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THERMAL TEST METHOD FOR FAN COIL UNITS

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1. THERMAL TEST METHOD FOR FAN COIL UNITS

1.1 SCOPE

This test method prescribes the procedures for determination of cooling and heating capacities and the various characteristics of fan coil units.

1.2 TEST CONDITIONS

1.2.1 Standard test conditions for the determination of the heating and cooling capacity

Standard test conditions	Heating	Cooling with dehumidifying
1. Heating or cooling medium (water)		
Temperature at entry	70 or 50°C	7°C
Water flow determined by :		
a rise of temperature		5°C
a drop of temperature	10°C	
2. Air		
Dry-bulb temperature at entry	20°C	27°C
3. Fan rotational speed (1)	Maximum and another one	Maximum and another one
4. Voltage and frequency current	Rated	Rated

(1) :

a) This other speed will be chosen by the manufacturer among the different working conditions available.

b) If the speed reduction is controlled by means of a continuous variator, the manufacturer should indicate the fan speed (t/mn). This speed will be checked during the test.

c) One of these speeds must obligatory correspond to the normal working speed representative for the data specified in the catalogue.

1.2.2 Test conditions for sweat tests

1 - Cooling medium (water)
Temperature at entry : 6°C
Rise of temperature : 4°C

2 - Air
Dry-bulb temperature at entry : 27°C
Wet-bulb temperature at entry : 24°C

3 - Fan rotational speed
Maximum speed and the lowest possible speed

4 - Rated voltage and frequency

1.2.3 Condensate disposal test

These tests will be conducted at the same conditions as specified for the sweat tests at maximum fan speed (see 1.2.2)

1.3 TEST SPECIFICATIONS

Tests should be carried out with a unit comprising following main components :

- one or more heat exchangers
- one or more fans with drive device
- a condensate collecting device
- an air filtering device
- an assembly framework
- an enclosure prescribed by the manufacturer

1.4 CALORIMETERS - GENERAL

For the determination of heating or cooling capacities fan coil units are tested in a room calorimeter of either calibrated or balanced ambient type similar to that which is used for the determination of the operating characteristics of the room air conditioners.

The two calorimeter compartments are separated by a partition. The opening used for mounting the air conditioners and the pressure-equalising device between both compartments should be closed by removable panels of the same heat resistance as the separating partition. Vapour-proofing should be provided.

The tests under heating conditions should be carried out in the so called « outdoor-side » compartment which is provided with reconditioning equipment, whose cooling capacity can be measured and controlled, to balance the heat capacity of the fan coil unit.

The tests under cooling conditions should be performed in the so called « room-side » compartment provided with a reconditioning equipment, whose heat capacity and humidity production can be measured and adjusted, for balancing the dehumidification capacity and the sensible cooling capacity of the fan coil unit.

When the room calorimeter is designed for testing fan coil units only it might have a single room provided with a reconditioning equipment whose cooling and heating capacity and humidity production can be measured and adjusted for balancing either the heating or the sensible cooling capacity and dehumidification capacity of the fan coil unit.

In the double enclosure and in each compartment not used for the tests, a dry-bulb temperature equal to that within the compartment used is maintained.

The so called « outdoor-side » compartment should be maintained at the dry-bulb temperature prescribed for the tests under heating conditions, while the « room-side » compartment should be maintained at the dry-bulb and wet-bulb temperatures prescribed for the test under cooling conditions.

Inside surfaces of the calorimeter compartments should be of non-porous material with all joints sealed again air and moisture leakage. Access doors should be tightly sealed against air and moisture leakage by use of gaskets or other suitable means.

The size of the compartments (see table 1) should be sufficient to avoid any restriction to intake or discharge openings of the fan coil unit.

Table 1 - Sizes of compartments

Maximum heating or cooling capacity of unit (*)	Suggested minimum inside dimensions of each room calorimeter		
	Width	Length	Depth
3 000 W	2,4 m	2,1 m	1,8 m
6 000 W	2,4 m	2,1 m	2,4 m
9 000 W	2,7 m	2,4 m	3,0 m
12 000 W	3,0 m	2,4 m	3,7 m

(*) All figures have been voluntarily rounded.

1.4.1 Calibrated room-type calorimeter

The calibrated room-type calorimeter is shown in figure 1. Each calorimeter, including the separating partition, should be insulated to prevent heat leakage (incl. Radiation) in excess of 5 % of the test unit capacity. It is recommended that an air space permitting free circulation be provided under the calorimeter floor.

Heat leakage may be determined in either the room-side or outdoor-side compartment by the following method : all openings should be closed ; either compartment may be heated by electric heaters for example to a temperature of at least 11°C above the surrounding ambient temperature. The ambient temperature should be maintained constant within + 1°C outside all six enveloping surfaces of the compartment including the separating partition.

If the construction of the partition is identical with that of the other walls, the heat leakage through the partition may be determined on a proportional area basis.

