

Methods for

Testing and rating fan coil units, unit heaters and unit coolers —

Part 3: Thermal and volumetric
performance for heating and cooling
duties; with additional ducting

UDC 697.971.001.42 + 697.356.001.42

NO COPYING WITHOUT BSI PERMISSION EXCEPT AS PERMITTED BY COPYRIGHT LAW



Document Sharing Hub

Co-operating organizations

The Refrigeration, Heating and Air Conditioning Industry Standards Committee, under whose supervision this British Standard was prepared, consists of representatives from the following Government departments and scientific and industrial organizations:

- Association of Consulting Engineers*
- Association of Manufacturers of Domestic Electrical Appliances
- Boiler and Radiator Manufacturers' Association*
- British Gas Corporation
- British Mechanical Engineering Confederation
- British Oil and Gas Firing Equipment Manufacturers' Association
- British Refrigeration and Air Conditioning Association*
- Department of the Environment
- Department of Health and Social Security*
- Electricity Supply Industry in England and Wales
- Engineering Equipment Users' Association
- Heating and Ventilating Contractors' Association*
- Heating and Ventilating Research Association *
- HEVAC Association*
- Institute of Fuel
- Institution of Gas Engineers
- Institution of Heating and Ventilating Engineers*
- Institute of Refrigeration*
- Lloyd's Register of Shipping
- Manufacturers' Association of Radiators and Convectors*
- Ministry of Defence*
- National Coal Board
- Society of British Gas Industries
- Water-tube Boilermakers' Association

The organizations marked with an asterisk in the above list, together with the following, were directly represented on the Committee entrusted with the preparation of this British Standard:

- Department of the Environment, Building Research Establishment
- Greater London Council
- Unit Heater Manufacturers' Association
- Oil Companies' Materials Association

This British Standard, having been approved by the Refrigeration, Heating and Air Conditioning Industry Standards Committee, was published under the authority of the Executive Board on 30 September 1975

© BSI 11-1999

The following BSI references relate to the work on this standard:
Committee reference RHE/6
Draft for comment 73/34432 DC

ISBN 0 580 08615 1

Amendments issued since publication

Amd. No.	Date of issue	Comments

Contents

	Page
Co-operating organizations	Inside front cover
Foreword	ii
1 Scope	1
2 References	1
3 Definitions	1
4 Operating conditions of units	1
5 Nomenclature	2
6 Object of the test method	3
7 Testing conditions	4
8 Instrumentation	4
9 Test equipment	5
10 Test facility	6
11 Air temperature measurement	7
12 Test method	7
13 Test method (air side measurements)	9
14 Calculations	9
15 Rating tests	11
16 Example	13
17 Sensible and latent cooling rating tests	15
18 Enclosure sweating tests and condensate disposal tests	17
Appendix A Heating units with fan installed downstream of the coil	19
Figure 1(a) — Thermometer pocket for steam test	20
Figure 1(b) — Thermometer pocket for hot water test	21
Figure 1(c) — Thermometer pocket for use in vertical pipes over 75 mm diameter	21
Figure 1(d) — Thermometer pocket for use in horizontal pipes over 75 mm diameter	22
Figure 2 — Multi-junction differential thermocouple	22
Figure 3(a) — Inverted U-tube manometer	22
Figure 3(b) — Piezometer ring	23
Figure 4(a) — Thermometer shield	24
Figure 4(b) — Thermocouple shield	24
Figure 5 — Inlet air sampling tube	25
Figure 6 — Outlet air sampling tube	26
Figure 7 — Steam test equipment	27
Figure 8 — Water test equipment	27
Figure 9 — Hot water test equipment (maximum water temperature above 95 °C)	28
Figure 10(a) — Arrangement A of test apparatus	28
Figure 10(b) — Arrangement B of test apparatus	29
Figure 11 — Temperature and total pressure probe	29
Figure 12 — Air flow mixers	30
Figure 13 — Inlet temperature measurement	31
Figure 14 — Traverse stations	32
Figure 15 — Definition of x	33
Figure 16 — Pressure-flow characteristics	33
Figure 17 — Heat transfer	34
Figure 18 — Thermal efficiency	34
Figure 19 — Water temperature correction factor heating	35

