CERTIFICATION OF DISTRICT HEATING SUBSTATIONS

Svensk Fjärrvärme

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Preface

These Technical Regulations, F:103-7e, have been produced and published by the Swedish District Heating Association *(hereinafter, generally 'the Association')* in conjunction with manufacturers. Approved testing is part of the process of obtaining certification for a district heating substation. In addition, the process includes an appraisal of documentation and of the manufacturer's production inspection procedures. A certified unit fulfils the requirements set out in the Association's document F:101, General Technical Requirements.

Until further notice, the Association has selected SP Technical Research Institute of Sweden for certification of district heating substations.

Certification indicates that the quality and function/performance of a prefabricated district heating substation have been examined and approved. Certification test method F:103-7e (this document) includes both static and dynamic tests and inspection requirements. Detailed information on the district heating substation and its properties is given in the certification test reports.

The unique feature of this certification is that the test reports are in the public domain. This is possible because the Association has full right of insight into the certification process, and because testing is performed in accordance with test programmes and procedures published by the Association.

In this document (F: 103-7e), the Association specifies what is to be reported when SP carries out inspections at the manufacturer's premises. This can include details of claims lodged with the manufacturer and/or non-compliances with the required specification of the district heating substation. Such cases will be considered by SP's Certification Panel.

Test reports and certificates provide information on the district heating substation's properties and performance, which can be used when assessing the substations. The technical tests do not address the long-term properties of substations, but SP's inspection specifically includes visual examination (as far as possible) and application of its experience of such equipment, to identify potential technical weaknesses that could present an increased risk of leakage or malfunctions during the life of the unit.

These Technical Regulations, F:103-7e, dated April 2009, replace the Association's previous test programme no. F:103-6e of January 2007, and are intended for application to district heating substations for detached houses and apartment buildings

These Technical Regulations, F:103-7e, have been ratified by the Association's Technical Panel.

This document, F:103-7e, is a translation of the original Swedish-language document, F:103-7. In the event of any dispute as to the intended content, the content of the Swedish document shall take precedence.

On behalf of the Swedish District Heating Association
Customer Installations

Conny Håkansson

Contents

1. General

District heating substations are required to fulfil the requirements set out in the latest edition of the Swedish District Heating Association's Technical Regulations no. F:101e, District Heating Substations - Design, Construction and Installation..

Certification and testing shall be performed in accordance with F:103-7e, Certification of District Heating Substations (this document), and in accordance with SP Technical Research Institute of Sweden's rules for certification of district heating substations, SPCR 113.

Certification bodies and their test sites and facilities shall be approved by the Association.

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The Association shall be entitled to receive documentation submitted in connection with certification applications, and to oversee the testing and inspection work of the certification process.

Test sites/organisations carrying out inspections in accordance with F:103-7e shall be accredited for the test methods concerned, and shall be independent organisations. The test site/facilities shall be approved both by the certifying organisation and by the Association. Before a test site/facility can be approved by the Association, it shall first have been approved by the company performing the certification.

The following groups of district heating substations are covered by the certification requirement:

- District heating substations for detached houses
- District heating substations for apartment buildings with up to about 80 apartments.

A certified district heating substation is one that has successfully undergone an impartial examination/inspection of its design, construction, function and performance.

A potential purchaser of a district heating substation must request sight of the unit's certificate and associated test report. The report provides detailed information on the function, construction and performance of the substation.

1.1. Certificates and test reports

An approval certificate will be issued for each type/model of district heating substation that is approved. The certificate indicates the type of system, and the method of testing, for which the unit is certified: see Section 2.1.

Approval indicates that the substation unit fulfils and complies with the technical requirements of the Association, all applicable standards, regulations published by Swedish authorities and EU directives. Certificates have a validity of two years, but can be extended for a further two years, provided that the substation's design. construction and performance are identical to those of the substation that was tested and described in the test report on which the certification certificate was based. Any such extension of validity is always based

on the test methods employed in connection with issue of the original certificate.

The certificate shows the model number, name etc. of the substation, details of the material supplied in connection with the certification process, the number/reference of the test report and the validity of the certificate. District heating substations may not be marketed as certified until the entire certification procedure has been successfully completed. A list of certified substations, their certificates and their test reports, is available on the Swedish District Heating Association's web site.

Certificates can be recalled if defects are found, or problems are encountered, in certified units when in service, whether in the design, construction or function of the units. They can also be recalled if subsequent surveillance inspection shows that the units being manufactured do not conform to the original unit that was tested.

Before a certificate can be issued, the substation concerned must have successfully undergone testing and have received an approved test report, while its manufacturer must have successfully passed a surveillance inspection visit from the certification body. The requirements applicable to the equipment, design and construction of a substation, as described in Section 2.3 and Chapter 4, must be fulfilled and be described in the test report.

These certification rules therefore specify a number of tests, measuring and recording powers, temperatures, volume flows and pressure drops. In addition, certification reports include component lists, with other information on the equipment forming part of the substation

Reports shall also show that the information specified in Section 1.3 of these rules has been provided and confirmed by the manufacturer or by a Notified Body that has been accredited and notified to the European Commission.

The test reports shall be so presented that it is possible to compare test results between similar substation units. Test reports and product marking shall clearly indicate the system data applicable to the certified unit. It shall be possible to compare both static and dynamic data.

The report shall show at least the degree of detail included in test reports as normally prepared by SP. The results of the dynamic test shall be presented in diagrammatic form, showing details of the following measured values: $\mathbf{t_{11}}$, $\mathbf{t_{12}}$, $\mathbf{t_{22}}$, $\mathbf{t_{31}}$, $\mathbf{t_{32}}$, $\mathbf{t_{33}}$. $\mathbf{q_{vv}}$, and $\mathbf{q_1}$. Measured values for t_{vvc} and q_{vvc} shall be given where applicable.

Flows shall be expressed in l/s (litres per second), and temperatures in ^{o}C.

Time axes of graphic dynamic presentations shall be in seconds.

1.1.1. Module certification - apartment buildings

Together with manufacturers, the Association has developed a sector standard for modular units for apartment buildings, consisting of two domestic hot water modules and four space heating modules, which can be combined in various ways to produce a complete district heating substation of the required capacity.

Obligatory inspection

The manufacturer may elect to submit specific combinations or the entire concept for inspection and testing for certification.

If the manufacturer elects to certify the entire concept, documentation for all modules shall be submitted in connection with the application for certification. The certification body will examine the documents. The manufacturer shall then send in two sets for testing: the smallest combination and the largest combination. The control equipment for the two sets shall be of the same make and model, type etc.

Additional inspection

If the manufacturer wants to use other control equipment with the same unit size combinations as submitted for the obligatory inspection, additional inspection is required, as described below for test cases 1, 5.1, 5.2 and 6. The results of these additional inspections shall be presented in the form of appendices to the main report.

Split delivery

If a certified district heating substation is delivered complete with control valves (valves with actuators) and sensors, but without a control unit, certification shall be valid even though the control unit may be supplied by another contractor, and provided that such a substation, for which the control unit will be supplied separately, complies with the function requirements in this document (F:103-7e), and has successfully passed additional inspection as above. The control unit shall be programmed with the same set values as determined in connection with certification testing, and shall use the same software as that used for the certification testing.

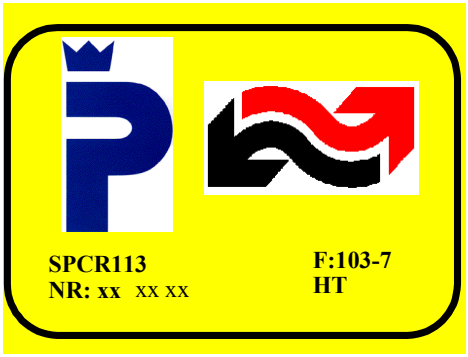
1.2. The certification symbol

The certification symbol indicates that the type of unit to which it is applied is certified. A certified district heating substation must clearly display the certification symbol, applied to it by the manufacturer.

The following certification symbols indicate that the unit has been tested and inspected in accordance with:

- The Swedish District Heating Association's test and specification rules for certification of district heating substations, no.F:103-7 (this document). It also indicates the type of system for which the unit is intended and has been tested. See Section 2.1.
- SP Technical Research Institute of Sweden's regulations for P-marking, SPCR 113.

Figure 1



An example of the certification symbol.

The certificate number as shown on the certification symbol consists of six figures, made up of a unique four-figure manufacturer's number, together with a consecutive certificate number from 01 to 99.

