EUROVENT/ CECOMAF

EUROVENT 6/4 - 1996

THERMAL TEST METHOD FOR INDUCTION UNITS

EUROVENT 6/4 - 1996

THERMAL TEST METHOD FOR INDUCTION UNITS

EUROVENT 6/4

Edition 1996

Published by EUROVENT/CECOMAF

15 rue Montorgueil

F-75001 PARIS

Tel 33 1 40 26 00 85

Fax 33 1 40 13 75 44

EXPLANATORY NOTES

This document is based on the following standards :

- ISO DIS 5151 Non-ducted air conditioners, testing and rating
- EUROVENT 6/3 Thermal Test Method for Fan Coil Units
- ARI 445-66 Standard for Room Air-Induction Units

This document specifies the application of the room calorimeter method.

The air flow measuring devices are derived from ARI 445-66 combined with document EUROVENT 6/3. The thermal power test is prescribed with dry coil and measures only the secondary air effect (sensible heat) as in induction systems, the primary air (for latent heat and fresh air) is treated outside the induction unit and its effect has to be measured there.

No particular difference was considered between testing air or water side control induction units as the test has to be conducted or in heat or in cool position. For air side control is pointed out only a « heat loss test », whose influence is measured testing by confront in heat and cool condition with and without flow respectively of cooling and heating medium.

TABLE OF CONTENTS

1. THERMAL TEST METHOD FOR INDUCTION UNITS

1.1 SCORE

The following test method prescribes the procedures for determining the capacity and the various characteristics of induction units supplied with warm and cold water.

1.2 TEST CONDITIONS

1.2.1 Standard test conditions for determination of heating and cooling power

Standard test conditions	Heating	Cooling (1)
1. HEATING OR COOLING MEDIUM (water)		
Temperature at entry	70 or 50°C (2)	10°C
Water flow determined by :		
- rise of temperature		5°C
- drop of temperature	10°C	
2. ROOM AIR (primary and secondary)		
Dry-bulb temperature at entry	20°C	24°C
Wet-bulb temperature at entry	--	15,5°C
3. NOZZLES PRESSURES	380 N/m2	380 N/m2

(1) Cooling test should be made without dehumidifying ; in order to obtain this condition, the air dew point must be least 0,5°C lower than water temperature at entry.

(2) 70°C is for systems with separate cooling and heating coils.
50°C is for systems using the same coil for heating and cooling.

1.3 TEST SPECIFICATIONS

Tests should be carried out with a unit comprising following main components :
- one or more heat exchangers
- one or several induction elements (nozzles) for the expansion of the primary air and the induction of the secondary air
- a damper for the primary air
- an enclosure prescribed by the manufacturer

These parts may be completed by :
- a condensate collecting device (1)
- one or several elements for the purification of air (filters) (1)

(1) Only if required by manufacturers and user prior to specific test

1.4 - CALORIMETERS - GENERAL

The induction units should be tested for determination of their heating or cooling capacities and characteristics in a calorimeter room of either calibrated or balanced ambient type similar to that which is used for the determination of operating characteristics of 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 « out-door-side » compartment which is provided with reconditioning equipment, whose cooling power can be measured and controlled, to balance the heat power of the induction unit.

The test under cooling conditions should be performed in the so called « room-side » compartment provided with a reconditioning equipment, whose heating power can be measured and adjusted, for balancing the cooling power of the induction unit.

Note : when the calorimeter is only designed for testing induction units it need only have one room provided with reconditioning equipment whose cooling and heating power can be measured and adjusted for balancing either the heating or the cooling powers of the induction unit.

In the double enclosure and in each compartment unused for the tests, a dry-bulb temperature equal to that within the compartment being 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.

Inner 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 induction unit.

