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Testing of refrigerant compressors

Essais des compresseurs pour fluides frigorigènes

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Contents

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

Draft International Standards adopted by the technical committees are circulated to the member bodies for approval before their acceptance as International Standards by the ISO Council. They are approved in accordance with ISO procedures requiring at least 75 % approval by the member bodies voting.

International Standard ISO 917 was prepared by Technical Committee ISO/TC 86, *Refrigeration.*

This second edition cancels and replaces the first edition (ISO 917 : 1974), of which it constitutes a technical revision.

Users should note that all International Standards undergo revision from time to time and that any reference made herein to any other International Standard implies its latest edition, unless otherwise stated.

Testing of refrigerant compressors

1 Scope and field of application

The provisions of this International Standard apply only to single-stage refrigerant compressors of the positive-displacement type. Selected test methods are described for the determination of the refrigerating capacity, the power, the isentropic efficiency and the coefficient of performance. These test methods provide results of sufficient accuracy to permit consideration of the suitability of a refrigerant compressor to operate satisfactorily under any set of basic test conditions required for a given refrigeration installation.

Attention is drawn in particular to a number of special precautions necessary to reduce testing losses to a minimum.

This International Standard applies only to tests carried out at the manufacturer's works, or wherever the necessary equipment for testing to the accuracy required can be made available. The types and calibration of measuring instruments and the accuracy of measurement are specified in annex A, which forms an integral part of this International Standard.

The test methods described may also be used as a guide for the testing of other types of refrigerant compressors.

NOTE — Tests on complete refrigeration installations are dealt with in ISO 916-1.

Annexes B and C, which provide additional information, do not form integral parts of this International Standard.

2 References

ISO 916-1, *Refrigeration systems — Test methods — Part 1 : Testing of systems for cooling liquids and gases using a positive displacement compressor.* [1)]

ISO 1662, *Refrigerating plants — Safety requirements.*

ISO 5167, *Measurement of fluid flow by means of orifice plates, nozzles and Venturi tubes inserted in circular cross-section conduits running full.*

ISO 5168, *Measurement of fluid flow — Estimation of uncertainty of a flow-rate measurement.*

3 Definitions

NOTE — A complete list of symbols and units used in the calculations, together with their definitions, is given in annex B.

3.1 refrigerating capacity of a refrigerant compressor Φ_0: Product of the mass flow rate of refrigerant through the compressor, as derived from the test, and the difference between the specific enthalpy of the refrigerant at the measuring point at the inlet of the compressor and the specific enthalpy of the saturated liquid at the temperature corresponding to the test discharge pressure at the measuring point at the outlet of the compressor.

3.2 volumetric efficiency, η_V: Ratio of the actual volume rate of flow at suction conditions, measured at the position specified in 4.3.2, to the displacement of the compressor.

3.3 power input, P: Power at the compressor shaft for an open compressor or power at the motor terminals for a hermetic motor compressor (or semi-hermetic motor compressor) together with the power absorbed by such ancillaries as are necessary to sustain the operation of the compressor, e.g. oil pump.

3.4 isentropic efficiency, η_i: Ratio of the product of the actual mass flow and the change in isentropic enthalpy across the compressor to the power input.

3.5 coefficient of performance, ε: Ratio of the refrigerating capacity to the power input.

NOTE — It should be made clear in the test resport whether the power input referred to is that measured at the compressor shaft or that at the motor terminals.

1) At present at the stage of draft.

Section one : Determination of refrigerating capacity and of volumetric efficiency

4 General procedure

4.1 Method of determination of refrigerating capacity and volumetric efficiency

The determination of the refrigerating capacity of a compressor comprises

a) the evaluation of the mass flow rate of the refrigerant, obtained for each test method used by means of an apparatus which is inserted in the outer part of the test circuit, between the outlet and the inlet of the compressor, as described in clauses 8 to 15, and

b) the determination from recognized tables, of the thermodynamic properties of the refrigerant, of the specific enthalpy of the refrigerant in the saturated-liquid state at the compressor discharge pressure and its specific enthalpy at the compressor suction pressure and temperature.

The volumetric efficiency is determined using the equation given in 6.7.2.

During the test, the refrigerant compressor should be furnished with all auxiliary equipment and accessories necessary for its satisfactory operation in normal use.

4.2 Tests

All tests shall comprise two test methods, a test X and a test Y, which shall be carried out simultaneously.

