

Methods for

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

Part 1: Thermal and volumetric
performance for heating duties;
without additional ducting

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- British Oil and Gas Firing Equipment Manufacturers Association
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- National Coal Board
- Royal Institute of British Architects
- Water-tube Boilermakers Association

The Government departments and scientific and industrial 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 Station
- Greater London Council
- Oil Appliances Manufacturers Association
- Steel Radiators & Convector Manufacturers Association
- Unit Heater Manufacturers Association

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Foreword

This Part 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 that appear in this standard.

Part 2 of this standard will give methods of testing and rating for cooling duties without additional ducting. It is intended that further Parts will deal with units fitted with ducting acoustic aspects of testing and construction and safety requirements.

The general approach to the test methods described has been to consider the simplest practical method of carrying out the measurements without any unnecessary sacrifice of accuracy. The main test method permits thermal rating to be carried out in a large open space, and does not make any attempt to relate the primary fluid heat transfer with the heat transferred to the secondary fluid. This test method is very desirable when testing certain units that recirculate the heated air, as it allows this recirculation to be measured and corrected for in the test results.

It is appreciated that some of the larger units may not be suitable for testing in an open laboratory because it may be impossible to obtain steady state conditions and to this end a second test method has been introduced where the heat is ducted away from the unit. The test is necessarily more complex involving the calibration of the test chamber.

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

Where reference is made to British Standards for which no metric version is available 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 and ii, pages 1 to 22, 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 forced convection units containing fluid-to-air heat exchangers and incorporating their own fans. The units are for heating applications and the tests are to be carried out on units in an essentially clean condition.

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

2 Definitions

2.1

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

2.2

unit heater

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

2.3

essentially clean conditions

these conditions are defined when further cleaning of a unit does not affect the rating figures

2.4

reference air conditions (heating)

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

3 Operating characteristics of units

3.1 The primary medium shall be any of the following fluids:

Water

Steam

Heat transfer fluid (excluding primary refrigerants).

3.2 The operating conditions of the units shall lie within the following ranges:

Water up to 100 °C

Pressurized water from 100 °C to 200 °C

Steam between atmospheric pressure and a gauge pressure of 8 bar¹⁾

Heat transfer fluid up to 100 °C for atmospheric pressure and from 100 °C to 200 °C when pressurized.

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

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

3.5 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 is to be completed.

¹⁾ 1 bar = 10^5 N/m^2 .

4 Nomenclature

Symbol	Quality	Unit
c_p	specific heat capacity	kJ/kg °C
K_w	temperature correction factor	—
L	latent heat of evaporation	kJ/kg
M	total mass flow of liquid	kg
M_t	net weight of condensate formed during test	kg
M_n	net weight of condensate formed during no load	kg
Δp	primary fluid pressure drop	N/m ²
Δp_r	primary fluid pressure drop at a reference temperature of 80 °C	N/m ²
Q	rate of heat emission	kW
Q_a	rate of heat emission based on true inlet air temperature	kW
Q_m	rate of heat emission based on room air temperature	kW
q_r	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 of 80 °C	m ³ /s
ρ_r	reference air density	kg/m ³
ρ_m	air density at test conditions	kg/m ³
ρ_f	primary fluid density at mean liquid temperature	kg/m ³
ρ_{fr}	primary fluid density at reference temperature of 80 °C	kg/m ³
T_t	duration of test	s
T_n	duration of no load test	s
t_a	entering air temperature	°C
t_i	inlet liquid temperature	°C
t_o	outlet liquid temperature	°C
t_R	room air temperature	°C
t_3	saturated steam temperature	°C
w	liquid mass flow rate	kg/s

5 Objects 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 space temperatures. The test procedures set out in this standard are for the determination of:

- 1) the gross thermal output;
- 2) the primary fluid pressure drop;
- 3) the secondary flow rate, where required.

6 Testing conditions

6.1 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.

Suitable inlet temperatures may be:

For inlet temperature up to 100 °C: at 50 °C, 70 °C, 90 °C.

For inlet temperature between 100 °C and 200 °C: at 130 °C, 150 °C, 180 °C.

6.2 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.

6.3 Entering air conditions. The entering air temperature shall be within the range 15 – 25 °C.

6.4 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.

6.5 Electrical supply conditions. The tests shall be carried out at the rated voltage and frequency of the unit.

7 Steady state conditions

Tests shall be carried out under steady state conditions and these are considered to be established if during 30 min the measurements given in Table 1 do not vary by more than the specified amount.

Table 1 — Steady state conditions

Quantity	Permitted variation from mean
Room air temperature, as defined in 11.1	0.5 °C
Entering air temperature, as defined in 11.2	0.5 °C
Entering liquid temperature	{ 0.5 °C range: less than 100 °C 1 °C range: between 100 °C and 200 °C
Liquid flow rate	2 %
Steam rate of condensation	3 %
Supply voltage	± 2.5 % of rated voltage.

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 1a, situated at the entry and outlet of the unit between 100 mm and 200 mm for the unit connections.

8.1.2 Pressure. Pressure gauges shall comply with the requirements of Clause 30a 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 bar, a liquid manometer is desirable.

8.1.3 Mass flow. Mass flow measurement shall be by weight of condensate. The weighing apparatus shall not have an error greater than ± 5 g over the range of weights used in the test.