Table 1 - Sizes of compartments

Maximum heating or cooling capacity of unit (*)	Suggested minimum inside dimensions of each compartment of the calorimeter		
	Width	Length	Depth
3000 W	2,4 m	2,1 m	1,8 m
6000 W	2,4 m	2,1 m	2,4 m
9000 W	2,7 m	2,4 m	3,0 m
12000 W	3,0 m	2,4 m	3,7 m

(*) All figures have been voluntarily rounded off

1.4.1 - Calibrated room-type calorimeter

The calibrated room-type calorimeter is shown in figure 1. Each compartment of the calorimeter including the separating partition, should be insulated to prevent heat leakage (incl. radiation) in excess of 5 % of the test unit power. 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 $\pm$ 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
12. Primary air fan supply
12'. Primary air fan supply

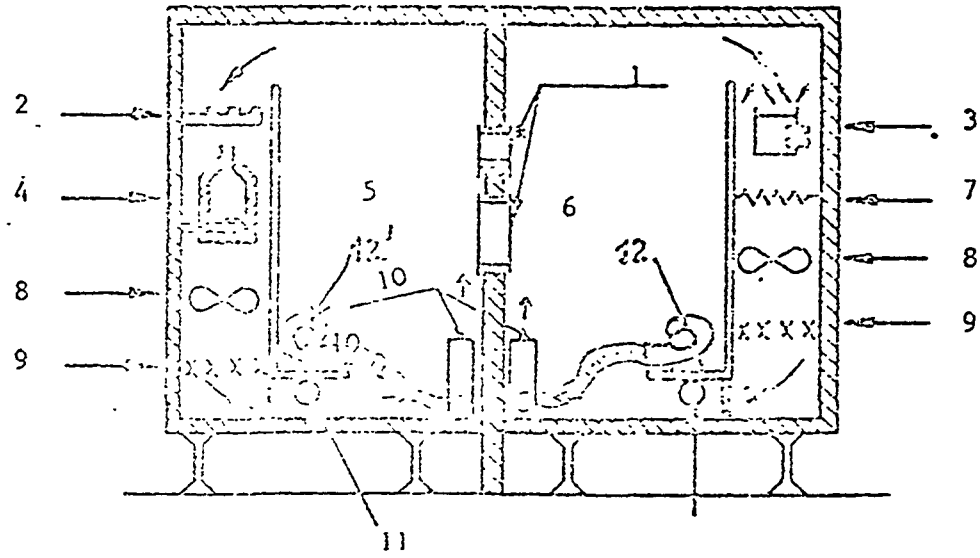
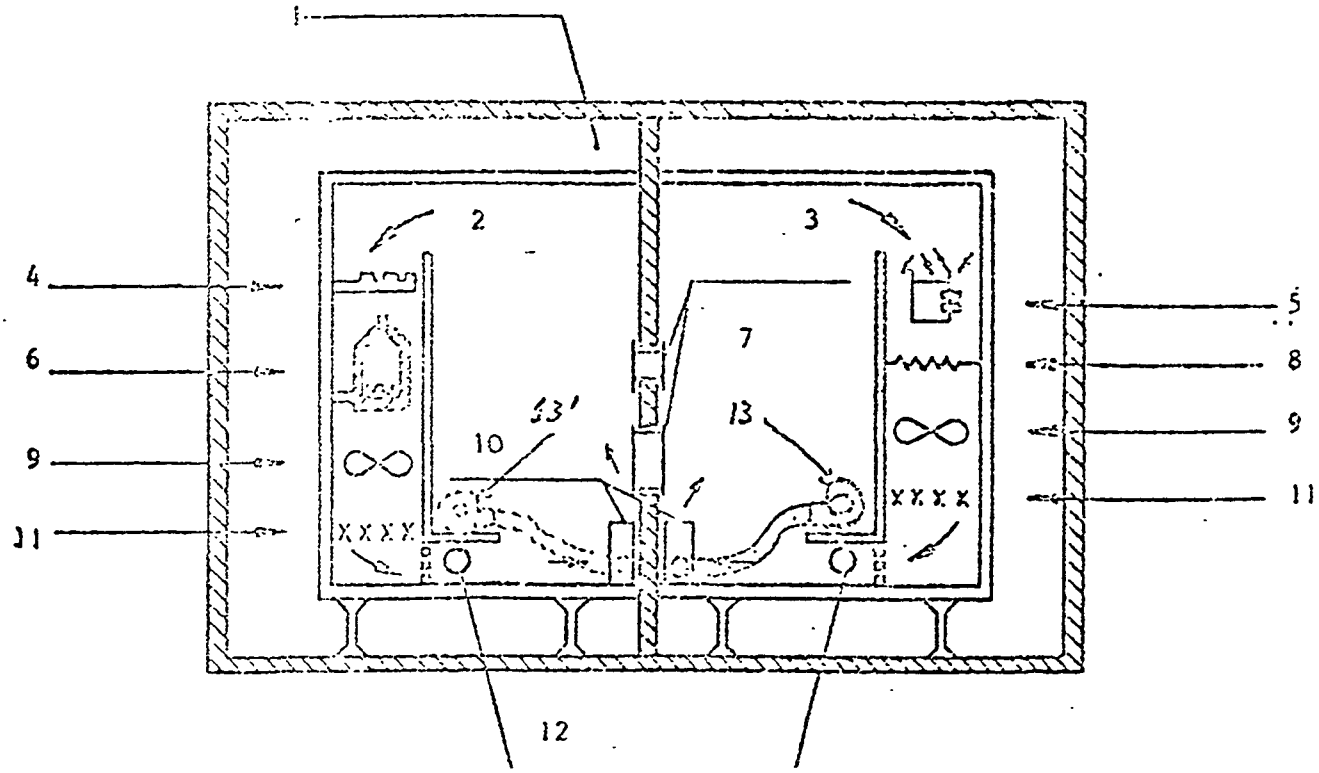


