BRITISH STANDARD

BS 4856-2:
1975

Methods for

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

Part 2: Thermal and volumetric performance for cooling duties: without additional ducting

UDC 697.97.001.42 + 697.356.001.42

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 Health and Social Security*
Department of the Environment
Electricity Supply Industry in England and Wales
Engineering Equipment Users' Association
Heating and Ventilating Contractors' Association*
Heating and Ventilating Research Association*
HEVAC Association*
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Lloyds Register of Shipping
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Ministry of Defence*
National Coal Board
Society of British Gas Industries
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 Establishment
Greater London Council
Oil Companies Materials Associations
Unit Heater Manufacturers' Association

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

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Contents

Foreword

Part 2 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 psychrometric method of testing which appears in this standard.

Part 1 of this standard covers units for heating duties, without additional ducting, and it is intended that further Parts will deal with units fitted with ducting, and acoustic aspects of testing.

Two different methods of thermal test are given in this Part, a gravimetric method and a psychrometric method. If variations in condensate flow rate are within the requirements specified (see clause **8**) it is considered that the gravimetric method provides the data required. If this proviso is not met then the psychrometric test method is used.

The unit cooler psychrometric tests given in this Part are very similar to those given for unit heaters in Part 1, with the exception of the latent cooling tests. Two approaches to the latent loading problem are presented, one a fixed point test which will yield accurate comparative data and a second test series for general rating purposes. The latter is based on the bypass factor method (see for example: Carrier, Cherne, Grant and Roverts. Modern air conditioning, heating and ventilating).

Where reference is made to British Standards for which no metric version is available then the appropriate British Standard in imperial units should be used in conjunction with BS 350 *"Conversion factors and tables";* attention is also drawn to BS 3763 *"The International System of units (SI)"* and PD 5686 *"The use of SI units"*.

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 30, 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

Part 2 of this British Standard deals with methods of carrying out thermal and volumetric tests of unit coolers without additional ducting. The unit coolers operate with or without condensation on the coils. The unit coolers are of the type used for cooling and dehumidifying purposes under frost-free conditions of operation. The cooling medium used is water or other heat transfer fluid (excluding volatile refrigerants). The range of approximate air volume flow rates is between 25×10^{-3} m^3/s and 5 m^3/s.

The tests are to be carried out on units in an essentially clean condition.

This standard applies to units having operating temperatures of primary fluid within the range 0 °C to 27 °C.

The primary fluids used are; water, brine, glycol, heat transfer fluid.

The minimum temperature differential (see **14.2**) of the primary fluid under test is 3 °C.

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

The standard specifies performance characteristics that are to be obtained from a unit. Although 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 have to be made.

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 Part of this British Standard the following definitions apply.

3.1
unit cooler or fan coil unit

a fluid-to-air heat exchanger apparatus through which air is passed by an electrically powered fan. This unit may or may not contain filters

3.2
reference air conditions (cooling)

temperature 20 °C, absolute pressure 1.013 bar[1)], relative humidity 43 %, and density 1.2 kg/m^3

3.3
room discharge air flow of a unit

rate of flow of air from the room-side outlet of the unit

3.4
room intake air flow of a unit

rate of flow of air into the unit from the conditioned space

3.5
local recirculation

flow of conditioned air directly from the room-side outlet to the room-side inlet of the unit

3.6
bypass factor (B)

it is assumed, for calculation purposes, that only a portion of the total air passing over the heat-exchanger surface (the coil) contacts the surface; the remaining air is assumed to bypass the surface and to leave unchanged from its entering condition

The bypass factor $B = (t_{ao} - t_B)/(t_a - t_B)$

$= (h_{ao} - h_B)/(h_{ai} - h_B)$

$= \exp\{-1/(R_a\ Cp_a\ m_a)\}$

where the symbols are as given in clause **4**.

3.7
net total room cooling effect (of a unit)

total available capacity of the unit for removing sensible and latent heat from the space to be conditioned

3.8
room dehumidifying effect

available capacity of the unit for removing moisture from the space to be conditioned

3.9
net room sensible cooling effect

available capacity of the unit for removing sensible heat from the space to be conditioned

3.10
total heat transferred

the total heat transferred (Q_T) is assumed to be related to the thermal resistances of the unit, thus:

$$Q_T = \Delta t_m/(SR_a + R_{wm})$$

where the symbols are as given in clause **4**

NOTE By rearranging this equation it can be seen that for a given air and water flow rate, a graph of $\Delta t_m/Q_T$ versus S will yield a straight line of slope R_a and will intercept R_{wm}. Once R_a is known, it is possible to calculate the bypass factor and consequently to obtain the coil performance for various inlet conditions.

[1)] 1 bar = 10^5 N/m^2 = 100 kPa.

3.11
rated voltage(s)

voltage(s) shown on the nameplate of the unit

3.12
rated frequency (s)

frequency(s) shown on the nameplate of the unit

4 Nomenclature

For the purposes of this Part of this British Standard the following nomenclature applies.

Symbol	Quantity	Unit
A	Free area of unit's cooled air outlet	m^3
B	Bypass factor	—
c_{pa}	Specific heat capacity of air	kJ/(kg K)
c_p	Specific heat capacity of primary fluid	kJ/(kg K)
c_{pw}	Specific heat capacity of water	kJ/(kg K)
E	Power dissipated in the room by the unit	kW
h_{ai}	Inlet air enthalpy	kJ/kg (dry air)
h_{ao}	Outlet air enthalpy	kJ/kg (dry air)
h_B	Enthalpy of saturated air at temperature t_B	kJ/kg (dry air)
Δh	Difference of air enthalpy across coil	kJ/kg (dry air)
K_w	Temperature correction factor	—
L	Latent heat of evaporation	kJ/kg
M	Total mass flow of primary fluid	kg
M_r	Net weight of condensate formed during test	kg
m_a	Air mass flow rate	kg/s
m_r	Condensate mass flow rate	kg/s
m_w	Primary fluid mass flow rate	kg/s
Δp_m	Primary fluid pressure drop	Pa
Δp_t	Primary fluid pressure drop at reference temperature (8 °C)	Pa
Q	Net total room cooling effect	kW
Q, Q_2	Total heat transferred when connected to air flow chamber	kW
Q_D	Room dehumidifying effect	kW
Q_S	Net room sensible cooling effect	kW
Q_T	Total heat transferred (primary fluid side)	kW
Q_{Ta}	Total heat transferred (air side)	kW
Q_{TR}	Total heat transferred with no recirculation	kW
q_f	Primary fluid volume flow rate	m^3/s
q_{fr}	Primary fluid volume flow rate at reference temperature (8 °C)	m^3/s
q_m	Air volume flow rate at measured conditions	m^3/s
q_r	Air volume flow rate at reference conditions	m^3/s
R	Overall appliance thermal resistance	°C/kW
R_a	Air side appliance thermal resistance	°C/kW
R_m	Mean overall appliance thermal resistance	°C/kW
R_{wm}	Primary fluid plus coil metal appliance thermal resistance	°C/kW
ρ_a	Air density at measured conditions	kg/m^3
ρ_F	Air density at the temperature and absolute pressure of the flow meter	kg/m^3
ρ_f	Primary fluid density at mean liquid temperature	kg/m^3
ρ_{fr}	Primary fluid density at reference temperature (98 °C)	kg/m^3
ρ_r	Air density at reference condition	kg/m^3
S	Ratio of sensible heat to total heat	—
T	Duration of test	s
t_a	Unit inlet air temperature (dry bulb)	°C
t_{ao}	Unit outlet air temperature (dry bulb)	°C
t_B	Apparatus dew point temperature	°C
t_i	Inlet primary fluid temperature	°C
t_o	Outlet primary fluid temperature	°C

Symbol	Quantity	Unit
t_R	Room air temperature (dry bulb)	°C
t'_R	Room air temperature (wet bulb)	°C
t_r	Condensate temperature	°C
Δt_m	Logarithmic mean temperature difference $[(t_a - t_o) - (t_{ao} - t_i)]/1_n [(t_a - t_o)/(t_{ao} - t_i)]$	°C
V_F	Measured air volume flow rate	m³/s
V_r	Air volume flow rate at reference air density (1.2 kg/m³)	m³/s
V_m	Mean air volume flow rate	m³/s

5 Objects of the tests

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

a) the net total room cooling effect;

b) the room dehumidifying effect,

c) the net room sensible cooling effect;

d) the primary fluid mass flow rate and pressure drop;

e) the nominal air flow rate,

f) freedom from sweating on the unit enclosure or casework;

g) adequate condensate disposal

6 Limits of accuracy of the test method

The test method, including the instrumentation, is suitable for obtaining results within the following limits of accuracy:

thermal duty:	± 5 % (psychrometric) ± 8 % (gravimetric)
primary fluid flow rate:	± 3 %
air volume flow rate:	± 10 %

7 Testing conditions

7.1 Primary fluid. 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 unit is to be rated.

7.2 Room air conditions. The room air temperature (dry bulb) range shall be chosen within the limits 5 °C to 30 °C, depending on the intended use of the unit.

The room air (wet bulb) temperatures shall be then chosen to cover the related range corresponding to the intended use of the unit.

7.3 Primary fluid flow rate. For duties to be 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 to cover the range over which the unit is to be rated.

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

7.5 Nominal rating. In the absence of a specified set of conditions, where a single nominal rating figure is required, the total cooling capacity under the following conditions shall be used:

room air temperature:	21 °C dry bulb 15 °C wet bulb
primary fluid inlet temperature:	5 °C
primary fluid outlet temperature:	10 °C

7.6 Complete description of unit performance. Where a complete description of the unit's performance over a range of conditions is required, it will be necessary to vary the primary fluid temperature, the room air conditions and the primary fluid flow rate so that a family of the required performance curves may be made.

The quantities shown on the four curves will be Q_S, Q_D plotted against, respectively, t'_R, t_R, t_i and m_w.

8 Steady state conditions

Tests shall be carried out under steady state conditions and these are considered to be established if, during 60 min, the measurements do not vary by more than the amounts specified in Table 1.

Table 1 — Steady state conditions

Quantity	Permitted variation from 60 min mean of individual 10 min readings
Room air temperature (as defined in **11.1**)	0.5 °C dry bulb; 0.3 °C wet bulb
Entering air temperature (as defined in **11.2**)	0.5 °C dry bulb; 0.3 °C wet bulb
Entering liquid temperature	0.5 °C
Primary fluid flow rate	2 %
Supply voltage	± 2.5 % of rated voltage

The condensate removal rate shall not vary by more than ± 3 % from the mean rate during 60 min. If the variation exceeds ± 3 %, the tests shall be continued either until a representative average rate of moisture extraction can be assessed or for a total period of 3 h, whichever first occurs. If, after 3 h, a representative rate of moisture extraction is not evident, the methods described in clauses **18**, **19** and **20** shall be used.

9 Instrumentation

9.1 Primary fluid

9.1.1 *Temperature.* The measurement of temperature of the primary fluid at entry and exit shall comply with the appropriate recommendations of BS 1041. If liquid-in-glass thermometers are used, they shall be graduated at intervals of 0.1 °C and shall comply with the requirements of BS 593.

Thermometers, thermocouples and resistance thermometers shall be calibrated against a NPI class A thermometer for partial immersion and shall be used in pockets similar to those shown in Figure 1, situated at the entry and outlet of the unit between 100 mm and 200 mm from the unit connections.

For temperature differences below 5 °C it will be necessary to take special care and the differential thermocouple system shown in Figure 2 is recommended, together with a separate measurement of inlet temperature.

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

9.1.3 *Mass flow.* Mass flow shall be preferably measured by direct weighing. Weighing machines shall have an error not greater than 0.2 % over the range weighings used in the test. Collecting vessels shall weigh not more than 50 % of their normal contents. The net weight of each charge shall be recorded by weighing the vessel both after emptying the previous charge and after filling.

Mass flow may also be obtained by means of an orifice plate installed in accordance with BS 1042-1.

9.2 Air

9.2.1 *Temperature.* Measurements of air temperature shall be made with mercury-in-glass thermometers, thermocouples or resistance thermometers calibrated against an NPL class A thermometer for total immersion. Thermometers shall be graduated at intervals not greater than 0.1 °C.

Temperature measuring instruments shall be shielded against radiation; suitable shields are shown in Figure 4. Inlet air temperatures shall be measured by thermocouples or resistance thermometers capable of being shielded as shown in Figure 4 (b).

The entry and exit air wet and dry bulb measurements shall be by means of the system given in Appendix D of BS 4194:1967. The measurement system shall be connected to sampling tubes similar to those shown in Figure 5 (a) and Figure 5 (b).

9.2.2 *Flow rate.* Flow rate shall be measured by means of an orifice plate installed in a chamber as shown in Figure 6 and generally in accordance with the requirements of BS 1042-1. Where the requirements 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.

9.2.3 ***Pressure***

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

9.2.3.2 Manometers shall be calibrated against an accepted standard.

9.2.3.3 It shall be possible to read the manometers to 0.5 Pa over a pressure differential of 25 Pa to 50 Pa and to 1 % at higher differential pressures.

9.3 Condensate

9.3.1 *Temperature.* Condensate temperature shall be measured in the well of a suitably insulated trap at the unit outlet using instrumentation as specified in **9.1.1**. The trap may be the collecting vessel specified in **9.3.2**.

9.3.2 *Mass flow.* Mass flow shall be measured by direct weighing. Weighing machines shall have an error of less than ± 1 % of the value measured. Collecting vessels shall weigh not more than 50 % of the mass of the contents weighed.