4.2.1 Test Y shall, wherever possible, be a different type of test than test X, so that its results are obtained independently from those of test X.

4.2.2 The values of the estimated errors for the refrigerating capacity shall be calculated for test X ($s\Phi_{0X}$) and for the selected test Y ($s\Phi_{0Y}$) (see annex C).

4.2.3 Specifications for test X and test Y and for their possible combinations are given in clause 7.

4.2.4 The results of test X and test Y for the refrigerating capacity shall be accepted provided that they correlate within ± 4 % (see annex C).

4.2.5 For results valid in accordance with 4.2.4, the refrigerating capacity and the volumetric efficiency shall be taken as the mean of the test X and test Y results.

The values of the estimated errors (sf_X and sf_Y) for test X and test Y, calculated as described in 4.2.2 and annex C, shall be used to determine the total estimated error (to one significant figure) for the valid result using the formula $[(sf_X^2 + sf_Y^2)/2]^{1/2}$.

4.3 General rules

In order to ensure that the results obtained are within the required limits of accuracy, it is essential to observe the following rules, and the instructions given in the note to 4.3.4 should be taken into account.

4.3.1 All instruments and auxiliary measuring apparatus shall be correctly located in relation to the compressor inlet and outlet, and shall be calibrated against master instruments of certified accuracy and adjusted if necessary to give readings within the limits of accuracy prescribed in annex A.

4.3.2 The pressure and temperature at the suction inlet to the compressor shall be measured at the same point which shall be located on a straight run of pipeline, at a distance of (or as close as possible to) eight times the pipe diameter, ahead of the point of entry or of the stop valve, if one is fitted.

The diameter of the pipe shall be consistent with that of the flange on the compressor for a length of at least sixteen times the pipe diameter.

4.3.3 The pressure and temperature at the discharge outlet of the compressor shall be measured at the same point which shall be located on a straight run of pipeline, at a distance not less than eight times the pipe diameter after the point of outlet or the stop valve, if one is fitted.

The diameter of the pipe shall be consistent with that of the flange on the compressor for a length of at least sixteen times the pipe diameter.

4.3.4 The correct refrigerant and lubricating oil charges shall be present in the circulation system. Efficient oil separators shall be fitted in the discharge line of the compressor unless it is shown by measurement that the oil pumping rate is less than 1,5 % of the refrigerant mass flow rate. If a separator is used, arrangements shall be made to return the separated oil direct to the compressor lubricating system.

If the compressor is designed for use on a normal oil returning circuit, the oil from the separator shall be returned to the suction line between the measuring apparatus and the compressor suction connection.

No refrigerant shall be added during the test, and no oil shall be added to enclosed crank cases which communicate with the refrigerant circuit.

During the whole of the test run, the circuit shall contain only the refrigerant and the lubricating oil in such conditions of purity that normal operation in the continuous running of the compressor will be assured and the precision of the test measurements will not be affected within the agreed tolerances.

NOTE — The complete elimination of liquid refrigerant and lubricating oil would be difficult to achieve. However, the error arising from these factors at the inlet of the compressor can generally be reduced to such an extent as to be negligible by

a) ensuring that the refrigerant vapour is sufficiently superheated at the inlet to the compressor (for this purpose a suction superheater may be required, and any heat supplied to it from an external source should be duly recorded), and

b) providing an efficient oil separator on the discharge line of the compressor.

In general, a correction for the effect of the lubricating oil is not necessary if the oil content of the oil-liquid refrigerant mixture is such as to cause an error not exceeding 1,5 % of the refrigerating capacity.

4.3.5 The system shall be tested for freedom from leaks of refrigerant and oil. The absence of non-condensable gases shall be confirmed by appropriate means.

4.3.6 The system shall be protected against abnormal air currents.

4.4 Test period

4.4.1 The tests specified refer exclusively to a refrigerant compressor operating continuously under conditions such that, for a specified period, fluctuations in all the factors likely to affect the results of a test remain between the limits prescribed and show no definite tendency to move outside these limits.

These conditions are termed steady working conditions.

4.4.2 After the compressor has been started, adjustments shall be made during a preliminary run until the measurements required for the test are within the allowable limits of variation.

4.4.3 Once steady working conditions having been reached, the readings for the test period shall be taken at equal time intervals not exceeding 20 min for a period of at least 1 h, during which at least four readings shall be taken.

If recording instruments are used, their accuracies shall be comparable with those specified in annex A.

