clearly display the certification symbol. The test report, which accompanies the certification document as an appendix, sets out the properties and features of the substation.

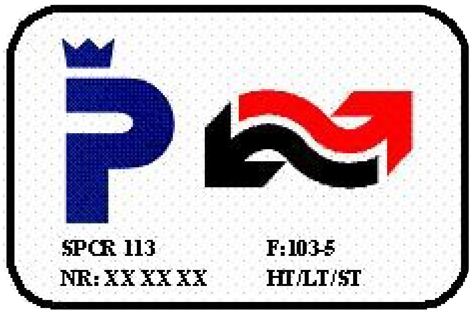


Figure 3. An example of a certification symbol.

The symbol confirms that the substation has been certified in accordance with the Association's Certification Rule No. F:103-x. The accompanying certificate gives details of the manufacturer, the type of unit, the test method and the validity of the certificate.

Information on certificates' validity and test reports is given on the Association's website, with test report details and results, and any observations noted during the tests. Each test report includes 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 of the Swedish Work Environment Authority's Regulations No. AFS 1999:4. In these cases, no third-party inspection is required for installation of the substation.

A CE-marked substation must therefore have a declaration of conformity, a copy of which must be delivered by the manufacturer to the heat supplier and to the user of the substation.

The manufacturer must 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 requires the manufacturer to show that the necessary inspections and tests have been performed.

4.3 Risk assessment

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

In addition, the plant owner (the user) must assess risks affecting operation, care and maintenance of the plant in accordance with *AFS 2002:1 – Use of Pressurised Equipment*.

5 DESIGN RATING OF DISTRICT HEATING SUBSTATIONS

5.1 Heat exchanger performance

Manufacturers of heat exchangers must show the heat exchangers' 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. Test procedures are set out in the Association's rules for testing, "F:109 – Testing Heat Exchangers and Water Heaters".

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

Heat exchangers for domestic hot water are 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.

5.2 Control equipment – general requirements

It is important that all components in the control system are suited for working together in order to provide optimum operation and comfort.

5.2.1 Controllers

It is recommended, when deciding on the choice of controller, to consider the possibility of its connection to a higher level control system.

5.2.2 Temperature sensors

The uncertainty of measurement of temperature sensors must not exceed ±0.8°K over the operating range concerned. Sensors must be installed at positions shown in the system flow diagram.

Particularly important parameters for ensuring that temperature sensors work as intended are:

1. The position of the sensor
2. The sensor's time constant
3. The sensor's accuracy of measurement.

5.2.2.1 Temperature sensors for tap water temperature at the output from the substation in systems not having a tap water circulation system

The sensor position is important when the domestic hot water system does not have a circulation system. It must be fitted as close to the heat exchanger as possible.

The sensor's time constant must be as short as possible: a maximum of eight seconds is recommended.

From a control point of view, the sensor's accuracy of measurement is not as important as its time constant.

5.2.2.2 Temperature sensors for tap water temperature at the output from the substation in systems having a tap water circulation system

The valves in a system incorporating tap water circulation are normally electronically controlled. The use of thermally controlled valves is less common.

The sensor should be installed further from the heat exchanger in order to give smoother control. In systems with high design rating powers but low actual power demands, it may be necessary to install the temperature sensor about a meter from the heat exchanger in order to prevent hunting of the domestic hot water temperature control.

The sensor's time constant must be as short as possible: a maximum of eight seconds is recommended.

5.2.2.3 Temperature sensors for space heating systems

If there is a risk of laminar flow past the temperature sensor, it should be installed after the space heating circulation pump in order to ensure turbulent flow past the sensor.

5.2.3 Control valve

The Pump Stop function must be interlocked with the space heating control valve such that the valve closes when the pump stops.

Select the control valve on the basis of the necessary design power capacity. The condition for good performance is that at least 50% of the differential pressure across the substation should be dropped in the valve when the valve is fully open (known as the valve authority), and that the valve should have a control range of at least 1:100. The size of the valve must include allowance for the total differential pressure, i.e. allowing for other components such as filters and heat exchangers.

Check the performance of the control equipment at the design rating power and at the operating point where the primary supply temperature changes to constant temperature, known as the 'knee point'. Sequentially controlled valves should be used if flows exceed 7.5 l/s. For such cases, k_{vs} for parallel-connected sequentially controlled valves = $k_{vs1} + k_{vs2}$.

For smaller valves, choose a kv value between ¼ and ⅓ of the entire k_{vs} value, so that the desired kvs value is delivered by the smaller valve and the larger valve together.

5.2.4 Valve actuators

Valve actuators must permit manual operation so that control valves can be manually operated. In the event of a power failure, the actuator for the domestic hot water valve should self-close. Actuators' torque or force must be suited to the type and size of valve as required by the temperature, pressure and flow in the system. Valve actuator manufacturers must state at what maximum differential pressure the actuator can close the specified control valve.

5.2.5 Communication

Equipment for load management, operational supervision and remote metering should be suitable for connection to the substation.

The communication protocol **must** be of open-source type, independent of manufacturer/supplier and freely available. Information from the substation control system's sensors and from the heat meter can be used in order to ensure effective operational and system supervision.

5.3 Domestic hot water systems

The National Board of Housing, Building and Planning's Building Regulations require a sub-station 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 the output temperature of the water from the substation is in the range 53-55 °C.

Some installations use a hot water storage tank, and in such cases the domestic hot water temperature must not be less than 60 °C, and held for a sufficiently long time to ensure that bacteria are eliminated. (See Appendix 7, Water Quality in District Heating Systems.) This is also the maxi-mum permissible temperature at the taps under the Board's regulations, in order to avoid the risk of scalding.

Control equipment and heat exchangers must be suited to each other in order to give good temperature control. If the system includes hot water circulation, the temperature throughout the circulation system must not be less than 50 °C

5.3.1 Design temperatures for domestic hot water heat exchangers

Rate the heat exchanger in accordance with the temperatures shown in the following Table 2. These temperatures are for heat exchangers with clean heat transfer surfaces.

	District heat-ing water temp., return	**District heating water temp., return**	**Cold water**	**Domestic hot water temp. at substation output**	**Vid Domestic hot water temp. at taps**
Apartment buildings, commercial premises, etc.	65°C*	≤22°C	10°C	55°C	50°C
Detached houses, apartment units	65°C*	≤22°C	10°C	50°C**	50°C
If a hot water storage tank is used	65°C	≤25°C**	10°C	60°C	50°C

Table 2. Design rating temperatures for heat exchangers.

*60 °C for low-temperature systems

**55 °C for detached houses with hot water circulation systems

5.3.2 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 demand. The diagram is valid for apartment buildings with a normal residential mix.

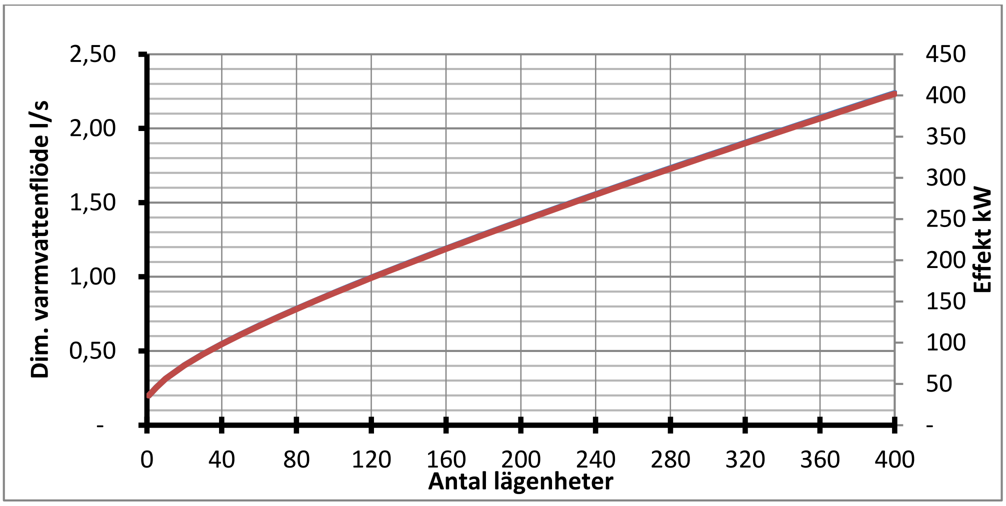


Figure 4. Design rating temperatures for new buildings.

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

Table 3. Design rating flow capacity for apartment buildings.

Residential buildings with a high demand for domestic hot water, such as apartments with baths or student apartments, may have a domestic hot water demand greater than indicated above.