	Page
Figure 20 — Water temperature correction factor cooling	35
Figure 21 — Graph of Q_n versus q_{ar} at $(t_{fi} - t_{ai}) = 60\text{ }^{\circ}\text{C}$	36
Figure 22 — Graph of Q_n versus m_f at $q_{ar} = 0.93\text{ m}^3/\text{s}$	36
Figure 23(a) — Graph of R_a and B versus q_{ar}	37
Figure 23(b) — Graph of R_{wm} versus m_f	37
Table 1 — Steady state conditions	7
Table 2 — Rating test for steam as primary fluid	12
Table 3 — Rating tests for water or heat transfer fluid	14
Table 4 — Latent cooling rating test series	15
Table 5 — Enclosure sweat test conditions	17
Publications referred to	Inside back cover

Foreword

Part 3 of this British Standard has been prepared under the authority of the Refrigeration, Heating and Air Conditioning Industry Standards Committee in response to requests from industry.

The Committee acknowledge their debt to the Heating and Ventilating Research Association for the Association's work in formulating the methods of testing which appear in this standard. These methods cover a range of testing conditions which encompass the complete performance envelope of the individual items of equipment.

The general approach to the test methods described has been to consider the simplest practical methods of carrying out the measurements without any unnecessary sacrifice of accuracy.

The standard relates to equipment with capacities of up to the equivalent of 75 kW.

Where reference is made to British Standards, and if no metric version is available (e.g. BS 1042 "*Methods for the measurement of fluid flow in pipes*", etc.), then the appropriate British Standard in imperial units shall be used in conjunction with BS 350 "*Conversion factors and tables*"; attention is also drawn to BS 3763 "*The International System of units (SI)*".

A British Standard does not purport to include all the necessary provisions of a contract. Users of British Standards are responsible for their correct application.

Compliance with a British Standard does not of itself confer immunity from legal obligations.

Summary of pages

This document comprises a front cover, an inside front cover, pages i to iv, pages 1 to 38, an inside back cover and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

1 Scope

This Part of this British Standard deals with methods of carrying out thermal and volumetric tests on units intended for use with additional ducting containing fluid to air heat exchangers and incorporating their own electrically powered fan system. The units may be either for heating or for cooling applications and the latter may be with or without dehumidification under frost-free conditions. The tests are to be carried out on units in an essentially clean condition.

2 References

The titles of the British Standards referred to in this standard are listed on the inside back cover.

3 Definitions

For the purposes of this British Standard the following definitions apply.

3.1

fan coil unit

a fluid-to-air heat exchanger apparatus through which air is passed by its electrically powered fan system and which is intended for general commercial use in the field of generating comfort conditions. This unit may or may not contain filters

3.2

unit heater and unit cooler

a fluid-to-air heat exchanger apparatus through which air is passed by an electrically powered fan system and which is intended for general industrial use in environmental control. This unit may or may not contain filters

3.3

essentially clean conditions

those conditions applying when further cleaning of a unit does not affect the rating figures

3.4

reference air conditions

temperature 20 °C; absolute pressure 1.013 bar¹⁾; relative humidity 43 %; density 1.200 kg/m³

4 Operating conditions of units

4.1 The aerodynamic performance of a ducted unit and consequently the thermal output is to some extent dependent upon the temperature and location of the heat exchanger. If a unit is to be used for a heating duty then temperature effects will be most significant if the fan is located downstream of the heat exchanger.

The rating tests described in the standard are for heating units with the fan located upstream of the coil, and for cooling units with the fan in any position. If the fan is located downstream of the coil then for heating units the modified test series described in Appendix A shall be applied.

4.2 The primary medium shall be any of the following fluids.

- a) Water.
- b) Steam.
- c) Heat transfer fluid (excluding volatile refrigerants).

4.3 The operating conditions of the units shall lie within the following ranges.

- a) Chilled water from 2 °C to 20 °C.
- b) Low temperature hot water from 40 °C to 95 °C.
- c) Pressurized water up to 200 °C.
- d) Heat transfer fluid from 40 °C to 200 °C.

4.4 The air volume flow rate of the unit shall lie within the range $25 \times 10^{-3} \text{ m}^3/\text{s}$ to $5 \text{ m}^3/\text{s}$.