4.4.4 The arithmetic mean of the successive readings for each measurement is taken as the value of the measurement for the test.

4.4.5 All quantitative measurements shall be made at the beginning and end of each time interval to check uniformity of operation, the difference between the first and last measurement of the test period being taken as the value for the test.

5 Basic test conditions and deviations

The basic test conditions, under which the test is to be performed, which shall be specified for the testing of a refrigerant compressor are as follows :

a) the absolute pressure at the measuring points in the suction and discharge pipelines of the compressor;

b) the suction temperature at the measuring point in the suction pipeline of the compressor;

c) the speed of rotation of the compressor.

The pressure readings shall not deviate by more than ± 1 % from the basic test conditions throughout the test period.

The temperature readings shall not deviate by more than ± 3 °C from the basic test conditions throughout the test period.

The speed shall not deviate by more than ± 1 % from the basic test conditions throughout the test period; for hermetic motor compressors, the voltage shall be within ± 3 % and the frequency within ± 1 % of the nameplate values throughout the test period.

6 Basis of calculations

6.1 Source of thermodynamic properties

The source from which thermodynamic properties are taken shall be stated in the test report.

6.2 Specific enthalpy

Subject to the rules and precautions defined under 4.3, the specific enthalpy of the refrigerant liquid at the compressor discharge pressure, and that at the compressor suction pressure and temperature, are obtained from recognized tables of the thermodynamic properties of the refrigerant used. In the case of the specific enthalpy at the compressor suction pressure and temperature, a correction for the presence of entrained lubricating oil to the equations from which the specific enthalpy values are derived may be necessary.

6.3 Mass flow rate of refrigerant

The mass flow rate is determined by using tests X and Y which are selected (see clause 7) from the tests described in clauses 8 to 15.

6.4 Specific volume of the refrigerant

The actual test value V_{ga} of the specific volume of the refrigerant vapour at the compressor inlet shall not differ by more than 2 % from the value V_{gl} of the specific volume of the refrigerant vapour corresponding to the specified basic test conditions.

6.5 Compressor speed

The actual test value n_a of the compressor speed shall not differ from the basic test conditions by more than the deviations specified in clause 5.

6.6 Value of the measured mass flow rate

Subject to the conditions given in 6.4 and 6.5, the value of the measured mass flow rate q_{m_f} shall be adjusted by multiplying it by the factor $(V_{ga}/V_{gl})(n/n_a)$ for open-type compressors and by the factor $(V_{ga}/V_{gl})(f/f_a)$ for hermetic motor compressors.

6.7 Basic equations

6.7.1 The refrigerating capacity as defined in 3.1 for open-type compressors is calculated using the following basic equation :

$$\Phi_0 = q_{m_f} \frac{V_{ga}}{V_{gl}} \frac{n}{n_a} (h_{g1} - h_{f1})$$

For hermetic motor compressors, the correction factor n/n_a is replaced by f/f_a.

6.7.2 The volumetric efficiency η_V as defined in 3.2 is calculated using the following basic equation :

$$\eta_V = \frac{q_{m_f} V_{ga}}{V_{sw}}$$

NOTE — Within the limits specified in this International Standard, it is assumed that the volumetric efficiency is constant.

7 Test methods

7.1 General

As specified in 4.2, all tests shall comprise two test methods. For each test, the information specified in the test report (see clause 20) together with the additional information specified for each test method (see clauses 8 to 15) shall be measured during the test period (see 4.4). Nine different test methods may be used as follows.

NOTE — Test methods A, B, C, G and K measure the total mass flow of the refrigerant by the use of calorimeters.

Method A : secondary fluid calorimeter in suction line (see clause 8).

Method B : flooded system refrigerant calorimeter in suction line (see clause 9).

Method C : dry system refrigerant calorimeter in suction line (see clause 10).

A heat-insulated calorimeter is connected with the suction inlet of the compressor to act as the evaporator.

Method D1 : refrigerant vapour flowmeter in the suction line (see clause 11).

Method D2 : refrigerant vapour flowmeter in the discharge line (see clause 11).

NOTE — Methods D1 and D2 measure the total mass flow of the refrigerant in the gaseous state.

Method F : refrigerant liquid flowmeter (see clause 12).

NOTE — Method F measures the total mass or volume flow of the refrigerant in the liquid state.

Method G : water-cooled condenser method (see clause 13).

The water-cooled condenser in the actual installation is suitably insulated and equipped to act as a calorimeter.