The following factors must be allowed for when choosing equipment:

- Pressure and temperature differences arising in the district heating system
- The types of heat exchanger
- The fact that the use or presence of older taps, etc., often result in higher flows
- That, for comfort reasons, newer taps, etc., may require higher flows
- That domestic hot water system circulation pipes must not be used for towel driers, floor heating, or radiators, as this could introduce a risk of bacteria growth
- That, if the domestic hot water system does not have a circulation connection (as in detached houses or small apartment substations) the control equipment should respond to both the cold water flow to the heat exchanger and the

temperature of the hot water delivered by the heat exchanger.

A shortage situation can arise under the following circumstances:

- A temperature lower than 65 °C at the district heating system's supply pipe connection
- A lower differential pressure than the design differential pressure
- A higher temperature drop than 5 °C between the heat exchanger and the taps
- A fault in the control equipment
- The domestic hot water circulation pump has stopped
- The expected flow rate has been exceeded.

Note: See Appendix 10 for calculation of domestic hot water flow rates and crisis situations.

Check the settings of the control equipment when the substation is commissioned. The control equipment must be marked to show what version of program it´s installed

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

5.4 The space heating system

5.4.1 Rating determination of heat exchangers

Heat exchanger design 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. Check calculations should be made at the break-point temperature, as shown in Figure 1.

The 'District Heating Substations - Connection Principles' report describes various ways in which substations may be connected in heating systems. (The report can be downloaded from the Association's website.)

5.4.2 Capacity determination alternatives for secondary space heating systems

The necessary capacities for radiator systems in buildings already connected to a district heating system can be determined in accordance with Table 3. 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.** Efforts must be made to obtain as low a return temperature as possible on the secondary side. A low secondary return temperature is the key to good system efficiency.

The primary return temperatures are shown in Table 4 below, and apply at the design ambient temperature for the location concerned. With higher ambient temperatures, the temperatures are lower, tracking the building's heating system's return temperatures.

Heating system	District heating system supply temperature High- / low-temp. system	District heating system return temperature	Space heating system supply temperature	Space heating system return temperature
Space heating systems in new buildings	100/75 °C	<22 °C <48 °C <43 °C	40 °C 60 °C 60 °C	20 °C 45 °C 40 °C
Ventilation systems in new buildings	100/75 °C	<33 °C	60 °C	30 °C
Space heating systems in older buildings built in accordance with 1975 Building Regulations or earlier	100 °C	<63 °C	80 °C	60 °C

Table 4. Temperature levels for secondary space heating systems.

Previous overgenerous determination of design capacities in older buildings can affect the choice of design rating temperatures.

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 extent of equipment required can vary from one district heating supplier to another.

	Low-temperature secondary system	High- / low-temperature primary systems	
	<100 kW	<100 kW	>100 kW
In the substation equipment room:			
Lighting	K	K	K
Power supply	K	K	K
Meter position	K	K	K
Access to floor drain	K	K	K
Ability to flush domestic hot water and cold water circuits	K	K	K
District heating circuit (primary side)			
Main isolating valves	T	T	T
Filter	K	K	K
Pressure gauge	R	R	R
Pressure sensor connection 3	R	R	K
Temperature display	R	R	R
Radiator / ventilation system 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
Instrumentation	T	T	T
Drain valve	R	R	K
Air bleed valve	R	R	R
Space heating circuit (secondary side)			
Circulation pump [2]	K	K	K
Expansion vessel [2]	K (if heat exchanger used)	K	K
Temperature display	R	R	R
Pressure gauge	R	K	K
Safety valve [4]	K (if heat exchanger used)	K	K
Filling valve	K (if heat exchanger used)	K	K
Check valve [1]	K	K	K
Filter	R	R	R
Domestic hot water system			
Safety valve [4]	K	K	K
Circulation pump	R	R	K
Temperature display [5]	K	K	K
Drain valve	R	R	R
Filter, incoming cold water	R	R	R
Check valve, incoming cold water to heat exchanger [1]	K	K	K
Bypass (emergency connection), isolating valve and check valve [1]	R	R	R

Table 5. Equipment on/in/for the district heating substation.

[1] Type EB check valve. Type EA is also acceptable.
[2] May be fitted outside the substation.
[3] Not required for units for use in detached houses.
[4] Overflow pipe must be run to floor drain.
[5] Not required if there is no circulation connection.

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

The Association's Test Regulations F:103-n describe the function requirements for the domestic hot water and space heating control equipment in more detail.

6.1.1 Pipes, valves and fitting 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 Association's Technical Regulations for distribution pipes (D:211, Regulations for Pipe Running). It must be possible to check, and further tighten if necessary, connections that incorporate gaskets as the seal. Note that different requirements apply to the district heating system's primary pipes and connections and to the building's internal secondary piping system, as pressures and temperatures differ in the two systems.

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.

Threaded connections larger than DN 25 (G1") must not be used. All threaded components must have a marked position to which an opposing force may be applied to prevent the component from turning when the thread is being tightened.

The quality of seals, gaskets and sealing surfaces, etc., in joints must be suitable for meeting the system's requirements. Joint materials must meet the requirements of the systems temperature and pressure demand.

Appendix 9. Seals etc. must be located and centred in relation to the sealing surface after tightening the joint. Sealing surfaces and materials must be rated for the system design conditions.

Incoming and outgoing pipes in the substation must be marked, in the form of indication of the type of flow and an arrow to indicate flow direction. The type of flow can be District Heating Primary, District Heating Secondary, Domestic Hot Water Circulation or Cold Water for cold water or public supply water.

6.1.2 Insulation

Insulate the primary side in accordance with the Swedish HVAC AMA codes, with insulation thickness in accordance with Table RB/1, Series 2.

6.1.3 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 great 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 must be opened by moving the lever (if the valve is not operated by a handwheel) upwards.

6.1.4 Potential equalisation

Electric fields and stray currents are an electrical problem, and must be solved using methods as described in the Heavy Current Regulations 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.

6.1.5 Filters

Filter mesh size must be 0.6 mm. It must be possible to clean the filter without having to remove the filter casing. The filter must be positioned so that there is no risk of water damaging electronic equipment when the filter is being cleaned.

6.1.6 Pressure sensors

Pressure sensors read the static pressure and the differential pressure in the substation, and must display between atmospheric pressure and the lowest design 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.

6.1.7 Temperature display

Temperature may be displayed either directly by means of thermometers or by means of sensors connected to control and/or supervisory equipment or to meters. Measurement ranges must cover at least the maximum temperature variation. As a safety measure, pockets for temperature sensors having a threaded connection must not be covered by insulation. It must be possible to see whether a sensor is fitted in a pocket. Both space heating and domestic hot water circuits must be fitted with temperature sensors.

6.1.8 Space heating, ventilation and domestic hot water heat exchangers

The materials in heat exchangers must withstand the liquids in both sides of the system. Contact the manufacturer for advice before carrying out chemical cleaning. It must be possible to pressure-test heat exchangers in their installed positions. Heat exchangers must be resistant on the high-temperature side to oxygenated water.

6.1.9 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 to control the valve manually.

Note and record the values after adjusting/setting the control parameters in the regulator.

6.1.10 Domestic hot water control system

The system consists of a control valve, a valve actuator, sensors and a controller, although self-acting 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 software setting values after adjusting/setting them in the regulator: appropriate settings are noted in the test certificates supplied with certified substations.

6.1.11 The meter position

The heat meter is supplied by, and is the property of, the district heating supplier. Its design and function comply with 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.

Further information on heat meters is given in the Swedish District Heating Association's Technical Regulations No. F:104.

Arrange the meter position as shown in Figure 5. 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 the district heating water supply and return temperatures.

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

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. Valves should be suitable for fitting of pressure gauges for check pur-poses.

Pressure may also be measured by differential pressure sensors, communicating with the existing communication system and fitted in the prepared measurement points.

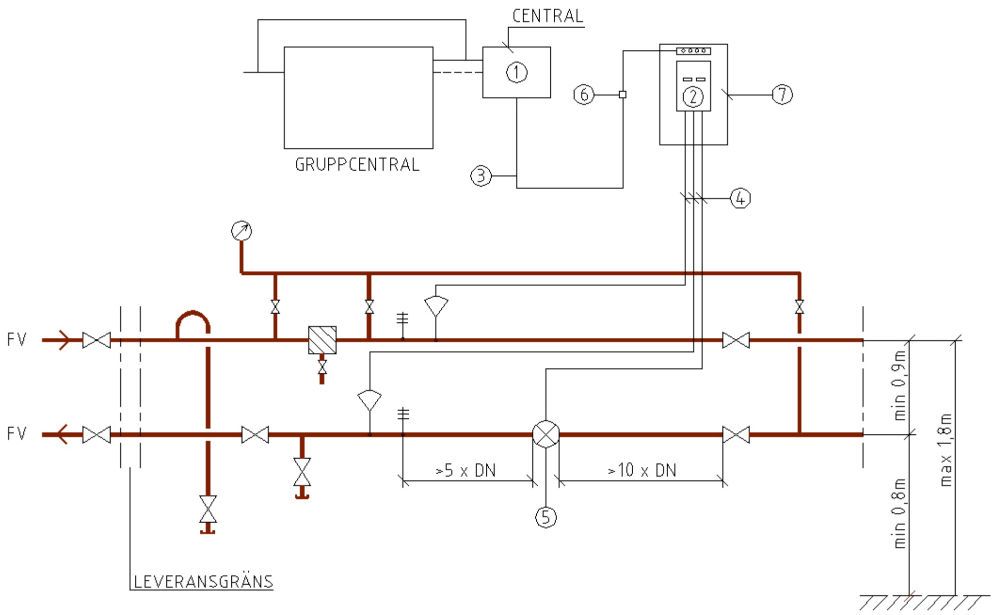


Figure 5. Schematic diagram of the meter position.