¹⁾ 1 bar = 10^5 N/m^2 = 100 kPa.

4.5 There is no restriction on the mounting of these units, provided that they are tested whilst mounted in a way representative of their intended use.

4.6 The requirements of the methods for individual tests may be followed to determine the performance of a unit at one specified set of conditions; where the performance at conditions other than those of the actual test are to be stated, the full schedule of tests specified in the standard shall be completed.

5 Nomenclature

For the purposes of this British Standard the following nomenclature is used.

Symbol	Quantity	Unit
A_D	Area of test duct	m^2
A_i	Area of air inlet duct	m^2
A_o	Area of unit air outlet	m^2
A_s	Surface area of insulated duct	m^2
B	Bypass factor	—
c_{pa}	Specific heat capacity of air	$kJ/(kg\ K)$
c_{pf}	Specific heat capacity of primary fluid	$kJ/(kg\ K)$
c_{pw}	Specific heat capacity of water	$kJ/(kg\ K)$
H_D	Test duct hydraulic diameter	m
h_{ai}	Inlet air enthalpy	kJ/kg of dry air
h_{ao}	Outlet air enthalpy	kJ/kg of dry air
h_b	Enthalpy of saturated air at apparatus dew point	kJ/kg of dry air
k_t	Thermal conductivity of insulating material	$W/(m\ K)$
K_f	Temperature correction factor	—
L	Latent heat of evaporation	kJ/kg
l	Thickness of insulating material	mm
M_t	Net mass of condensate formed during test	kg
M_n	Net mass of condensate formed during no-load test	kg
M_f	Total mass flow of primary fluid	kg
m_a	Air mass flow rate	kg/s
m_f	Primary fluid mass flow rate	kg/s
Δp_f	Primary fluid pressure drop	Pa
Δp_{fr}	Primary fluid pressure drop at reference temperature (cooling $10\ ^\circ C$, heating $80\ ^\circ C$)	Pa
p_b	Barometric pressure	Pa
p_{br}	Reference barometric pressure ($101\ 325\ Pa$)	Pa
p_f	Upstream static pressure at flow meter	Pa
Δp_F	Flow meter pressure drop	Pa
p_v	Dynamic pressure of airstream	Pa
p_{vn}	Dynamic pressure at point n	Pa
p_s	Test duct static pressure	Pa
p_d, p_h, p_B, p_i	Pressure loss corrections defined in 14.3	Pa
p_{sc}	Static pressure rise corrected for friction, etc.	Pa

Symbol	Quantity	Unit
p_{so}	Static pressure rise corrected to unit outlet area	Pa
p_{sr}	Static pressure rise at reference conditions	Pa
Q_n	Net heat transfer	kW
Q_o	Heat losses or gains	kW
Q_g	Gross heat transfer	kW
q_a	Air volume flow rate	m ³ /s
q_{ar}	Air volume flow rate at reference conditions	m ³ /s
q_f	Primary fluid volume flow rate	m ³ /s
q_{fr}	Primary fluid volume flow rate at reference temperature (cooling 10 °C, heating 80 °C)	m ³ /s
R	Overall appliance thermal resistance	K/kW
R_a	Air side appliance thermal resistance	K/kW
R_{wm}	Water plus coil metal appliance thermal resistance	K/kW
R_m	Overall appliance thermal resistance at mid range air flow rate	K/kW
S	Sensible to total heat ratio	—
t_{ai}	Inlet air dry bulb temperature	°C
t_{ao}	Outlet air dry bulb temperature	°C
t'_{ao}	Outlet air wet bulb temperature	°C
t_{an}	Air dry bulb temperature at transfer point n	°C
t_F	Temperature at flow meter	°C
t_{fi}	Inlet primary fluid temperature	°C
t_{fo}	Outlet primary fluid temperature	°C
t_s	Saturated steam temperature	°C
t_b	Ambient air dry bulb temperature	°C
t_{ar}	Reference air dry bulb temperature at 20 °C	°C
Δt_m	Logarithmic mean temperature difference	°C
T_t	Duration of test	s
T_n	Duration of no-load test	s
Δw	Change in moisture content across coil	kg/kg of dry air
ρ_a	Air density	kg/m ³
ρ_{ar}	Reference air density (1.2 kg/m ³)	kg/m ³
ρ_f	Primary fluid density at mean fluid temperature	kg/m ³
ρ_{fr}	Primary fluid density at reference temperature (cooling 10 °C, heating 80 °C)	kg/m ³

6 Object of the test method

The object of the tests is to establish the performance of the unit over a specified range of primary and secondary fluid conditions and room temperatures. The test procedures set out in this standard are for the determination of:

- the gross and net thermal outputs;
- the secondary fluid flow rates;

- c) the primary fluid pressure drop;
- d) freedom from sweating on the unit enclosure or casework;
- e) adequate condensate disposal.