10 Test equipment

10.1 Chilled primary fluid. There shall be available chilled fluid supply and measurement equipment as detailed below and arranged generally as shown in Figure 7.

10.1.1 There shall be available a means for providing a continuous supply of fluid.

10.1.2 There shall be a means for controlling the chilled fluid to any desired temperature which may be required for the tests.

10.1.3 There shall be available a means for providing a constant flow of fluid, such as a constant head tank or a circulation pump.

10.1.4 There shall be a means of controlling the chilled fluid to any desired flow rate which may be required for the test.

10.1.5 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.

10.1.6 Hydraulic resistance side wall tappings shall be adjacent to the connection to the appliance. The tappings shall be as shown in Figure 8 and connected to form a piezometric ring.

10.1.7 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).

10.1.8 When mass flow measurement is by weighing, care shall be taken to minimize condensation on and evaporation from vessels awaiting weighing.

10.2 Air flow rate apparatus. There shall be a means for continuously measuring the air volume throughput rate of the unit, under conditions approximating to the normal use of the unit, as detailed below and arranged generally as shown in Figure 6.

10.2.1 The unit shall be connected to a chamber as shown in Figure 6.

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 auxiliary fan as shown in Figure 6.

10.2.4 There shall be a means of controlling the auxiliary fan to give any desired air flow rate which may be required for the test.

10.2.5 For the psychrometric test method, the air flow rate apparatus shall be extended, as shown in Figure 9, to include mixers and temperature samples similar to those shown in Figure 5 (a). The whole of the chamber shall be constructed from a non-absorbent material and insulated with at least 50 mm thickness of insulating material having a thermal conductivity not exceeding 0.06 W/(m K).

11 Air temperature measurements

The selection of a suitable fan coil unit or unit cooler is very often based upon its output at some specified values of room temperatures. The room temperatures are not necessarily equal to the unit inlet temperatures. They will not be so if the design of the unit allows a proportion of the air to circulate from outlet to inlet.

11.1 Room air temperature

11.1.1 The room air temperature shall be measured at the stations indicated in Figure 10. If at least 75 % of all the measured temperatures are within 1 °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 °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 °C of the lowest measured temperature the mean of the sample within this limit shall be taken as the mean room temperature (see Table 1).

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 altered until satisfactory conditions are achieved.

11.2 Unit air inlet temperature. Where the mean unit air inlet temperature differs significantly from the mean room temperature, and is required as part of the performance data, then it shall be measured as specified in **11.2.1** to **11.2.4**.

11.2.1 The unit inlet temperature (t_a) shall be measured 10 mm in front of the inlet grille (s) by means of shielded point measuring instruments (see Figure 4).

11.2.2 Measuring stations shall be evenly distributed about the inlet(s) as shown in Figure 11. 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, 20, 20.6, 18.5 °C, the mean of these is 19.6 °C, and two extra stations will be required.

11.2.3 The extra temperature measuring stations shall be located as shown in Figure 11.

11.2.4 For the psychrometric test method, the inlet wet and dry bulb temperatures shall be measured via an inlet air sampling tube, similar to that shown in Figure 5, located at a point 200 mm in front of the unit air inlet, as indicated in Figure 5.

12 Primary fluid measurements

12.1 The primary fluid temperatures shall be selected in conformity with **7.1**.

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

12.3 The test shall be started only after a state of equilibrium has been reached. Such a state of equilibrium may be considered to exist when the conditions of clause **8** are satisfied.

12.4 Each test shall be continued until three consecutive sets of readings, each taken over a period of 15 min, give rated outputs agreeing within ± 2 %.

12.5 During any test the variation in primary fluid flow rate shall not exceed 2 % and the air temperature (mean inlet and room) shall not differ by more than ± 1 °C from the mean temperature recorded during the equilibrium period.

12.6 The following measurements shall be taken in the manner specified.

a) Primary fluid flow rate shall be measured as specified in **9.1.3**.

b) Primary fluid temperatures shall be 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 0.5 °C. The range of temperature difference readings obtained during the test shall not exceed 0.25 °C. The average of the inlet temperatures and the average of the outlet temperatures over the appropriate period shall be used for calculation of the rating.

c) The pressure drop across the unit under test shall be read at the beginning and end of the test.

13 Test facility

13.1 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. The room shall be such as to permit the operation of the instruments and of the other detailed requirements given below.

13.2 The unit shall be tested with a clear space in the direction of discharge not less than $5\sqrt{A}$ (m), where A (m^2) is the free area of the unit's cooled air outlet.

13.3 Units designed for mounting on or standing against a wall shall be so installed for test. This wall 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.

13.4 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 (see **13.2**).

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

13.6 Insulating material with a thermal conductivity not less than 1 W/(m K) and of 10 mm minimum thickness shall be used between the unit and any adjacent surfaces.

13.7 The test shall take place in a space where vertical and horizontal temperature gradients do not exceed 0.5 °C/m when the unit is not operating.

13.8 Any air supply outlet, or inlet, used for stabilizing the test environment shall have a face velocity not greater than 0.5 m/s.

14 Thermal rating: results and analysis

14.1 General. The thermal rating shall be determined as indicated in this clause and shall comprise the values obtained for the following:

a) net total room cooling effect (see **14.2**);

b) room dehumidifying effect (see **14.3**);

c) net room sensible cooling effect (see **14.4**);

d) room air wet bulb and dry bulb temperatures;

e) primary fluid (nature to be stated) flow rate and temperature;

f) electricity supply nominal voltage and frequency.

14.2 Net total room cooling effect *(Q)*. The rating of the unit shall be calculated for each test using the formula:

a) for weight or volume method

$$Q = \left[\frac{M c_p (t_i - t_o)}{T}\right] - E - \left[\frac{M_r c_{pw} (t_R - t_r)}{T}\right]$$

b) for direct mass flow measurement (i.e. orifice plate)

$$Q = \left[m_w c_p (t_i - t_o)\right] - E - \left[m_r c_{pw} (t_R - t_r)\right]$$

where

Q is the output, net total room cooling effect (kW);

M is the total primary fluid mass flow (kg);

M_r is the net weight of condensate formed during test (kg);

T is the duration of test;

t_i is the average fluid inlet temperature (°C);

c_p is the specific heat capacity of primary fluid (kJ/kg K);

c_{pw} is the specific heat capacity of water kJ/(kg K);

t_o is the average outlet liquid temperature (°C);

t_R is the room air temperature (°C):

t_r is the condensate temperature (°C);

m_w is the primary fluid mass flow rate (kg/s);

E is the power dissipated in the room by the unit (kW);

m_r is the condensate mass flow (kg/s).

NOTE Where, for example, the fan motor is effectively isolated from all contact with the room air, then E is equal to the room air impeller shaft horse power measured by the method described in BS 848.

14.3 Room dehumidifying effect *(Q_D)*. The room dehumidifying effect *(Q_D)* is the rate of energy extraction due to removal of water and is given by the formula:

$Q_D = LM_r/TM_r$ (kW)

where

L is the latent heat of evaporation of water (kJ/kg);

M_r is the net weight of condensate formed during test (kg);

T is the duration of test;

m_r is the condensate mass flow rate (kg/s).

14.4 Net room sensible cooling effect (Q_s). The net room sensible cooling effect (Q_s) is the difference between the net total room cooling effect and the room dehumidifying effect and is given by the formula:

$Q_s = Q - Q_D$(kW).

14.5 Primary fluid mass flow rate and pressure drop

14.5.1 The primary fluid mass flow rate shall be determined either from the formula $m_r = M_r/T$ by direct weighing or by means of an orifice plate (see **9.1.3**).

14.5.2 The primary fluid pressure drop determined in accordance with the provisions of **9.1.2** and **10.1** shall be corrected for any difference in height between the inlet and outlet measuring stations and converted to the pressure drop at a mean water temperature of 8 °C by means of the equation:

$\Delta p_c = \Delta p_m/K_w$

where

Δp_c is the hydraulic pressure drop at 8 °C (Pa);

Δp_m is the measured hydraulic pressure drop corrected (Pa) for height difference;

K_w is the temperature correction factor, obtained from Figure 12, at the mean test water temperature.

14.5.3 Δp_c shall be plotted against the primary fluid mass flow rate (m_r) on logarithmic graph paper and the best line through the test points shall be used (in conjunction with the above equation) to determine the pressure drop at any flow rate within, and to ± 10 % outside, the range of the test variables.

NOTE At least three readings are required for the case of a single nominal flow rating.

15 Air volume flow rate measurements

15.1 The unit shall be connected to the chamber described in **10.2** (see Figure 6).

15.2 The chamber and the junction between the chamber and the unit shall be carefully sealed against leaks.

15.3 The necessary equipment for primary fluid supply shall be connected to the appliance (see clause **10**).

15.4 All primary fluid measurements shall be carried out as described in clause **12**.

15.5 The desired unit fan speed shall be selected and primary fluid conditions set at 5 ± 0.5 °C ON and 10 ± 0.5 °C OFF and room conditions set to nominal temperatures 21 °C dry bulb and 15 °C wet bulb.

15.6 The static pressure in the chamber shall be set to zero by means of the auxiliary fan connected to the chamber (see Figure 6).

15.7 The pressure drop across the flow meter shall be recorded at three equally spaced time intervals during the test and the mean value used to compute the volume flow.

15.8 The temperature at the flow meter shall be recorded at similar intervals to all other temperature measurements and the mean value computed.

15.9 The barometric pressure shall also be recorded.

15.10 The air volume flow rate shall be converted to the volume flow rate under reference conditions by the equation:

q_r $\quad q_r = q_m \rho_a \rho_r$

where

q_r is the air volume flow rate at reference

q_m is the volume flow rate; measured value

ρ_a is the air density at conditions measured at the flow meter (kg/m^3);

ρ_r is the reference air density (kg/m^3) = 1.2 kg/m^3.

16 Enclosure sweating tests and condensate disposal tests

16.1 Enclosure sweat test conditions. The conditions which shall be used during enclosure sweat tests for all models are given in Table 2.

Table 2 — Enclosure sweat test conditions

Room air temperature	
dry bulb	27 °C
wet bulb	24 °C
Test frequency	Rated frequency[a]
Test voltage	Rated voltage[b]

[a] Units with dual rated frequencies shall be tested at each frequency.
[b] Units with dual rated voltages shall be tested at the higher voltage.

16.2 Condensate disposal test conditions. Condensate disposal tests shall be conducted under the same conditions as those specified for enclosure sweat tests in **16.1**.

16.3 Enclosure sweat test

16.3.1 *General.* Unit coolers shall meet the requirements of the following enclosure sweat test when operating at the test conditions specified in **16.1**. The unit's controls, fans, dampers and grilles shall be set to produce the maximum tendency to sweat, provided such settings are not contrary to the manufacturer's operating instructions.

16.3.2 *Procedure.* After establishment of the specified temperature conditions, the unit shall be operated continuously for a period of 4 h.

16.3.3 *Requirements.* During the test, no condensed water shall drip, run or blow off the unit.

16.4 Condensate disposal test

16.4.1 *General.* Unit coolers shall meet the requirements of the following condensate disposal test when operating at the test conditions specified in **16.2**. The unit's controls, fans, dampers and grilles shall be set to produce the maximum tendency to sweat, provided such settings are not contrary to the manufacturer's operation instructions.

NOTE This test may be conducted concurrently with the enclosure sweat test (see **16.3**).

16.4.2 *Procedure.* After establishment of the specified temperature conditions, the unit cooler shall be started, inspection having ensured that its condensate collection pan is filled to the overflow point, and shall be operated continuously for 4 h after the condensate level has reached equilibrium.

16.4.3 *Requirements.* During this test, the unit cooler shall have the ability to dispose of all condensate and there shall be no dripping or blowing-off of water from the unit such that the building or surroundings may become wet.

17 Electrical rating test

Electrical input values used for rating purposes shall be measured during the cooling capacity test as specified in clauses **7** and **8**.

18 Psychrometric test method

18.1 General test instructions. These instructions apply to all the *sensible* cooling tests made under these test conditions (see clause **8**) but they are applicable only to the fixed condition single point *sensible and latent* cooling test (see **20.2.1**). The distinction between the two types of test is explained in clause **20**.

18.1.1 The tests shall be carried out under steady state conditions (see clause **8**).

18.1.2 If the test is to be for sensible heat only then the inlet air dew point shall not exceed the inlet primary fluid temperature.

18.1.3 Before commencing the test the following procedures shall be carried out:

a) bleed the primary fluid supply system to remove all air;

b) circulate the primary fluid through the unit and regulate the flow and temperature to those desired for the test;

c) start the unit fan and set the required speed.

18.1.4 The test shall occupy not less than 30 min (60 min if there is a latent load) and complete sets of test data shall be recorded at intervals not exceeding 10 min, with the exception of barometric pressure which shall be recorded at start and finish. A complete set of data shall comprise:

a) inlet air temperature } wet and dry bulbs
b) room air temperature } if necessary;

c) inlet and outlet water temperatures;

d) primary fluid flow rate;

d) primary fluid pressure drop;

f) supply voltage.

18.1.5 A test shall be void if:

a) the data varies by more than the tolerances referred to in **18.1.1**.

b) the heat transferred $m_w c_p (t_o - t_i)$ for individual samples varies by more than 2 % from the mean of the test measurements.