1.3. Documentation

The following information shall be provided when a substation is submitted for certification:

- the unit itself shall be marked with its model name etc., type number and serial number;
- specifications of all components, materials and methods of making joints, connections etc. used in it. Technical Regulations no. F:101e specify the requirements relating to the provision of design information and presentation of data.
- the following details shall be provided for the control equipment (for the domestic hot water function) for both obligatory and additional inspection:
  - the opening and closing times of actuators
  - P-band, I-time and D-time
  - K-value (the controller's gain constant for DUCs)
  - the software version used in the controller
  - set values.
- a schematic diagram and drawings showing the structure and arrangement of the substation, with dimensions and weights;
- a function description / description of operation, and care instructions, as suited to the intended user category;
- details of calculation programs used for the heat exchangers in the unit;
- a Declaration of Conformity for CE-marked substations, with a certificate that the unit has been inspected during manufacture in accordance with the requirements of Table 4 in Technical Regulations no. F:101e;
- substations that may not be CE-marked in accordance with the requirements of the Pressure Vessels Directive (97/23/EC), Article 3 / AFS 1999/4 shall undergo manufacturing inspection in accordance with

the requirements set out in Technical Regulations no. F:101e. This inspection shall be performed by a Notified Body, which shall issue a certificate confirming that the substation is suitable for use with high-temperature systems.

- the manufacturer shall certify, through the provision of test records, that heat exchangers used in the substation fulfil the requirements of Swedish Standard SS-EN 1148, as specified in the Association's regulations no. F:109e.

- The test report shall indicate that the above information, material etc. has been examined and approved.

2. Technical and performance requirements

2.1. Technical system data

The Association's technical regulations for district heating substations for high-temperature (HT) systems specify the following primary side rating and design data:

Rating data:	100 °C and 1,6 MPa	
Design data:	System temperature	120 °C
	Design pressure 1,60 MPa	
	Maximum pressure drop	0,60 MPa
	Minimum pressure drop	0,10 MPa

2.2. Differential pressures in district heating systems

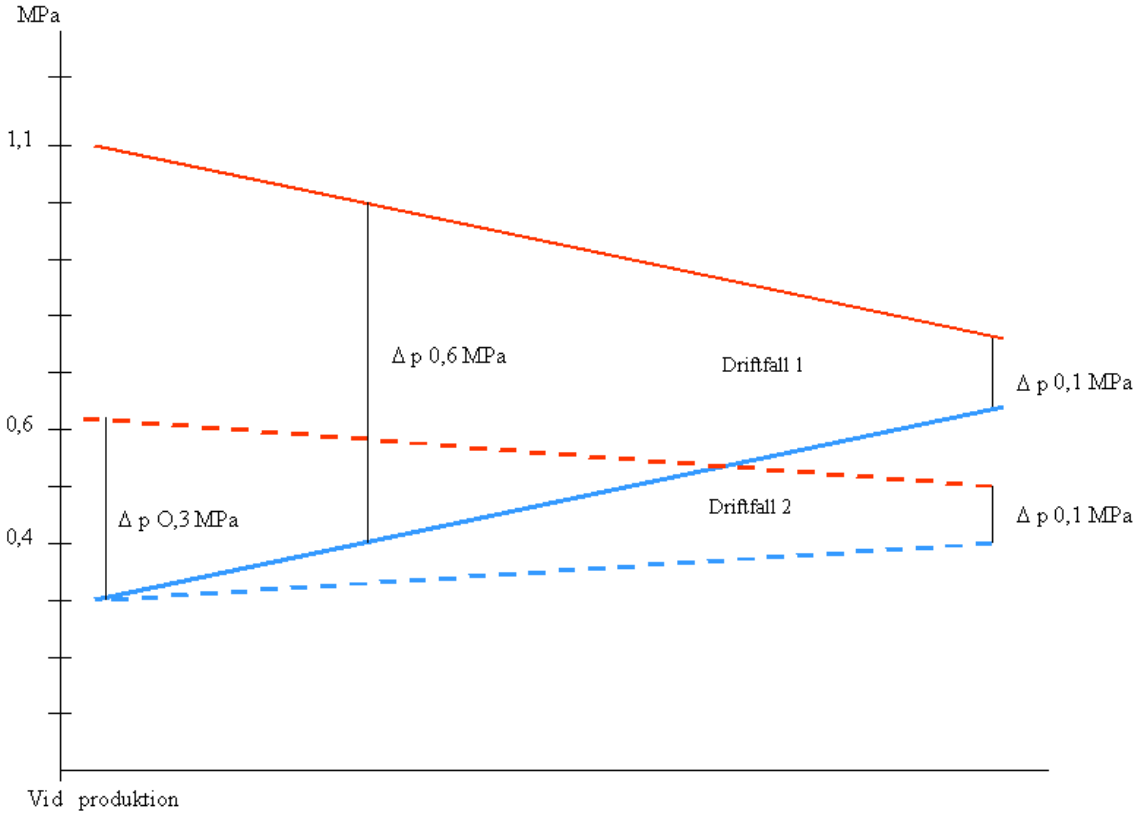
District heating substations connected to public district heating systems must meet the design and operating conditions and strategies of the distribution system. The following diagram shows the differential pressures and static pressures that can occur in high-temperature systems at different times of the year. In the case shown in the diagram, it is assumed that the heat production plant is connected to the system at one point only. If there are several production plants, they can be connected to the system at other points, with the result that the differential pressures in the system become more complicated. Depending on which production units that are in operation at any particular time, substation units may experience either high or low differential pressures.

The system operator (heat supplier) can take steps to restrict the differential pressure. This may be done either individually for individual substation units, or jointly for an entire distribution area.

Normally, high-temperature substations are certified for 0,60 MPa or 0,10 MPa differential pressures. They can also be certified, if required, for a differential pressure of 0,80 MPa.

The control valve shall have sufficient authority to be able to maintain stable control throughout the operating range in all operational cases used for the tests.

Differential pressures in district heating supply systems



This diagram is for illustration only, and is not to scale

2.3. Equipment and construction of district heating substations

The Association's regulations in respect of the design, construction and materials in substations apply for all sizes of substations. Equipment for load and temperature control of space heating and domestic hot water supplies shall fulfil the function requirements as set out in the Association's Technical Regulations no. F:101e.

The Association's Technical Regulations no. F:101e set out the requirements in respect of the design and equipment of substations.

The pressure drops at 100 % design load across heat exchangers used in district heating substations shall not exceed the following values:

- for the domestic hot water system: primary and secondary sides < 25 kPa
- for the space heating circuit: primary side < 25 kPa, secondary side < 15 kPa.

Isolating valves on the primary side shall comply with the requirements specified in the Association's Technical Regulations no. F:101e. It shall be possible conveniently and safely to service or replace equipment. Isolating valves in the primary circuit shall be clearly identified as such.

Manufacturers shall be able to confirm that methods of jointing, connections, sealing materials, gaskets, pipe materials and valves and fittings fulfil the requirements set out in the Association's Technical Regulations. Connectors that incorporate washers, packings, gaskets etc. shall be designed so that they actively centre any such washers, packings or gaskets etc. used in them, so that the entire sealing area is covered by the washer, packing or gasket etc., and which cannot be displaced from its correct position.

The design of connections and sealing surfaces shall be appropriate to the type of material used in the connected pipes, and to the substation's design data.

The relief pressures of safety valves, forming part of the equipment of the substation in the space heating and domestic hot water systems, shall be stated in the report. Safety valves in certified substations may be capable of being set to operate at relief pressures other than those given in the report..

It shall be possible to perform tradesman-quality erection and service work without risk of distorting or otherwise damaging the piping. Equipment intended for operation, supervision, indication or inspection shall be clearly visible and easy to read. Components that may need to be operated during use shall be positioned such that contact with hot surfaces is avoided. Electronic equipment shall not be subjected to higher temperatures than that for which it is intended..

2.3.1. Equipment

See F:101e for requirements relating to equipment for detached house substations.

Substations for apartment buildings are constructed from modules: see 1.1.1 above, and Section 4, Tables 1b and 2b.

The modules shall be equipped as follows:

Primary side

- Filter
- Pressure measurement connection point
- Metering arrangements in accordance with F:101e. The thermometers may be omitted if the temperature is displayed on the metering integrator. A thermometer shall be fitted in the return district heating water connection from the space heating heat exchanger.
- Space heating heat exchanger
- Domestic hot water heat exchanger
- Control equipment for the space heating system
- Control equipment for the domestic hot water system
- Space for a flow sensor
- Necessary drain and vent valves and connections.

Space heating side

- The module unit does not include a circulation pump
- Module units for apartment buildings do not include expansion vessels, pressure gauges or safety valves
- A filling valve, with a Type EB check valve in accordance with SS-EN 1717, shall be fitted. (A Type EA valve may also be used.)
- Filter

Domestic hot water system

- Isolating valve, check valve and safety valve in the incoming cold water supply to the heat exchanger. The check valve shall be of Type EB, in accordance with SS-EN 1717: a Type EA valve may also be used.
- Domestic hot water circulation pump
- Temperature display for the domestic hot water and for the circulation system.