Förklaringar:

1. Electrical distribution board.
2. Integrator.
3. Supply from distribution board. Cable size at least 1.5 mm².
4. Connections between the parts of the meter. Wire size at least 0.75 mm². Use at least 1.5 mm² conductors if the distance exceeds 7.5 m.
5. Flow sensor, DN = sensor connection size
6. Safety isolator, with lock-out facility and/or lead seal. Must be fitted if the meter position and the fuse (1) are not in the same room.
7. Meter board.

Figure 6 shows schematic details of required meter positions, pipe runs etc. The integrator must be mounted within 2 m cable length from the flow sensor.

Most flow sensors require straight lengths of pipe upstream and downstream of them; follow the supplier's recommendations for the necessary lengths of straight piping. However, in order to be able to change to some other type of flow sensor in the future if necessary, it is recommended that straight runs of pipe should be provided on each side of the sensor position, of lengths 10 x DN upstream of the sensor and 5 x DN downstream of it. It is also desirable that the sensor can be rotated around its own axis in order to avoid air pockets. The meter supplier should be able to verify that the meter can perform within the permitted error limits even without straight stretches of pipe. Manufacturers of flow sensors complying with EN 1434 must state the necessary lengths of straight pipe runs in the information material supplied with the meter. Type testing includes tests to verify this information.

6.1.12 Vent valve

Fit a vent valve, with its discharge connection, to the highest points of the district heating pipes for manual venting of air in the system. The discharge pipes must be run to a floor drain and be fitted with an end plug..

6.1.13 Drain valve

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

6.2 Radiator and ventilation circuit components

6.2.1 Circulation pump

The pump must be capable of delivering the head, flow quantity and pressure class for which the radiator and ventilation heating system are designed, and must be speed-controlled.

The pump stop function must also close the main heating circuit control valve.

6.2.2 Expansion vessel

The expansion vessel in secondary heating systems must be able to accommodate normal thermal volume variations, and must withstand the static pressure for which the radiator and ventilation heating system are designed.

6.2.3 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 the lower design rating pressure, and must be marked to indicate the pressure at which the system's safety valve operates. Pressure gauges must be of Class 1.0 accuracy, or better, in order to be reliable.

6.2.4 Safety valve

The safety valve can most suitably be fitted to the connection to the heat exchanger having the lowest pressure. No shut off valves are allowed in the pipe between the safety valve and the heat exchanger. A safety valve is not required for open expansion systems. The discharge pipe from the safety valve must be run to the floor drain.

6.2.5 Filling valve and check valve

This valve is used for filling the radiator and ventilation heating system with water (preferably hot water) to the correct working pressure. The equipment normally consists of a shut-off valve with the addition of a check valve function. Filling is performed manually and under supervision. This connection is closed during normal operation of the system.

6.2.6 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 the filter casing.

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 domestic hot water heat exchanger. No shut off valves are allowed between the safety valve and the heat exchanger. Fit the check valve between the shut-off valve and the safety valve.

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, maintaining a temperature of at least 50 °C at taps, as required by the National Board of Housing, Building and Planning's regulations. The required temperature is different in other countries.

6.3.3 Domestic hot water circulation system capacity

Determine the necessary capacity of the domestic hot water circulation system on the basis of the heat losses from the hot water pipes to each tap, as necessary, in order to maintain a minimum temperature in the domestic hot water circulation system in accordance with the National Board of Housing, Building and Planning's regulations.

6.3.4 Emergency connection

The emergency connection is a pipe that is intended, in the event of 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 check valve.

7 INSTALLATION

7.1 Design and specification

Contact the heat supplier for information on connection to the district heating system and on choice of suitable substation units. The necessary power requirement for the substation should be discussed with the supplier. When performing work such as modification or conversion of an existing substation, obtain energy statistics for the building in order to determine the new design capacity or requirements.

Ways of reducing the return temperature from the secondary system should be investigated. An example of one such way can be to adjust the heating system and investigate the feasibility of introducing a low-flow system for the radiator circuit.

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, which must be handed over to the heat supplier and to user of the substation.

7.2 Piping and its installation

Various standards for selection of district heating piping are recommended by the Association; see the Association's website [1]. According to the Association's regulations for laying district heating and district cooling mains, all joints of steel pipes must be made by personnel who hold welders' certificates in accordance with SS-EN 287-1 Qualification tests of welders – Fusion welding – Part 1: Steel.

Components, piping parts and joint/sealing materials must be of at least the pressure and temperature ratings required for the system concerned. Piping and components must be capable of withstanding the dynamic pressure variations that can occur in district heating systems; examples of 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.

7.3 Selection of heat exchangers

Manufacturers of heat exchangers and water heaters must be able to prove that their heat exchangers and equipment fulfil the requirements of Swedish Standard SS-EN 1148. 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).

7.4 Welding and brazing

Work on the primary side must be performed by companies meeting the requirements of the following standards for welding and brazing. All welders performing erection work must hold a valid certificate for the particular welding or brazing method in use.

[1] http://www.svenskfjarrvarme.se/Medlem/Fokusomraden-/Distribution/Standardisering/Standarder/

Welding qualifications	
SS-EN 287-1:2004	Qualification tests of welders – Fusion welding – Part 1: Steel, (replaces EN 287-1:1992 +A1:1997
SS-EN ISO 9606-3:2000	Qualification tests of welders – Fusion welding – Part 3: Copper and copper alloys
SS-EN ISO 9606-5:2000	Qualification tests of welders – Fusion welding – Part 5: Titanium and titanium alloys, zirconium and zirconium alloys
Brazing qualifications	
SS-EN ISO 13585:2012	Brazing - Qualification test of brazers and brazing operators
Testing of personnel	
SS-EN 1418:1998	Welding personnel - Approval testing of welding operators for fusion welding and resistance weld setters for fully mechanized and automatic welding of metallic materials (also published as ISO 14732)
Welding coordination (welding manager)	
SS-EN ISO 14731:2006	Welding coordination. Tasks and responsibilities

Table 6. Personnel qualification requirements for welding and brazing.

Equipment installed in the substation or plant 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.

The method to be used when fitting valves in district heating systems must not damage the valve's seal. This means that electric welding must be used if the joint face is less than 0.5 m from the end of the valve body. In all other cases, follow the valve manufacturer's instructions.

There are no legal requirements applying to testing of welders or brazers, or requirements for a welder's licence, for those making joints in secondary systems (<10 bar, <100 °C). However, from a quality point of view it is advisable to apply the same standards and requirements for these systems as used for primary systems.

7.5 Electricity supply

If a detached-house-size substation is CE-marked and fitted by the manufacturer with a 230 V plug, the manufacturer is indicating that he takes responsibility for connecting the unit to a power supply in this manner. The manufacturer's instructions must be complied with, in order to ensure that the equipment is used as intended by the manufacturer.[2]

7.6 Inspection and testing

The Swedish Work Environment Authority's regulations specify the inspections that must be performed, and who may perform them. The heat supplier will always inspect the substation and the installation to ensure that they fulfil the requirements in these regulations. The records of results of leak and pressure testing that have been carried out must be submitted to the inspector(s).

Appendix 6 is a Model Form of Final Inspection that can be used.

On conclusion of the work, its quality must be tested by leak testing and pressure testing of the system in accordance with the Swedish HVAC AMA codes. Records of the leak and pressure test results must be kept by the piping contractor in accordance with the requirements of the AMA codes. The heat supplier can also require welded and brazed or soldered joints to be inspected.

[2] The National Electrical Safety Board

8 COMMISSIONING AND MAINTENANCE

8.1 Operating and care instructions

Written operating and maintenance instructions must be available before the substation is taken into use. These instructions must include:

- A description of the equipment's function, with associated drawings, flow diagrams and operation cards with instructions.
- Data sheets and manufacturers' instructions for components.
- A list of components that need periodic inspection or attention.
- A description of inspection and maintenance procedures that are regarded as necessary for problem-free and uninterrupted operation.
- Addresses and telephone numbers for calling for service and/or corrective maintenance.