Fig. 2 - Balanced ambient room-type calorimeter

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
13. Primary air fan supply
13'. Primary air fan supply



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 operated 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 in order to limit heat leakage (including radiation) to not more than 10 % of the induction unit power with a temperature difference of 11°C or 300 W for the same temperature difference, which ever 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 quantity water 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 power to circulate not less than twice the quantity of air discharged by the induction unit to the room-side as the case may be. In no case should the reconditioning equipment discharge less than one air change per minute per compartment.

Perforated plates or other suitable grilles should be provided at the discharge openings of 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 induction unit to avoid interference with the air flow.

1.4.4 - Position of the points of measurements 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 combined operation the reconditioning equipment and the induction 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 induction 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 induction 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 the temperature of the 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 air-flow 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 discharged to intake opening, the specified temperatures may be measured immediately upstream of such intake opening.*

1.4.5 - Installation of the induction units to be tested within the compartments

Window type induction 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 induction 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.

Induction 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.

Induction units should be connected to a device (rep. 12, 12' fig. 1, 13 and 13' fig. 2) which supplies the necessary primary-air. Room air is used as primary air. This device shall be

placed in the same room as the unit on test. This thermal energy source will be added to the total energy supplied to the calorimeter compartment.

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 me made as per the diagram in figure 3. The heating or cooling medium flow rate can be measured by weighting or by any other measuring method of the same precision.