2.4. Comfort requirements

The delivery of hot water within a reasonable time of turning on the tap is a basic comfort requirement, as is the requirement that no primary water flow should pass through the substation unit when there is no load on it. For this purpose, an unloaded unit is one which is not being called on to supply space heating, domestic hot water or domestic hot water circulation.

District heating substations for detached houses that do not have a domestic hot water circulation system shall include a temperature-holding function that maintains the temperature in the service connection at such a level that the unit can respond quickly to a demand for domestic hot water. This function shall be activated when there is no demand for space heating.

This no-load flow shall cease when the temperature on the primary side ($\mathbf{t_{11}}$) and the domestic hot water side ($\mathbf{t_{32}}$) of the heat exchanger reaches 50 °C. As there is no flow of domestic hot water while the no-load performance is being tested, the heat exchanger will settle with the same temperature on the primary and the domestic hot water sides.

The manufacturer may arrange for the no-load function to be activated either in response to temperature or after a time interval. See F:101e, Appendix 5.

The test report for the unit shall describe how temperature maintenance is provided, how it is controlled, and how the domestic hot water temperature from the heat exchanger is measured.

If the no-load function is provided by means of a direct connection between the primary supply and return connections, without the water passing through the heat exchanger, the no-load control valve shall close at a maximum temperature of 45 °C ($\mathbf{t_{12}}$).

The report shall state whether the resulting temperature maintenance flow is metered by the substation's heat meter or not.

Temperature maintenance systems in district heating substations installed in hard water areas shall not be of such a design as to create a risk of lime build-up in the heat exchanger, and nor may the domestic hot water temperature at taps exceed 60 °C.

2.5. Heat metering

In their technical documentation, manufacturers of district heating substations shall give details of the measuring ranges of the flow meters in/for the heat meter. The Association's Technical Regulations no. F:104e, Heat Meters - Technical Requirements and Advice on Meter Installation, specify requirements in respect of necessary lengths of straight pipes and positions of temperature sensors. Certified district heating substations shall comply with these requirements.

The pressure drop across the meter's flow sensors shall be allowed for when balancing the pressure drops across the other components of the substation..

3. Test method

3.1. Assumptions and preparations

Test the substation, which shall be of the same type as the units covered by the certificate, in the same position (i.e. vertically, horizontally etc.) as when it is installed in a building.

The substation's pipes and pressure vessel shall be filled and pressurised during the tests.

The test rig's instrumentation shall record the substation's static and dynamic functions and performance at various loads.

For a pressure drop of 0,60 MPa, the static pressure at the primary side supply connection of the test rig shall be 1,00 MPa.

For a pressure drop of 0,10 MPa, the static pressure at the primary side supply connection of the test rig shall be 0,50 MPa.

If the test is to be performed with a pressure drop of 0,80 MPa, the static pressure at the primary side supply connection shall be 1,40 MPa.

The static pressure of the incoming cold water supply to the domestic hot water heat exchanger shall be 0,40 MPa.

Measure the pressure drop across the substation, to include the heat meter flow sensor. State values of measured pressures in the certification testing report with the following accuracy, e.g. 0,10 MPa.

The test method is intended to reflect the different operating cases for the district heating supply system and the building's energy use:

- The technical system data to be used for the tests.
- Perform the tests at supply temperatures of (for example) 65 °C and 100 °C on the primary side.
- Measure pressure drops, flows and temperatures at the specified power ranges.

The substation shall be able to deliver its rated powers with low or high pressure drops in the district heating system. Even with low outdoor temperatures, pressure drops in the district heating system can be low or high, depending on the design of the system and the distance from heating plants.

Start testing by pressure-testing the substation with cold water on the district heating side at a pressure of 1.43 times the design pressure for 30 minutes

Inspect the control valves, to ensure that they are tight when closed against the specified pressure drop. See the table in Section 2, Technical System Data.

Decide on the setting parameters for the control equipment, set them and note them in the test report: see Section 1.3. The set value for domestic hot water temperature is 50 °C for detached houses and 55 °C for apartment buildings.

The substation control equipment shall have the same settings for all operating conditions to be tested. It shall be easy to locate the necessary positions on the tested components, as needed in order to set the values that have been decided on for the tests.

Substation units intended for apartment buildings include a circulation pump for hot water, and units intended for detached houses may also have such a pump. The temperature of the domestic hot water in the circulation system shall be 50 °C at the point where it is connected to the district heating substation.

The circulation pump shall be in operation during the dynamic performance tests of the substation.

As the space heating circuit is powered by the circulation pump in the test rig, replace the circulation pump in the substation by a pipe link for the purposes of the tests.

Measure and note the lengths of the straight runs of pipe upstream and downstream of the position of the flow sensor, and also note if the flow sensor is intended to be mounted horizontally or vertically. Fit a spacer with a pressure drop of 25 kPa in the substation unit for the test with a flow of 0,28 l/s.

4. The tests

The total group of tests of the substation to be performed in the test rig is as follows:.

- Inspection of conformity of the substation's primary circuit with the requirements of F:101e
- Static performance tests of the space heating and domestic hot water parts of the unit: Test Cases 1, 2 and 3.
- Dynamic performance tests of the domestic hot water function: test cases 4, 5 and 6, with special function requirements for domestic hot water comfort for substation units for detached houses.
- Checking the installation position of the heat meter.

Dynamic testing of district heating substations for detached houses not having domestic hot water circulation systems

Load changes occur in the hot water system during the dynamic performance tests in accordance with the draw-off rates and durations specified in Section 4.3. The system shall respond to these changes within two seconds. In this context, the load change time is the time needed to re-establish steady-state hot water flow conditions after a load change.

Conditions are regarded as stable when the temperature settles within ±1 °C.

Measure the temperature of the domestic hot water at its point of delivery from the heat exchanger ($\mathbf{t_{32}}$) This is also the test point for checking the performance of the temperature regulator: the temperature at this point shall not exceed 65 °C for more than ten seconds, measured as the time from when the temperature exceeds 65 °C until it has again fallen below 65 °C.

Measure the temperature of the domestic hot water at the point of discharge from the heat exchanger ($\mathbf{t_{32}}$). This shall also be the point where the performance of the control system shall be measured.

In order to ensure accurate measurement of the temperature at $\mathbf{t_{32}}$, the rate of measurement shall be at least 5 Hz.

Test point $\mathbf{t_{33}}$ represents the tap to which the hot water is being supplied, at which point the temperature may not exceed 60 °C, or be less than 50 °C, after steady state conditions have been reached.

Dynamic testing of district heating substations with domestic hot water circulation systems

This dynamic test involves domestic hot water load changes in terms of draw-off durations and rates as described below in Section 4.3. Domestic hot water load changes shall be made within three seconds. For this purpose, a load change is the time required to reach steady-state domestic hot water flow rate conditions.

Conditions are regarded as stable when the domestic hot water temperature has settled within ±2,5 °C.

Note the maximum flow in the circulation connection when no domestic hot water is being drawn off. Maintain the temperature at 50 °C.

The maximum flow rate in the circulation circuit for a detached house during the test shall be 31 l/h (0,009 l/s).

The maximum flow rate in the circulation circuit for the V1 domestic hot water module shall be 145 l/h (0,040 l/s), while that for the V2 module shall be 487 l/h (0,135 l/s).

The circulation flow is reduced when hot water is being drawn off. Note the circulation flow rate when hot water is being drawn off at 50 % of the design flow rate, and also at a draw-off rate of 0,1 l/s.

4.1. Static testing of the space heating circuit capacity

Perform static testing in order to investigate the capacity of the substation to meet a specified space heating load.

The hot water circulation pump on substations having a circulation function shall not be in operation during the static test.

System temperatures

Test point designation		**HT** [ºC]
Primary supply connection	t_{11}	100
Primary return connection	t_{12}	$\leq t_{21}+3$ *
Secondary supply connection	t_{22}	80 (70)
Secondary return connection	t_{21}	60 (30)

* $\leq t_{21}$ + 5 for heat exchangers with (70-30) temperature rating

4.1.1. Units for detached houses

Table 1a Test cases for detached houses

Test Cases	**Temperatures** [^{o}C]	**Load** Power as percentage of nominal [%]
1	100-x / 60-80	100
2	65-x / 45-55	50

Measure Test Cases 1 and 2 in Table 1a at the lower pressure drop of 0,10 MPa.

The primary return temperature for the 100-x/60-80 case must not exceed 63,0 °C.