Operating and maintenance instructions are intended to facilitate good performance of the substation and the building's heating system. The Association's report "Your district heating substation" (2004:1) describes how to prepare such instructions.

8.2 Commissioning

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.

<u>Commissioning involves:</u>

- Checking and, if necessary, adjusting the control parameters.
- Appropriate setting values for controlling the domestic hot water system are given in the test record form supplied with certified substations.
- Adjust the heating system circulation pump and the heating characteristic curve to provide efficient return water cooling. Note that it is the building's secondary systems that determine whether efficient cooling can be delivered.
- Adjust the domestic hot water circulation flow as required by the National Board of Housing, Building and Planning's Building Regulations.
- Checking, and tightening if necessary, all connections and face seals or flange gaskets.

8.3 Function checking

When installation is concluded, and the system has been properly set up and balanced, a function inspection should be carried out, with measurement of temperatures, in order to confirm that the promised performance has been achieved.

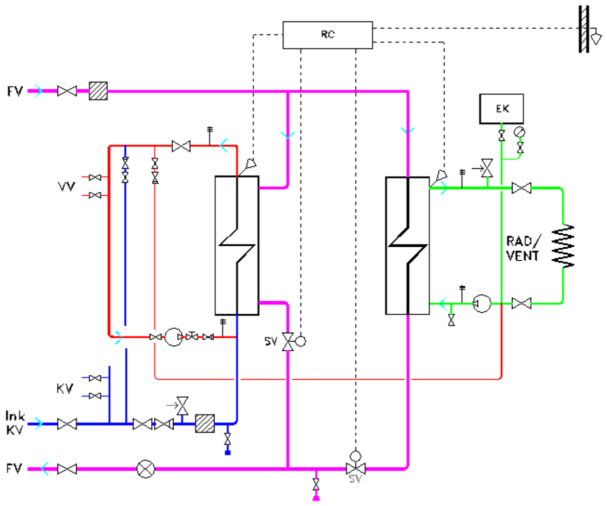
Appendix 4 describes the necessary function checks.

9 CONNECTION PRINCIPLES

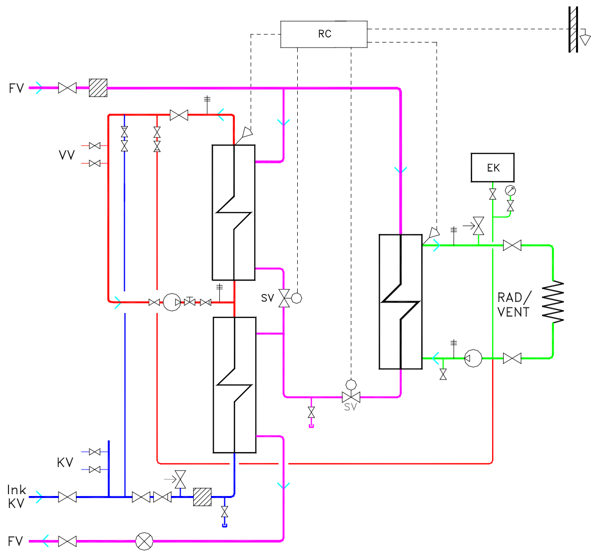
Various connection arrangements are possible, depending on the building's power require-ments, heating requirements and the design of its heating system.

The Swedish District Heating Association has published a report, No. 2009:3, entitled 'Substa-tions - Connection Principles', which describes different arrangements and their characteristics. The two commonest principles are shown in the diagrams below:

Parallel connection



Two-stage connection



Parallel connection is an arrangement of district heating substation connections in which the heat exchangers are connected in parallel across the supply's incoming and return connections. One heat exchanger supplies the radiator circuit, and the other supplies the domestic hot water circuit. This arrangement is that which is most commonly used.

Two stage connection is also commonly used. The return water from the radiator circuit heat exchanger is used to preheat the domestic hot water. The proportions of heat supplied as pre-heating and post-heating respectively are set in such a way as to make best use of the return temperature from the radiator circuit. If the building has a substantial demand for hot water, this connection arrangement generally results in a lower return temperature than from parallel connection.

10 APPENDICES

1. New potential application areas for district heating
2. Examples of local regulations
3. Procurement of district heating substations
4. Checking substation functions
5. Information on determining substation capacity
6. Model form of final inspection requirements
7. Water quality in district heating systems
8. Environmental requirements for domestic hot water, with particular attention to avoiding risks of Legionnaires' disease
9. Requirements for seals
10. Calculation of domestic hot water flow rates
11. Calculation of kvs values for control valves
12. Definitions and technical performance indicator values

APPENDIX 1.
NEW POTENTIAL APPLICATIONS FOR DISTRICT HEATING

The following are new or partly new uses of district heating, both large and small, that have a considerable potential for increasing deliveries of district heating. See these uses as manifestations of first thoughts.

1. Low-temperature / return connections for residential buildings and ground heating

District heating suppliers will need to be able, in the future, to offer their customers alternative forms of district heating supplies, in order to meet the increasing competition from alternative forms of heating.

One way in which heat might be delivered at low temperature is to limit the maximum temperature of the supply to the customer, while another is to use return water from other parts of the network to supply those customers whose heating systems have been designed for low-temperature operation. Both these arrangements use the normal district heating supply line for domestic hot water production.

A comparative analysis has shown that the second alternative, of using lower-temperature return water for space heating, has the greatest savings potential, while reducing the energy charge would increase the likelihood of customers choosing district heating instead of other forms of heating for new builds.

Göteborg Energi has shown that it is possible to provide low-temperature return water connections, regardless from which direction in the distribution network that the water comes.

For this alternative to be realised, customers must of course have low-temperature space heating systems in their houses. The district heating companies therefore need to run a massive information campaign to increase customers' awareness.

2. Ground heating and lobby heating

The advantage of ground heating is that it presents a market that is not saturated, and therefore has substantial future potential. Its drawback, on the other hand, is that it requires a major investment cost for customers, although this is somewhat offset by savings in the steadily rising costs of snow clearance.

A characteristic of ground heating is that it requires a very high level of power at a time when the production of district heating is at its most expensive, but that it does not use very much energy over the year as a whole. Payback times are difficult to calculate using conventional methods.

The benefits of ground heating extend to many categories of customer. In addition to ordinary street heating, which has been around for decades for pedestrian zones and some traffic routes etc., there are fringe users such as hotels, restaurants, office blocks, shops of various kinds, healthcare centres, sheltered housing and old people's homes.

254 substation units were investigated in Göteborg. Among these, about ten potential customers were found for ground heating and/or lobby heating.

The markets are there, just waiting for an entrant to present a concept (whether technical or cost-based) that is attractive for various types of customer. If the price is right, detached house owners could consider heating the ramp to or from their garage, or perhaps even clearing the snow from a long drive that otherwise always has to be cleared by hard work

Solutions based on the use of low-temperature return water, and tariffs without power-dependent charge elements, could have reasonable prospects.

Ground heating using low-temperature return water and customer acceptance of poorer performance when the ambient temperature is at its lowest (and it is seldom so when demand is highest) are factors that can considerably simplify urban management in an environmentally responsible, low-cost manner.

Smaller floor or pavement heating installations in lobby areas can be supplied directly from radiator circuits etc., but there is a need to develop flexible designs.

3. Solar heating, heat pumps, pellet boilers and/or heat stores run in parallel with district heating. (Below referred to as joint operation with external heat source.)

There are three connection principles for external heat sources that can be operated in parallel with a district heating system.

Principle 1

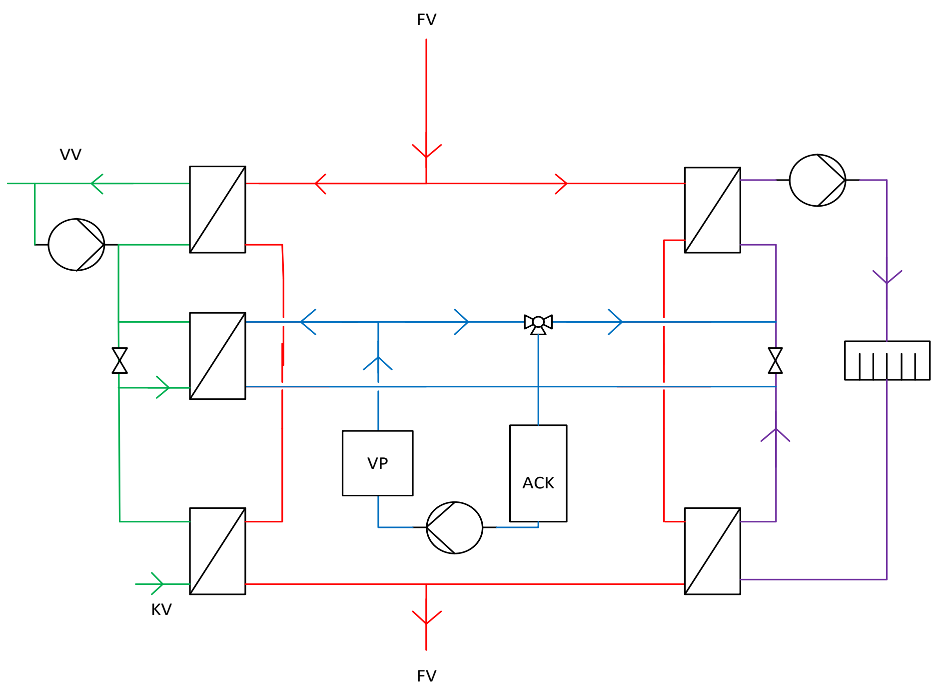
Space heating and hot water with district heating – External heat source – District heating

District heating provides preheating and post-heating, while an external heat source is connected as an intermediate stage between the two district heating heat exchangers. The heat pump is used as the preferred heat source, with the connection valves for district heating opening when the heat pump is unable to deliver the required power and/or temperature.