For calibrating the heat leakage through the separating partition alone, the following procedure may be used : a test is carried out as described above, then the temperature of the adjoining area on the other side of the separating partition is raised to equal the temperature in the heated compartment, thus eliminating heat leakage through the partition, while the 11°C differential is maintained between the heated compartment and the ambient surrounding the other five enveloping surfaces. The difference in heat between the first test and second test will permit determination of the leakage through the partition alone.

Fig. 1 - Calibrated room type calorimeter

1. Removable panels
2. Heater
3. Cooling coil
4. Humidifier
5. Room side compartment
6. Outdoor side compartment
7. Reheat coil
8. Fan
9. Mixers
10. Test unit
11. Air sampling tubes

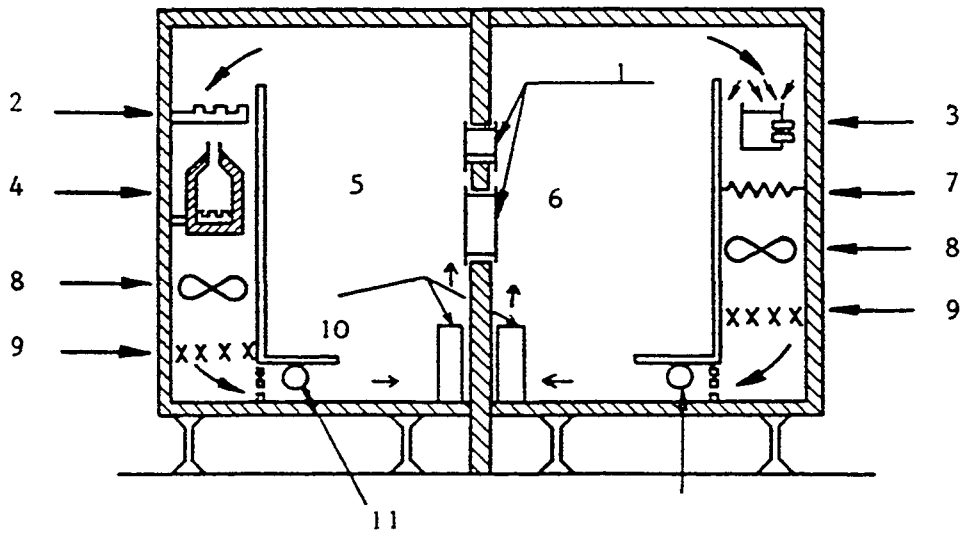
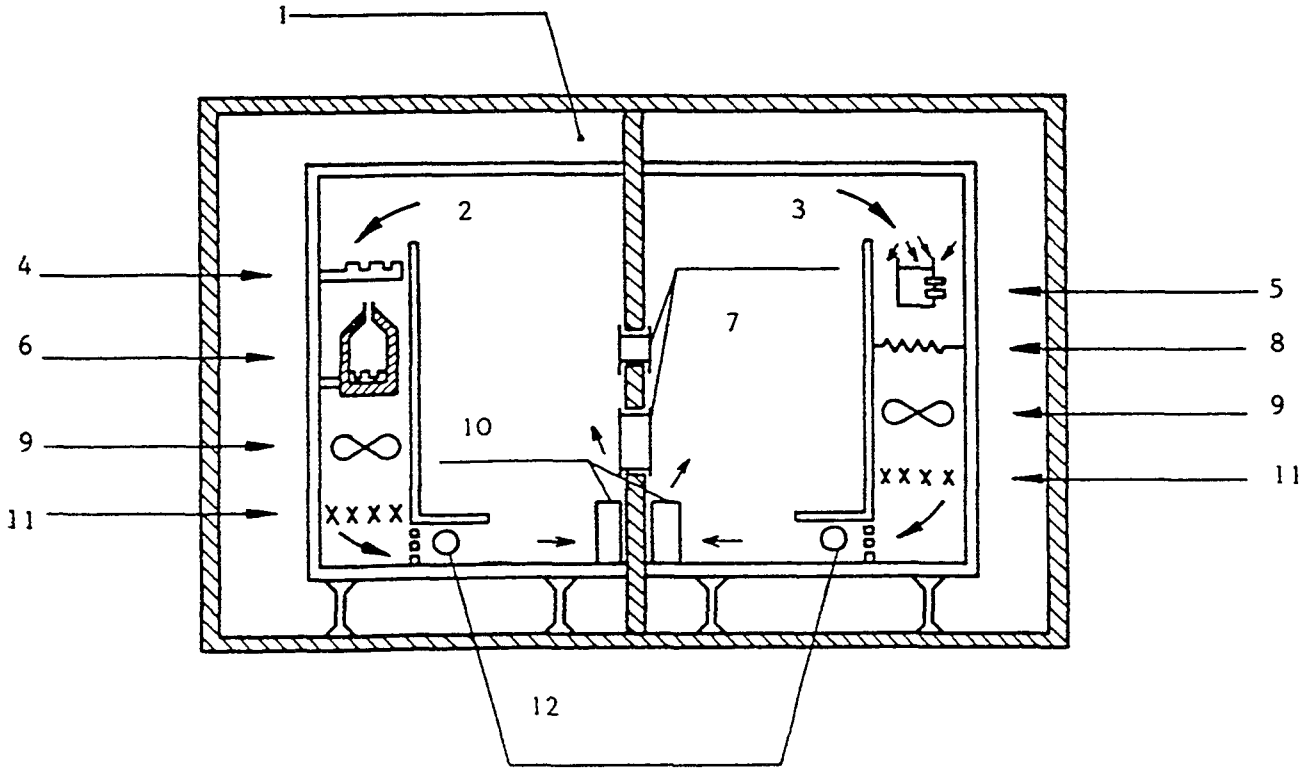