4.1.2. Apartment buildings

Table 1b Test cases for apartment buildings (HT systems)

Test cases	Temperature rating [°C]	Module R1 [kW]	Module R2 [kW]	Module R3 [kW]	Module R4 [kW]
1	100-x / 60-80 100 -x / 30-70	80,0	125,0	230,0	365,0
2	65- x / 45-55 65-x / 35-55	11,5	40,0	62,5	115,0
Recommended control valve, k_{vs}		1,6	2,5	4	10
Guide values for number of apartments		≤ - 18	19 – 28	29 – 51	52 – 80

Test case 1 = 100 % power for the heat exchanger.

Make test case measurements 1 and 2 in Table 1b at the lower pressure drop of 0,10 MPa.

The primary return temperature for the 100-x/60-80 case must not exceed 63,0 °C.

The primary return temperature for the 100-x/30-70 case must not exceed 35,0 °C.

The $\mathbf{k_{vs}}$ values for the control valves should be as shown in Table 1b. However, if it would be more suitable to use a control valve having a lower $\mathbf{k_{vs}}$ value in the actual installation in a building, this can be accepted provided that the alternative valve is of the same make and type. Details of the valves must be given in the test report submitted for the certificate.

Calculate the pressure drops across the primary and secondary side of the heat exchangers using the deign program supplied to the test site by the manufacturer, and state the results in the report.

4.2. Static testing of the domestic hot water production capacity

Perform the static test in order to investigate the ability of the unit to meet a specified hot water load.

If the system has a hot water circulation pump, it shall not be in operation during the static test.

4.2.1. Detached house units

Perform static tests of domestic hot water heat exchangers in units for detached houses under Test Case 3 conditions, with a hot water flow rate of 0,2 l/s and a pressure drop of 0,10 MPa.

The following additional test may be performed, but are not obligatory for certification.

The manufacturer can request an additional test to show how much domestic hot water that the heat exchanger can supply with a primary return temperature of 22 °C. If this test is performed, the pressure drop shall also be measured and stated in the report.

The manufacturer may also request an additional test of the performance with a domestic hot water flow of 0,3 l/s, measuring the primary return water temperature. If this test is performed, the pressure drop shall also be measured and stated in the report.

Table 2a Test case for detached house units

Test case	Temperatures [°C]	Domestic hot water flow [l/s]
3	65 – x / 10-50[1)]	0,2

Primary return temperature for detached house units: $t_{12} \leq 22$ °C

1) 55 °C for units with hot water circulation

4.2.2. Apartment buildings

Test apartment building domestic hot water heat exchangers under Test Case 3 conditions, with a domestic hot water flow as shown in Table 2b and a pressure drop of 0,10 MPa.

Table 2b Test cases for apartment building unit modules

Test case	Module	No. of apartments	Temperature rating	Power [kW]	Domestic hot water flow [l/s]
3	V 1	<23	65-x / 10-55	80	0,430
3	V 2	< 80	65-x / 10-55	140	0,760

Primary return temperature for apartment building units: $t_{12} \leq 22$ °C

The manufacturer selects the control valve for domestic hot water modules V1 and V2. Select k_{vs} values as needed in order to provide the powers and domestic hot water flow rates shown in Table 2b.

4.3. Dynamic testing of the domestic hot water function

Perform the dynamic tests at two different space heating loads and with varying hot water draw-off rates. Before starting the dynamic tests, draw off domestic hot water in order to establish steady-state conditions. The following sections show the draw-off cycles of domestic hot water flow rates to be used in the tests.

4.3.1. Detached house units

Test case: 4 = 50 % of space heating load pressure drop 0,10 MPa
5.1 = 100 % of space heating load pressure drop 0,10 MPa
5.2 = 100 % of space heating load pressure drop 0,60 MPa

Test Cases 4 and 5 apply for the following domestic hot water flow rates and durations:

0 l/s 100s - **0,1 l/s** 300s - **0,2 l/s** 300s - **0,1 l/s** 300s - **0 l/s** 300s

4.3.2. Apartment buildings

Perform the tests at Test Cases 4 and 5 in accordance with the following table for selected combinations of domestic hot water modules V1 and V2 and space heating modules R1, R2, R3 and R4.

Table 3 Test cases for apartment buildings

Test case	Primary supply temperature [°C]	Pressure drop	Power
4	65	Δ $\mathbf{p_1}$= 0,100 MPa	50% of R-module rated power
5.1	100	Δ $\mathbf{p_1}$= 0,100 MPa	100% of R-module rated power
5.2	100	Δ $\mathbf{p_1}$= 0,600 MPa	100% of R-module rated power
6	65	Δ $\mathbf{p_1}$= 0,100 MPa	0% of R-module rated power

Perform the tests at test cases 4, 5.1 and 5.2 with the following domestic hot water flows and durations:

Module V1 **0 l/s** 200s - **0,1 l/s** 300s - **0,215 l/s** 300s - **0,1 l/s** 300s – **0 l/s** 300s

Module V2 **0 l/s** 200s - **0,1 l/s** 300s - **0,380 l/s** 300s - **0,1 l/s** 300s – **0 l/s** 300s

Test Case 6 applies for the following domestic hot water flows and durations:

Module V1 **0 l/s** 200s - **0,1 l/s** 200s - **0,215 l/s** 50s - **0 l/s** 100s - **0,215 l/s** 50s – **0 l/s** 100s - **0,215 l/s** 50s - **0 l/s** 400s

Module V2 **0 l/s** 200s - **0,1 l/s** 200s - **0,380 l/s** 50s - **0 l/s** 100s - **0,380 l/s** 50s - **0 l/s** 100s - **0,380 l/s** 50s - **0 l/s** 400s

4.3.3. Domestic hot water temperature for Test Cases 4 and 5

The requirement is that the temperature at $\mathbf{t_{32}}$ shall stabilise within 100 s of a temperature change starting to occur at $\mathbf{t_{32}}$. In this context, 'stabilisation' permits a variation in the temperature of ±1 °C from the expected mean value within the specified temperature range, without domestic hot water circulation. With circulation, the permitted variation is ± 2,5 °C.

For detached houses, temperature variations at $\mathbf{t_{32}}$ higher than 65 °C can be accepted for a maximum of 10 seconds during the settling period after each

load change: for apartment buildings, the corresponding permitted duration is 30 seconds. However, the objective is that a temperature of 65 °C should not be exceeded.

When steady-state conditions have been reached, the domestic hot water temperature at test point $\mathbf{t_{33}}$ must not exceed 60 °C or fall below 50 °C.

For detached houses, the temperature at test point $\mathbf{t_{32}}$ shall stabilise within the temperature range of 50 - 60 °C, while for apartment buildings/commercial premises it shall stabilise at 55 ± 2,5 °C.

4.3.4. Domestic hot water functions for detached house units

Always being able to obtain domestic hot water within a reasonable time of turning on the tap is a basic comfort requirement. During those times of the year when no space heating is required, or at times when no domestic hot water is being drawn off, various types of temperature-holding functions come into operation in order to ensure that domestic hot water will be quickly available. These functions have been previously described in Chapter 2, Technical and Performance Requirements.

4.3.4.1. Testing the control equipment at low domestic hot water flow rates

Hot water is sometimes drawn off at extremely low flow rates. Test the ability of the system to meet this condition by measuring the temperature at test point $\mathbf{t_{32}}$ at a flow rate of only 0.02 l/s. Measure the temperature at test point $\mathbf{t_{32}}$ under this condition, with a design supply temperature of 65 °C and no space heating load. Repeat the test for the lowest design value of pressure drop, as specified in Chapter 2.

4.3.4.2. No-load characteristics of units not having domestic hot water circulation systems

With no space heating load, draw off domestic hot water at a rate of 0,2 l/s and then turn off the hot water. Measure the primary flow rate and the primary supply and return temperatures until steady-state conditions have been reached, for at least three hours. In this context, steady-state conditions mean that at least two supply/return temperature variation cycles have been observed or, if no cycle can be observed, that the average values of the supply and return temperatures have not changed by more than ± 3 °C for an hour. The feature of cycles is that the primary flow varies periodically.

Chapter 2 specifies the requirements applicable to the no-load function.

Carry out this test at a temperature of 65 °C in the primary supply connection, and at the minimum pressure drop design value, as described in Chapter 2.

The maximum duration of this test shall be six hours.

4.3.4.3. Domestic hot water response time for units not having hot water circulation

Immediately after testing the no-load characteristics, carry out a test to measure the time taken until a steady-state supply of domestic hot water at the correct temperature is obtained. When steady-state conditions, without domestic hot water draw-off or space heating load, have been established, draw off domestic hot water at a flow rate of 0.2 l/s. The requirement is that the temperature at test point $\mathbf{t_{32}}$ shall have stabilised within 100 s of turning on the tap.

For this test, the substation's service connection is represented by the connection hoses from the test rig.