This connection arrangement does not raise the return water temperature to the district heating system, as heating is performed in three stages. The district heating supplier supplies less energy over the whole year, which can even fall to no energy at all during the summer if a suitable tariff has not been agreed.

The heat pump has a good chance of operating with a high COP, as it does not have to deliver the highest temperature. As domestic hot water is not stored in a hot water tank, there is no increased risk of bacteria growth. A factor against this arrangement, however, is the need for a large number of components, including a heat storage tank and a heat exchanger, and so requiring high investment cost and more maintenance. Nevertheless, it is not particularly complicated, as the heat pump and the district heating system can be operated more or less independently of each other.

As investment cost is likely to be high, and if the price of district heat is very low in the summer, the property-owner can calculate whether this particular connection arrangement is economically viable.



Space heating and domestic hot water in parallel, both produced in three stages with district heating providing pre- and post-heating, with a heat pump as an intermediate stage.

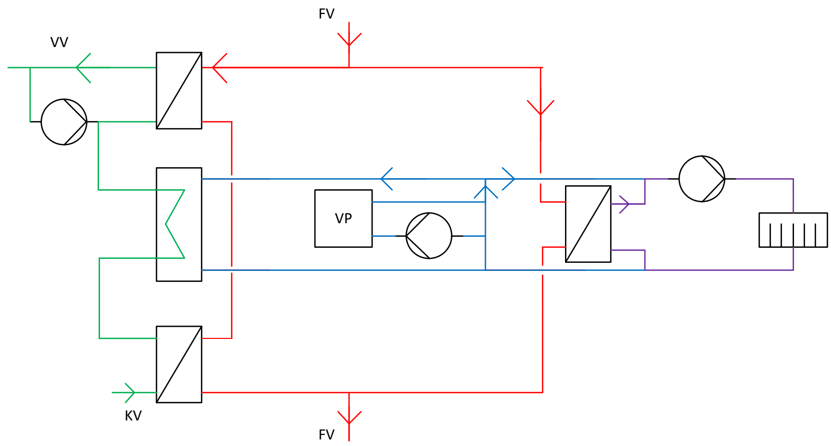
Principle 2

Space heating with district heating and an external heat source in parallel, with do-mestic hot water provided by DH – HP – DH

This arrangement uses district heating for preheating and post-heating the domestic hot water, while the heat pump heats it to an intermediate level. The heat pump does not charge up a buffer storage tank, but heats domestic hot water in a hot water tank containing a heater coil. On the space heating side, these two designs differ in that the heat pump and district heating are here used in parallel. This design also uses the heat pump as the first choice for supply, with the district heating control valves opening if the heat pump cannot supply the required power or temperature levels.

The district heating return temperature is not normally adversely affected by the use of the heat pump. However, the design does presuppose that the heat pump can deliver heat at a sufficiently high temperature for the building's heating system so that the temperature needs to be further raised by district heat. The design reduces the amount of heat supplied by the utility, in the same way as in the previous design. The heat pump's COP is presumably somewhat lower with this design than with the previous one, as it has to supply heat to the space heating system at a higher temperature. In comparison with the previous design, it requires fewer components, but control is somewhat more complicated.

This design has advantages under approximately the same conditions as the previous one, i.e.. when there is little difference in cost between the price of electricity and that of district heating.



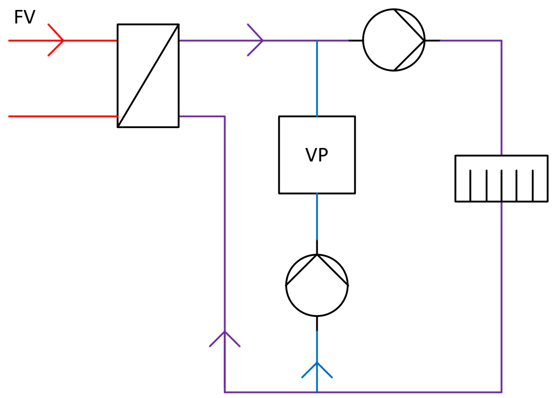
Domestic hot water produced in three stages, with district heating as the preheating and post-heating stages, and the heat pump as an intermediate stage. Space heating is provided by the heat pump and district heating in parallel.

Principle 3

Space heating with DH and HP in parallel

The above principle can be somewhat simplified by eliminating the post-heater, so that only one district heating heat exchanger is used in parallel with the heat pump, as shown in the diagram below. There is no risk to the district heating return water temperature if the heat pump cannot deliver a sufficiently high temperature to the space heating system. However, the heat pump's COP suffers, as it has to supply heat at a higher temperature.

This arrangement should work well in a low-temperature system (floor heating or low-temperature radiators), as both the district heating substation unit and the heat pump deliver low temperatures. It is also of interest to the property-owner under similar conditions to those described above when the price of district heating is considerately lower than that of electricity.



In this arrangement, the heat pump supplies only space heating. It and the district heating supply are connected in parallel.

4. Temporary or overflow premises for schools, child day-care centres, libraries, site offices etc.

No special technology is required for these applications; the most important point is that the site conditions must be suitable. Essentially, this means that the recipient building or fitted-out container must have a waterborne heating system.

Site offices and accommodation modules, etc., range from single units in connection with the building of a house up to larger semi-permanent groups consisting of temporary or overload premises for schools, libraries etc. which, in most cases today, are heated by electricity. By far the majority of these provisional premises remain on their site for many years, which means that they represent a very large potential market for district heating in GWh terms.

5. Interruptible district heating

One alternative is that of an interruptible supply which permits the customer temporarily to disconnect his district heating substation from the supply system in response to various conditions, such as days of the week or ambient temperatures. These disconnections may be performed by the customer or by the supplier.

This is a simple arrangement, involving little in the way of additional costs. In hardware terms, supply interruption can be effected by valve actuators that close the existing isolating valves on the primary side.

It may be difficult to find valve actuators that suit existing isolating valves. There are several makes of isolating valves, and the actuators need to be capable of a high torque in order to close the valve.

Interruption / restoration of supply can be controlled by conditions or parameters programmed into the substation's local control equipment, or by remote control.

Circulation in closed circuits is maintained by thermal convection.

From the point of view of general cost-effectiveness, this arrangement is practical only for larger properties or office blocks.

6. Utility room washing machines

Washing machines require hot water, but it is only recently that machines suitable for externally supplied heating have become available and are beginning to be installed.

This application presents a large potential, both for new build installations and for existing properties. White goods designed for use with district heating need to be developed; one type for a separate circuit supplied by the substation, and another for apartments.

7. Bathroom floors and towel dryers

As has been the case in recent years, future new properties will largely incorporate heated bathroom floors and towel dryers. The difference between then and now is that in the future such features should be heated by district heating and not by electricity.

Both of these home comforts should preferably be connected to the radiator system, regardless of whether this is of conventional type or of some form of low-energy system, e.g. airborne heating.

APPENDIX 2.
EXAMPLE OF LOCAL REQUIREMENTS

Design temperature for high-temperature systems

Under certain conditions, the supply temperature can exceed the ... °C operating temperature. Systems must therefore be designed so that they can safely withstand a maximum temperature of 120 °C and a pressure of 1.6 MPa.

Classification of district heating system

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

Diagram of the district heating system's supply temperature as a function of various outdoor temperatures, in accordance with the system classification.

Documents to be submitted to the district heating supplier

- Situation plan
- Running of district heating pipes to the district heating equipment room
- General-arrangement drawing of the district heating equipment room and the district heating substation, showing the position of the heat meter
- Schematic diagram of the district heating substation and the building's heating system
- Labour and materials schedule for installation of the district heating substation
- For installations with a capacity of less than 100 kW, it is necessary only to submit the schematic diagram and the materials schedule
- Data as required for determination of the design rating: see Appendix 3.