Method J : refrigerant vapour cooling water (see clause 14).

NOTE — Method J measures the flow of a portion only of the liquid refrigerant obtained from a special condenser.

Method K : calorimeter in discharge line (see clause 15).

A heat-insulated calorimeter is installed in the discharge pipeline of the compressor to receive the total flow of refrigerant in the gaseous state.

7.2 Choice of test methods for test X and test Y

Any of the methods A, B, C, D1, D2, F, G and K may be used for test X.

Any of the methods described may be used for test Y with the following exceptions :

a) the method used for test X;

b) any methods measuring the same quantity as test X. For example, if the method for test X measures the gas flow at the discharge side of the compressor, other methods that measure the gas flow at the discharge side of the compressor shall not be used for test Y.

Preferably, the methods for tests X and Y shall be of basically different types. The table gives allowed and recommended combinations of methods for tests X and Y.

Table 1 — Combinations of tests X and Y

Method for test X	Method for test Y	
	Allowed	Recommended
A	D1, D2, F, G, K	F, G, K
B	D1, D2, F, G, K	F, G, K
C	D1, D2, F, G, K	F, G, K
D1	A, B, C, D2, F, G, J, K	F, G, J, K
D2	A, B, C, D1, F, J	F, J
F	A, B, C, D1, D2, J, K	D1, D2, J, K
G	A, B, C, D1, F, J	D1, J
K	A, B, C, D1, F, J	D1, J

8 Method A : Secondary fluid calorimeter

8.1 Description

The secondary fluid calorimeter (see figure 1) consists of a direct expansion coil or a set of coils in parallel serving as a primary evaporator. This evaporator is suspended in the upper part of a pressure-tight heat-insulated vessel. A heater is located in the base of this vessel, which is charged with a volatile secondary fluid so that the heater is well below the liquid surface. The refrigerant flow is controlled by either a manual or a constant-pressure expansion valve, which shall be located close to the calorimeter. The expansion valve and the refrigerant pipelines connecting it to the calorimeter may be insulated to minimize the heat gain.

The calorimeter shall be insulated in such a manner that the heat leakage does not exceed 5 % of the refrigerating capacity of the compressor.

Provision shall be made for measuring the temperature of the secondary fluid.

Provision shall be made in accordance with the requirements of ISO 1662 to ensure that the refrigerant pressure does not exceed the safety limit for the apparatus.

8.2 Calibration

The calorimeter shall be calibrated by using the following heat loss method.

8.2.1 Adjust the heat input to the secondary fluid to maintain a constant pressure at a value corresponding to a temperature of saturation approximately 15 °C above the ambient air temperature. Maintain the ambient air temperature constant to within ± 1 °C.

8.2.2 If the heater is operated continuously, maintain the heat input constant to within ± 1 % and measure the pressure of the secondary fluid at hourly intervals until four successive values of the corresponding temperature of saturation do not vary by more than ± 0,5 °C.

8.2.3 If the heater is operated intermittently, the control shall be such that the temperature of saturation corresponding to the secondary fluid pressure is maintained constant to within ± 0,5 °C and readings of the heat input are taken at hourly intervals until four successive readings do not vary by more than ± 4 %.

8.2.4 Calculate the heat leakage factor using the formula

$$F_l = \frac{\Phi_h}{t_p - t_a}$$

8.3 Procedure

Adjust the suction pressure by means of the refrigerant expansion valve and the temperature of the refrigerant vapour entering the compressor by varying the heat input to the secondary fluid. Adjust the discharge pressure by varying the temperature and flow of the condensing medium, or by a pressure control device in the discharge line.

8.4 Requirements

8.4.1 If the heater is operated continuously, the fluctuation in heat input due to any cause during the test period shall not be such as to cause a variation of more than 1 % in the calculated compressor capacity.

8.4.2 If the heater is operated intermittently, the temperature of saturation corresponding to the secondary fluid pressure shall not vary by more than ± 0,6 °C.

8.5 Additional information

The following information shall be recorded :

a) the pressure of the refrigerant vapour at the evaporator outlet;

b) the temperature of the refrigerant vapour at the evaporator outlet;

c) the pressure of the refrigerant liquid entering the expansion valve;

d) the temperature of the refrigerant liquid entering the expansion valve;

e) the ambient temperature at the calorimeter;

f) the pressure of the secondary fluid;

g) the heat input to the secondary fluid.