7 Testing conditions

7.1 Primary fluid, liquid. The unit shall be tested at a minimum of three primary fluid inlet temperatures. The selected temperatures shall cover the range of duty over which the appliance is to be rated, that is, to within 10 % at either end of the range.

7.2 Primary fluid, steam. Gauge pressures for the tests shall be selected such that temperature intervals are not greater than 20 °C, and that a minimum of three test points are obtained. The steam shall have a minimum of 1.5 °C superheat to ensure the absence of entrained moisture, and a maximum of 3 °C superheat.

7.3 Entering air conditions. The entering air temperature shall be within the range 15 °C to 25 °C for heating and 20 °C to 30 °C for cooling.

7.4 Primary fluid flow rate. For duties quoted over a range of primary fluid flow rates, tests shall be carried out at a minimum of three primary fluid flow rates, spaced approximately equally over the required range and covering the range to within 10 % at either end.

7.5 Electrical supply conditions. The tests shall be carried out at the rated voltage and frequency of the unit which shall be stated in the test report.

7.6 Nominal rating. In the absence of a specified set of conditions, where a single nominal rating for either cooling or heating is required, the total capacity under the following conditions should be used:

Condition	Cooling	Heating
Room air temperature	21 °C dry bulb 15 °C wet bulb	18 °C dry bulb —
Primary fluid inlet temperature	5 °C	85 °C
Primary fluid outlet temperature	10 °C	70 °C

8 Instrumentation

8.1 Steam

8.1.1 Temperature. Temperature measurement shall comply with the requirements of BS 1041-2, BS 1041-3 and BS 1041-4. Thermometers, thermocouples and resistance thermometers shall be calibrated to a precision of 0.5 °C against a NPL thermometer (accurate to 0.25 °C) and shall be used in pockets similar to those shown in Figure 1(a), situated at the entry and outlet of the unit between 100 mm and 200 mm from the unit connections.

8.1.2 Pressure. Pressure gauges shall comply with clause 30 a of BS 1780:1960. They shall be at least 150 mm in diameter and shall have a total scale range not more than three times the measured test pressure. For test pressures below 0.3 bar²⁾, a liquid manometer is desirable.

8.1.3 Mass flow. Mass flow shall be by mass of condensate preferably measured by direct weighing. Weighing apparatus shall be accurate to 0.2 % and collecting vessels shall not weigh more than 50 % of their normal contents. Covers shall be provided to prevent evaporation of liquid from any collecting vessels awaiting weighing.

8.2 Water or heat transfer fluid

8.2.1 Temperature. The measurement of temperature of the water or heat transfer fluid at entry and exit shall comply with the requirements of BS 1041. If liquid-in-glass thermometers are used, they shall be graduated for partial immersion at intervals of 0.1 °C and shall comply with the requirements of BS 593. Thermometers, thermocouples and resistance thermometers shall be calibrated to a precision of 0.1 °C against a NPL thermometer (accurate to 0.05 °C), and shall be used in pockets similar to those shown in Figure 1(b), situated at the entry and outlet of the unit between 100 mm and 200 mm from the unit connections.

²⁾ 1 bar = 10⁵ N/m² = 100 kPa.

For primary liquid temperature differences of less than 5 °C it will be necessary to take special care and the differential thermocouple system shown in Figure 2 is recommended.

8.2.2 Pressure. The pressure drop across the unit shall be measured with an inverted U-tube manometer similar to that shown in Figure 3(a). The manometer shall be vertical and calibrated in intervals not exceeding 2 % of the measured drop.