Information from the district heating supplier

- Indication of whether the system is high-temperature or low-temperature
- District heating system classification temperature
- Delivery boundaries
- Differential pressure at the supply point
- Proposal for suitable connection principle
- Date of supply of district heating
- Operational data from the existing plant (when converting of or to a district heating substation)

The district heating supplier will provide the following equipment if required:

All supplied equipment is to be installed by the customer's piping contractor:

- Calibrated dummy for flow sensors
- Pocket for temperature sensors

Procedures during/after installation

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

When installation work is started, a representative of the heat supplier must be present to check the erection work.

Before the system 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 3. PROCUREMENT

Scope

The Act Concerning Public Procurement Within the Supply Sector covers all activities that have a substantial public influence. This means that it includes all public, municipal and state-owned companies. The National Price and Competition Board has also stated that privately-owned businesses that can be regarded as operating as monopolies in particular geographical areas fall within the remit of the Act. It is therefore important that the evaluation method described here for use in connection with procurement should be followed.

Technology procurement

A) As far as district heating substations that are factory-produced as standard units and have an assigned product item number are concerned, and which are also produced and available year after year, there should be a tried and tested and properly documented method of testing and evaluation.

B) For custom-built substations (often larger ones), with a large number of different components that are assembled to form a service unit, it is most important that the supplier / consultant responsible for the design should provide insurance against any miscalculations found subsequently. It is also very important that the manufacturer should guarantee that all the aspects that affect the design rating and/or function have been dealt with.

Technical requirements associated with procurement

Procurement must start from the technical specifications that the district heating supplier has assigned to the system. However, it must be borne in mind that there are various ways in which equipment suppliers can show that their products meet the technical specifications that the district heating utilities specify. Procurement is therefore simplified if there is a sector-wide standard for technical requirements and regulations, as well as for test methods used by all parties. This makes the selection process easier for both suppliers and district heating utilities.

The Association's technical specifications Nos. F.101 and F.103 set out specific requirements for substation performance and function, and it is therefore appropriate to use them as a basis for procurement. Any requirements that the district heating supplier specifies in respect of the products over and above those in these specifications should be clearly expressed and in a particular manner. It is advisable to depart from the sector-wide requirements as little as possible for two reasons. The first is that suppliers who manufacture the products can have larger production runs if any departures from the standard specification are minor and easier to accommodate in production. The second reason is that it makes the procurement process as a whole less complicated.

The contract

The contract is the basis for the continued relationship between the parties. It is recommended that the negotiating entity should put some extra care into formulation of the contract. As far as its technical element is concerned, warranties and terms of delivery are the most important.

Specifications F.101/103 set out several guidelines concerning warranties and other elements that are helpful for inclusion in the contract.

The contract should be evaluated during the contract period so that both the district heating supplier and the substation supplier are satisfied with it and feel that it provides all necessary protection. This evaluation forms part of the input preparations for the next procurement process.

It is important to consider the overall life cycle cost of the equipment during the procurement process.

APPENDIX 4.

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 T Pressure, return	kPa

Temperature in the district heating mains

6 Temperature supply	°C
7 Temperature returne	°C
8 Temperature After radiator heat exchanger	°C

Other meter readings r

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

THE BUILDING'S HEATING SYSTEM

Radiators		Ventilation system.
9 Temperature supply	°C	°C
10 Temperature return	°C	°C
11 Domestic hot water Supply		°C
12 Domestic hot water circulation Return		°C

Miscellaneous

15 Ambient temperature at time of visit	°C

Item	System / Component	pos	Fault description. / Observations Status: 1=acute 2=Attention required 3=Information 4=Dealt with by inspector	Pos	Cost estimate for rectification
1	District heating circuit				
1.1	Main isolating valves				
1.2	Dirt filter				
1.3	Pressure gauge				
1.4	Thermometer				
1.5	Flow sensor				
1.6	Integrator				
1.7	Temperature sensor				
1.8	Other				
2	Space heating circuit				
2.1	Heat exchanger				
2.2	Dirt filter				
2.3	Sensors				
2.4	Control unit				
2.5	Control valve				
2.6	Thermometer				
2.7	Pumps				
2.8	Expansion vessel / Safety valve				
2.9	Valves				
2.10	Filling and backflow protection				
2.11	Other				
3	Domestic hot water system				
3.1	Heat exchanger				
3.2	Dirt filter				
3.3	Control unit				
3.4	Control valve				
3.5	Sensors				
3.6	Thermometer				
3.7	Hot water circ. pump				
3.8	Valves				
3.9	Backflow protection				
3.10	Other				
4	Miscellaneous				

APPENDIX 5.
RATING AND CAPACITY DATA

Enter the rating and capacity data on the plant's flow diagram

Heated floor area.............m^2 Block..

No. of apartments .... Address ....

Flow (domestic hot water).........................l/s

Transmission.................. kW at ODT.......................... °C

Transmission.................. kW at T_{out}............................. °C knee point

Ventilation...................... kW at ODT.......................... °C

Heat recovery

Heat pumps.................. kW from waste heat source ....

Other type...................... kW from heat source ....

Heat exchangers **Make ....**	**Domestic hot water**	**Radiators**	**Floor heating**	**Ventilation**	**Other**
Type / no. of plates					
District heating system					
Rated flow, m^3/h					
Differential pressure, kPa					
Estimated temp. °C					
Building's system					
Rated flow, m^3/h					
Differential pressure, kPa					
Estimated temp., °C					

Control valves / Actuators **Make ....**	**Domestic hot water**		**Radiators**	**Floor heating.**	**Ventilation**	
Type of control unit / Program version						
Type of control valve						
Flow, m^3/h						
Differential pressure, kPa						
Calculation of valve , DN/k_{vs}-value						
Selected valve, DN/k_{vs}-value						
Actuator run times, open/close, close/open						

APPENDIX 6.
M ODEL FORM FOR FINAL INSPECTION

Inspection results for district heating installation

Customer:
Address:
Property name:
Telephone no.:

Date of connection: ____________
Date of inspection : ____________

Primary pipes:	Main isolating valves:	☐	OK	☐	Observation. ______		
	Securing against wall:	☐	OK	☐	Observation. ______		
	Supports:	☐	OK	☐	Observation. ______		
	Penetrations:	☐	OK	☐	Observation. ______		
	Routing :	☐	OK	☐	Observation. ______		
	Insulation:	☐	OK	☐	Observation. ______		
	Vent connection:	☐	OK	☐	Observation. ______		
	Floor drain:	☐	Present	☐	Not present	☐	Observation. ___
Other heating and domestic hot water pipes:	Radiator circuit	☐	OK	☐	Observation. ______		
	Domestic hot water circuit	☐	OK	☐	Observation. ______		
	Insulation	☐	OK	☐	Observation. ______		
Heat exchanger installations:	Pipe running	☐	OK	☐	Observation. ______		
	Cubicle	☐	OK	☐	Observation. ______		
Control equipment:	Space heating	☐	OK	☐	Observation. ______		
	Domestic hot water	☐	OK	☐	Observation. ______		
	System balancing	☐	OK	☐	Observation. ______		
Electrical installation:	220 Volt	☐	OK	☐	Observation. ______		
	Outdoor sensor	☐	OK	☐	Observation. ______		
	Room sensor	☐	Present	☐	Not present	☐	Observation. ___
	Signal cable	☐	Present	☐	Not present	☐	Observation. ___
Heat metering:	Meter	______					
	Meter reading	______ MWh					
	Seals	☐	OK	☐	Observation. ______		

____
____

Miscellaneous:
Faults and shortcomings noted above are not sufficiently serious to hinder proper function of the installation.
The inspected parts of the installation are hereby declared approved.

The warranty period is two years, starting from ____/______-______________

APPENDIX 7.
DISTRICT HEATING SYSTEM WATER QUALITY

Treatment of the water used in district heating systems is carried out at the production plants, which is where top-up water is also supplied. A dye is often added to the water, in order to assist leak tracing. The method is described in the Swedish Thermal Engineering Research Association's report No. 343, "Colour Dyes for Leakage Indication in District Heating Systems".

Optimum conditions for low internal corrosion are that the water in the circuit has:

- a pH value within a suitable interval
- low dissolved oxygen content
- low conductivity

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

Table 7. Recommended limit values for district heating water.

*pH must not be less than 9.5 if there is copper in the piping system (erosion of copper).

**This value applies for make-up water.

***There may be a need, in systems having inductive meters, to increase the conductivity by dosing, but this adversely affects the rate of system corrosion.

****A value <1 can be accepted if there is a heat exchanger between the boiler circuit and the district heating system network.