Fig. 2 - Balanced ambient room-type calorimeter

1. Controlled temperature air space
2. Room side compartment
3. Removable panels
4. Heater
5. Cooling coil
6. Humidifier
7. Outdoor side compartment
8. Reheat coil
9. Fan
10. Test unit
11. Mixers
12. Air sampling tubes



For the outdoor-side compartment equipped with means for cooling, an alternative means of calibration may be to cool the compartment to a temperature at least 11°C below the ambient temperature (on six sides) and carry out a similar analysis.

1.4.2 Balanced ambient room-type calorimeter

The balanced ambient room-type calorimeter is shown in figure 2. It operates on the principle of maintaining the dry-bulb temperatures surrounding the particular compartment equal to the dry-bulb temperatures maintained within that compartment. If the ambient wet-bulb temperature is also maintained equal to that within the compartment, the vapour-proofing provisions, previously determined, are not required.

The floor, ceiling and walls of the calorimeter compartments should be spaced a sufficient distance away from the floor, ceiling and walls of the controlled areas in which the compartments are located in order to provide uniform air temperature in the intervening space. It is recommended that this distance be at least 0.3 m. Means should be provided to circulate the air within the surrounding space to prevent stratification.

Heat leakage through the separating partition should be introduced into the heat balance calculation and may be calibrated in accordance with clause 1.4.1, or may be calculated.

It is recommended that the floor, ceiling and walls of the calorimeter compartments be insulated so as to limit heat leakage (including radiation) to not more than 10 % of the air conditioner capacity, with a 11°C temperature difference, or 300 W for the same temperature difference, whichever is greater, as tested using the procedure given in clause 1.4.1.

1.4.3 Reconditioning equipment

Each compartment should be provided with reconditioning equipment to maintain specified air flow and prescribed conditions. Reconditioning equipment for the room-side compartment should consist of heaters to supply sensible heat and a humidifier to supply moisture.

The energy supply may be electric, steam, or any other than can be controlled and measured. Reconditioning equipment for the outdoor-side compartment should provide cooling. A cooling coil equipped with by-pass dampers and supplied with variable temperature water or variable water quantity to control the dry-bulb temperature may be used.

If desired, reheating apparatus may be used in combination with the cooling coil. Reconditioning equipment for both compartments should be provided with fans of sufficient capacity to circulate not less than twice the quantity of air discharged by the fan coil unit to the room-side or to the outdoor-side as the case may be. In no case should the reconditioning equipment discharge less than one compartment air change per minute.

Perforated plates or other suitable grilles should be provided at the discharge openings from the reconditioning equipment to avoid face velocities exceeding 0.5 m/s. Sufficient space should be allowed in front of any inlet or discharge grilles of the fan coil unit to avoid interference with the air flow.

1.4.4 Position of the points of measurement of dry-bulb and wet-bulb temperatures prescribed by the rated test conditions

It is recognised that in both the room-side and outdoor-side compartments, temperature gradients and air-flow patterns result from the interaction of the reconditioning equipment and the fan coil unit being tested. Therefore, the resultant conditions are peculiar to, and dependent upon, a given combination of compartment size, arrangement and size of reconditioning equipment, and the fan coil unit air-discharge characteristics.

Accordingly, no single location for the measurement of dry- and wet-bulb temperatures can be specified which will be acceptable for all combinations of calorimeter facilities and fan coil units which may be tested.

It is intended that the specified test temperatures surrounding the unit being tested should simulate as nearly as possible the normal conditions of use of such a unit.

The point of measurement of specified test temperatures should be such that the following conditions are fulfilled:

- the measured temperatures should be representative of the temperature surrounding the unit, and simulate the conditions encountered in an actual application for both room and outdoor sides as indicated below.

- at the point of measurement of specified test temperatures of air should not be affected by air discharged from the test unit. This makes it mandatory that the temperatures are measured upstream of any recirculation produced by the test unit.