8.2.3 Mass flow. Mass flow shall preferably be measured by direct weighing. Weighing apparatus shall be accurate to 0.2 % and collecting vessels shall not weigh more than 50 % of their normal contents. Covers shall be provided when necessary to prevent evaporation of liquid from any collecting vessels awaiting weighing.

Liquid flow rate may also be measured by means of any of the appropriate devices described in BS 1042-1.

8.3 Air

8.3.1 Temperature. Measurements of air temperature shall be made with mercury-in-glass thermometers, thermocouples or resistance thermometers, calibrated to 0.1 °C against a NPL class A thermometer. Thermometers shall be graduated at intervals not greater than 0.1 °C and calibrated for total immersion. Temperature measuring instruments shall be shielded against radiation; suitable shields are shown in Figure 4(a). Inlet air temperatures shall be measured by thermocouples or resistance thermometers capable of being shielded as in Figure 4(b).

Where it is necessary to measure wet and dry bulb air temperatures these shall be measured by means of instruments installed in sampling tubes similar to those shown in Figure 5.

Psychrometric data shall be measured by means of the system given in Appendix D of 4194:1967 connected to a suitable sampling system as shown in Figure 6.

8.3.2 Flow rate. Flow meters should comply with the requirements of BS 1042-1. Where the recommendations of BS 1042-1 cannot be followed the flow meter may be calibrated in situ by the method given in BS 1042-2. It is suggested that the air flow measurement be carried out by means of the orifice plate method described in BS 1042-1 or by means of the pitot traverse method described in BS 848-1, circular airways, 24 point traverse.

8.3.3 Pressure

8.3.3.1 The minimum differential pressure readings for flow measurement shall be 25 Pa for inclined U-tube manometers and micro-manometers, and 500 Pa for vertical U-tube manometers.

8.3.3.2 It shall be possible to read the manometer to an accuracy of 0.5 Pa over a pressure differential of between 25 Pa and 50 Pa and 1 % at higher differential pressures.

8.3.3.3 Wall static pressures shall be measured with static taps complying with the specifications laid down in BS 1042-2. A minimum of four taps shall be symmetrically disposed about the duct walls and connected to form a piezometric ring. Total pressures shall be measured with the pitot-static tube described in BS 1042-2.

9 Test equipment

9.1 Steam. The steam supply and consumption test equipment shall be as detailed in 9.1.1 to 9.1.5 and arranged as shown in Figure 7.

9.1.1 The length of pipe between the steam pressure and temperature measurement positions and the unit casing shall not exceed 300 mm and shall be insulated with at least 40 mm thickness of insulating material having a thermal conductivity not exceeding 0.06 W/(m K).

9.1.2 The pipe conveying the condensate to the sight glass shall not exceed a total length of 1 m and shall be insulated as described in 9.1.1.

9.1.3 An air cock, throttle valve, pressure gauge or manometer, a temperature measuring instrument and a separator with drain shall be fixed in the steam pipe close to the steam inlet to the unit, as a means for controlling and indicating the steam pressure and temperature. A superheater, preferably electrically heated, is also advisable.

9.1.4 An air cock, automatic or otherwise, a sight glass with water level indicator and a throttle valve shall be fixed close to the heater condensate outlet.

9.1.5 The condensate shall be collected and weighed and means shall be employed to minimize loss by evaporation. An after cooler may be employed if desired.

9.2 Water or heat transfer liquid

9.2.1 There shall be available a means for providing a continuous supply of fluid, together with a means for controlling the temperature of this fluid at any desired temperature that may be required for the test.

9.2.2 There shall be available a means for providing a constant flow of fluid such as a constant head tank or a circulation pump. A means shall also be available for controlling the fluid to any desired flow rate which may be required for the test.

9.2.3 The equipment shall be arranged generally as in Figure 8.

9.2.4 For water temperatures above 95 °C a closed pressure vessel such as a boiler operating at constant pressure should be used as the source of hot water, and an after cooler inserted before the water control valve at the discharge end. A typical arrangement is shown in Figure 9.

9.2.5 The pipework shall be arranged to give an unobstructed straight run at entry to and exit from the appliance, the pipe diameter being equal to that demanded by the unit connections and of length at least equal to five pipe diameters.