18.2 Calculation of total heat transferred. The total heat transferred shall be calculated with mean values obtained from the test data from the equation:

$Q_T = m_w c_p (t_o - t_i)$ (kW)

where

m_w is the primary fluid mass flow rate (kg/s);

c_p is the specific heat capacity of the primary fluid [kJ/(kg K)];

t_o is the mean primary fluid outlet temperature (°C);

t_i is the mean primary fluid inlet temperature (°C).

19 Air volume flow measurement for psychrometric test method

19.1 Before the air flow test itself is made, a minimum or three sensible cooling tests shall first be carried out (as described in **18.1**) at a fixed unit fan speed and primary fluid flow rate, and a minimum of three inlet primary fluid temperatures.

19.2 These test results shall be plotted on logarithmic graph paper in the form Q_T versus $(t_a - t_i)$ and the best line drawn through the test points.

19.3 The unit shall then be connected to the air flow rate apparatus described in **10.2** and to the heat transfer apparatus. The specified temperature measuring instruments shall be set up for the measurement of inlet air temperature.

19.4 The unit fan shall be set to give the speed employed for the sensible cooling tests previously made (see **19.1**) and the auxiliary fan set to give a zero chamber static pressure.

19.5 The primary fluid inlet temperature shall be set to approximately the mid point of the range used for the sensible cooling tests (see **19.1**). The primary fluid flow rate shall be within 2 % of that used for the sensible cooling tests (see **19.1**).

19.6 The test shall now be made as described in **18.1**, but with the air flow meter temperature and air flow meter pressure drop also recorded at the same intervals as the other data. The air flow meter pressure drop shall not vary by more than 4 % during the test.

19.7 The heat transferred when connected to the air flow chamber (Q_1) shall be calculated (see **18.2**) and compared with that (Q_2) obtained from the graph (see **19.2**),if these two figures are within ± 3 % then the test air flow rate may be considered to be the unit air flow rate. This air flow rate shall be corrected to that at reference conditions by means of the equation:

$V_r = V_F \rho_F / 1.2$

where

V_r is the air volume flow at the reference density of 1.2 kg/m³ (m³/s);

V_F is the measured air volume flow rate (m³/s);

ρ_F is the density of air at the temperature and absolute pressure of the flow meter (kg/m³).

19.8 If the two heat transfer rates Q_1 and Q_2 are outside the limits given in **19.7**, then the air flow test shall be repeated at two other air volume flow rates, and the ratio Q_1 to Q_2 plotted versus V_r as shown in Figure 13. These air flow rates shall be chosen such that the values of Q_1/Q_2 fall on either side of unity.

NOTE It is suggested that if Q_1/Q_2 is greater than unity then the chamber static pressure should be increased to about 5 Pa and if below unity then the status pressure should be reduced to about – 5 Pa.

19.9 The unit air volume flow rate (V_r) shall be obtained from the graph (see Figure 13) at $Q_1/Q_2 = 1$.

20 Rating tests (psychrometric test method)

The sensible cooling rating tests will enable the unit sensible heat performance to be evaluated to within 5 % at any condition within the range of temperatures and flow rates employed in the test series described in this clause.

The added complexity of a latent cooling load is allowed for by a separate test series designed to obtain the unit bypass factor without knowledge of the physical properties and dimensions of the coil. The result is necessarily less accurate than that from the sensible cooling test series since the method used involves an approximation to the actual physical processes occurring arid does not consider casing radiation or leakage from the unit casing. It is therefore necessary to carry out the latent cooling test at certain specified inlet conditions in order that accurate *comparative* data may be obtained.

20.1 Sensible cooling rating tests

20.1.1 The series of tests shown in Table 3 shall be carried out in accordance with clauses **18** and **19**. The room air temperature shall be between 18 °C and 29 °C.

Table 3 — Sensible cooling test series

Test series	Primary fluid flow rate m_w	Air flow rate V_r	Inlet temperature difference $(t_R - t_i)$
	kg/s	m³/s	°C
1	Near bottom of range	Maximum	Three different, evenly spread
2	Top and middle of range	Maximum	Near middle of range
3	Middle, top and bottom of range	Middle of range	Near middle of range
4	Middle, top and bottom of range	Minimum	Near middle of range

Tests at top and bottom of the range shall be within 10 % of the maximum and minimum range of the test variables. Air and primary fluid flow rates shall be repeated to within 2 % of the original values used for each test.

If in test series 3 or 4 the ratio:

$$(t_a - t_i)/(t_R - t_i) \leqslant 0.95$$

then these tests shall also be carried out at three primary fluid inlet temperatures (as specified for test series 1).

20.1.2 *Recirculation correction.* If at any of the test air flow settings the ratio:

$$(t_a - t_i)/(t_R - t_i) \leqslant 0.95$$

then it is considered that a proportion of the outlet air is returning directly to the inlet. The amount of any recirculating air is a function of the outlet air velocity, the outlet air temperature and the ambient temperature.

It is desirable to rate the unit with reference to the temperature of the surroundings and not to the air inlet temperature. For this reason a recirculation correction curve is established as detailed in **20.1.2.1** to **20.1.2.3**.

20.1.2.1 Draw a separate curve for each air flow setting employed in the test series.

20.1.2.2 Plot Q_T against $(t_a - t_i)$ on logarithmic graph paper. From this curve obtain Q_{TR}, the heat transferred if the inlet air temperature was equal to the room temperature. (This is the value of Q_T at the point corresponding to a temperature differential $(t_R - t_i)$ and is the maximum possible heat transfer under the test conditions.)

20.1.2.3 Plot the ratio Q_T/Q_{TR} against $Q_{TR}/(t_R + 273)$ as shown in Figure 14. This curve is employed to determine the recirculation correction as shown in **21.1** e).

20.1.3 *Rating curves.* Two log-log graphs, A and B, are plotted (see Figure 15).

From test series 1 (see **20.1.1**) draw line 1 of graph A, Q_T versus $t_a - t_i$, the best straight line through the test points. No point shall deviate by more than 2 % Q_T from this line.

From test series 2, 3 and 4 complete the set of curves A by plotting the measured Q_T versus $(t_a - t_i)$ and draw lines parallel to line 1 through the test points. If recirculation occurred at the test conditions (see **20.1.1**) then the additional test points shall be included in this graph, and no point shall deviate by more than 2 % from the best line.

Select a value of ($t_a - t_i$) at the centre of the test range (15 °C for the example in Figure 15) and, using the values of Q_T where lines A intercept this constant temperature value, carry out the cross-plot for graph B (variation of heat transferred with water flow rate). Graph B comprises three approximately parallel lines corresponding to three air flow rates. These lines shall not cross.

20.2 Sensible and latent cooling rating tests

20.2.1 *Fixed condition test.* One test shall be carried out with the unit operating at maximum air flow rate and a room air temperature of 21 °C dry bulb, 15 °C wet bulb and a primary fluid inlet temperature of 5 °C (in accordance with **7.5**). This test shall be used for comparative purposes only and the results may not be extrapolated to any other conditions.

20.2.2 ***Rating tests***

20.2.2.1 Tests as described in **20.1** shall first be carried out and analysed by the methods given.

20.2.2.2 The unit shall then be connected to the extended air flow rate measuring apparatus described in **10.2.5** and air flow tests carried out, as described in **19.3** to **19.9**, at each unit fan speed setting employed for the tests under **20.2.2.1**. In addition to plotting air volume flow rate V_r versus Q_1/Q_T, chamber static pressure shall also be plotted against Q_1/Q_T and the chamber static pressure for $Q_1/Q_T = 1$ determined for each unit fan speed employed in the tests.

20.2.2.3 The series of tests shown in Table 4 shall be carried out with the inlet air temperature between 18 °C and 29 °C (dry bulb). The primary fluid inlet temperature should be left as low as possible consistent with the required sensible to total heat ratio.

Table 4 — Sensible and latent cooling test series

Test series	Primary fluid flow rate m_w	Air flow rate V_r	Sensible/ total heat ratio S
	kg/s	m^3/s	
1	Bottom of range	Three evenly spaced	1
2	Middle and top of range	Middle of range	1
3	Bottom of range	Middle of range	0.9 ± 5 %
4	Bottom of range	Middle of range	0.8 ± 5 %
5	Bottom of range	Middle of range	0.7 ± 5 %
6	Bottom of range	Middle of range	0.65 ± 5 %

The primary fluid flow rate termed “bottom of range” shall be reproduced to within 2 % for all the tests made at this primary fluid flow rate. The air flow rates shall be those as set on the unit speed control with the chamber static pressure set as determined in **20.2.2.2**.

20.2.2.4 The tests shall be carried out under the steady state conditions laid down in clause **8** with the addition that the outlet dry bulb and wet bulb temperatures shall not vary by more than 0.3 °C, and the chamber static pressures shall not vary by more than 5 % from their mean values.

20.2.2.5 After steady state conditions have been achieved, the data given below shall be recorded at 10 min intervals, for a minimum period of either 30 min ($S = 1$) or 60 min ($S < 1$). The barometric pressure shall be recorded at the start and finish of the test.

Inlet primary fluid temperature

Outlet primary fluid temperature

Inlet air temperature (wet and dry bulb)

Outlet air temperature (wet and dry bulb)

Primary fluid mass flow rate

Chamber static pressure and temperature

Chamber flow meter pressure drop

Chamber temperature

20.2.2.6 The following items are calculated from the mean test data:

$Q_T = m_w c_p (t_o - t_i)$

$S = c_{pa}\ (t_a - b_o)/(h_{ai} - h_{ao})$

$Q_{Ta} = m_a\ (h_{ai} - h_{ao})$ where $S < 1$

$Q_{Ta} = m_a c_{pa}\ (t_a - t_{ao})$ where $S = 1$

The values of the air enthalpies are taken from tables and corrected for barometric pressures different from standard.

NOTE 1 It is unlikely that Q_{Ta} will be equal to Q_T because of leaks in the unit casing, heat from the fan and casing radiation. However, it will normally be possible to obtain a heat balance in the range $0.925 < Q_{Ta}/Q_T < 1.025$. If the heat balance is outside these limits, then the test may be invalid or the unit may have an unusually large heat leakage rate.

NOTE 2 It is to be expected that the air mass flow rate will change with the sensible to total heat ratio. In order to compensate for such changes a mean mass flow rate is employed in rating calculations.

20.2.2.7 The coil appliance thermal resistances and bypass factor are calculated as follows.

a) Calculate the overall appliance thermal resistance (R) for all results of test series 1 to 6 (see Table 4) from the equation:

$R = \Delta t_m / Q_T$ (°C/kW)

where Δt_m is the log mean temperature difference.

b) Compute the mean air flow rate V_m for test series 2 to 6.

c) Plot R against air flow rate for test series 1 and hence obtain R_m at the mean air flow rate V_m computed at b) above.

d) The approximate air side appliance thermal resistance (R_a) and the approximate primary fluid plus metal appliance thermal resistance (R_{wm}) for test series 1, 3, 4, 5 and 6 at the mid range air flow rate V_m, are obtained from the following two equations:

$R_a = \Sigma\,(1 - S)\,(R_m - R)/\Sigma\,(1 - S)^2$

and $R_{wm} = R_m - R_a$

NOTE The first equation is a least squares fit to $Q = \Delta t_m/(SR_a + R_{wm})$.

e) R for the other test air flow rates is calculated by subtracting R_{wm} obtained at d) above from the value of R for the top and bottom air flow rates employed in test series 1.

f) The primary fluid and metal appliance thermal resistances for the mid and top range primary fluid flow rates employed in test series 2 may be computed from the equation:

$R_{wm} = R - R_a$

where R_a is obtained from d) and R from a)

g) Plot R_{wm} against m_w and list R_a as a function of unit speed setting.

h) The bypass factor may be calculated from the equation:

$B = \text{Exp}\,[-1/(1.2\,c_{pa}\,V_r\,R_a)]$ and listed against unit fan speed setting (see clause **3** and **19.7**).

21 Examples (psychrometric test method)

21.1 Sensible cooling only. It is required to compute the thermal output of a unit, with test data as shown in Figure 14 and Figure 15, at air volume flow rates of 0.12, 0.23 and 0.36 m^3/S, a primary fluid flow rate of 0.25 kg/s and a primary fluid inlet temperature of 12 °C when cooling a room at 25 °C. The performance may be calculated in the following manner, taking V_r = 0.23 m^3/s.

a) From Figure 15(b) at 0.23 m^3/s and 0.25 kg/s, the heat transferred at a temperature difference ($t_a - t_i$) of 15 °C is 1.9 kW.

b) Assuming that t_a and t_R = 25 °C, then $t_a - t_i$ = (25 °C – 12 °C) = 13 °C.

c) Replot line 1 from the test characteristics given in Figure 15(a) on logarithmic graph paper (see Figure 16) and draw a line, parallel to line 1, through the point 15 °C, 1.9 kW.

Table 5 — Calculation of sensible cooling duty at room temperature of 25 °C

$t_R - t_i$	m_w	V_r	Q_{TR}	$Q_{TR}/(t_R + 273)$	Q_T/Q_{TR}	Q_T
°C	kg/s	m^3/s	kW	kW/K	from Figure 14	kW
13	0.25	0.12	1.16	0.003 90	0.95	1.10
13	0.25	0.23	1.65	0.005 55	0.975	1.61
13	0.25	0.36	2.18	0.008 40	1.00	2.18

d) At ($t_a - t_i$) = 13 °C, the heat transferred (Q_{TR}) is then equal to 1.65 kW.

e) The results are corrected for recirculation (using Figure 14) as shown in Table 5. All values of Q_{TR} in the table are obtained from steps a) to d).