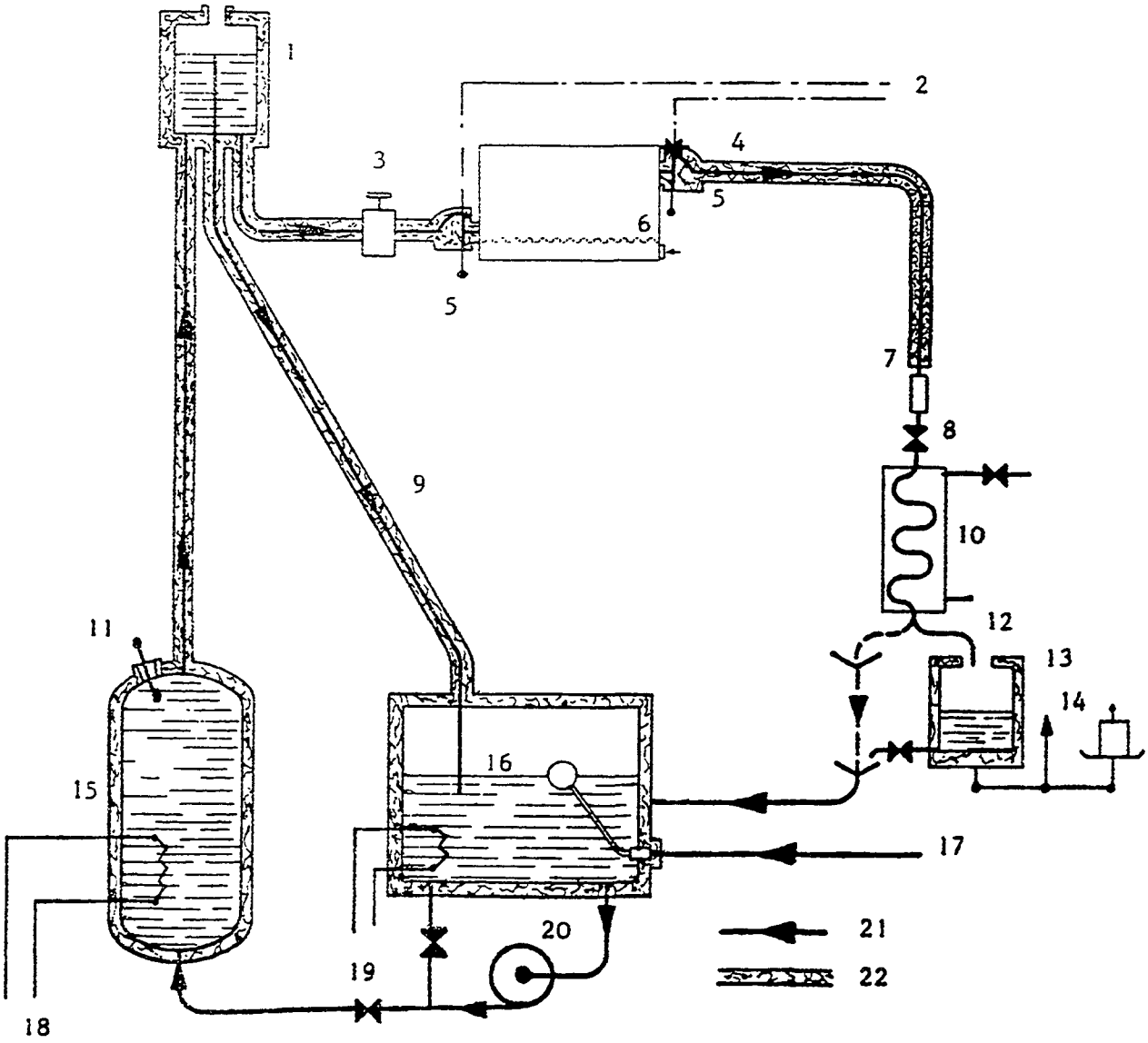
1.6 - MEASURING INSTRUMENTS

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

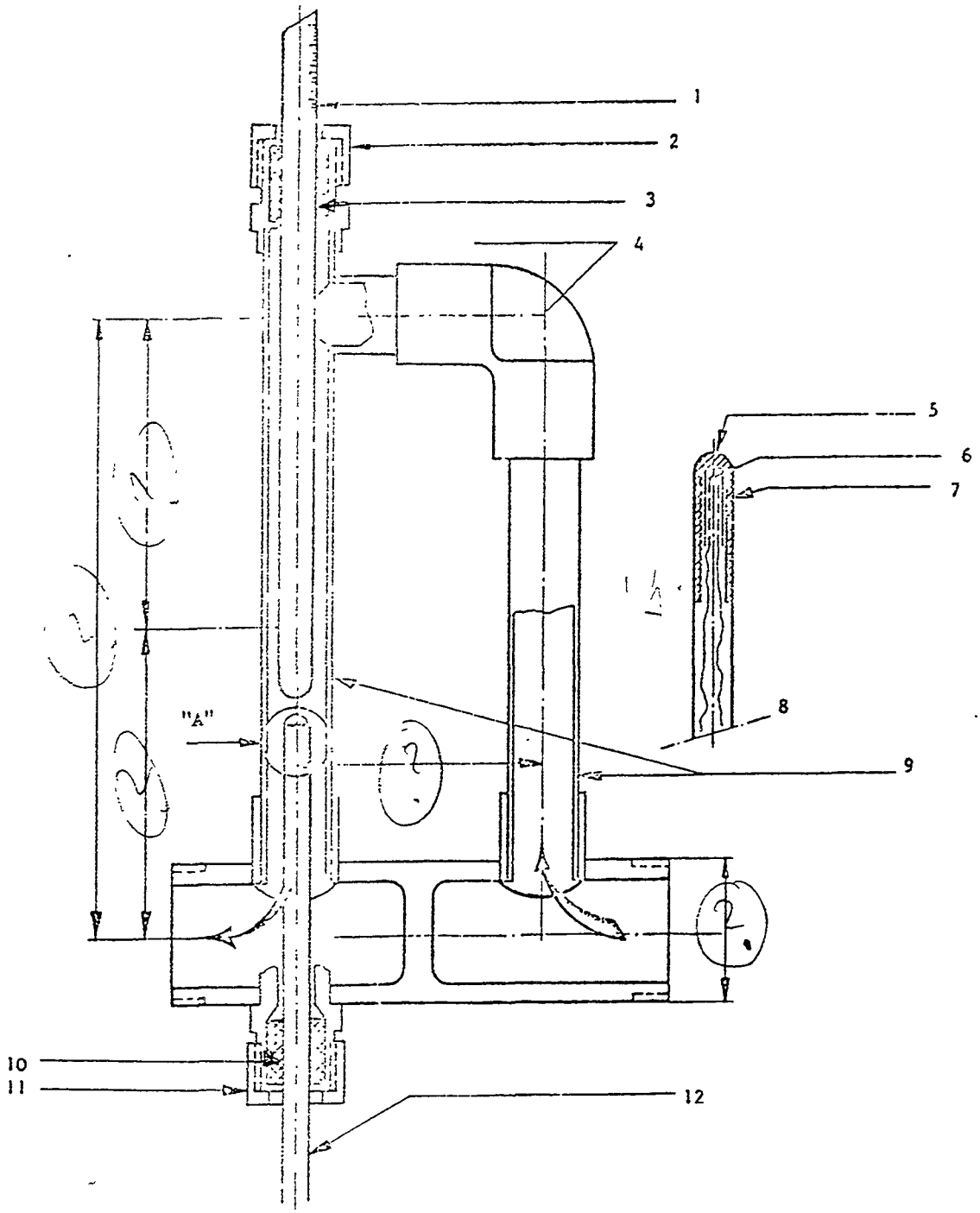
Figure 3 - Diagram of the heating or cooling medium production circuit



1. Constant level full expansion tank
2. Junction of the thermocouples and thermoresistances to the measuring instruments and recorders
3. Gas purge
4. Drain cock
5. Water measuring probe (see detail in fig. 3) at inlet of the heat exchanger
6. Induction unit
7. Rotameter controlling flow rate
8. Valve regulating water flow through the heat exchanger under test
9. Over-flow
10. Cooler (for a short draining circuit)
11. Mercury thermometer controlling boiler outlet temperature
12. Movable tube for draining water either to the measuring container, or to the supply tank
13. Insulated container
14. Balance for accurate measurement of the flow rate
15. Generator heated by variable electric resistance
16. Water supply tank, with auxiliary electric heating for rapid starting of tests
17. Softened water supply
18. Local electrical supply circuit
19. Valves for regulating the air flow to the boiler
20. Circulating pump
21. Warm water circuit
22. Insulation

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

1. Precision mercury thermometer
2. Tight 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. Tight cap
12. Stainless steel tube, 7/8 mm



Instrument accuracy should be within the following limits :

- wet and dry-bulb temperatures of air in room-side compartment ± 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 ± 0,05°C
- all other temperature ± 0,3°C

The smallest scale division of the thermometer shall not exceed twice the specified accuracy. For example, for the specified accuracy of ± 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.

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 pipes should be measured by inserting the temperature measuring instrument directly into the fluid, or into a well inserted 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 ± 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 of ± 0,1 %.

1.6.3 - Electrical instruments

Electrical measurements should be made with a wattmeter or ammeter.

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 power sufficient to accumulate 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 being measured.

1.7 - HEATING CAPACITY MEASUREMENT

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 induction 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 induction unit.

1.8 - COOLING CAPACITY MEASUREMENT

The tests for determining the cooling capacity shall 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 induction 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 induction unit.

1.9 - TEST OPERATION

Grille positions, damper position, and the like should be set to result in maximum power.
When normal working conditions are reached, the period of stabilisation begins. Its length depends on the type of the test bench and the type of the apparatus to be tested. From experience, it is observed that this condition is achieved within 30 minutes.

The period of stabilisation is terminated when a state of equilibrium is reached. The criterion for this state is that the 4 complete measured values will not exceed the fluctuations given in the table 2 on the basis of statistical distribution.