Note :

- If the conditions of air movement and airflow patterns in the calorimeter compartments are favourable, the temperatures may be measured at the outlet of the reconditioning equipment.

- If it has been established that the unit being tested does not produce any bypassed air from discharge to intake opening, the specified temperatures may be measured immediately upstream of such intake opening.

1.4.5 Installation of the fan coil units to be tested within the compartments

Fan coil units should be located in normal operating position, as close as possible and parallel to the separating partition at equal distance from the side walls.

« Ceiling » type fan coil units should be located in an appropriate holder, in normal operating position, 1,5 m above the floor, parallel to the separating partition, and at equal distance from the side walls.

Fan coil units should be connected to the heating or cooling medium flow (hot or cold water) by insulated ducts that pass through the double enclosure of the room enclosure.

1.5 HEATING OR COOLING MEDIUM FLOW

The heating or cooling medium flow designed to supply the heat exchanger comprises essentially two energy-generators respectively producing warm or cold water. The heating or cooling medium flow can be made after the diagram of figure 3. The heating or cooling medium flow rate can be measured by the ponderable method or by any other measuring method of the same precision.

1.6 MEASURING INSTRUMENTS

1.6.1 Thermometers

Temperature measurements should be carried out with one or more of the following instruments :

- mercury-in-glass thermometers
- thermocouples
- electric resistance thermometers

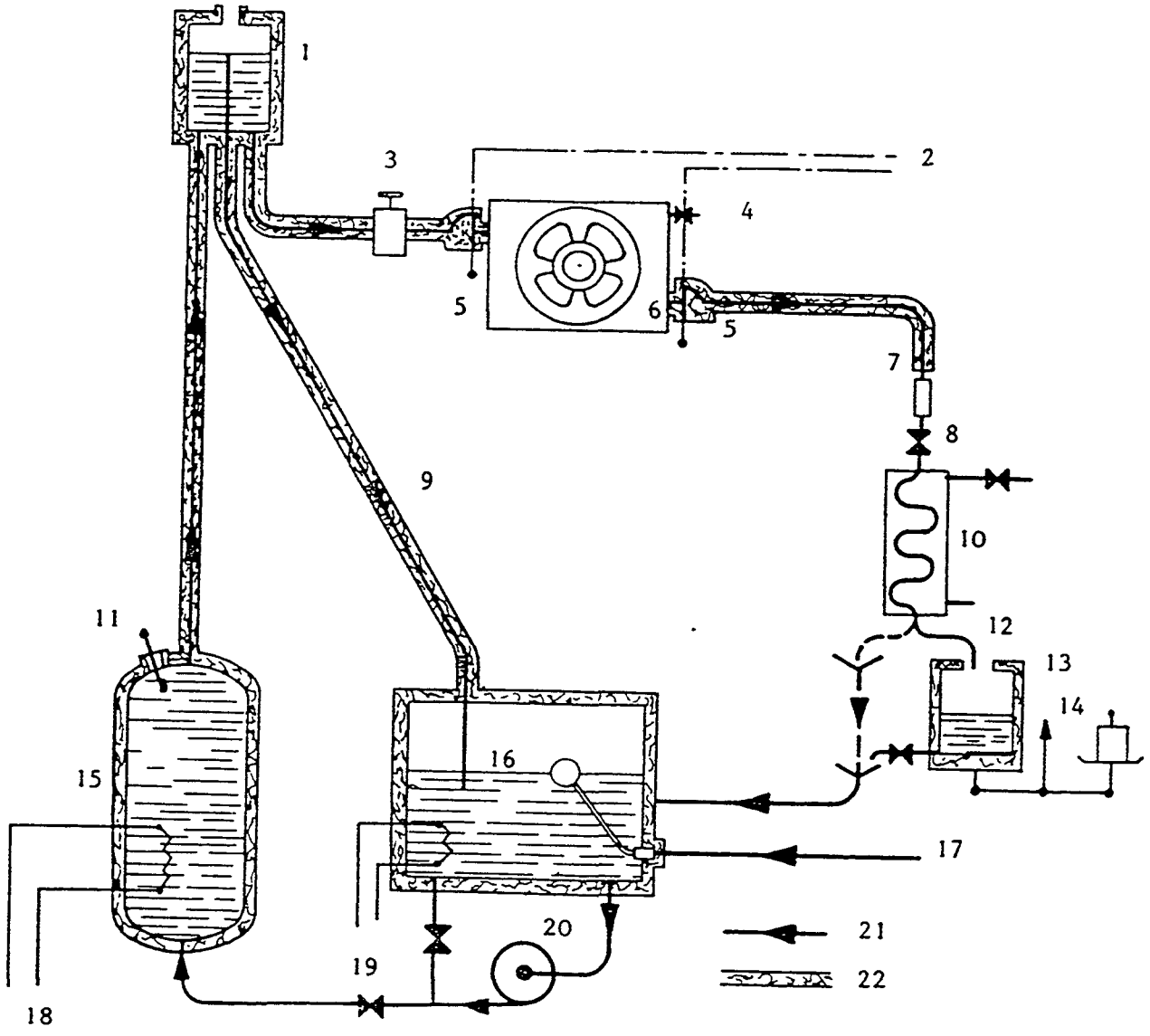
Instrument accuracy should be within the following limits :