21.2 Sensible and latent cooling. Test results on a fan cooler operating with a latent load have yielded the values shown in Table 6 of air side heat transfer parameters [see **20.2.2.7** g) and h)].

Table 6 — Results for example of sensible and latent cooling

Speed setting	V_r	R_a	B
	m^3/s	°C/kW	
Low	0.12	4.40	0.23
Normal	0.21	3.15	0.29
High	0.35	2.15	0.33

The test results for the primary fluid side plus metal appliance thermal resistance are shown plotted versus primary fluid flow rate in Figure 17. It is required to compute the duty of the unit when operating at Normal speed setting (0.21 m^3/s) in a room at 25 °C, 60 % relative humidity, and supplied with 0.2 kg/s of primary fluid at 8 °C. The calculation may be made, using successive approximations, as follows.

a) Assume a value of the total heat transfer Q, say 4 kW.

b) The enthalpy (h) of saturated air at the apparatus dew point (t_B) is:

$h_B = h_{ai} - \Delta h/(1 - B)$ kJ/kg

In the present example, h_{ai} = 55.56 kJ/kg (from tables).

Also, $\Delta h = Q/\rho_a\,V_r = 4/1.2 \times 0.21 = 15.9$ kJ/kg.

Thus, h_B = 55.56 – 15.9/(1 – 0.29) = 33.16 kJ/kg and the corresponding temperature of saturated air is t_B = 11.6 °C (from tables).

c) The outlet air temperature (t_{ao}) is obtained from the equation:

$$t_{ao} = t_B + (t_R - t_B)\,B$$
$$= 11.6 + (25 - 11.6)\ 0.29 = 15.48\ °C$$

d) The sensible to total heat ratio is obtained from the equation:

$$S = c_{pa}\ (t_R - t_{ao})/\Delta h = 0.61$$

e) The total heat transferred will be given by the equation:

$$Q = \Delta t_m/(SR_a + R_{wm})\ \text{kW}$$

from the test results: $R_a = 3.15$ $R_{wm} = 2.7$ and from

$$\Delta t_m = \frac{[(t_R - t_o) - (t_{ao} - t_i)]/}{\ln\ [(t_R - t_o)/(t_{ao} - t_i)]}$$

where t_o is calculated, from **18.2**,

$$Q = m_w\ c_p\ (t_o - t_i),$$

with the assumed total heat load of 4 KW, as 12.78 °C. Thus $\Delta t_m = 9.6$ °C.

f) Instead of computing Q, however, it is necessary first to calculate the ratio:

$$\Delta t_m/Q\ (SR_a + R_{wm})$$
$$= 9.6/4(0.61 \times 3.15) + 2.7] = 0.52.$$

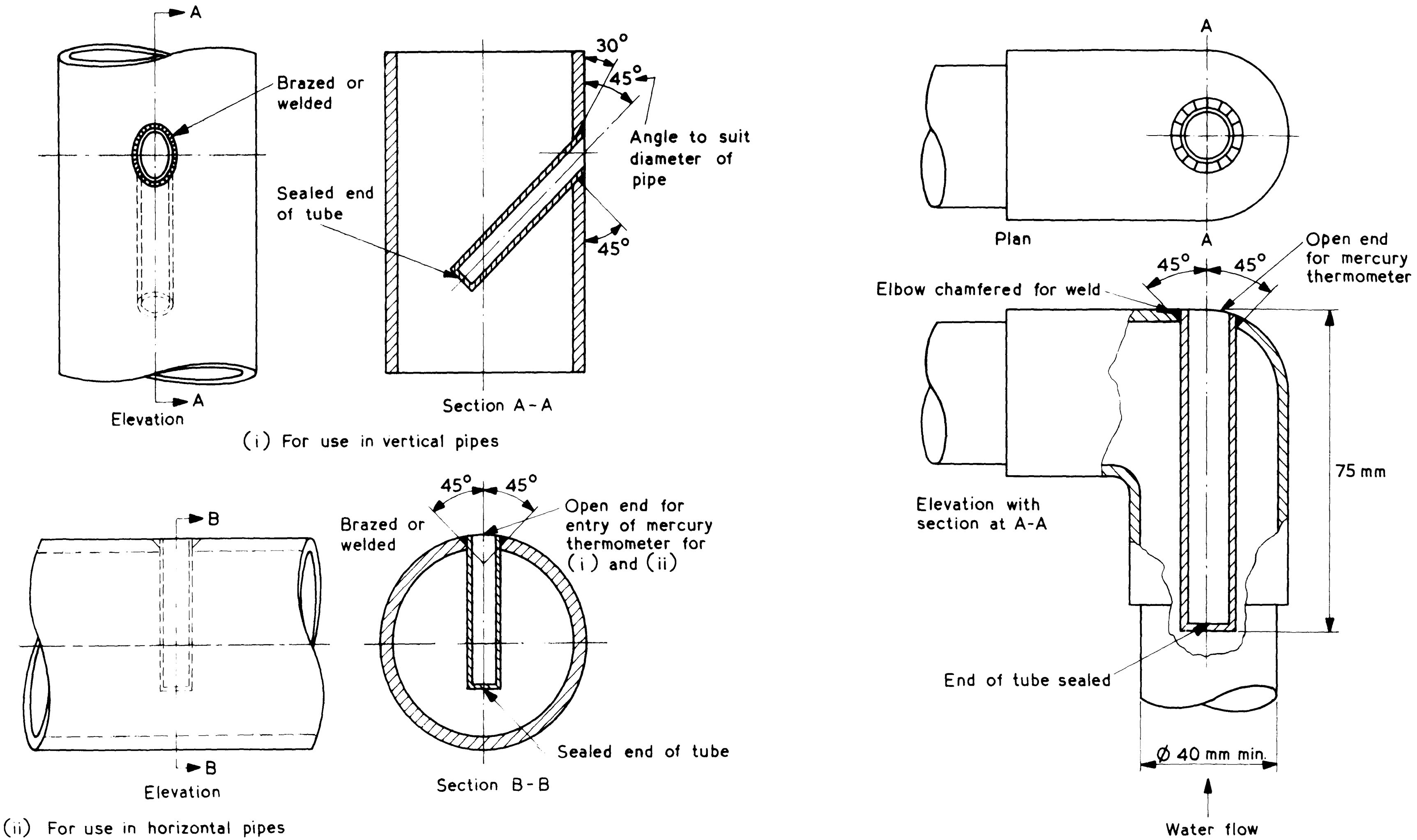
Thus the assumed value of Q as 4 kW is too large. (The assumed value would have been correct if this ratio had been unity.)

g) It is now necessary to assume a minimum of two additional values of total heat transfer and to recalculate steps b) to f) for each of these values. A plot of three values of the ratio $\Delta t_m/Q$ ($SR_a + R_{wm}$) versus the three assumed values of Q will then yield the correct total heat transfer for the unit (i.e. the total heat transfer at the point where this ratio is unity). In the present example we have:

Q,	$\Delta t_m/Q(SR_a + R_{wm})$
kW	
4	0.52
3	0.75
2	1.16

By interpolation, the total heat transfer is thus 2.5 kW. Completing steps a) to d) for $Q = 2.5$ kW the sensible to total heat ratio is 0.75, and consequently the sensible heat transferred is 1.86 kW.

h) The recirculation correction is not normally applied because the approximate nature of the calculation does not merit it. However, if it is desired to correct for recirculation then the factor Q_T/Q_{TR} should be applied to the total heat transfer [see **21.1** e)].



NOTES for (i) *and* (ii)

1. The tube should be not less than 50 mm in length but preferably a minimum of 100 mm.
2. The tube length should accommodate the centre of the thermometer bulb at approximately the pipe centre.
3. Maximum 1 mm wall stainless steel tube 8 mm to 9.5 mm bore, brazed or welded into hole drilled in pipe and finished flush.

(a) Thermometer in pipes of 75 mm diameter and over

(b) Thermometer pockets in pipes less than 75 mm diameter

Figure 1 — Thermometer pockets

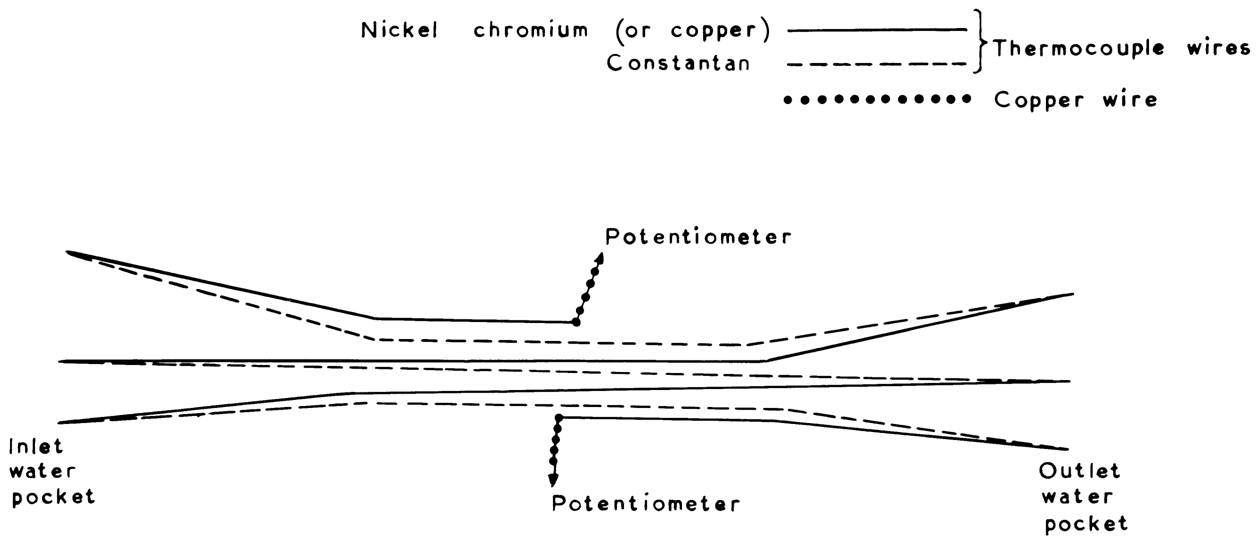


Figure 2 — Multi-junction differential thermocouple

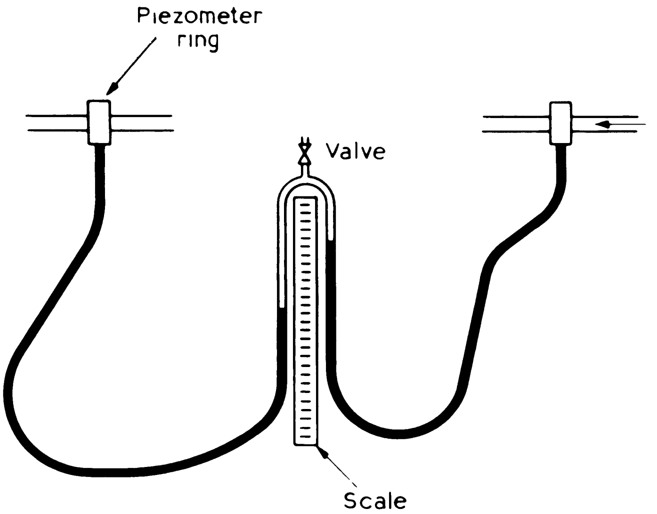
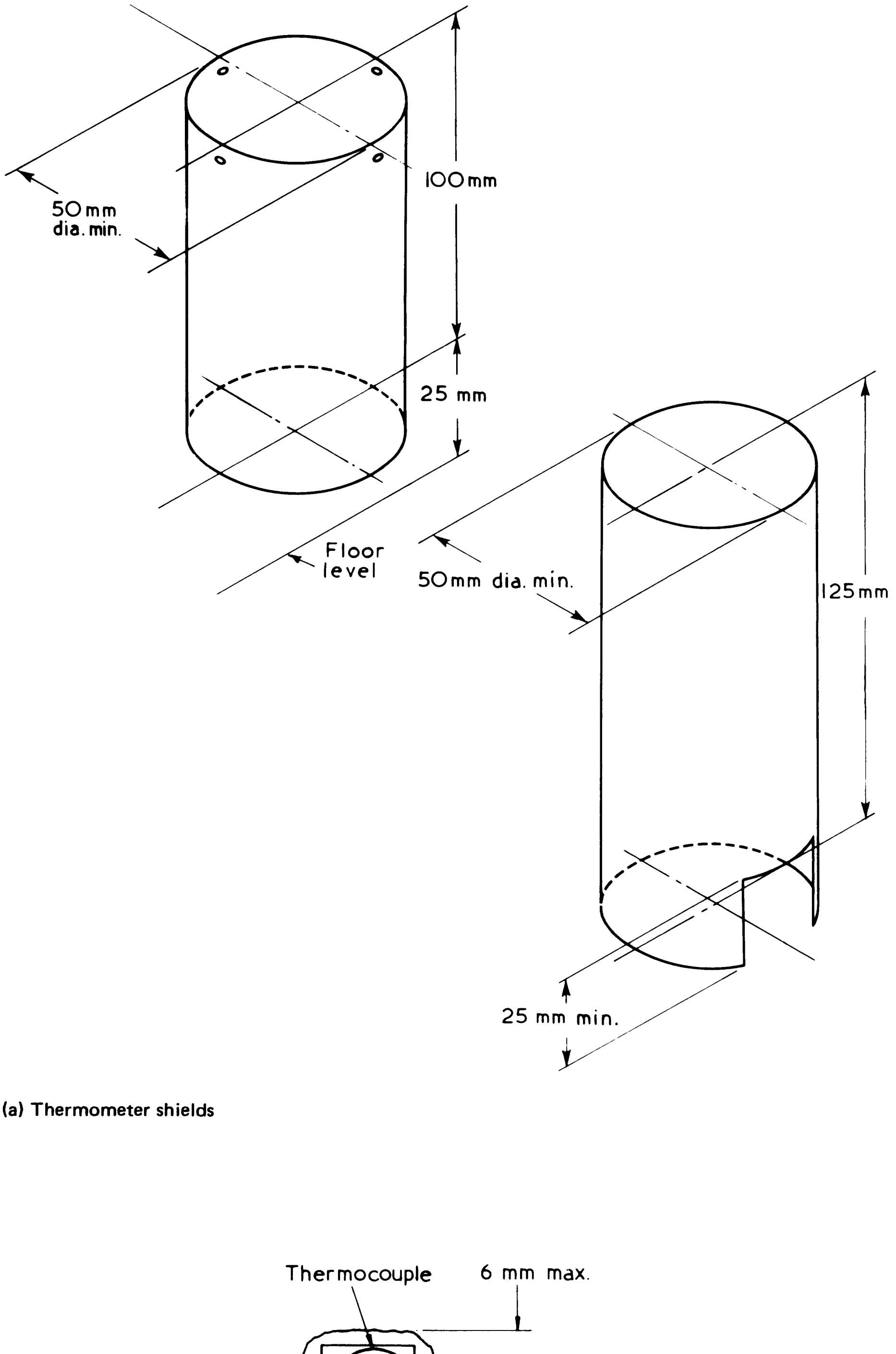
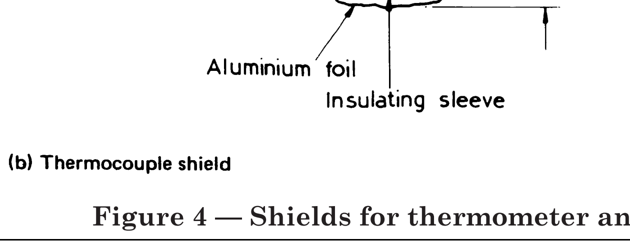