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-power tests is given in table 3. The table shows the general information required, but is not intended to limit the data to be obtained.

1.10 - CALCULATION OF CAPACITY

The heating and cooling capacities are calculated as follows according to § 1.7 :

- Heating power :

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

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

- Cooling power :

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

$$P = q_{mc} (h_{ce} - h_{cs}) - P_{sc} + P_{tc} \text{ (1)}$$

where :

P	power
q_{m1}	heating or cooling medium mass flow rate
h_{1e}	enthalpy per unit mass of the heating cooling medium when entering the induction unit
h_{1s}	enthalpy per unit mass of the heating or cooling medium when leaving the induction unit
q_{mc}	mass flow rate of the heating or cooling medium of the reconditioning equipment
h_{cs}	enthalpy per unit mass of the heating or cooling medium when entering the reconditioning equipment
p_{cs}	sum of all power input to compartment (not including the heat leakage or the walls)
p_{tc}	heat leakage determined by calibration according clause 1.4.1.

(1) if electric power is used, the expression $q_{mc} (h_{ce} - h_{cs})$ is deleted.

1.11 - HEATING OR COOLING MEDIUM PRESSURE LOSS MEASUREMENT

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

- 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 show in 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 in abscise and the pressure losses in ordinate.

1.12 - MEASUREMENT OF PRIMARY AIR PRESSURE

The primary air pressure at the unit inlet should be measured by means of a pressure tapping located on the supply duct downstream of the convection to the flow measuring device, and at a distance equal to ten (10) diameters at least from that of the duct. The pressure at the nozzle inlet shall be measured by means of a pressure probe introduced into one nozzle at sufficient depth to avoid the velocity effect. Three successive measurements with the same probe shall be made at the points indicated in fig. 6. A curve shall be drawn on logarithmic paper by plotting the pressure in ordinate and the volume flow rate of primary air in abscise.

1.13 - AIR FLOW RATE MEASUREMENTS

Total and primary air flow rates should be measured at the following operating conditions :

- coil not supplied with heating or cooling medium
- ambient air temperature between 10 and 30°C.

They may be measured by means of the air performance test system illustrated in fig. 6 using standardised air flow measuring devices.