9.2.6 Hydraulic resistance side wall tappings shall be adjacent to the connection to the appliance. The tappings shall be as specified in Figure 3(b) and connected to form a piezometric ring.

9.2.7 The lengths of pipe between the temperature measurement positions, the unit connections and the unit casing shall be insulated with at least 40 mm thickness of insulating material having a thermal conductivity not exceeding 0.06 W/(m K).

9.2.8 When mass flow measurement is by weighing means shall be taken to minimize evaporation from vessels awaiting weighing.

10 Test facility

10.1 General. A room shall be available in which air conditions can be controlled to provide any values which are required for the tests. The room shall be such as to permit the unit under test to be mounted and operated so as to represent the intended manner of use for the particular unit.

In many cases, such as when testing units on heating only, it will be possible to test units in the ordinary laboratory. In the case of the larger unit heaters or coolers it may not be possible to obtain steady state conditions and the treated air may have to be ducted away from the test environment.

Two standard test arrangements are recommended. Arrangement A is suitable for units with a mean discharge velocity in excess of 6 m/s. Arrangement B may be used for all types of unit. The two test arrangements do, however, have certain common features, as detailed below.

The test arrangement shall either be with the test duct in line with the unit outlet or with a right angle bend introduced between the unit outlet and test duct [see Figure 10(a) or Figure 10(b)]. This bend shall be fitted with a minimum of five turning vanes.

Units fitted with multiple air outlets shall be tested with a standard single air outlet (of cross-sectional area equal to the discharge area of the multiple outlets) or with the single outlet recommended by the manufacturer.

Units for use with ducted inlet and outlet shall be tested with an inlet duct of a minimum length of 4 hydraulic diameters, and of cross-sectional dimensions equal to those of the unit air inlet. This duct may be fitted with a low-loss entry.

10.2 Test arrangement A

10.2.1 The general arrangement of the test airways shall be as shown in Figure 10(a).

10.2.2 The test duct indicated in Figure 10(a) shall be circular in cross section and of a minimum length of 8 diameters. If the unit air outlet is non-circular then a transition to circular cross section shall be fitted between the unit outlet and the test duct. This transition shall be fitted downstream of any bend fitted [see Figure 10(a)], shall have a maximum included wall angle of 15°, and the outlet area shall not differ from the area of the unit's own outlet by more than 20 %.

10.2.3 The discharge end of the test duct shall be fitted with a symmetrical throttling device as a means of providing an adjustable resistance.

10.2.4 Provision shall be made for a total pressure pitot tube and temperature traverse at a point 2 test duct diameters from the discharge end of the test duct. This traverse shall be carried out with a combined temperature and total pressure probe, as shown in Figure 11. The duct wall static pressure shall be measured at the plane of the temperature and total pressure traverse.

10.2.5 The whole of the test airways shall be insulated with at least 50 mm thickness of insulating material having a thermal conductivity not exceeding 0.06 W/(m K).

10.3 Test arrangement B

10.3.1 The general arrangement of the test airways shall be as shown in Figure 10(b).

10.3.2 The test duct may be of non-circular cross section, in which case no transition shall be used between the unit outlet (or right angle bend) and the test duct; in other respects the duct shall be as described in 10.2.2 but of 5 hydraulic diameters minimum length. A ring of four static pressure taps shall be fitted 3 hydraulic diameters downstream of the flow straightener.

10.3.3 The test duct shall be fitted to a temperature mixing and sampling section; a thin orifice plate (as described in BS 1042-1) shall be installed having 10 duct diameters upstream and 5 diameters downstream with a flow straightener at each end. A booster fan as shown in Figure 10(b) shall be installed. Suitable air mixers and sampling equipment are shown in Figure 12 and Figure 6 respectively.

10.3.4 The whole of the test airway between the unit outlet and temperature sampling station shall be insulated with at least 50 mm thickness of insulating material having a thermal conductivity not exceeding 0.60 W/(m K).

11 Air temperature measurement

11.1 Unit inlet temperature

11.1.1 The unit inlet temperature (t_{ai}) shall be measured 10 mm in front of the inlet (or inlet grilles) by means of point measuring instruments [see Figure 4(b)].

11.1.2 Measuring stations shall be evenly distributed about the inlet (or inlets) as shown in Figure 13. At least four measuring stations per inlet shall be employed, and an extra measuring station shall be introduced for every degree Celsius deviation of individual readings from the mean temperature.