Figure 3 — Inverted U-tube manometer

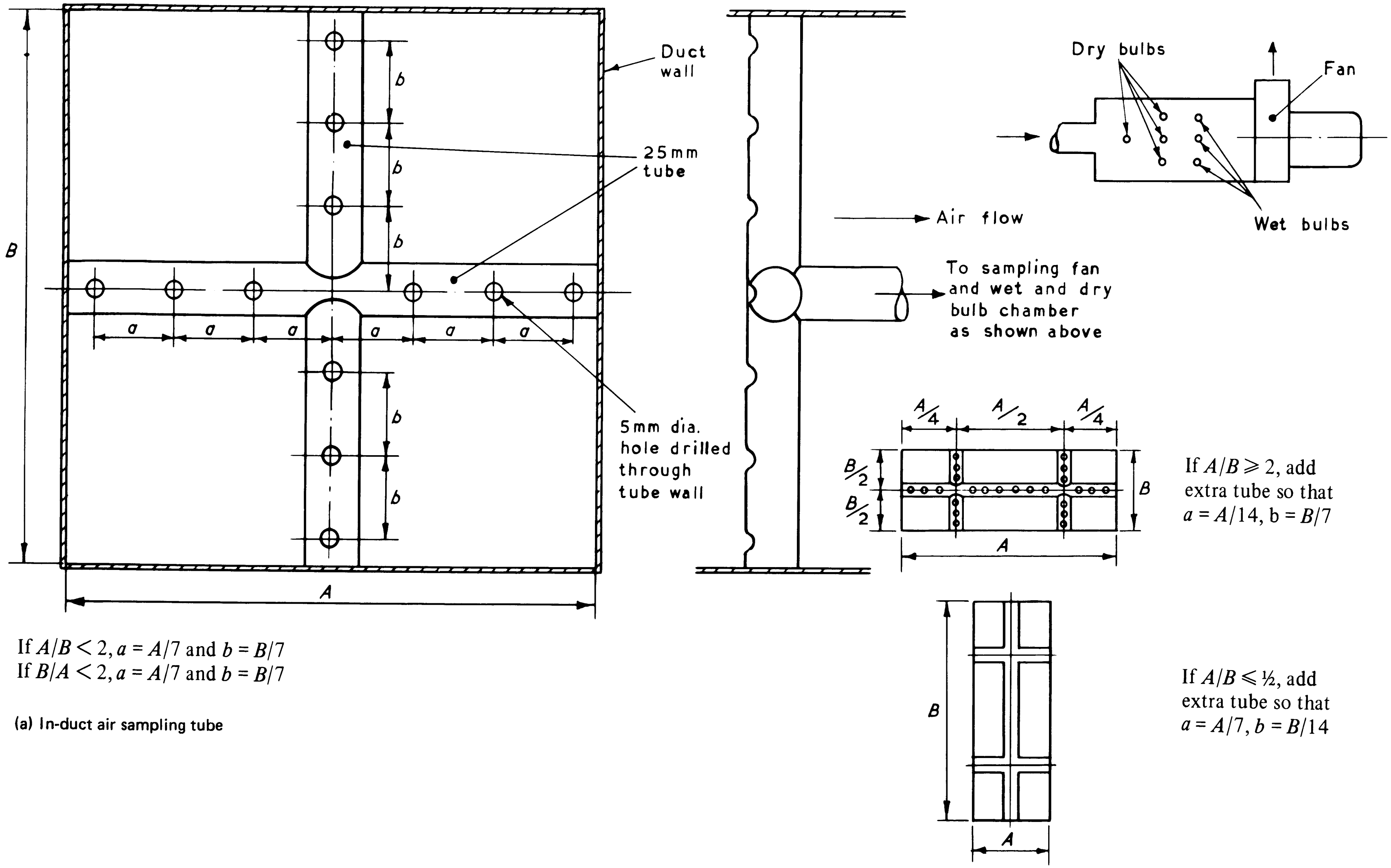


(a) Thermometer shields



(b) Thermocouple shield

Figure 4 — Shields for thermometer and thermocouple



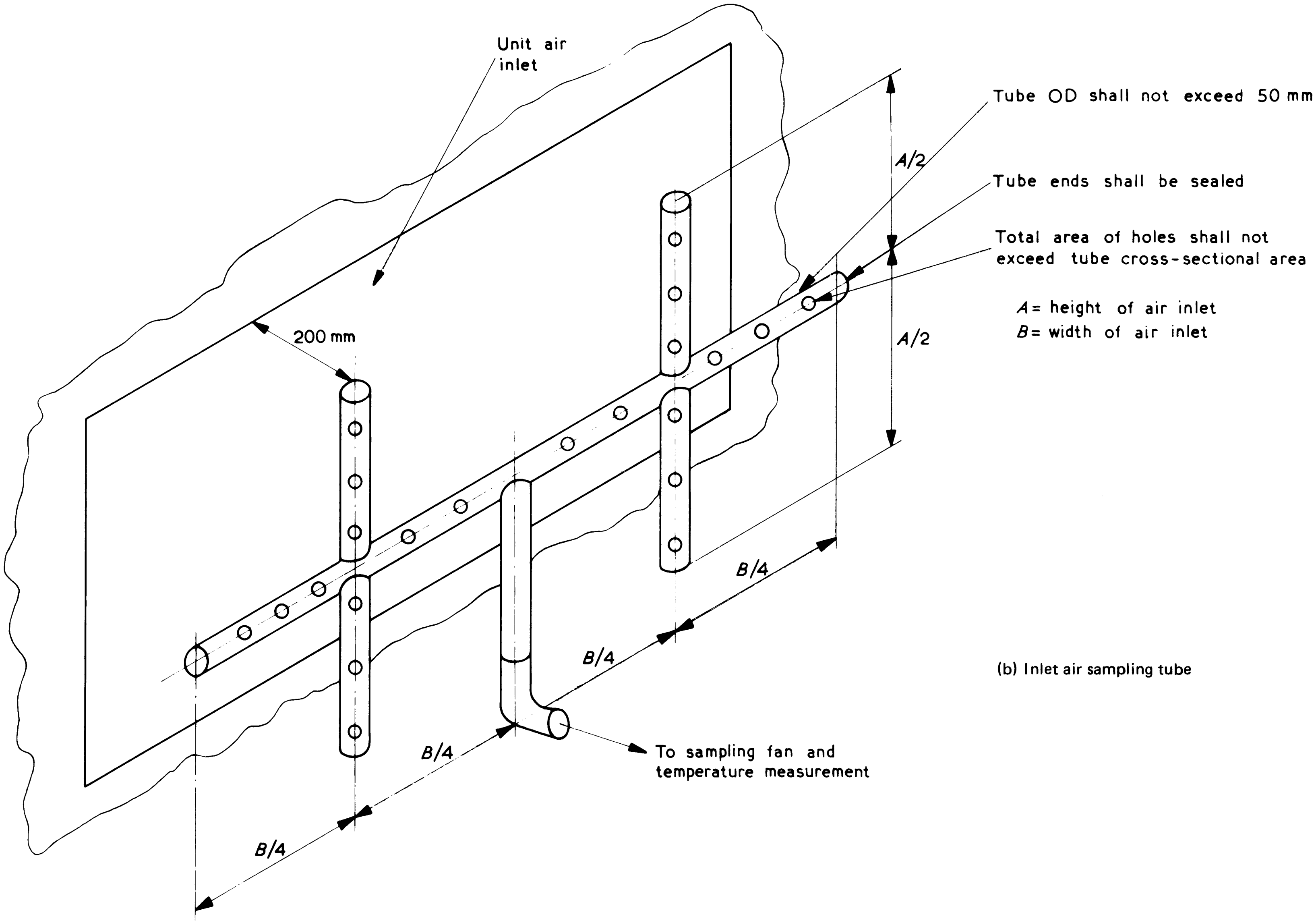
If $A/B \geqslant 2$, add extra tube so that $a = A/14$, $b = B/7$