4.3.5. Observations on the domestic hot water temperature for Test Case 6

Test Case 6 is a dynamic test case, intended to determine the function of the substation under operating conditions consisting only of brief draw-offs of hot water, and no space heating load. It is preformed only on units for apartment buildings, and records the performance of the substation.

Measure and assess the following:

- What is the value of the district heating return water temperature, $\mathbf{t_{12}}$?
- How well does the substation maintain good comfort while at the same time meeting the temperature requirements for domestic hot water and domestic hot water circulation?

This test reveals the abilities of the substation. Low temperatures in the district heating system return connection and a stable domestic hot water temperature provide good comfort and low running costs.

4.4. Pressure drops across the substation

Record the pressure drop across the substation for each operating case. Measure the pressure drops between the supply and return connections on the space heating side, and between the hot and cold water supplies from and to the test rig. The pressure drops to be noted in the report include those across the heat exchangers, control equipment, pipes, valves and fittings and the flow sensors for the heat meter.

4.5. The installation position and measurement range of the heat meter

District heating substations for detached houses shall have DN 15 flow sensors, with G ¾ B threaded connections and an overall length of 110 mm.

For apartment buildings, select flow sensors in accordance with EN 1434-2, Table 3, and with the Association's Technical Regulations for Heat Meters, no. F:104e.

Fit the meter display in such a position that it can be easily read.

5. Manufacturing inspection

The certification body's surveillance inspection visits to companies include inspection to ensure that substations comply with the sector requirements set out in the Association's Technical Regulations nos. F: 101e and F:103-7e.

Examine and assess the company's quality management system. Note any claims lodged with the company and details of the company's response.

The work includes follow-up monitoring to ensure that certified substations put on the market comply with the specification of the actual unit that was submitted for certification testing.

Prepare reports from manufacturing inspection and surveillance inspection and send them to the manufacturer and to the Swedish District Heating Association. Reports will be presented and discussed at the meetings of the Certification Panel.

6. Modifications to substation designs

If the manufacturer wishes to modify an existing certified design of substation, this shall be notified in writing to the certification body without delay. In general, any non-compliant equipment, or modifications that can affect function of the unit, will require renewed assessment if they have not been declared in connection with certification.

In conjunction with the manufacturer, the certification body will decide whether the proposed modifications require renewed inspection/assessment, or whether compliance with the requirements of the test programme can be verified in some other way. The certification body will then complement the report upon which certification is based, and notify the Association of the results. Any additional tests, together with evaluation and decisions, shall be documented and presented.

The following are examples of what are regarded as extensive changes:

- The fitting of controllers/valve actuators/control valves having a different function or design, and/or from a different manufacturer.
- The fitting of heat exchangers of a different type or from a different manufacturer.

7. The Certification Panel

The duty of the Certification Panel is to deal with matters relating to certification, appeals or disputes, and to provide recommendations and material for decisions, e.g. concerning the recall of certificates. Discussions are treated as commercially confidential, except those relating to products that are marketed or available on the market.

The panel consists of two representatives from the certification body and two from the Swedish District Heating Association. The certification body is the convening party for the panel, and holds the chair and secretary positions on the panel. The panel meets at least twice a year, with each representative having one vote.

8. Test rig arrangement and uncertainty of measurement

The test report shall include a schematic diagram of the test rig that has been used for certification testing.

The maximum permissible total uncertainties of measurement for the sensors, installation and system voltmeters in the test rig are:

Differential pressure	± 1 kPa
Temperature	± 0,1 °C
Volume flow	± 1,5 %

The time constant of the temperature sensor for $\mathbf{t_{32}}$ shall not exceed 1.5 seconds.

Temperature sensors, volume flow meters and pressure drop sensors shall normally be calibrated at least once a year. Instrumentation shall be tested before each set of tests.

9. Designations

P1	Power, primary side	[kW]
$\mathbf{P_2}$	Power, space heating system	[kW]
$\mathbf{P_3}$	Power, domestic hot water	[kW]
$\mathbf{t_{11}}$	Temperature, primary side supply connection	[°C]
$\mathbf{t_{12}}$	Temperature, primary side return connection	[°C]
$\mathbf{t_{21}}$	Temperature, space heating system return connection	[°C]
$\mathbf{t_{22}}$	Temperature, space heating system supply connection	[°C]
$\mathbf{t_{31}}$	Temperature, cold water	[°C]
$\mathbf{t_{32}}$	Temperature, domestic hot water leaving heat exchanger	[°C]
$\mathbf{t_{33}}$	Temperature, domestic hot water 5 m from heat exchanger (det. house)	[°C]
$\mathbf{t_{33}}$	Temp., domestic hot water 25 m from heat exchanger (apt. building)	[°C]
$\mathbf{t_{vvc}}$	Temperature, substation connection for hot water circulation system	[°C]
$\mathbf{q_1}$	Volume flow, primary side	[l/s]
$\mathbf{q_2}$	Volume flow, space heating system	[l/s]
$\mathbf{q_3}$	Volume flow, domestic hot water	[l/s]
$\mathbf{q_{vvc}}$	Volume flow, hot water circulation system	[l/h]
$\Delta\mathbf{p_1}$	Pressure drop across entire substation unit	[MPa]
$\mathbf{\Delta p_2}$	Pressure drop, space heating system	[MPa]
$\mathbf{\Delta p_3}$	Pressure drop, domestic hot water	[MPa]

10. Presentation of results

After each test, prepare a test report showing the results against the requirements specified in F:103-7e.

Present the results of dynamic tests in diagram form, with values as specified in Section 1.1. Diagram scales shall be the same for all certification tests on substations for detached houses and for apartment buildings.

Record notes, details of any actions taken, and observations during the tests under 'Other Information' in the test report.

Summarise the results as follows: **Complies / Does Not Comply with the requirements of the test programme**.

This means that a certified substation complies with the requirements of the Swedish District Heating Association's Technical Regulations no. F:103-7e and with the certification requirements in SP's document no. SPCR 113.

On completion of the tests, the manufacturer/client requesting the tests receives a test report and, if the tests are successful, a certificate. From the certification body, the Swedish District Heating Association receives:

- A copy of the test report, with documentation as described in Section 1.3. The report is submitted in the form of a write-protected PDF file.
- Measured values from the certification tests, which provided the basis for the test report.
- Reports from surveillance visits for manufacturing inspection, with details of non-compliances or shortcomings that have been reported in connection with the certified product.

The Association lists names etc. of certificate-holders and test reports for approved district heating substation units on its web site www.svenskfjarrvarme.se.

11. Model form of test report

1. Work requested

On behalf of _____, XX has tested a district heating substation, manufactured by _____.

The work has included examination of the manufacturer's documentation submitted with the application, in order to ensure that it complies with the substation's equipment, and also to ensure that the equipment complies with the requirements in the Swedish District Heating Association's Technical Regulations nos. F:101e and F:103-7e.

2. Item for testing

Supplier:
Manufacturer:
Type:
Serial number:
Year of manufacture:
Regulator: … (version)

This substation unit is of the following type: _____
The unit has been tested for operation with a pressure drop range of _____ MPa.

2.1 Substation design data

<u>Design pressure</u>	
Primary side:	MPa.
Secondary side, space heating:	MPa.
Secondary side, domestic hot water:	MPa
<u>Design temperature</u>	
Primary side:	^{o}C
Secondary side, space heating:	^{o}C
Secondary side, domestic hot water:	^{o}C

[Picture of test object]

Figure 1. A district heating substation unit

2.2 Documents accompanying the item for testing

The following documents etc. have been examined to check their conformity with the district heating substation tested and its equipment, and that the equipment complies with the Association's Technical Regulations F:103-7e:

- Marking of the substation with its model name/type/number etc. and serial number.
- Specifications of all components, materials and methods of jointing.
- The following performance details and characteristics of the control equipment, as needed for obligatory and additional inspection:
  - Opening and closing times for the valve actuator for domestic hot water temperature control.
    Opening time: _____s Closing time: _____s
  - P-band……., I-time ……, D-time ……..
  - K-factor (for DUC) …….
  - Software version in the control unit ……...
  - Set value: domestic hot water temperature
    ……
- A schematic diagram of the connection arrangement, and a general arrangement drawing of the unit and its equipment, with dimensions and weights
- A function description and operating and care instructions, as appropriate for the intended type of user.
- Design information for heat exchangers.
- A declaration of conformity for CE-marked substations, as required by the requirements of the Pressure Vessels Directive (97/23/EC) and a certificate of approved manufacturing inspection in accordance with the requirements of Table 4 in F:101e.
- For district heating substations that are not CE-marked in accordance with the Pressure Vessels Directive (97/23/EC, Article 3), a statement that manufacturing inspection has been performed by a Notified Body
- A statement, together with the relevant test results, that heat exchangers of the same type as those fitted in the district heating substation fulfil the requirements of SS-EN 1148 with a temperature programme in accordance with the Swedish District Heating Association's Technical Regulations no. F:109e.