8.6 Determination of refrigerating capacity

8.6.1 The mass flow rate of the refrigerant, as determined by this test, is given by the formula

$$q_{m_f} = \frac{\Phi_i + F_l (t_a - t_s)}{h_{g2} - h_{f2}}$$

8.6.2 The refrigerating capacity, adjusted to the specified basic test conditions, is given by the formula

$$\Phi_0 = q_{m_f} \frac{V_{ga}}{V_{gl}} (h_{g1} - h_{f1})$$

9 Method B : Flooded system refrigerant calorimeter

9.1 Description

The flooded system refrigerant calorimeter (see figure 2) consists of a pressure-tight evaporator vessel, or vessels in parallel, in which heat is applied directly to the refrigerant in respect of which the compressor is being tested. The refrigerant flow is controlled by a manual or constant-pressure expansion valve, or a suitable level control device, which shall be located close to the calorimeter. The expansion valve and the refrigerant pipeline connecting it to the calorimeter may be insulated to minimize the heat gain.

The calorimeter shall be insulated in such a manner that the heat leakage does not exceed 5 % of the refrigerating capacity of the compressor.

Provision shall be made for measuring the temperature of the secondary fluid and for ensuring that the pressure does not exceed the safety limit for the apparatus.

Provision shall be made in accordance with the requirements of ISO 1662 to ensure that the refrigerant pressure does not exceed the safety limit for the apparatus.

9.2 Calibration

The calorimeter shall be calibrated by using the following heat loss method.

9.2.1 Fill the calorimeter with refrigerant liquid to its normal operating level and close the liquid and vapour outlet stop valves. Maintain the ambient temperature constant to within ± 1 °C and supply heat to maintain the refrigerant temperature approximately 15 °C above the ambient temperature. Where liquid is used for heating, maintain the inlet temperature constant to within ± 0,3 °C and control the flow so that the temperature drop is not less than 6 °C. Where electric heating is used, maintain the input constant to within ± 1 %.

9.2.2 After thermal equilibrium has been established, take readings for the following periods :

a) for liquid heating, at hourly intervals until four successive readings of both inlet and outlet temperatures, with constant rate flow, do not vary by more than ± 0,3 °C;

b) for electric heating, at hourly intervals until four successive values of the temperature of saturation of the refrigerant do not vary by more than ± 0,5 °C.

9.2.3 Determine the heat input to the calorimeter as follows :

a) for liquid heating,

$$\Phi_{\mathrm{i}} = c\,(t_1 - t_2)\,q_{m_{\mathrm{t}}}$$

b) for electric heating, Φ_{i} is given by the electrical power input to the heater.

9.2.4 Calculate the heat leakage factor from the following formula :

$$F_{\mathrm{l}} = \frac{\Phi_{\mathrm{i}}}{t_{\mathrm{r}} - t_{\mathrm{a}}}$$

9.3 Procedure

Adjust the suction pressure at the compressor by means of the refrigerant expansion valve and the inlet temperature to the compressor by varying the heat input. However, when a level control is used, adjust the suction pressure by means of the heat input to the evaporator, and the inlet temperature to the compressor by the heat input to a superheater. Adjust the discharge pressure by varying the temperature and flow of the condensing medium, or by a pressure control device in the discharge line.

Where liquid is used for heating, the inlet temperature shall be maintained constant to within ± 0,3 °C and the flow shall be controlled so that the temperature drop is not less than 6 °C. The flow rate of the liquid shall be maintained constant to within ± 1 %. Where electric heating is used, the input shall be maintained constant to within ± 1 %.

9.4 Requirements

9.4.1 If the heater is operated continuously, the fluctuation in heat input due to any cause during the test period shall not be such as to cause a variation of more than 1 % in the calculated compressor capacity.

9.4.2 If the heater is operated intermittently, the temperature of saturation corresponding to the secondary fluid pressure shall not vary by more than ± 0,6 °C.

9.5 Additional information

The following information shall be recorded :

a) the pressure of the refrigerant vapour at the evaporator outlet;

b) the temperature of the refrigerant vapour at the evaporator outlet;

c) the pressure of the refrigerant liquid entering the expansion valve;

d) the temperature of the refrigerant liquid entering the expansion valve;

e) the ambient temperature at the calorimeter;

f) the temperature of the heating liquid entering the calorimeter;

g) the temperature of the heating liquid leaving the calorimeter;

h) the mass flow rate of heating liquid circulated;

i) the electrical input to the calorimeter.