Fig. 5 - Heating or cooling medium flow pressure loss measuring device

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

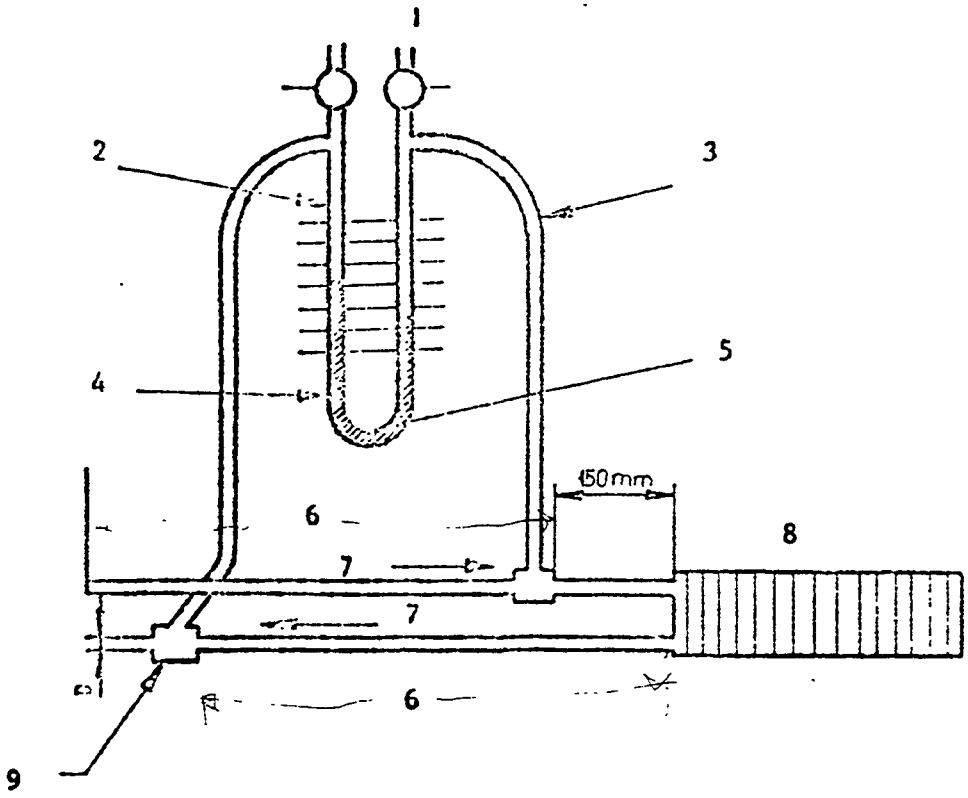


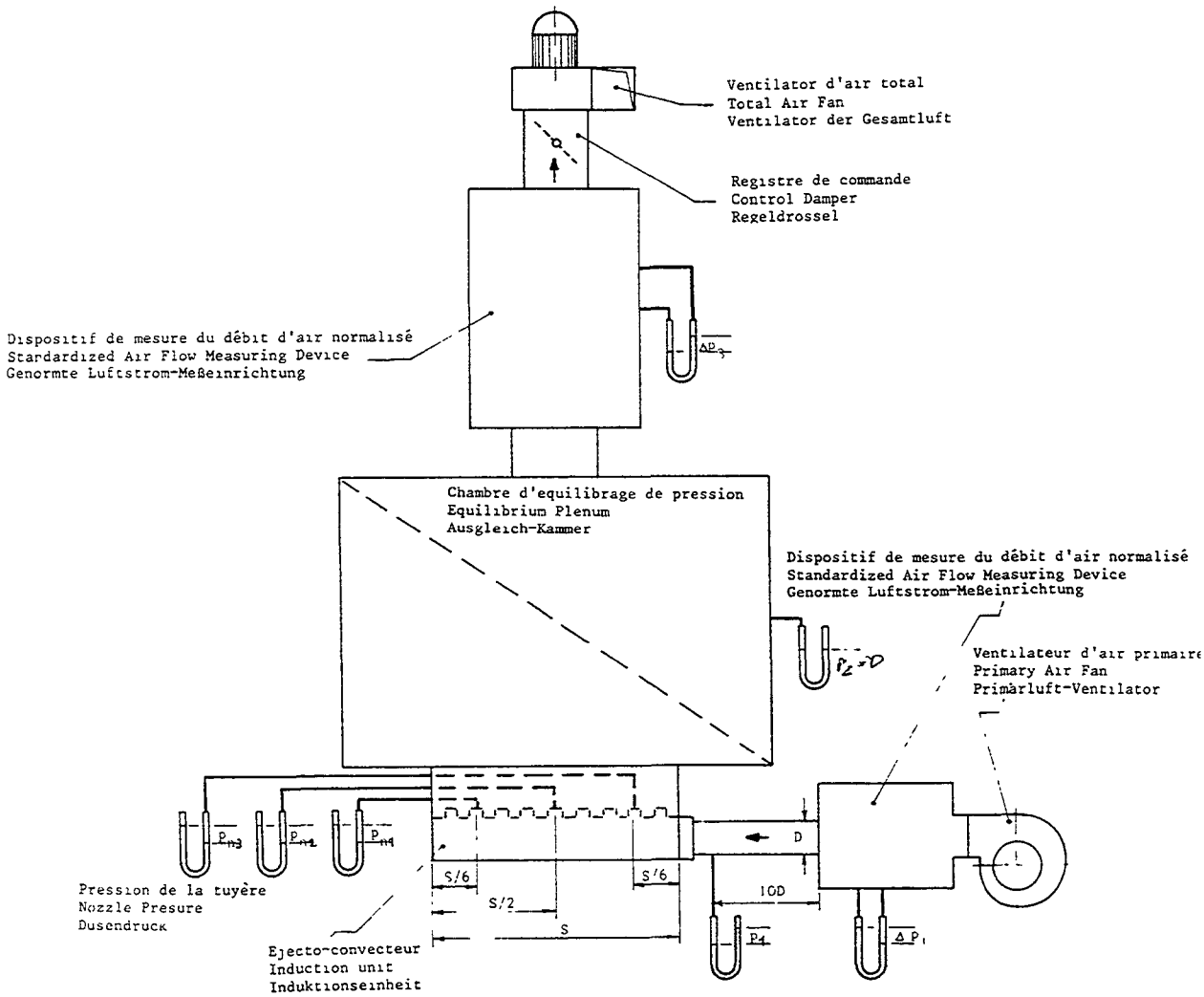
Table 2 - The medium value of these measurements is considered as the measured value during equilibrium.