For example, if the measured temperatures are 19.2 °C, 20 °C, 20.6 °C, 18.5 °C, the mean of these is 19.6 °C and two extra stations will be required.

11.1.3 The additional temperature measuring stations shall be located as shown in Figure 13.

12 Test method

12.1 Steady state conditions. Carry out the tests under steady state conditions; these shall be said to exist when the following measurements have not varied by more than the specified amounts from their mean value for a minimum period of 30 min, readings being taken at 10 min intervals.

Table 1 — Steady state conditions

Quantity	Permitted variations from mean	
	Heating	Cooling
Entering air temperature		
Dry bulb	0.5 °C	0.25 °C
Wet bulb	—	0.25 °C
Entering fluid temperature		
< 100 °C	0.5 °C	0.25 °C
> 100 °C	1 °C	—
Fluid flow rate	2 %	2 %
Steam, rate of condensation	3 %	—
Supply voltage	2½ % of rated voltage	

12.2 Steam as primary fluid

12.2.1 With steam at the required pressure adjust the condensate control such that the condensate level is visible in the sight glass. Only start after a state of equilibrium has been reached. Such a state of equilibrium may be considered to exist when the conditions of **12.1** are satisfied.

12.2.2 Continue each test until three consecutive sets of readings, each taken over a 15 min period (one of which may be taken at the completion of the last 15 min of the equilibrium period) give outputs agreeing within $\pm 2\%$.

12.2.3 Read the supply steam temperature (t_s) at the beginning and end of each test and at intervals of 15 min during the test. All readings of the supply steam temperature (t_s) shall comply with the conditions of superheat laid down in **7.2**.

12.2.4 Read the supply steam pressure at intervals of 15 min during the test; successive readings shall not vary from their mean value by more than $\pm 5\%$ absolute.

12.2.5 Collect the total condensate and weigh it on the apparatus described in **8.1.3**. Also note the mass of condensate collected in each 15 min period of the test; the condensate rate during any one of these periods shall not vary by more than $\pm 3\%$ from the mean.

12.2.6 Make a no-load test to determine the amount of steam which is condensed in the steam and condensate piping between the temperature measuring station and the condensate collecting vessel. Run this no-load test under the same conditions and following the same procedure as for testing the appliance itself. The degree of superheat shall be at least 1.5°C and not more than 3°C .

One of the two following methods of determining no-load condensation shall be employed.

- a) Move either the supply piping or the condensate piping and the condensate seal and then joint them directly using the shortest possible connection. The condensate collected per hour will represent the total no-load correction.
- b) If the piping is inflexible, substitute in place of the test unit a pipe of the same diameter and insulated in exactly the same manner as the condensate piping. Divide the condensate mass collected per hour by the total length of pipe from the inlet temperature measuring station to the condensate seal and then multiply it by the length of the permanent condensate piping. This value will then represent the total no-load correction as in **12.2.6 a)**.

12.3 Water or heat transfer fluid as primary fluid

12.3.1 Before starting a test the unit and all supply pipes shall be thoroughly vented by means of manual or automatic air vents.

12.3.2 Only start the test after a state of equilibrium has been reached. Such a state of equilibrium may be considered to exist when the conditions of **12.1** are satisfied.

12.3.3 Continue each test until three consecutive sets of readings, each taken over a period of 15 min, give outputs agreeing with $\pm 2\%$.

12.3.4 During any test the variation in fluid flow rate about the mean shall not exceed 2% and the air temperature (both wet and dry bulb temperature if cooling) shall not differ by more than the value given in Table 1 from the mean temperature recorded during the equilibrium period.

12.3.5 The following readings shall be taken.

- a) Fluid flow rate measured in the manner specified in **8.2.3**.
- b) Fluid temperature read at the beginning and end of the test and at intervals of 5 min. The extreme readings of each instrument shall not differ by more than the value given in Table 1. The range of fluid temperature difference readings obtained during the test shall not exceed 0.25°C . The average of the inlet fluid temperatures and the average of the outlet fluid temperatures over the appropriate period shall be used for calculation.
- c) The pressure drop across the unit under test read at the beginning and end of the test.