2.3 Place and date of testing

Testing was performed by …… on ……..[date]

The item for testing arrived at ……... on ……, and was in good condition when received.

2.4 Method of testing

This district heating substation has been tested in accordance with the Swedish District Heating Association's Technical Regulations no. F:103-7e.

3. Test rig equipment and arrangement

The following equipment was used for the tests:

…

3.1 Measured data acquisition, static measurements

Measured values have been recorded for at least 60 seconds, after steady-state conditions have been established. For this purpose, steady-state conditions are regarded as having been achieved when individual temperatures are within ±0,5 K of the mean values, and mass flow is within ±1,5 % of its mean value. Recorded measured values are, in turn, the mean values of at least 60 instantaneous measured values, at a sampling rate of 1 Hz.

3.2 Measured data acquisition, dynamic measurements

The sampling rate of dynamic measurements at test points $\mathbf{t_{32}}$ and $\mathbf{t_{33}}$ has been at least 5 Hz.

The time constant of the temperature sensors at test points $\mathbf{t_{32}}$ and $\mathbf{t_{33}}$ was ≤ 1,5 s, corresponding to 63 % of the final value of a temperature change from 10 °C to 90 °C.

The time constant of the flow meter that measured the domestic hot water flow was ≤ 0,2 s.

The static pressure of the incoming cold water supply from which domestic hot water was heated by direct heat exchange was 0,4 MPa.

The test rig had two parallel-connected solenoid valves for controlling the hot water flow: each valve passing a fixed preset flow, to suit the particular type of substation being tested. The flow change for hot water loads occurred in less than 1,5 seconds. The total time constant of the hot water system measured in the tests, and under the specified conditions, was that of the test rig and the substation under test together.

Results presented in diagrammatic form are also confirmed by presentation in the form of numerical values.

3.3 Domestic hot water control system

For detached houses

The district heating substation described in this report is intended for direct (on-demand) heating of hot water: this means that incoming cold water at a temperature of about 10 °C is heated directly in a heat exchanger to about 50 °C. The temperature of the hot water has been measured at test point $\mathbf{t_{32}}$, which is the connection point for delivery of the hot water supply from the substation, i.e. to the distribution system in the house.

The temperature of the domestic hot water was measured at test point $\mathbf{t_{33}}$ in the same pipe as that for $\mathbf{t_{32}}$, at a distance of 5 m from $\mathbf{t_{32}}$. The hot water pipe in the test rig was an uninsulated 22*3 mm PEX pipe.

For apartment buildings

The district heating substation described in this report is intended for direct (on-demand) heating of hot water: this means that incoming cold water at a temperature of about 10 °C is heated directly in a heat exchanger to about 55 °C. The temperature of the hot water has been measured at test point $\mathbf{t_{32}}$, which is the connection point for delivery of the hot water supply from the substation, i.e. to the distribution system in the building.

The domestic hot water test circuit consisted of a hot water pipe test arrangement and a hot water circulation system, in the form of three insulated riser mains, all similar.

The hot water pipe consisted of:
- a 4 m long copper pipe, of size 70*2,0 mm, and
- a 6 m long copper pipe, of size 28*1,2 mm.

Each riser in the hot water circulation system consisted of:
- a 4 m long copper pipe, of size 70*2,0 mm.
- a 6 m long copper pipe, of size 28*1,2 mm
- a 1 m long copper pipe, of size 70*2,0 mm.
- a 1 m long copper pipe, of size 70*2,0 mm.
- a 1,5 m long copper pipe, of size 28*1,2 mm.

The last two pipes (above) could be shunted, i.e. short-circuited when testing domestic hot water module V1.

The domestic hot water temperature at the tap position (test point $\mathbf{t_{33}}$) was measured at the hot water pipe between $\mathbf{t_{33}}$ and $\mathbf{t_{32}}$. A cooler was installed in order to ensure a temperature of 50 °C in the circulation system return connection.

3.4 Uncertainty of measurement

Uncertainty of measurement was estimated as better than the following values:

Differential pressure, 0-100 kPa	±… kPa
Temperature, 0-100 °C	±…°C
Flow	±…%
Power (Δt = 10,0 ºC)	±…%
Power (Δt = 20,0 ºC)	±…%
Pressure, 0-7 MPa	±… MPa

4. Presentation of results

After each test, the results were assessed in order to decide whether the item under test complied with the requirements set out in F:103-7e, grading the results into two categories only: **Complies / Does Not Comply with the requirements of the test programme**. All requirements must be fulfilled if a certificate is to be issued for the substation under test.

4.1 Test results

The test results given in this report relate only to the specific substation unit that was tested, of ..... manufacture, type ..... and with serial number .....

4.1 Equipment and construction

The substation's equipment and construction were compared with the requirements set out in Technical Regulations nos. F:101 and F:103-7e, Section 2.3.

Seals, gaskets etc. **Comply / Do Not Comply** with the requirement that the entire joint surface shall be covered, and that it shall not be possible to displace, or fail to locate, the seals, gaskets etc. from/in their intended positions.

*Results: The equipment and its assembly **Comply / Do Not Comply** with the requirements of the test programme.*

4.2 Pressure testing

The primary side was pressure-tested at 2,29 MPa (1,43 * the design pressure of 1,6 MPa).

Results: No leakage.

4.3 Control valve performance

Tightness of the control valve for the space heating circuit at a pressure difference of 0,60 or 0,80 MPa when closed:
Results: No leakage.

Tightness of the control valve for the domestic hot water circuit at a pressure difference of 0,60 or 0,80 MPa when closed:
Results: No leakage.

4.4 Static testing of the space heating capacity

Table 1 shows the measured values from the two test cases specified in Section 4.1 of the test programme. The thermal powers shown in the table are calculated values.

Test Case 1 was tested at 0,10 MPa primary differential pressure, with a space heating load of 100 % of P_{nom}.

Test Case 2 was tested at 0,10 MPa primary differential pressure, with a space heating load of 50 % of P_{nom}.

Table 1

Test case	Primary t_{11} [°C]	t_{12} [°C]	q_1 [l/s]	P_1 [kW]	Secondary t_{21} [°C]	t_{22} [°C]	q_2 [l/s]	Δp_2 [kPa]	P_2 [kW]
1									
2									

The test programme requirements:

Detached houses:

$t_{12} - t_{21} \leq 3$ °C at 100 % of P_{nom} for 60-80 °C space heating temperatures.

Apartment buildings:

$t_{12} - t_{21} \leq 3$ °C at 100 % of P_{nom} for 60-80 °C space heating temperatures.

$t_{12} - t_{21} \leq 5$ °C at 100 % of P_{nom} for 30-70 °C space heating temperatures.

Results:
*The recorded measured values **Comply / Do Not Comply** with the requirements of the test programme.*

4.5 Static testing of the domestic hot water capacity

The control valve for the space heating system was closed during this test.

Test Case 3 in Table 2 measures the test values for the load case specified in Section 4.2 of Technical Regulations F:103-7e.

The thermal powers shown in Table 2 are calculated values.
Test Case 3 has been tested at 0,100 MPa primary differential pressure.

Design domestic hot water flow rate: ……. l/s.

Apartment buildings:

Test Case 3 has been tested without hot water circulation flow.

Table 2

Test case	Primary t_{11} [°C]	t_{12} [°C]	q_1 [l/s]	P_1 [kW]	Secondary t_{31} [°C]	t_{32} [°C]	q_3 [l/s]	Δp_3 [kPa]	P_3 [kW]
3									

Test programme requirement for apartment buildings: $t_{12} \leq 22$ °C.

Results:
*The recorded measured values **Comply / Do Not Comply** with the requirements of the test programme.*

4.6 Dynamic testing of the domestic hot water function

Detached houses

Before making the measurements, the hot water system was in operation in order to achieve steady-state conditions. The hot water temperature at measurement point $\mathbf{t_{32}}$ was about 50 °C, and the incoming cold water temperature at measurement point $\mathbf{t_{31}}$ was about 10 °C, with a hot water flow rate of 0,2 l/s.

Test Cases 4 and 5 were performed with space heating loads as given in F:103-7e, Section 4.3.1. The tests were performed at three different load cases, as shown in Diagrams 1, 2 and 3 in Appendix 3.

The diagrams show the performance of the unit when responding to load changes, concentrating on the domestic hot water temperature in the outgoing connection from the heat exchanger at measurement point $\mathbf{t_{32}}$ and at measurement point $\mathbf{t_{33}}$, representing the draw-off point.

Diagram 1: Test Case 4, 50 % space heating load.

This test was carried out at 0,50 MPa static pressure in the primary supply connection, and 0,10 MPa primary pressure drop.