- wet and dry-bulb temperatures of air in room-side compartment $\pm$ 0.05°C
- water temperature of the outdoor-side compartment conditioning coil and temperature of the heating or cooling medium supplied to the apparatus to be tested $\pm$ 0,05°C
- all other temperatures $\pm$ 0,3°C

The smallest scale division of the thermometer shall not exceed twice the specified accuracy. For example, for the specified accuracy of $\pm$ 0,05°C, the smallest scale division should not exceed 0,1°C.

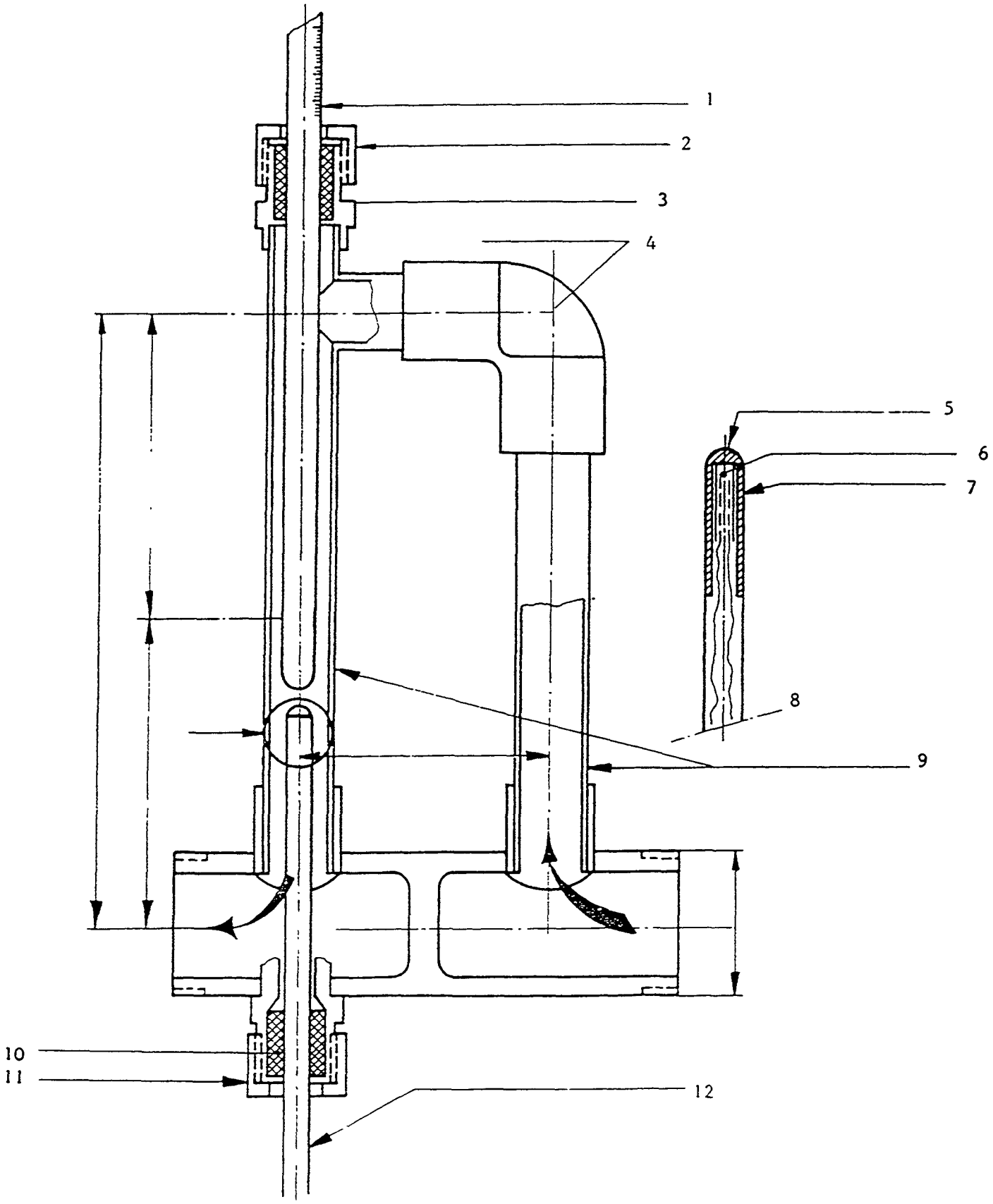
Where an instrument accuracy of + 0,05°C is specified, the instrument should have been subjected to recent calibration certified by a legally recognised authority.