Measured values	Cold water	Warm water	Units
Temperature of the heating or cooling medium at the input or at the output	± 0,1	+ 0,2	°C
Mass flow of the heating or cooling medium	± 1	± 1	%
Temperature of the air at the input	± 0,3	± 0,3	°C
Wet temperature of the air at the input	± 0,2	-	°C
Temperature of the air at the output	± 0,6	± 0,6	°C
Mass flow of the air at the input	± 2	± 2	%
Primary air pressure	± 2	± 2	%

Table 3 - Data to be recorded for capacity tests

1. Date
2. Observers
3. Barometric pressure
4. Primary air pressure
5. Control dry-bulb and wet-bulb temperature of air room side calorimeter compartment
6. Control dry-bulb and wet-bulb temperature of air, outdoor side calorimeter compartment
7. Total power input to room-side and outlet-side compartment
8. Cooling water-flow compartment heat rejection coil
9. Temperature of cooling water entering outdoor-side compartment for heat rejection coil
10. Temperature of cooling water leaving outdoor-side compartment from heat rejection

Figure 6 - Total and Primary Air flows Measurement System



LIST OF THE MEMBER ASSOCIATIONS

BELGIUM
FABRIMETAL
21 rue des Drapiers -
B-1050 BRUXELLES
Tel 32/2/5102518 - Fax : 32/2/5102563

GERMANY
FG ALT im VDMA
Postfach 71 08 64 - D-60498 FRANKFURT AM MAIN
Tel. 49/69/6603 1227 - Fax : 9/69/6603 1218
E-mail: Lorenz_ALT@VDMA.org

SPAIN
AFEC
Francisco Silvela, 69-1°C - E-28028 MADRID
Tel. 34/1/4027383 - Fax : 34/1/4027638

FINLAND
AFMAHE
Etaläranta 10 - FIN-00130 HELSINKI
Tel. 358/9/19231 - Fax : 358/9/624462

FINLAND
FREA
P.O. Box 118
FIN-00811 HELSINKI
Tel : 358/9/759 11 66 - Fax : 358/9/755 72 46

FRANCE
UNICLIMA
F-92038 PARIS LA DEFENSE CEDEX
Tel : 33/1/47176292 - Fax : 33/1/47176427

GREAT BRITAIN
FETA (HEVAC and BRA)
Sterling House - 6 Furlong Road - Bourne End
GB-BUCKS SL 8 5DG
Tel 44/1628/531186
Fax 44/1628/810423
E-mail: info@feta.co.uk

ITALY
ANIMA - CO.AER
Via Battistotti Sassi, 11 - I-20133 MILANO
Tel : 39/2/73971 - Fax : 39/2/7397316

NETHERLANDS
NKI
Postbus 190 - NL-2700 AD ZOETERMEER
Tel: 31/79/353 12 59 - Fax : 31/79/353 11 15
E-mail: nki@fme.nl

NETHERLANDS
VLA
Postbus 190 - NL-2700 AD ZOETERMEER
Tel. 31/79/353 11 00 - Fax : 31/79/353 13 65
E-mail: vla@fme.nl

NORWAY
NVEF
P.O.Box 850 Sentrum - N-0104 OSLO
Tel. 47/2/413445 - Fax : 47/2/2202875

SWEDEN
KTG
P.O. Box 5510 - S-114 85 STOCKHOLM
Tel. 46/8/782 08 00 - Fax : 46/8/660 33 78
E-mail: bo.gostring@isab.postnet.se

SWEDEN
SWEDVENT
P.O. Box 175 37 - S-118 91 STOCKHOLM
Tel . 46/8/762 75 00 - Fax : 46/8/668 11 80

TURKEY
ISKID
ARCELIK A.S.
Klima Isletmesi
TR-81719 TUZLA ISTANBUL
Tel : 90/216 395 45 15
Fax : 90/216 423 23 59
E-mail: alatli@arcelik.com.tr