8.2 Hot water

8.2.1 Temperature. The measurement of temperature of the water 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 1b, situated at the entry and outlet of the unit between 100 mm and 200 mm from the unit connections.

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 2. The manometer shall be vertical and calibrated in intervals not exceeding 2 % of the measured drop.

8.2.3 Mass flow. Mass flow shall be preferably measured by direct weighing. Weighing machines shall have an error of not greater than ± 50 g over the range of weights used in the test. Collecting vessels shall not weigh more than 50 % of their normal contents.

Flow rate may also be measured by means of an orifice plate installed in accordance with 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 3. Inlet air temperatures shall be measured by thermocouples or resistance thermometers capable of being shielded as in Figure 3b.

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. It is suggested that the orifice plate at the junction of a void and duct be employed, as described in Clause 49 of BS 1042-1:1964.

8.3.3 Pressure

8.3.3.1 The minimum differential pressure readings for flow measurement shall be 25 N/m² for inclined U-tube manometers and micro-manometers, and 500 N/m² for vertical U-tube manometers.

8.3.3.2 Manometers shall be calibrated against an accepted standard.

8.3.3.3 It shall be possible to read the manometer to an accuracy of 0.5 N/m² over a pressure differential of 25 – 50 N/m² and to 1 % at higher differential pressures.

9 Test equipment

9.1 Steam. The steam supply and consumption test equipment shall be as detailed below and arranged as shown in Figure 4.

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 °C.

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 of the unit, as means for controlling and indicating the steam pressure and temperature. The use of 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 Hot water or heat transfer fluid

9.2.1 There shall be available a means for providing a continuous supply of heated 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.

9.2.3 Figure 5 shows the arrangement of the hot water test equipment.

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 6.

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 tapings shall be adjacent to the connection to the appliance. The tapings shall be as specified in Figure 7 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 °C.

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

10 Test facility

In many cases it will be possible to test units in the open laboratory and the test arrangement described in **10.1** will be suitable. In the case of the larger unit heaters it may not be possible to obtain steady state conditions and the heated air may have to be ducted away, in this case the tests can be carried out with the unit connected to the air flow rate measuring apparatus described in **10.2**, except where recirculation of the heated air occurs.

10.1 Open laboratory testing

10.1.1 The unit shall be tested with a minimum of 3 m or $5\sqrt{A}$ (where A is the outlet area, m^2), whichever is the greater, of clear space in the direction of discharge.

10.1.2 Units designed for mounting or standing against a surface shall be tested standing against a surface. This surface shall extend to a minimum of 1.5 m on either side of the unit, and to a height of 2.5 m or to the unit height, whichever is the greater.

10.1.3 Freely suspended units shall be tested with a minimum of 2 m clear space around them and the requisite space in the direction of discharge (**10.1.1**).

10.1.4 If a unit is designed for use in a specific situation then the test facility shall reflect this situation.

10.1.5 Insulating material with a thermal conductivity not less than $1 \text{ W/m } ^\circ\text{C}$ and of 10 mm minimum thickness shall be used between the unit and any adjacent surfaces.

10.1.6 The test shall take place in a space where vertical and horizontal temperature gradients do not exceed $0.5 \text{ } ^\circ\text{C/m}$ when the unit is not operating.

10.2 Air flow rate apparatus

10.2.1 The unit shall be connected to a chamber as shown in Figure 8.

10.2.2 The chamber volume shall be such that the number of air changes, with the unit set for maximum flow, is less than 1.7 per second. The cross-sectional area of the chamber shall be such that the mean chamber velocity is no greater than 40 % of the mean discharge velocity from the unit outlet.

10.2.3 The chamber shall be connected to a flow meter and booster fan with a means of varying the air flow rate as shown in Figure 8.

11 Air temperature measurement

The selection of a suitable fan coil unit or unit heater is very often based upon its output at some specified value of room temperature. The room temperature is not necessarily equal to the unit inlet temperature. It will not be so if the design of the unit allows a proportion of the heated air to circulate from outlet to inlet.

11.1 Room temperature

11.1.1 Measure the room air temperature at the stations indicated in Figure 9. If at least 75 % of all the measured temperatures are within $1 \text{ } ^\circ\text{C}$ of the lowest then the mean of the sample within this limit shall be taken as the mean room temperature (t_R). If more than 25 % of the temperatures recorded are greater than $1 \text{ } ^\circ\text{C}$ above the lowest, then the length of the temperature traverse lines shall be doubled, with a corresponding increase in the number of measuring stations. Provided that at least 50 % of the measured temperatures are within $1 \text{ } ^\circ\text{C}$ of the lowest measured temperature, the mean of the sample within this limit shall be taken as the mean room temperature.

11.1.2 If the conditions stated in **11.1.1** cannot be met, the size of the space in which the test is being carried out shall be increased until satisfactory conditions are achieved, or the unit tested in accordance with **14.2** provided that recirculation of the heated air does not occur.

11.2 Unit entering air temperature

11.2.1 Measure the unit entering air temperature (t_a) 10 mm in front of the inlet grille (or inlet grilles) by means of point measuring instruments; see Figure 3b.

11.2.2 Measuring stations shall be evenly distributed about the inlet (or inlets) as shown in Figure 10. 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.