Figure 3 - Diagram of the heating or cooling medium production circuit



1. Constant level loaded expansion tank
2. Junction of the thermocouples and thermoresistances to the measuring instruments and recording
3. Gas purger
4. Drain cock
5. Water measuring probe (see detail in fig. 4) at the inlet and outlet of the heat exchanger
6. Fan coil unit
7. Flow rate controlling rotameter
8. Regulation valve of the water flow through the heat exchanger under test
9. Over flow
10. Cooler (for a short draining circuit)
11. Temperature controlling mercurial
12. Moving pipe draining off water towards the measure container or towards the supply tank
13. Insulated container
14. Balance for accurate measurement of the flow rate
15. Generator heated by electric resistances with adjustable power or cooled by water cooling unit
16. Water supply tank, with auxiliary electric heating for the rapid starting of the tests
17. Softened water supply
18. Local supply circuit
19. Regulation valves of the air flow through the boiler
20. Circulation pump
21. Warm water circuit
22. Insulation

Figure 4 - Medium temperatures measuring probe at inlet and outlet of the fan coil unit



1. Precision mercurial thermometer
2. Tightness cap
3. Compressible gasket
4. Bend to be welded
5. Copper tip
6. Thermocoupled welding
7. Welding orifice
8. Detail « A »
9. Copper tube 12/14
10. Compressible gasket
11. Tightness cap
12. Stainless steel tube 7/8 mm

In all measurements of wet-bulb temperature, sufficient wetting should be provided and sufficient time should be allowed for the state of evaporative equilibrium to be attained.

For mercury-in-glass thermometers, having a bulb diameter not over 6,5 mm, temperatures should be read under conditions which ensure a minimum air velocity of 3 m/s.

For any other instrument, a sufficient air velocity should be provided to give the same equilibrium conditions as those defined above.

Wherever possible, thermometers used to measure the change in temperature should be arranged so that they can be readily interchanged between inlet and outlet positions to improve accuracy.

Temperature of fluids within conduits should be measured by inserting the temperature measuring instrument directly within the fluid, or within a well inserted into the fluid.

If a glass thermometer is to be inserted directly into the fluid, it should be calibrated for the effect of pressure.

Thermometers should be adequately shielded from radiation from any adjacent heat sources.

1.6.2 Manometers

Accuracy of manometers, not including barometers, should permit measurements within $\pm$ 1 Pa. The smallest scale division of the manometer shall not exceed twice the specified accuracy.

Barometric pressure should be measured by a barometer having scale markings permitting readings with an accuracy within $\pm$ 0,1 %.

1.6.3 Electrical instruments

Electrical measurements should be made with a wattmeter or a counter.

Accuracy should be within ± 0,5 %.

1.6.4 Water-flow measuring instruments

Water flow measurements should be made with either of the following instruments having an accuracy of ± 1 % of the quantity measured :

- liquid quantity meter, measuring either mass or volume
- liquid flow rate meter

The liquid quantity meter should employ a tank having a capacity sufficient to accumulate-e the flow for at least 2 minutes.

1.6.5 Other instruments

The chronometer's accuracy should be ± 0,2 %. Mass measurement should be made with apparatus whose accuracy is ± 1 % of the quantity measured.

1.7 HEATING CAPACITY MEASUREMENTS

Heating capacity measurement should be conducted in the « outdoor-side » compartment, according to the rated test conditions specified, under paragraph 1.2.1.

Two determinations of the heating capacity should be made ; one on the heating or cooling medium supplying the exchanger of the fan coil unit, the other on the reconditioning equipment of the compartment.

These two simultaneous determinations should agree within 7,5 % for the test to be valid, the reference heating capacity is that one determined on the heating or cooling medium of the heat exchanger of the fan coil unit.

1.8 COOLING CAPACITY MEASUREMENT

The tests for determining the various cooling capacities should be conducted in the « room-side » compartment at the rated test conditions specified, under paragraph 1.2.1.

Two determinations of the total cooling capacity should be made ; one on the heating or cooling medium supplying the heat exchanger of the fan coil unit, the other on the reconditioning equipment of the compartment.

These two simultaneous determinations should agree within 7,5 % for the test to be valid, the reference cooling capacity is that one determined on the heating or cooling medium of the heat exchanger of the fan coil unit.

Two determinations of the dehumidifying capacity should be made ; one on the basis of the water quantity condensed by the fan coil unit, collected outside the compartment, the other on the basis of the water quantity vaporised by the reconditioning equipment.

These two simultaneous determinations should agree within 7,5 % for the test to be valid, the reference dehumidifying capacity is that one calculated on the basis of the water quantity condensed by the fan coil unit.

1.9 TEST OPERATION

Grille positions, damper position, and the like should be set to result in maximum capacity.