Information on water treatment and water quality in district heating systems has been published by the Swedish Thermal Engineering Research Association, in its handbook "Guide Values for Water and Steam in Swedish Energy Plants", No. 2006:958, published in February 2006. See also the Swedish District Heating Association's Technical Regulations No. F:104.

Classification of various water systems

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

The requirements of the various categories in respect of water quality 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 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.

Check valves must be fitted in order to prevent reverse flows between the various water systems. It is the responsibility of the plant owner to ensure that they are working properly.

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 of this document gives further details of the requirements applicable to check valves in district heating substations.

The intention of the standard is to protect against contamination of the cold water supply (Category 1). Several mutually independent faults must happen simultaneously in the system for backflow to occur from the space heating system to the cold water system, which is regarded as unlikely.

Two stages of backflow protection are provided

1. A check valve is fitted in the incoming cold water connection to the substation, i.e. between Category 1 water and Category 2 water.
2. An isolating valve and a check valve are fitted between Category 2 water (domestic hot water) and Category 3 water (the space heating system). The isolating valve must be closed when the heating system is being filled, which must also occur under controlled conditions.

Note: The security of the backflow protection devices in the filling connection can be checked by releasing the pressure in the domestic hot water system at the substation and then opening the filling valve. If the pressure in the space heating system drops this can indicate that back flow is occurring, and that the backflow protection devices need to be changed. (This procedure assumes that the domestic hot water system incorporates an emergency bypass valve.)

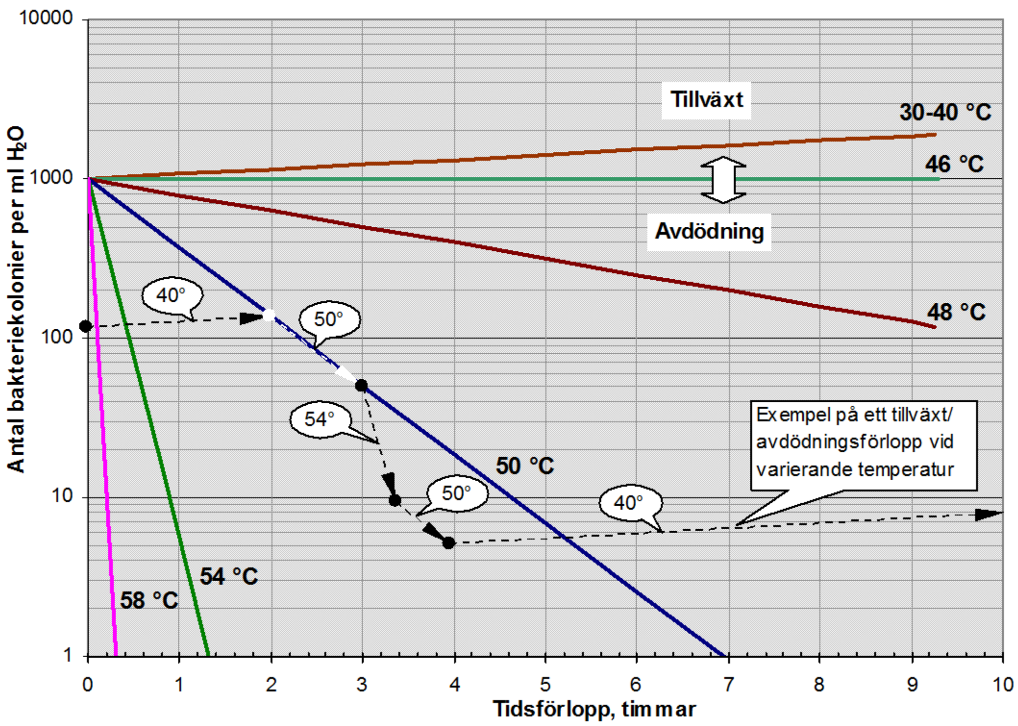
APPENDIX 8.
ENVIRONMENTAL REQUIREMENTS FOR DOMESTIC HOT WATER, WITH PARTICULAR ATTENTION TO AVOIDING RISKS OF LEGIONNAIRES' DISEASE

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

Towel dryers and floor heating coils connected to domestic hot water systems are a source of risk. If they are turned off, colonies of Legionnaires' disease bacteria can become established in them, infecting the entire system when these parts are again turned on. For this reason, towel dryers and floor heating coils should be on a separate circuit from the domestic hot water system, which should not be used for any purposes other than the supply of sanitary water.

The Swedish District Heating Association recommends that there should be no storage of water below the domestic hot water design temperature, in order to achieve the best possible environmental requirements applicable to the water. A temperature of 60 °C must be reached and maintained in hot water storage or buffer tanks for a sufficient time to ensure that any Legionnaires' disease bacteria are eliminated before the water is distributed to taps.

The bacteria will not be eliminated by secondary heating of water from, say, 40 °C up to 55 °C in a heat exchanger supplied with water from a district heating supply. Such secondary heating raises the temperature very quickly, without sufficient time to kill all Legionnaires' disease bacteria. Such an arrangement is unsuitable, and does not meet the National Board of Housing, Building and Planning's requirements in respect of health and environmental conditions as prescribed in the Building Regulations.



This diagram is reproduced from Report No. FoU 2002:75

It can be seen from the above diagram how dangerous it is to temporarily reduce the water temperature in a domestic hot water circulation circuit. In a ten-hour period, the water temperature has been at 50-54 °C for only two hours, and as low as 40 °C for the remaining eight hours. Such conditions are extreme in anything other than a very badly setup domestic hot water circulation riser. Nevertheless, despite the unfavourable temperature conditions, any bacteria colonies will have been more than decimated. From this point of view, it can be seen that temporary temperature drops to 40-45 °C, resulting from very high draw-off rates, have no practical significance if they do not last for more than 15-20 minutes, and do not occur more than once a day.

APPENDIX 9.

Required properties for seals for use in district heating pipes with a discontinuous water temperature of up to 120 °C and 1,6 MPa

Seals, gaskets, etc., must meet the requirements set out in the following table. The table shows the necessary tests and requirements.

		Requirements for different hardnesses				
Property	**Test method**	**50**	**60**	**70**	**80**	**90**
Teflon						
Volume change after 7 days in water at 95 °C	ISO 1817	+8/-1	+8/-1	+8/-1	+8/-1	+8/-1
Relaxation in compression, maximum, % 7 days at 23 °C 7 days at 125 °C	ISO 3384	15 30	15 30	15 30	18 30	18 30
Fibre gaskets						
Volume change after 7 days in water at 95 °C	ISO 1817	+8/-1	+8/-1	+8/-1	+8/-1	+8/-1
Relaxation in compression, maximum, %: 7 days at 23 °C 7 days at 125 °C	ISO 3384	15 30	15 30	15 30	18 30	18 30
Rubber						
Volume change after 7 days in water at 95 °C	ISO 1817	+8/-1	+8/-1	+8/-1	+8/-1	+8/-1
Relaxation in compression, maximum, %: 7 days at 23 °C 7 days at 125 °C	ISO 3384	15 30	15 30	15 30	18 30	18 30
Maximum set, %: 72 hours at 23 °C 24 hours at 125 °C	ISO 815	15 20	15 20	15 20	15 20	15 20
Set in water, 70 days at 110 °C, maximum. %	EN 681-1, Annex B	30	30	30	30	30

APPENDIX 10.
FORMULAE FOR CALCULATION OF HOT WATER DEMAND

Calculate hot water demand for buildings with more than 250 apartments from the following formula.

Note that the formula applies only for determining the necessary heat exchanger capacity, and not for determining the design capacity of the distribution system in the building.

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

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

n = number of apartments

qm = 0.15= aggregated flow per apartment

Qm = 0.2 = total maximum flow per apartment

O = 0.015 = probability of exceeding q_m

A = 2.1 = probability of exceeding q

The value of A can be increased to 3.1 for specific cases:

- residential buildings with a high demand for hot water, such as student hostels or types of buildings other than residential buildings.

Several situations have to occur at the same time for a shortage situation to occur:

- Temperature below 65 °C in the district heating system's supply main.
- Lower differential pressure than the design value.
- Higher temperature drop than 5 °C between the heat exchanger and the taps.
- Hot water flow value exceeding q l/s in the above calculation for a longer period of time.
- The hot water circulation pump has stopped, or some other fault has occurred.

In addition to this, the pipes for hot water supply and the circulation system pipes have an evening-out effect on the hot water temperature.

Conditions for determining the necessary sizes of hot water pipes in a building are set out in European standard No. PR-EN 806-3, Specifications for installations inside buildings conveying water for human consumption. Part 3: Pipe sizing. Pipe sizes in a building must therefore not be based on the sizes and capacities determined for heat exchangers and associated control valves.