If $A/B < 2$, $a = A/7$ and $b = B/7$
If $B/A < 2$, $a = A/7$ and $b = B/7$

If $A/B \leqslant ½$, add extra tube so that $a = A/7$, $b = B/14$

(a) In-duct air sampling tube

Figure 5 — Air sampling tubes



(b) Inlet air sampling tube

Figure 5 — Air sampling tubes *(concluded)*

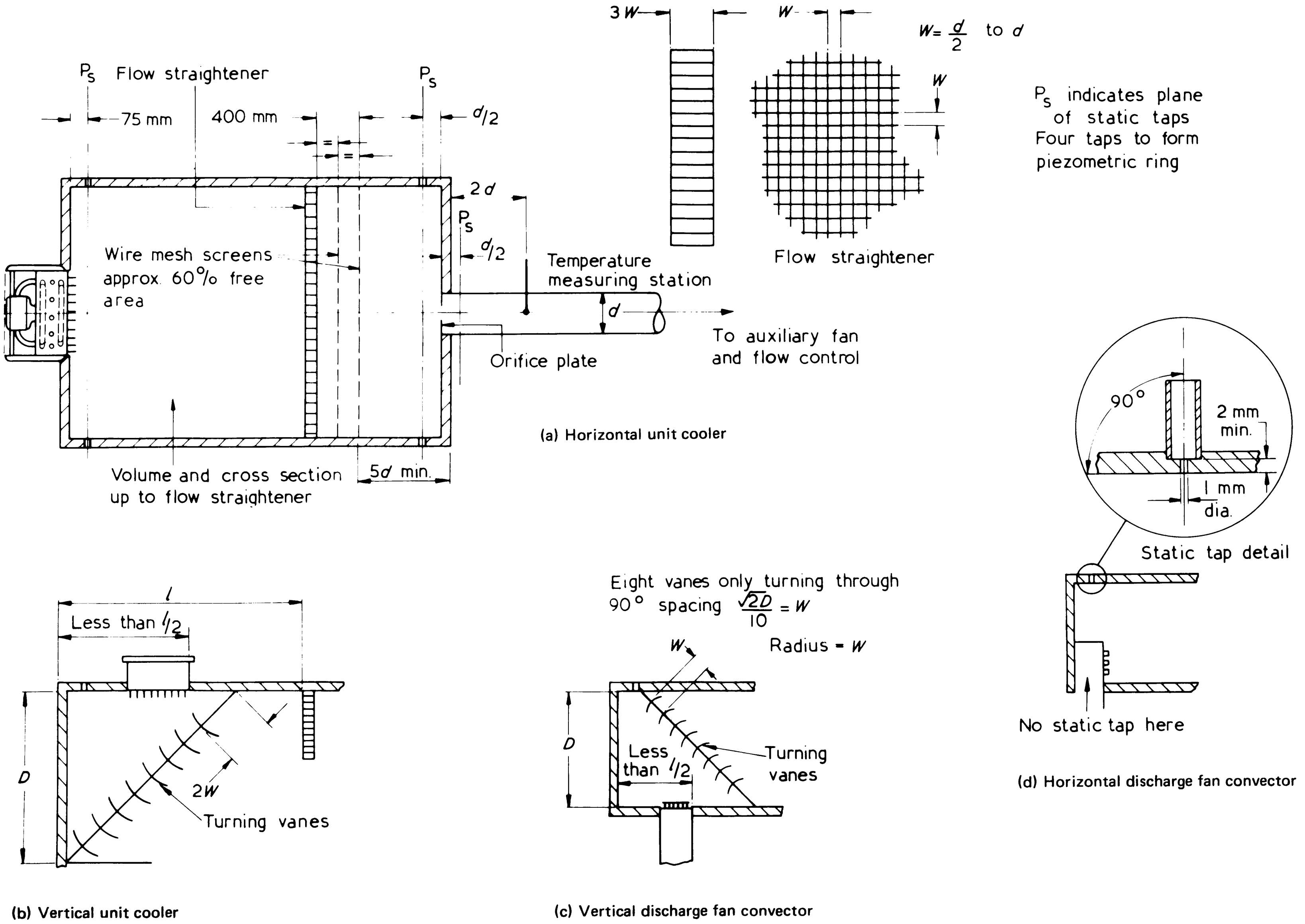


Figure 6 — Air flow chamber

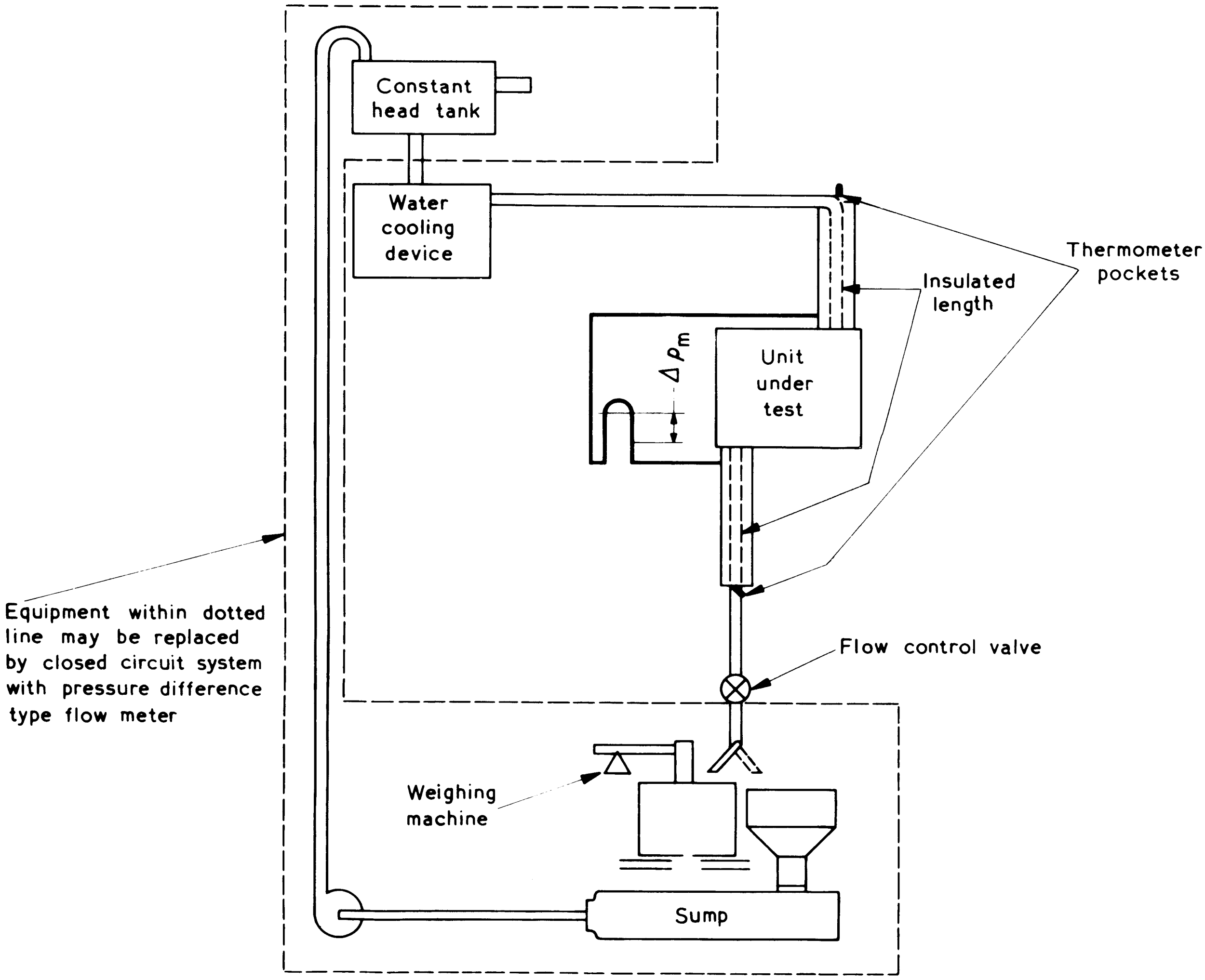
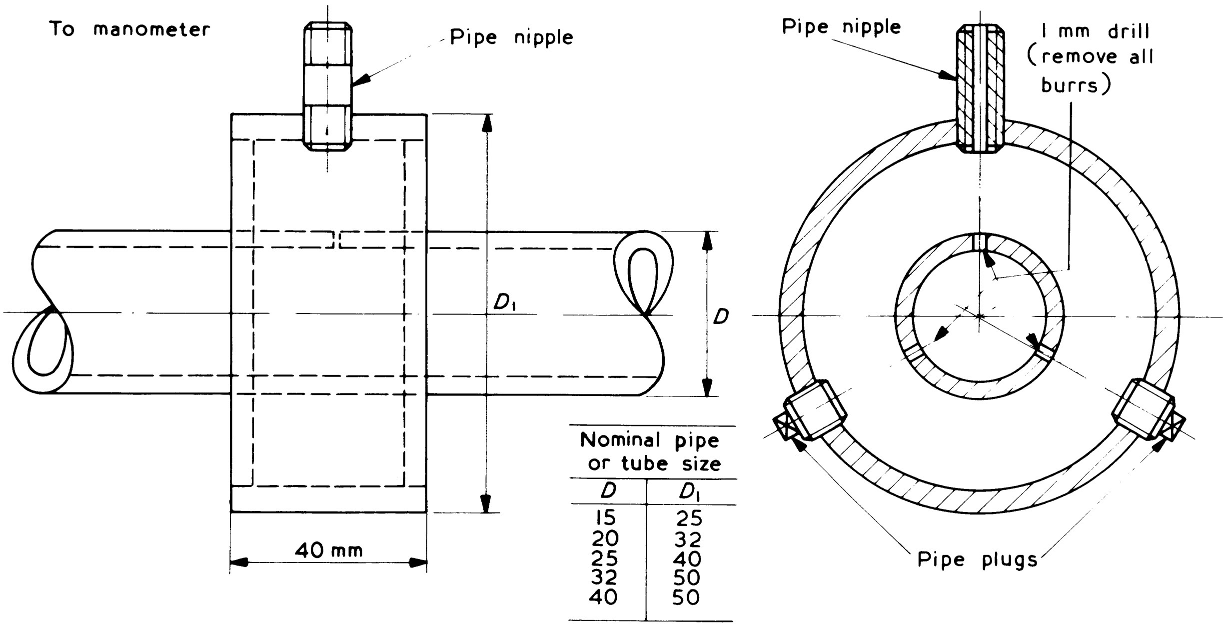
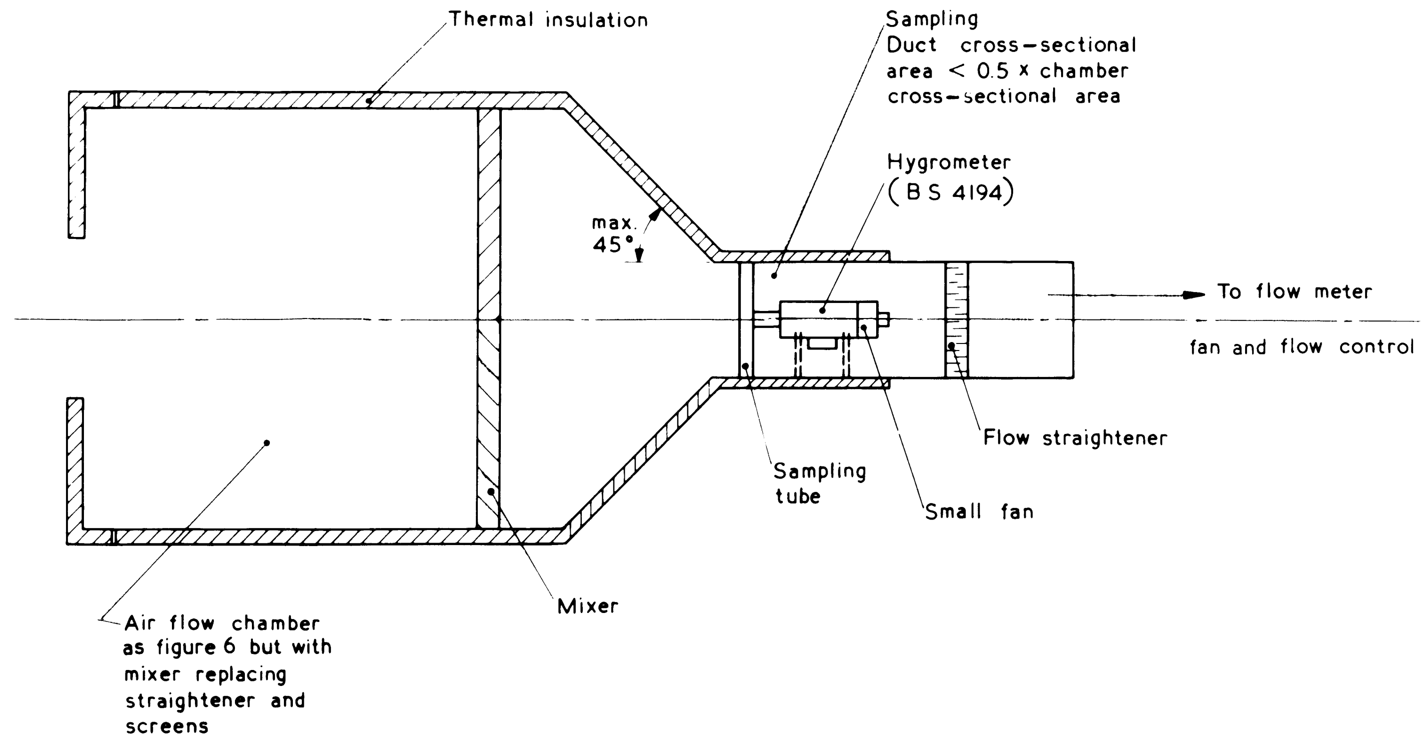


Figure 7 — Chilled fluid test equipment



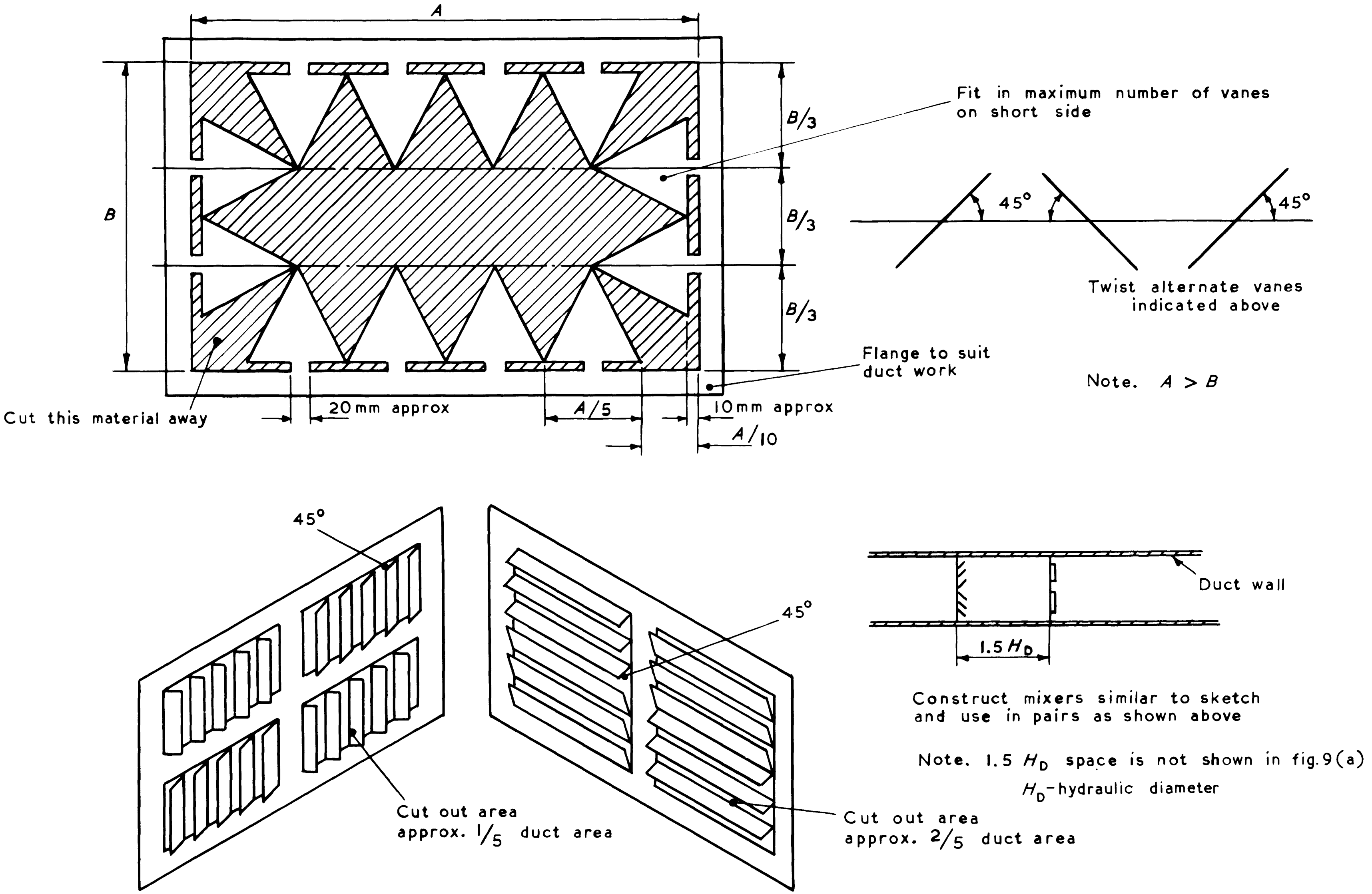
Nominal pipe or tube size	
D	D_1
15	25
20	32
25	40
32	50
40	50