Recording of the date necessary to determine the capacity should be started when the test conditions have been reached and maintained for not less than 1 hour, according to the specifications of § 4.22 and to the values of the table of document EUROVENT 6/1 Fan Coil Unit. The test should then be run for 1 hour recording data every 10 minutes, giving seven sets of readings.

Data to be recorded for cooling-capacity tests is given in table 2. The table shows the general information required, but is not intended to limit the data to be obtained.

Table 2 - Data to be recorded for capacity tests

1. Date
2. Observers
3. Barometric pressure
4. Speed of test unit cooling fan, where such speed is adjustable or variable
5. Applied voltage for each test unit motor
6. Frequency of applied voltage for each test unit motor
7. Total power input to unit
8. Total current input to unit
9. Control dry-bulb and wet-bulb temperature of air, room-side calorimeter compartment
10. Control dry-bulb and wet-bulb temperature of air, outdoor-side calorimeter compartment
11. Total power input to room-side and outdoor-side compartments
12. Water quantity evaporated in humidifier
13. Temperature of humidifier water entering room-side compartment, or in humidifier tank
14. Cooling water-flow rate through outdoor-side compartment heat rejection coil
15. Temperature of cooling water entering outdoor-side compartment, for heat rejection coil
16. Temperature of cooling water leaving outdoor-side compartment, from heat rejection coil
17. Water condensed in outdoor-side compartment
18. Temperature of condensed water leaving outdoor-side compartment
19. Heating or cooling medium flow rate supplying the fan coil unit
20. Heating or cooling medium temperature at the entry
21. Heating or cooling medium temperature at the outlet

1.10 CALCULATION OF THE CAPACITIES

1.10.1 Heating capacity

$P_t = q_{m1} (h_{1e} - h_{1s}) + P$

$P_t = q_{mc} (h_{cs} - h_{ce}) - P_{sc} \pm P_{tc}$

where :

P_t = heating effect

q_{m1} = heating or cooling medium (warm water) mass flow rate

h_{1e} = enthalpy per unit mass of the heating or cooling medium when entering the fan coil unit

h_{1s} = enthalpy per unit mass of the heating or cooling medium when leaving the fan coil unit

P = power input to the motor (s) of the fan coil unit

q_{mc} = mass flow rate of the heating or cooling medium of the reconditioning equipment (cold water)

h_{cs} = enthalpy per unit mass of the heating or cooling medium when leaving the reconditioning equipment

h_{ce} = enthalpy per unit mass of the heating or cooling medium when entering the reconditioning equipment

P_{SC} = sum of all power input to compartment (not including the heat leakage of the walls)

P_{tc} = heat leakage determined by calibration according clause 1.4.1.

1.10.2 Total room cooling effect under cooling working conditions with dehumidifying

Total room cooling effect under cooling working conditions with dehumidifying is calculated as follows according to § 1.8 :

$P_f = P_{sc} + (h_{w1} - h_{W2}) \times q_{mc} + P \pm P_{tc}$

$P_f = q_{m1} \times h_{1s} - h_{1e}$

where :

P_f = total cooling effect

P_{sc} = sum of all power supplied to compartment (not heat leakage by the walls)

P_{tc} = heat leakage determined by calibration after clause 1.4.1

h_{w1} = enthalpy of water entering the reconditioning equipment

h_{w2} = enthalpy of water condensed by the fan coil unit (the temperature of the water condensed is measured at the outlet of the room calorimeter)

q_{mc} = mass flow rate of water supplied to the reconditioning equipment to maintain the humidity specified

P = power input to the motor (s) of the fan coil unit

q_{m1} = heating or cooling medium mass flow rate

h_{1s} = enthalpy per unit mass of the heating or cooling medium when leaving the fan coil unit

h_{1e} = enthalpy per unit mass of the heating or cooling medium when entering the fan coil unit

1.10.3 Dehumidifying effect

Dehumidifying effect is calculated as follows according to § 1.8 :

$P_d = L_v \cdot q_{mv}$

$P_d = L_v \cdot q_{mc}$

where :

P_d = net humidifying effect
L_v = steam generating heat 2460 kj/kg (588 kcal/kg)
q_{mv} = mass flow rate of water condensed by the fan coil unit
q_{mc} = mass flow rate of water supplied to the reconditioning equipment

1.10.4 Sensible cooling effect

Sensible cooling effect is calculated as follows :

$P_s = P_f - P_d$

(the values of P_f and P_d are the reference values mentioned in clause 1.8)

1.10.5 Sensible heat ratio

Sensible heat ratio is calculated as follows :

$$C_s = \frac{P_s}{P_f}$$

(the values for P_s and P_f are the values of reference mentioned in clause 1.8 and 1.10.2)

1.11 HEATING OR COOLING MEDIUM PRESSURE LOSS MEASUREMENTS

The measurements should be made at following working conditions for each exchanger :