Diagram 2: Test Case 5,1 100 % space heating load.

This test was carried out at 0,50 MPa static pressure in the primary supply connection, and 0,10 MPa primary pressure drop.

Diagram 3: Test Case 5.2, 100 % space heating load.

This test was carried out at 1,0 MPa static pressure in the primary supply connection, and 0,60 MPa primary pressure drop.

*Results: The requirements as set out in F:103-7e, Section 4.3.3, were fulfilled for all operating cases: **Yes/No**.*

Summary:

- Set values for the control equipment:
  - Opening and closing times for the domestic hot water control valve actuator; Opening time: .....
    Closing time: .....
  - P-band: … ; I-time:… ; D-time: …
  - K-factor (for DUC): …
  - Software version of this control function: …
  - Set value of domestic hot water temperature: .....
- Temperature at the domestic hot water connection at measurement point $\mathbf{t_{32}}$ is (lowest) … °C, and (highest) … °C in Test Cases 4, 5.1 and 5.2.

- Domestic hot water temperature at measurement point $\mathbf{t_{32}}$ stabilises within … seconds.
- Temperature exceeding 65 °C registered at measurement point $\mathbf{t_{32}}$ for ..... seconds
- The stability requirement for domestic hot water temperature at measurement point t_{32} (variations not to exceed ± 1 °C), **Is Fulfilled / Is Not Fulfilled**.
- The highest measured domestic hot water temperature at measurement point $\mathbf{t_{33}}$ is … °C (see diagram …).
- The lowest measured domestic hot water temperature at measurement point $\mathbf{t_{33}}$ is … °C (see diagram …).

Results:
*The recorded measured values **Comply / Do Not Comply** with the requirements of the test programme.*

Apartment buildings

Before making the measurements, the hot water system was in operation in order to achieve steady-state conditions. The water temperature at measurement point $\mathbf{t_{32}}$ was about 55 °C, and the incoming cold water temperature at measurement point $\mathbf{t_{31}}$ was about 10 °C, with a hot water flow rate of ..... l/s. The hot water circulation system temperature at test point $\mathbf{t_{vvc}}$ was 50 °C.

Test Cases 4 and 5 were performed with space heating loads and dynamic domestic hot water loads as specified in F:103-7e, Section 4.3.2.

Tests were performed for four different load cases, as shown in Diagrams 1, 2, 3 and 4 in Appendix 3.

The diagrams show the performance of the substation in response to load changes, concentrating on the domestic hot water temperature at the point of supply from the heat exchanger ($\mathbf{t_{32}}$), and at the point of delivery, $\mathbf{t_{33}}$. The diagrams also show the water circulation system flow and temperature at the connection to the substation.

The hot water circulation flow was adjusted before the dynamic test was carried out. For zero draw-off, the flow was ..... l/s.

Diagram 1: Test Case 4, 50 % space heating load.

This test was carried out at 0,50 MPa static pressure in the primary supply connection, and 0,10 MPa primary pressure drop.

Diagram 2: Test Case 5.1, 100 % space heating load.

This test was carried out at 0,50 MPa static pressure in the primary supply connection, and 0,10 MPa primary pressure drop.

Diagram 3: Test Case 5.2, 100 % space heating load.

This test was carried out at 1,000 MPa static pressure in the primary supply connection, and 0,60 MPa primary pressure drop.

The requirements set out in F:103-7e, Section 4.3.3, are required to be fulfilled for all test cases.

Summary:

- Set values for the control equipment:
  - Opening and closing times for the domestic hot water control valve actuator; Opening time: .....
    Closing time: .....
  - P-band: … ; I-time:… ; D-time: …
  - K-factor (for DUC): …
  - Software version of this control function: …
  - Set value of domestic hot water temperature: ……..
- Temperature at the domestic hot water connection at measurement point $\mathbf{t_{32}}$ is (lowest) … °C, and (highest) … °C in Test Cases 4, 5.1 and 5.2.
- Domestic hot water temperature at measurement point $\mathbf{t_{32}}$ stabilises within … seconds.
- Temperature exceeding 65 °C registered at measurement point $\mathbf{t_{32}}$ for ..... seconds
- The stability requirement for domestic hot water temperature at measurement point t_{32} (variations not to exceed ± 1 °C), **Is Fulfilled / Is Not Fulfilled**.
- The highest measured domestic hot water temperature at measurement point $\mathbf{t_{33}}$ is … °C (see diagram …).
- The lowest measured domestic hot water temperature at measurement point $\mathbf{t_{33}}$ is … °C (see diagram …).
- The domestic hot water circulation system flow, with no draw-off of hot water, is ..... l/s.
- The domestic hot water circulation system flow, with draw-off of 0,1 l/s of hot water, is ..... l/s.
- The domestic hot water circulation system flow, with draw-offs of 0,215/0,380 l/s of hot water, is ..... l/s.

Results:
*The recorded measured values **Comply / Do Not Comply** with the requirements of the test programme.*

Test Case 6 is intended to be performed without space heating load, and with dynamic domestic hot water loads as specified in F:103-7e, Section 4.3.2. It is a dynamic test case, intended to determine the function of the substation under operating conditions consisting only of draw-off of hot water. It records the performance of the substation when space heating is not required: see F:103-7e, Section 4.3.5.

The test requirement is that the domestic hot water temperature at $\mathbf{t_{33}}$ shall not exceed 60 °C, while the hot water circulation circuit temperature at measurement point $\mathbf{t_{vvc}}$ is 50 °C.

Diagram 4: Test Case 6, without space heating load

This test was carried out at 0,50 MPa static pressure in the primary supply connection, and 0,10 MPa primary pressure drop (Appendix 3).

From Temperature Diagram 4 in Appendix 3, it can be seen that:

- The domestic hot water temperature at measurement point $\mathbf{t_{33}}$ was not less than _____ °C, and did not exceed _____ °C.
- The domestic hot water circulation system temperature at measurement point $\mathbf{t_{vvc}}$ was not less than _____ °C, and did not exceed _____ °C.
- The district heating system return water temperature at measurement point $\mathbf{t_{12}}$ was not less than _____ °C, and did not exceed _____ °C.

Results:
*The recorded measured values **Comply / Do Not Comply** with the requirements of the test programme.*

5. Domestic hot water supply performance

Detached houses

5.1 Testing control equipment at low hot water draw-off rates

This test was performed at a hot water draw-off rate of 0,02 l/s in order to check that the control equipment can supply domestic hot water at the proper temperature at this low rate. The test was performed without a space heating load, with a primary supply temperature of 65 °C and with a pressure drop of 0,1 MPa. See F:103-7e, Section 4.3.4.

Before making the measurements, the system was in operation for a sufficiently long time to achieve steady-state conditions. The water temperature at $\mathbf{t_{32}}$ was about 50 °C, and the incoming cold water temperature at measurement point $\mathbf{t_{31}}$ about 10 °C with a hot water flow of 0,13 l/s. When steady-state conditions had been reached with these values, the flow was reduced to 0,02 l/s.

Diagram 4 shows the results of testing the control equipment at low domestic hot water flow rate (Appendix 3). The requirement is that domestic hot water can be produced with a low flow rate of 0,02 l/s.

- A domestic hot water flow rate of 0,02 l/s was started. The water temperature at measurement point $\mathbf{t_{32}}$ reached stability after about ____ seconds, at a temperature of about ____ °C.

Results:
*The recorded measured values **Comply / Do Not Comply** with the requirements of the test programme.*

5.2 Testing no-load performance

District heating substations for detached houses, not having circulation systems for the domestic hot water supply, shall incorporate a temperature-holding feature that maintains the temperature in the service connection at a level that provides good readiness for delivering domestic hot water when it is required: See F:103-7e, Section 4.3.4.2.

To test this, domestic hot water was drawn off at a rate of 0,2 l/s, with no space heating load and with a primary supply temperature of 65 °C and 0,10 MPa pressure drop. The hot water was turned off when steady-state conditions had been established, after which the primary flow rate and the primary supply and return temperatures were measured for three hours.

The requirement is that the temperature in the service connection return pipe shall not exceed 45 °C.

[Here, a description of how the temperature-holding function works.]

The energy required for this temperature-holding function ***is / is not*** measured by the unit's heat meter.

Diagram 5: Testing the no-load performance of units without hot water circulation circuits (Appendix 3).

- *Temperature-holding started after _____ seconds.*
- *Steady-state conditions were reached after …… seconds, with the temperature at measurement point* $\mathbf{t_{12}}$ *being _____°C.*
- *The no-load flow rate was measured as about _____ l/hour.*

Results:
*The recorded measured values **Comply / Do Not Comply** with the requirements of the test programme.*

5.3 Domestic hot water response time

Immediately after testing the no-load characteristics, a test was performed to measure the time until the domestic hot water temperature had reached the correct temperature and stabilised at that temperature. After three hours, when the substation had reached steady-state conditions without domestic hot water or space heating loads, a hot water draw-off was started at a flow rate of 0,2 l/s. See F:103-7e, Section 4.3.4.3.