Figure 8 — Piezometer ring



(a) General arrangement

Figure 9 — Extended air flow chamber



(b) Air flow mixers

Figure 9 — Extended air flow chamber *(concluded)*

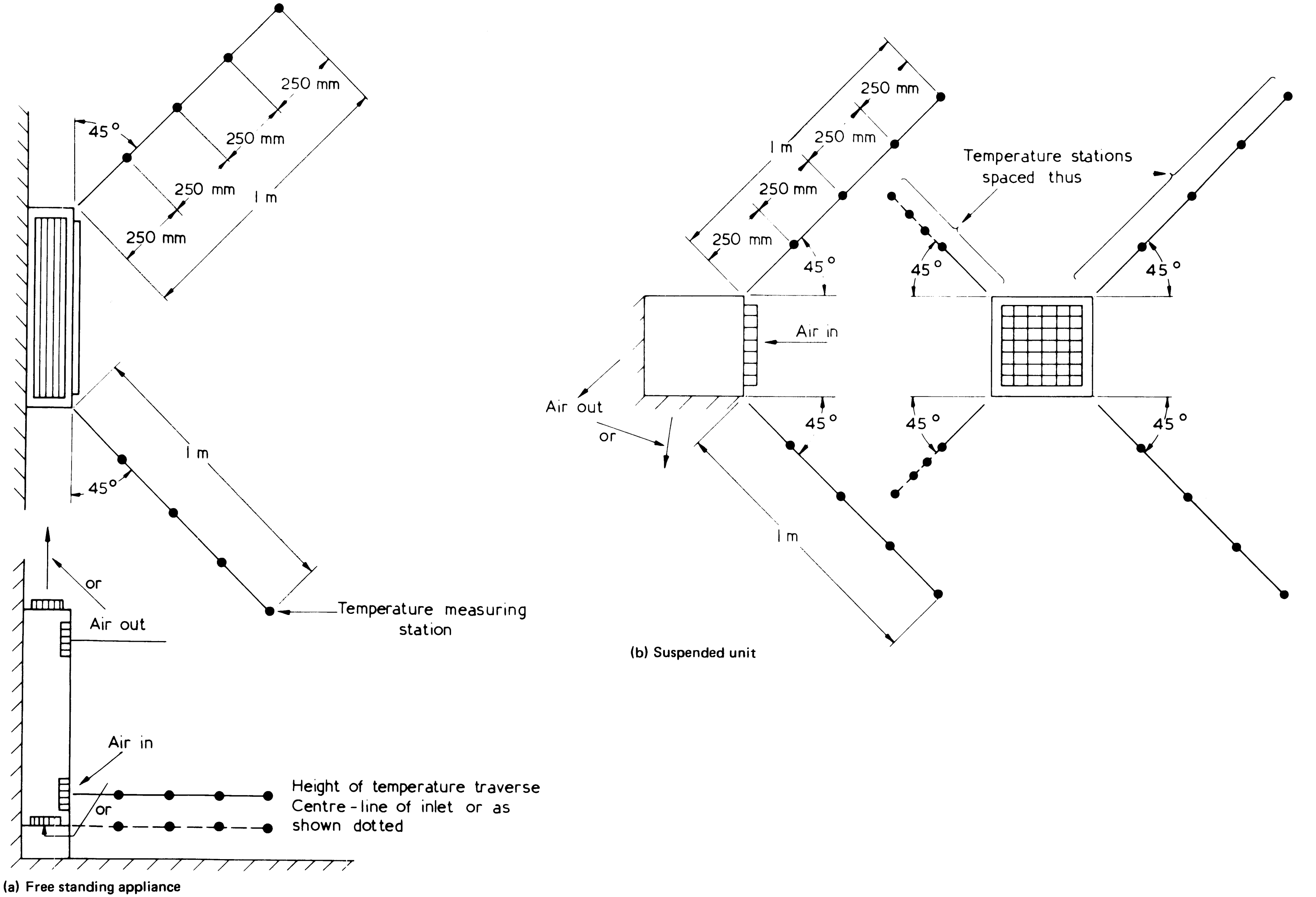


Figure 10 — Room temperature measuring stations

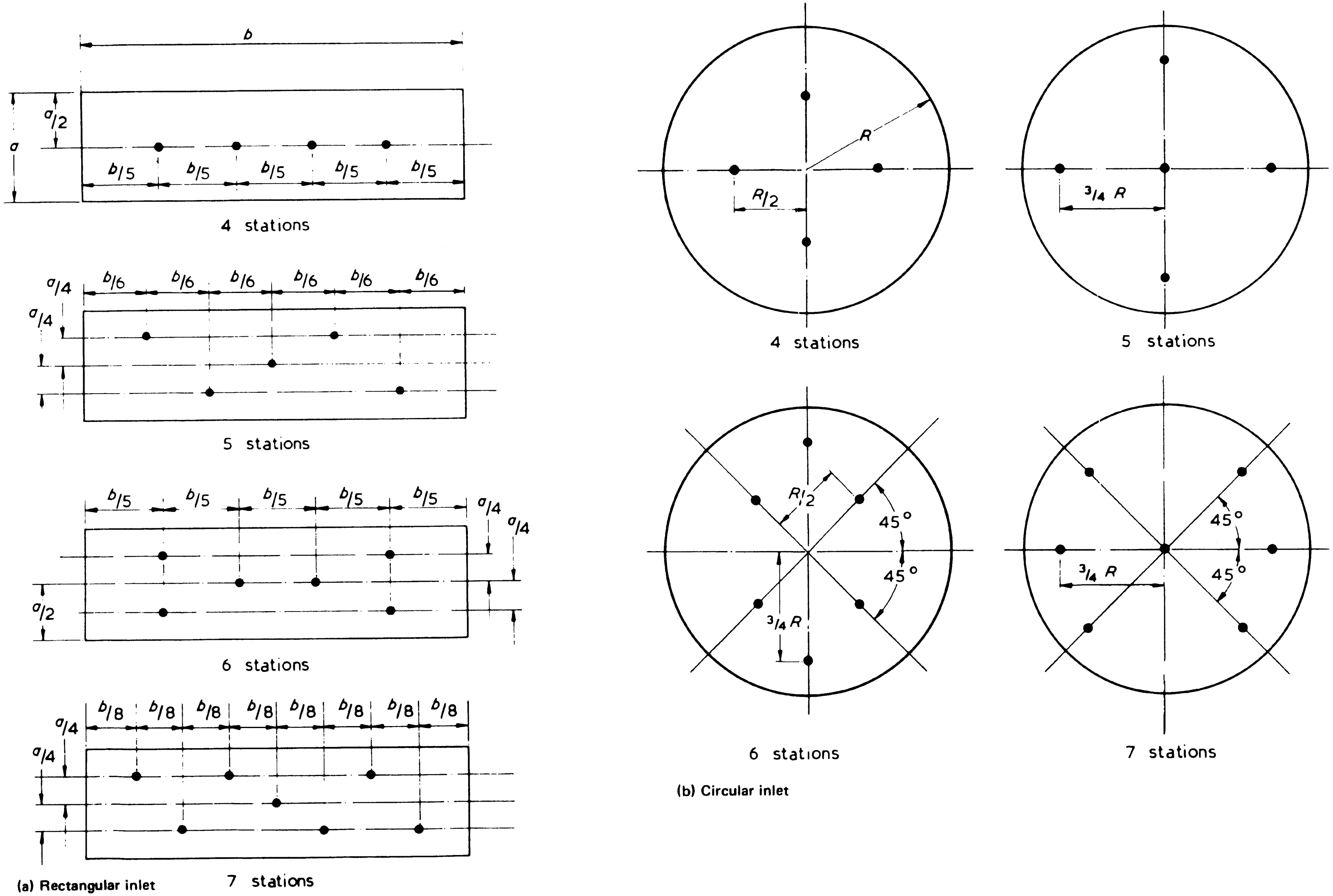


Figure 11 — Inlet temperature measurement

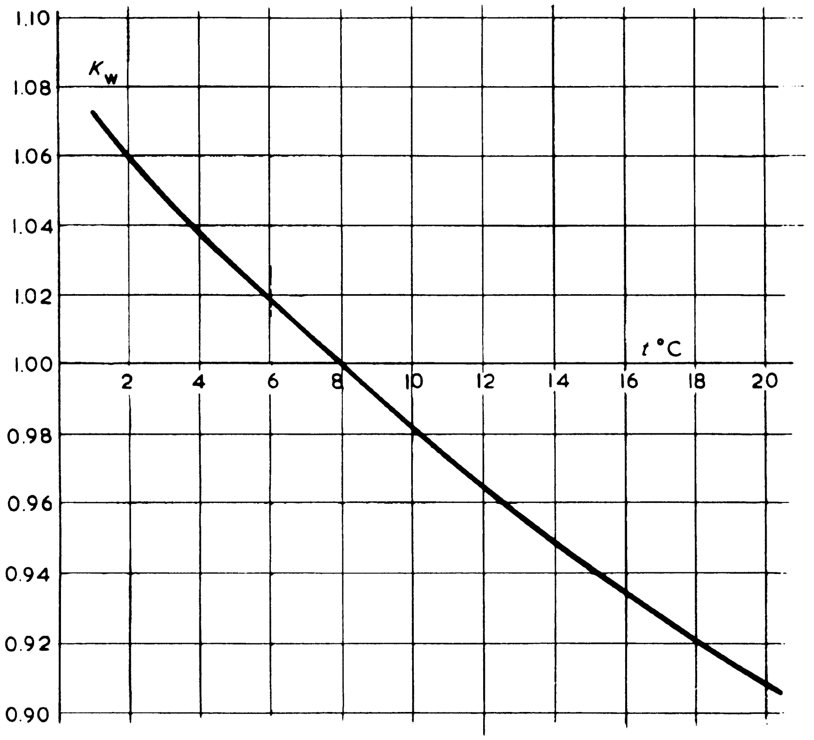


Figure 12 — Water temperature corrector factor K_w

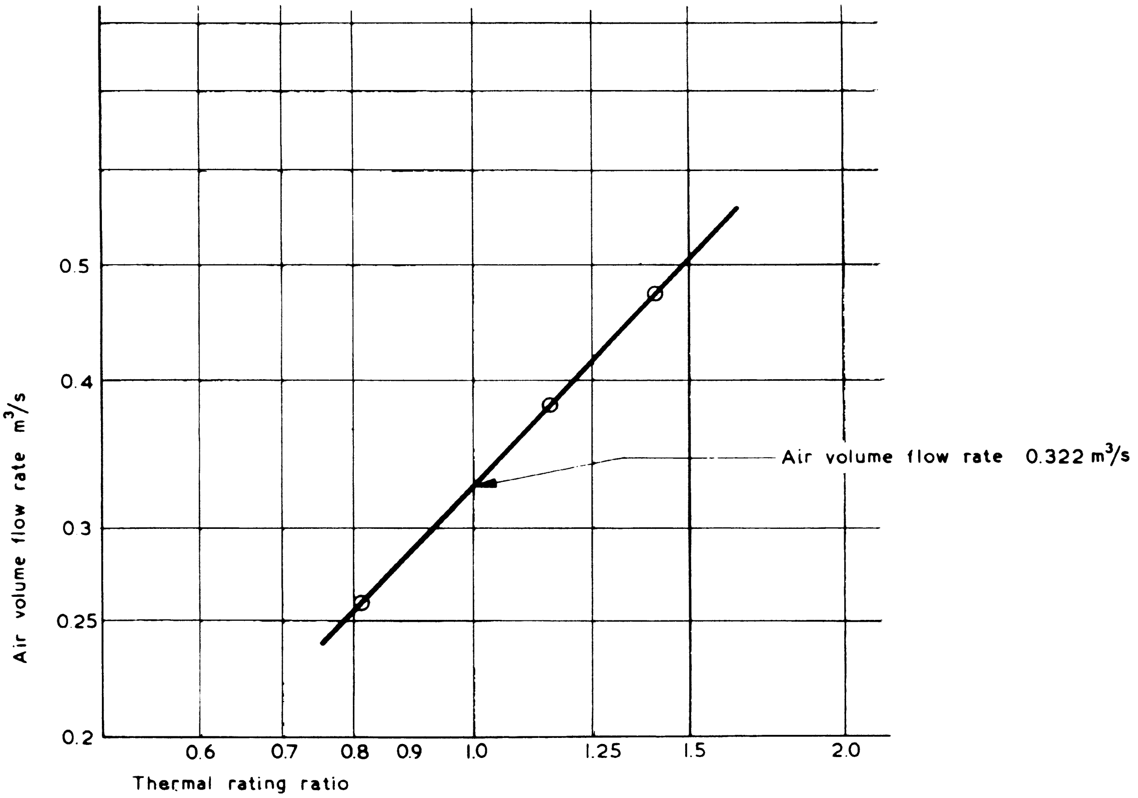


Figure 13 — Determination of air flow rate

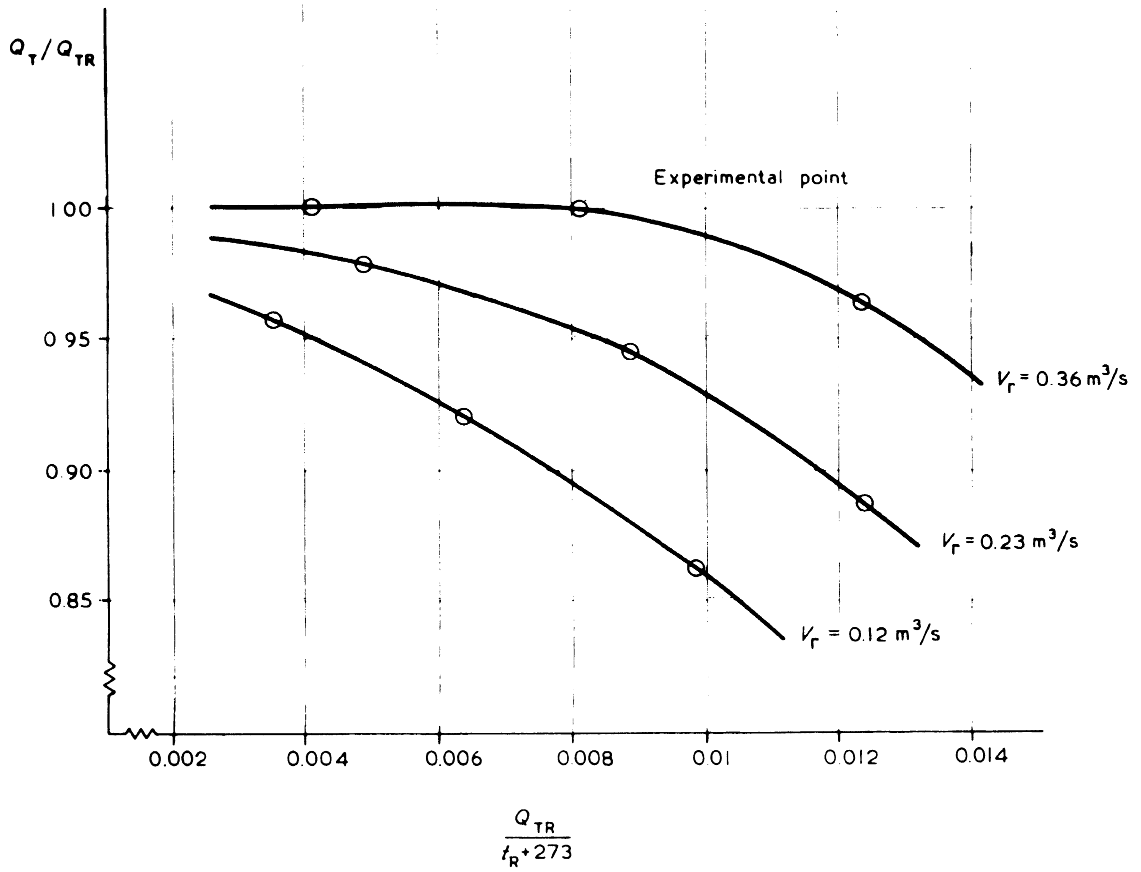
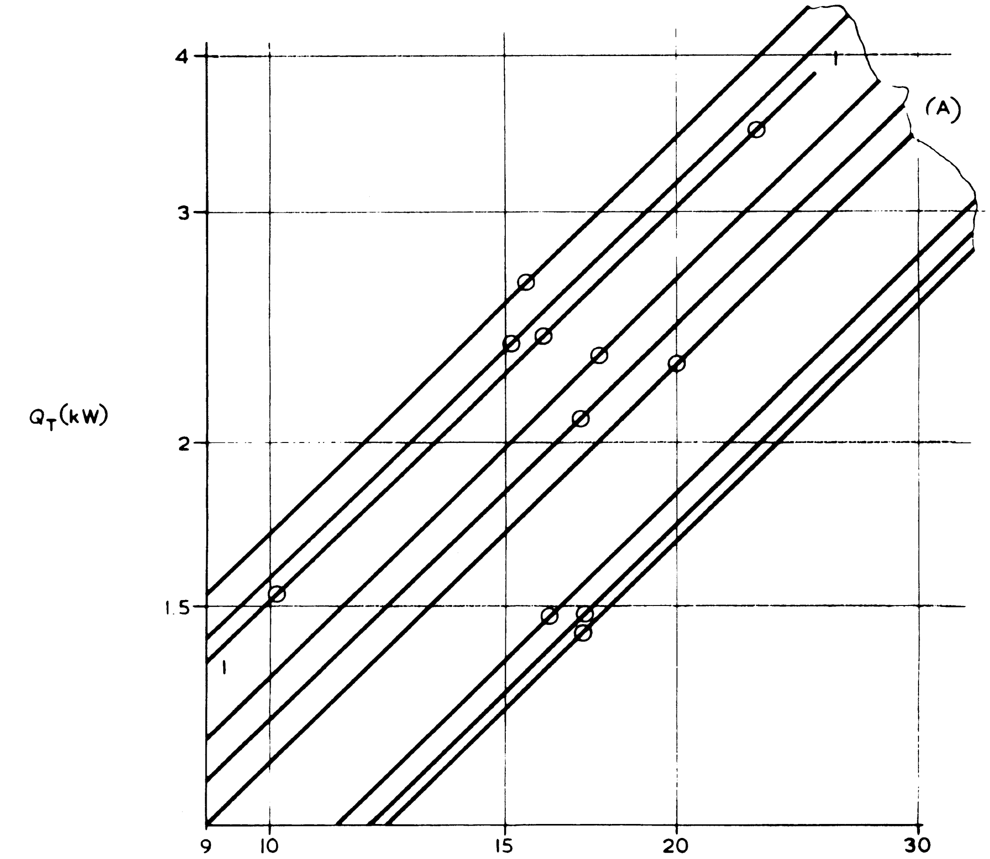
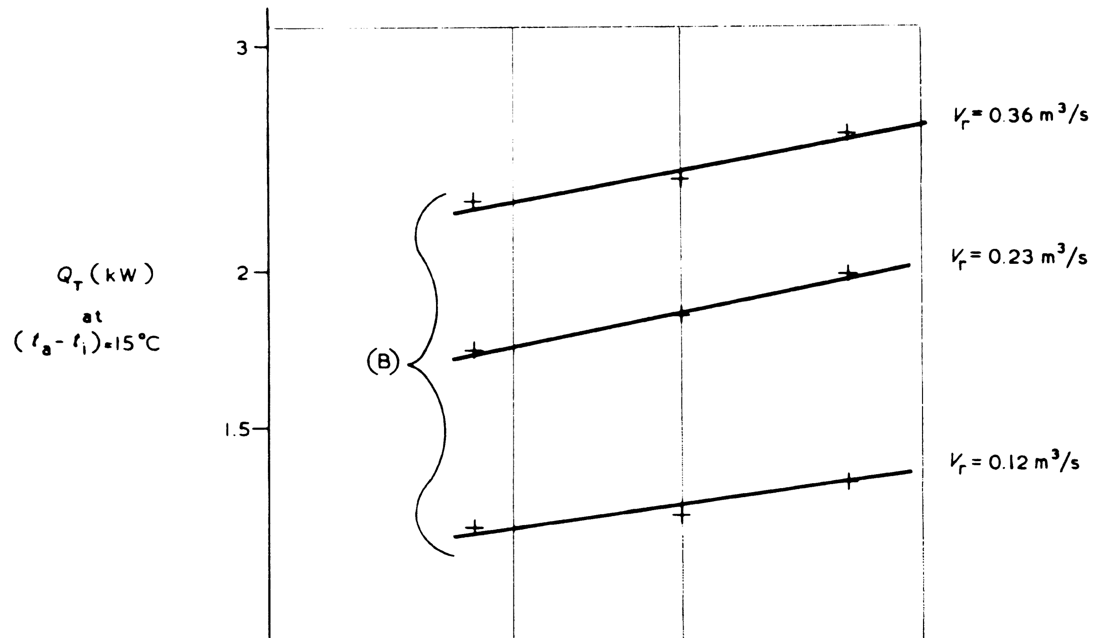


Figure 14 — Example of recirculation correction factor



(a) Heat transferred versus inlet temperature difference $(t_a - t_i)$ °C



(b) Heat transferred as function of primary fluid flow rate m_w kg/s