- fans stopped
- mean entering water temperature < 10°C
- water mass flow rates : 4 flow rates including the maximum and minimum flow rates specified by the manufacturers

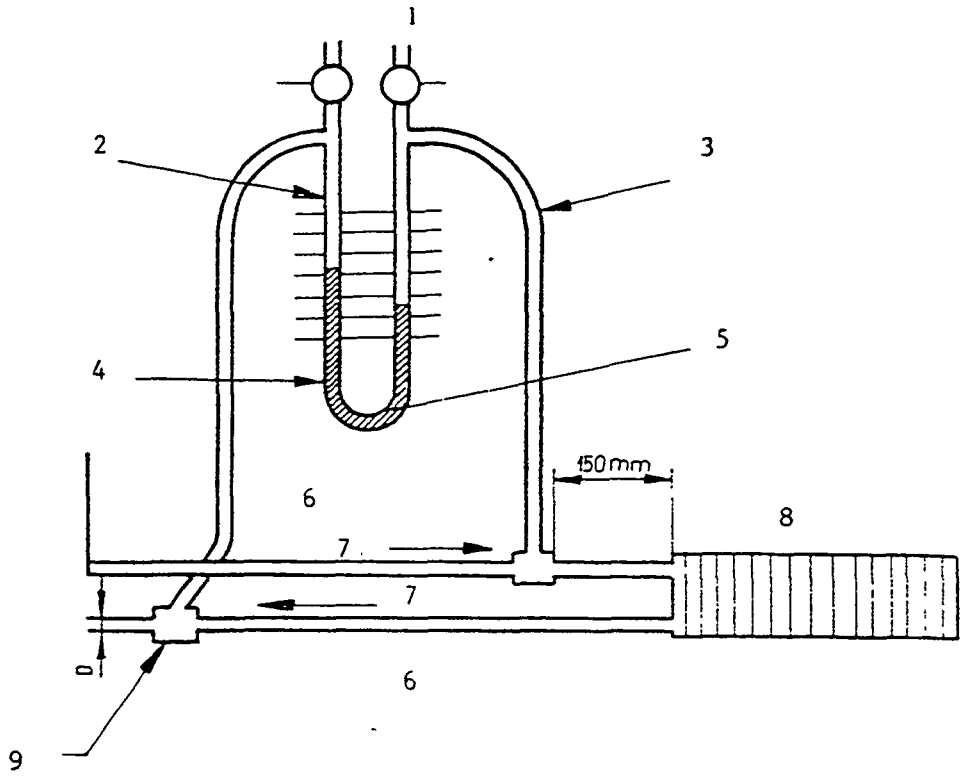
The measuring device of figure 5 may be used for this measurement.

The pressure loss in the apparatus is equal to the measured pressure loss minus the pressure loss of the measuring device, experimentally determined or calculated by means of a standard friction diagram.

A curve shall be set out on logarithmic paper, with the water flow rates on the abscise and the pressure losses on the ordinates.

Figure 5 - Heating or cooling medium flow pressure loss measuring device

1. Drain cock
2. Heating or cooling medium flow
3. Rounded tubes
4. Manometric tube
5. Mercury or other fluid
6. Straight length 25 D
7. Flow
8. Battery
9. Adapter



1.12 AIR FLOW MEASUREMENT

The air flow should be measured at following working conditions :

- coil not supplied with heating or cooling medium
- maximum speed of the fan
- ambient air temperature between 10 and 30°C
- rated voltage and frequency

It should be expressed in volume flow rate at the conditions of pressure, temperature and humidity of the measurement.

The air flow rate may be measured with any standardised method.

1.13 CHECKING OF THE OPERATIONAL CHARACTERISTICS

1.13.1 Sweat test

Fan coil units should meet the following sweat tests, when operating at the test conditions specified in clause 1.2.2. The grilles, dampers, etc. should be set to produce maximum power.

1.13.1.1 Procedure

After establishment of the specified temperature conditions, the unit should be operated continuously for a period of 4 hours.

1.13.1.2 Requirements

During the whole test there must not be any trace of condensed water on the enclosure, and no condensed water should drip, run, or blow off the unit.

1.13.2 Condensate disposal test

Fan coil units should meet the following condensate disposal test, when operated at the test conditions specified in clause 1.2.3. The grilles, dampers, etc. should be set to produce maximum power.

Note : This test may be conducted concurrently with the sweat test.

1.13.2.1 Procedure

After establishment of the specified temperature conditions, the unit should be operated for 4 hours after the condensate level has reached equilibrium.

1.13.2.2 Requirements

During the whole test, the fan coil unit should have the ability to dispose of all condensate and there should be no dripping or blowing-off of water from the unit.

1.13.3 Low voltage test

Fans should be able to start at a supply voltage corresponding to 90 % of the nameplate rated voltage, at all speed settings.

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