The requirement is that the temperature at $\mathbf{t_{32}}$ shall stabilise within 100 s of a temperature change starting to occur at $\mathbf{t_{32}}$. In this context, 'stabilisation' means that the temperature may vary by ± 1 °C, and that the domestic hot water temperature is within the range 50 - 60 °C.

Diagram 6: Response time for domestic hot water temperature (Appendix 3)

- *The domestic hot water temperature at measurement point* $\mathbf{t_{32}}$ *was stable after ____ seconds, at a temperature of ____ °C.*

Results:
*The recorded measured values **Comply / Do Not Comply** with the requirements of the test programme.*

.

6. Heat meter installation position

During this part of the tests, the flow sensor was replaced by a length of plain pipe, nominal diameter DN….

[Describe the position of the heat meter.]

Length of straight pipe upstream of the heat meter position: .....…

Length of straight pipe downstream of the heat meter position: ….....

Results: The installation positions of the heat meter flow sensor and temperature sensors Comply / Do Not Comply with the requirements in Technical Specification F:104e.

7. Other information

[This heading covers any comments or observations made during the tests.]

8. Material for certification decision

The tested substation, of ..... manufacture, type ..... and with serial number ....., **fulfils / does not fulfil** the requirements in the Swedish District Heating Association's Certification Regulations F:103-7e.

Name of the company performing the certification inspection / testing

Manager Technical officer

12. Appendices

12.1. Appendix 1

Component list and technical data

Heat exchangers for space heating and domestic hot water systems

Manufacturer:

Type of heat exchanger:

Type number, space heating system heat exchanger:

Type number, domestic hot water heat exchanger:

Manufacturing inspection in accordance with PED 97/23/EC in applicable cases, lowest Class A 1.

Manufacturing inspection performed by:

Type approval number:

Rating data for the space heating system heat exchanger:

Power:

Pressure drop:

Temperature, primary / secondary:

Rating data for the domestic hot water system heat exchanger:

Power:

Pressure drop:

Temperature, primary / secondary:

Rated domestic hot water flow:

Control valve

Manufacturer:

Type:

Size:

Kvs:

Valve actuator

Manufacturer:

Type:

Operating time:

Temperature sensors

Temperature sensor, supply connection

Manufacturer:

Type:

Temperature sensors, outdoors

Manufacturer:

Type:

Temperature sensors, indoor

Manufacturer**:**

Type:

Domestic hot water control equipment

Control unit

Manufacturer:

Type:

Program version:

Control valve

Manufacturer:

Type:

Size:

Kvs:

Valve actuator

Manufacturer:

Type:

Operating time:

Temperature sensor

Manufacturer:

Type:

Control valve / flow monitor for domestic hot water

Manufacturer:

Type:

Or.

Thermal regulator

Manufacturer:

Type:

Size:

Kvs:

Other equipment

Space heating system circulation pump

Manufacturer:

Type:

Capacity:

Domestic hot water circulation system pump

Manufacturer:

Type:

Capacity:

Expansion vessel

Manufacturer:

Type:

Volume:

Pre-load pressure:

Safety valves

Safety valves, space heating system

Manufacturer:

Relief pressure:

Safety valves, cold water

Manufacturer:

Relief pressure:

Pressure gauge

Manufacturer:

Pressure:

Thermometer

Manufacturer:

Type:

Position:

Seals, washers, gaskets etc.

Seals, washers, gaskets etc **Comply / Do Not Comply** with the requirements of EN 681-1, Table 3.

Pipe connections

Manufacturer:

Type:

Filling valve

Manufacturer:

Type:

Check valve, cold water

Manufacturer:

Type:

Dirt filter

Manufacturer:

Mesh size

Shunts

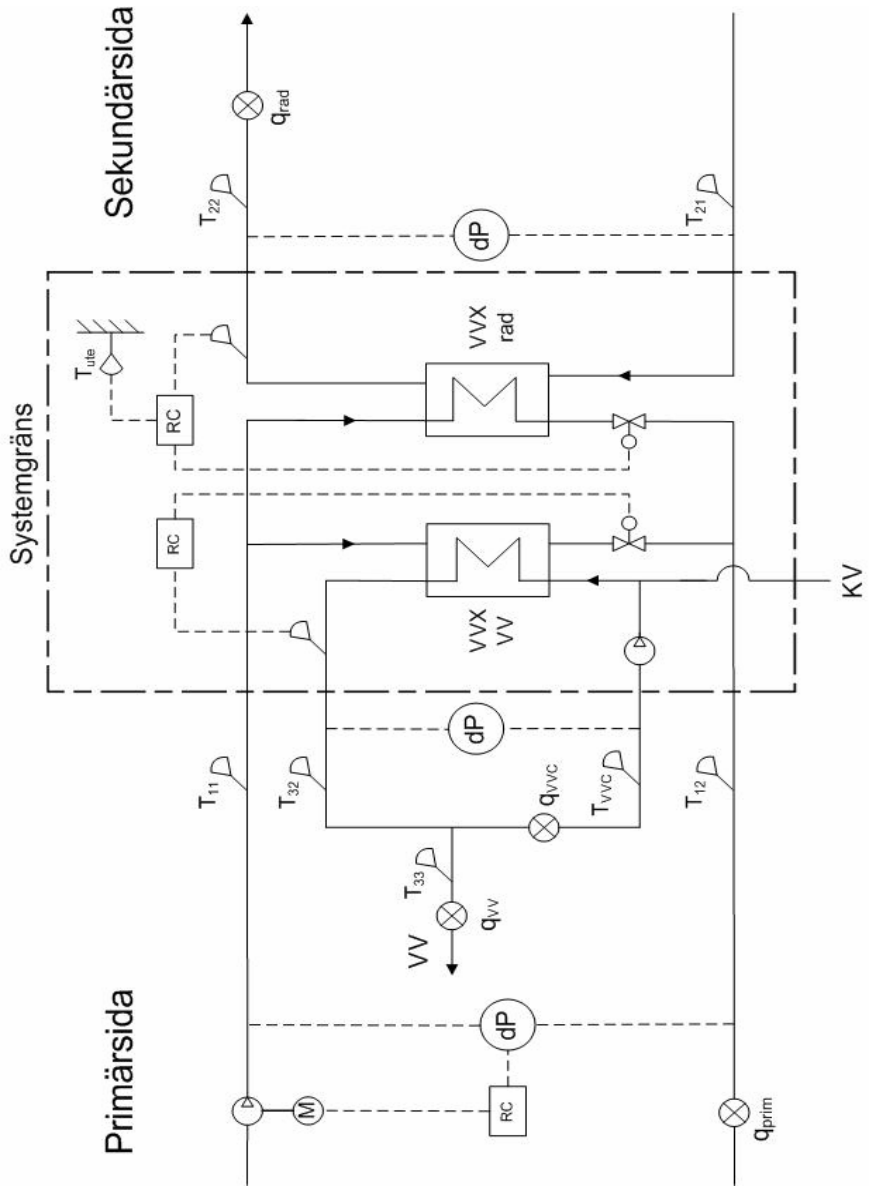
In addition to the integral temperature maintenance function in the control system, there may be a second temperature maintenance function.

Manufacturer:

Type:

The flow **Is / Is Not** measured by the heat meter

12.2. Appendix 2



Technical regulations

District heating substations **F:101e**
Design, construction and installation

District cooling substations **F:102e**
Design, construction and installation

Certification of district heating substations **F:103-7e**
Test and inspection regulations

Heat meters **F:104e**
Technical requirements and guidelines for meter applications

Test requirements for heat exchangers and water heaters **F:109e**

Heat meters **F:111e**
Dynamic function testing of heat meters for detached houses

Reports

(Note that these reports are not necessarily available in English.)

Manufacture and inspection of district heating systems **2006:1**
Rules and advice for complying with the Swedish Work Environment Authority's regulations

Your district heating substation **2004:1**
Instructions and advice on looking after district heating substations

Safety in district heating systems **2004:2**
Regulations and advice on risk assessment

The district heating substation **2004:3**
Connection principles

Magnetic/inductive flow meters **1993**

Ultrasonic flow meters **1994**

Maintenance systems for district heating substations **1998:5**
Performance specification for use in connection with purchasing

Remote communications for energy utilities **1997:3**

Publications

Publications can be ordered from the Association's Publications Service by phone on +46 26-24 90 24, or by fax on +46 26-24 90 10. An up-to-date list of publications available can be found on the Association's web site **www. svenskfjarrvarme.se**

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