Figure 15 — Heat transference

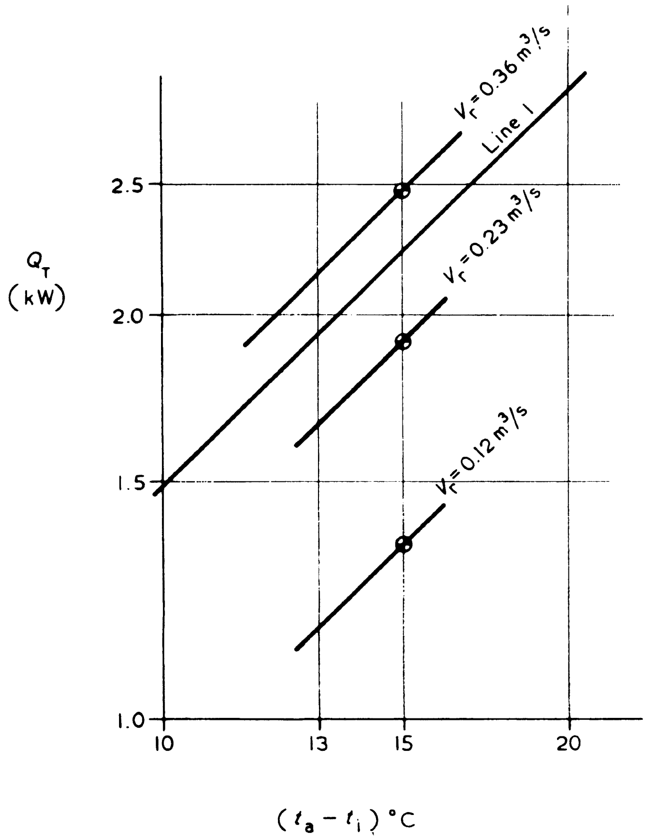


Figure 16 — Rating example

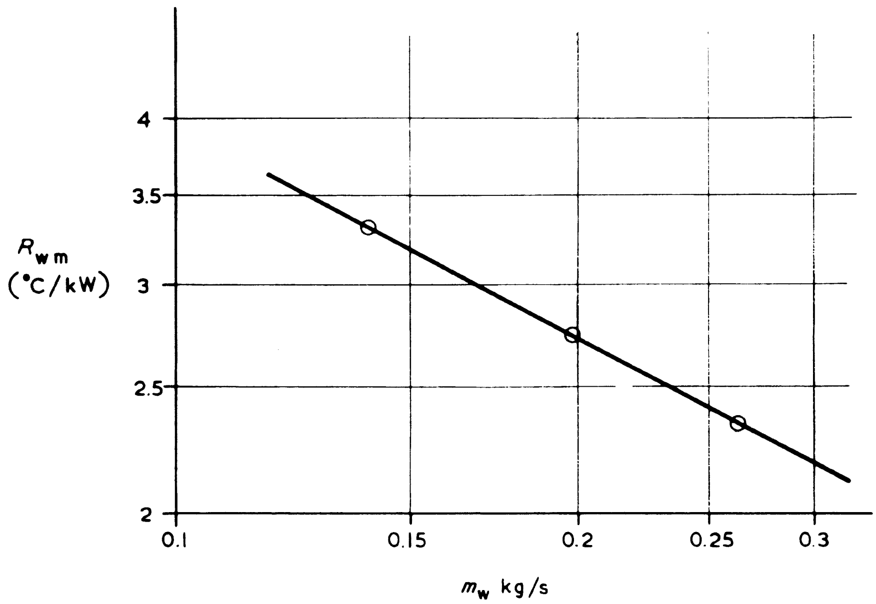


Figure 17 — Primary fluid plus metal thermal resistance

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Publications referred to

This standard makes reference to the following British Standards:

BS 593, *Laboratory thermometers*.
BS 1041, *Code for temperature measurement*.
BS 1041-2, *Expansion thermometers*.
BS 1041-3, *Industrial resistance thermometry*.
BS 1041-4, *Thermocouples*.
BS 1042, *Methods for the measurement of fluid flow in pipes*.
BS 1042-1, *Orifice plates, nozzles and venturi tubes*.
BS 4194, *Design requirements and testing of controlled — atmosphere laboratories*.

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