APPENDIX 11.
DETERMINING THE KVS VALUE OF THE CONTROL VALVE

To assist in choosing a suitable control valve for use in the substation, the Association has produced a simple model form for determination of the necessary valve capacity. The valve's authority at different differential pressures can be decisive for the energy dynamics of the system. The form can be downloaded from *www.svenskfjarrvarme.se*

Model form of calculation

Fjärrvärmecentralens installerade effekt och dim. temperaturer

Effekt kW	300	Primär sida		Sek.sida	
Dim temp		100,00	42,00	40,00	60,00
Flöden l/s		1,24		3,59	

kv -värden väljs från tillvekarens datablad för vald

0,25 1,0 1,25 1,6 2,5 4 6,3 10 12,5 16 27 39

Formler

kvs = q [m³/h] / √Δp_4 [bar]

β = Δp_5 [kPa] / Δp max [kPa]

Fjärrkylcentralens värden	
Effekt **P** [kW]	300
Dim flöde **q** [m³/h]	4,45
Dim flöde **ql** [l/s]	1,24
Primärt Δt [°C]	58,00
Högsta differenstryck Δp_1 [kPa]	600
Lägsta differenstryck Δp_2 [kPa]	100
Tryckfall,vvx,rör,armatur Δp_3 [kPa]	49

Grönt markerade fält är indata.

Lämplig ventils kv-värde fås från tillverkarens datablad.

Δp max kan vara Δp_1 eller Δp_2 och väljs utifrån vilket drifttillstånd beräkningen utgår från

För parallellkopplade ventiler gäller följande
kvs = kvs 1 + kvs 2

Den mindre ventilens kvs-värde väljs från 1 / 4 till 1 / 3 av hela kvs-värdet så att den mindre ventilen tillsammans med sen stora ventilen uppnår önskat kvs-värde.

Lösen:Göte

Styrventilens kvs-värde vid lågt differenstryck	
Tryckfallet över öppen ventil Δp_4 [bar]	0,51
Tryckfallet över öppen ventil Δp_5 [kPa]	51
Beräknat kvs-värde vid dim effekt	**6,2**
Vald ventils kv-värde väljs mellan + 40% och	8,7
-20% av kvs-värdet	5,0
Valda ventilens kv-värde, se ex. på kv-värden	**6,3**
Auktoritet $\beta \geq 0,5$	0,51

Styrventilens kvs-värde vid högt diff.tryck	
Tryckfallet över öppen ventil Δp_4 [bar]	5,51
Tryckfallet över öppen ventil Δp_5 [kPa]	551
Beräknat kvs-värde vid dim effekt	**1,9**
Vald ventils kv-värde väljs mellan + 40% och	2,7
- 20% av kvs-värdet	1,5
Valda ventilens kv-värde, se ex. på kv-värden	**4**
Auktoritet $\beta \geq 0,5$	0,92

Den valda ventilen för fjärrvärme centr. får kv- värdet	**6,3**

APPENDIX 12.
DEFINITIONS, ABBREVIATIONS AND TECHNICAL PERFORMANCE INDICATORS

For suppliers, customers and contractors to better understand each other, we should have a common language. For this reason, we list below definitions that are accepted as being common to several sectors. The main terms come from SS-EN 13306, while those related to property come from ABFF (Allmänna Bestämmelser FastighetsFörvaltning [General Regulations for Property Management]). Other definitions have been taken from earlier reports, and are regarded as being well-established within the Swedish District Heating Association.

DUC – computer sub-centre

DUT – outdoor design temperature

VVC – domestic hot water circulation

District heating substation: a unit that transfers heat from the district heating system to the building's heating system.

District heating equipment room: the special area in which the district heating substation is installed.

Customer's installation: the system distributing heat within the property, starting from the delivery boundary.

Heat meter: equipment consisting of a flow sensor, two temperature sensors, and an integrator with communication equipment.

Maintenance: The combination of all technical, administrative and managerial actions during the life cycle of an item – workplace (building), work equipment, or means of transport – intended to retain it in, or restore it to, a state in which it can perform the required function.

Maintenance safety: The ability of the maintenance organisation to deliver the required maintenance resources and services at the necessary site, in order to perform the required maintenance measures on a unit, at a specified time or during a specified time interval.

Functional security: The ability of a unit to perform its required function under given conditions and for a specified time interval.

Availability: Ability of an item to be in state to perform a required function under given conditions at a given instant time or interval, assuming that the required external resources are provided.

Inspection: Check for conformity by measuring, observation, testing or gauging the relevant characteristics of an item.

Modification: Combination of all technical, administrative and management actions, intended to change the function of an item.

Operating time: Time interval during which an item is performing its required function.

Preventive maintenance: Maintenance carried out at predetermined intervals or according to prescribed criteria and intended to reduce the probability of failure or degradation of the functioning of an item.

Scheduled maintenance: Preventive maintenance carried out in accordance with an established time schedule or established number of items in use.

Condition-based maintenance: Preventive maintenance based on performance and/or parameter monitoring and sequence.

Corrective maintenance: Maintenance carried out after fault recognition and intended to put an item into a state in which it can perform a required function.

Valve authority, k_{vs}: the relationship between Δp_{min} in the control valve at a prescribed flow and Δp_{max} across the closed valve.

Kv: Waterflow in m^3/h with a pressure drop with fully open valve of 100 kPa and 20 °C.

Kvr: Minimum flow through the valve in m3/h and the pressure drop at 1 bar and preserved flow characteristic.

Kvs: The chosen valve's Kv-value and with fully open valve, usually with 30 % safety margin to the calculation.

Sv: Set factor (Adjustment factor/nicety) (k_{vs}/k_{vr}, e.g. 1:100).

The system efficiency: The Greek letter eta (η), and is expressed in %.

Key performance indicators

The Association's report, Key Performance Indicators for District Heating Substations (1998:12), lists appropriate key indicators for the district heating sector. SS-EN 15341 describes a system for applying key performance indicators to measure maintenance performance in connection with other factors of influence, such as economic, technical and organisational, with the aim of evaluating and improving efficiency in order to maintain optimum performance of physical plants. These key indicators should be used for measuring status, making comparisons (at national and international levels), diagnosis (analysis of strengths and weaknesses), identifying and defining targets, planning improvement work and regularly monitoring changes over time.

Size and energy sold: [no., MW] No. of customers, No. of detached houses, Contracted efficiency, Average efficiency at 63% of ODT, Energy sold.

Installation cost: [SEK/building] Detached houses <25 kW (SEK/building), 30-50 kW (SEK/kW), 200-400 kW (SEK/kW).

Technical lifetime: [Years] Weighted value, Min., Max., Median, Control equipment, Heat exchanger installation.

Running costs: [SEK/year per kW] (contracted power), meter measurement, maintenance and inspection.

Average temperature difference: [C°] Yearly average, Winter, Summer, Winter ODT max., Summer Min.

Unavailability statistics: [h/year] Weighted value, Min., Max., Median, Planned downtime (MTTR Mean time to total repair), Unplanned downtime (MDT Mean time down time), Meter replacement. Average downtime duration per customer, calculated from the company's total number of customers.

TECHNICAL REGULATIONS

District heating substations **F:101**
Utförande och installation (Execution and installation)

District cooling substations **F:102**
Utförande och installation (Execution and installation}

Certification of district heating substations **F:103-n**
Program för provning och kontroll
(Programme for testing and monitoring)

Heat meters **F:104**
Tekniska branschkrav och råd om mätarhantering
(Technical sector requirements and advice on meter management)

Testing heat exchangers and water heaters **F:109**

Heat meters **F:111**
Dynamisk funktionskontroll av värmemätare för småhus
(Dynamic functional control of heat meters for detached houses)

REPORTS

Your district heating substation **2004:1**
A handbook for building caretakers

Safety of district heating installations **2004:2**
Regulations and advice for risk assessment

District heating substations **2009:3**
Connection principles

Key performance indicator values **1998:12**
for district heating substations

The Work Environment Handbook **2013**

PUBLIKATIONS

Publications can be downloaded from the Association’s website:
www.svenskfjarrvarme.se

Denna tekniska bestämmelse för fjärrvärmecentraler är en gemensam bestämmelse för svenska fjärrvärmebranschen. Här beskrivs hur en byggnad anpassas till ett fjärrvärmesystem och vilka krav som gäller för fjärrvärmecentraler avseende dimensionering, utförande, installation, drift och underhåll. Bestämmelsen är en bilaga till det avtal som upprättas mellan fastighetsägare och fjärrvärmeleverantör.

För att en fjärrvärmecentral ska fungera på bästa sätt krävs att byggnadens värme- och varmvatteninstallationer anpassas efter anvisningarna i denna bestämmelse. Bestämmelsen kan kompletteras med lokala anvisningar, där det ska framgå om en specifik fjärrvärmeleverantör på grund av lokala förutsättningar har avvikelser från denna bestämmelse.

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