9.6 Determination of refrigerating capacity

9.6.1 The mass flow rate of the refrigerant, as determined by this test, is given by the formula

a) for liquid heating,

$$q_{mf} = \frac{c\,(t_1 - t_2)\,q_{ml} + F_l\,(t_a - t_r)}{h_{g2} - h_{f2}}$$

b) for electric heating,

$$q_{mf} = \frac{\Phi_h + F_l\,(t_a - t_r)}{h_{g2} - h_{f2}}$$

9.6.2 The refrigerating capacity, adjusted to the specified basic test conditions, is given by the formula

$$\Phi_0 = q_{mf}\,\frac{V_{ga}}{V_{gl}}\,(h_{g1} - h_{f1})$$

10 Method C : Dry system refrigerant calorimeter

10.1 Description

The dry system refrigerant calorimeter (see figure 3) consists of an arrangement of refrigerant tubes or tubular vessels of suitable length and diameter to accomplish evaporation of the refrigerant circulated by the compressor. The external surface of the evaporator may be heated either by means of a liquid circulating in an outer jacket, which may be a concentric tube, or electrically. Alternatively, a similar means of heating may be used within the evaporator.

The refrigerant flow is controlled by either a manual or a constant-pressure expansion valve, which shall be located close to the calorimeter. The expansion valve and the refrigerant pipeline connecting it to the calorimeter may be insulated in order to minimize the heat gain.

The calorimeter shall be insulated in such a manner that the heat leakage does not exceed 5 % of the refrigerating capacity of the compressor.

If the means of heating is external to the evaporator surface, a sufficient number (not less than ten) of suitably spaced temperature measuring devices shall be provided to determine the mean surface temperature for heat leakage calculations.

Provision shall be made for measuring the temperature of the secondary fluid and for ensuring that the pressure does not exceed the safety limit for the apparatus.

Provision shall be made in accordance with the requirements of ISO 1662 to ensure that the refrigerant pressure does not exceed the safety limit for the apparatus.

10.2 Calibration

The calorimeter shall be calibrated by using the following heat loss method.

10.2.1 Maintain the ambient temperature constant to within ± 1 °C and supply heat to maintain the mean surface temperature approximately 15 °C above the ambient temperature. Where liquid is used for heating, maintain the inlet temperature constant to within ± 0,3 °C and control the flow so that the temperature drop is not less than 6 °C. Where electric heating is used, maintain the input constant to within ± 1 %.

10.2.2 After thermal equilibrium has been established, take readings for the following periods :

a) for liquid heating, at hourly intervals until four successive readings of both inlet and outlet temperatures, with constant rate flow, do not vary by more than ± 0,3 °C;

b) for electric heating, at hourly intervals until four successive values of the temperature of saturation of the refrigerant do not vary by more than ± 0,6 °C.

10.2.3 Determine the heat input to the calorimeter as follows :

a) for liquid heating,

$$\Phi_i = c\,(t_1 - t_2)\,q_{mt}$$

b) for electric heating, Φ_i is given by the electrical power input to the heater.

10.2.4 Calculate the heat leakage factor from the formula

$$F_l = \frac{\Phi_i}{t_c - t_a}$$

10.3 Procedure

Adjust the suction pressure at the compressor by means of the refrigerant control and the inlet temperature to the compressor by varying the heat input. Adjust the discharge pressure by varying the temperature and flow of the condensing medium, or by a pressure control device in the discharge line.

Where liquid is used for heating, the inlet temperature shall be maintained constant to within ± 0,3 °C and the flow controlled so that the temperature fall is not less than 6 °C. The mass of liquid circulated shall be maintained constant to within ± 0,5 %. Where electric heating is used, the input shall be maintained constant to within ± 1 %.

10.4 Requirements

10.4.1 If the heater is operated continuously, the fluctuation in heat input due to any cause during the test period shall not be such as to cause a variation of more than 1 % in the calculated compressor capacity.

10.4.2 If the heater is operated intermittently, the temperature of saturation corresponding to the secondary fluid pressure shall not vary by more than ± 0,6 °C.

10.5 Additional information

The following information shall be recorded :

a) the pressure of the refrigerant vapour at the evaporator outlet;

b) the temperature of the refrigerant vapour at the evaporator outlet;

c) the pressure of the refrigerant liquid entering the expansion valve;

d) the temperature of the refrigerant liquid entering the expansion valve;

e) the ambient temperature at the calorimeter;

f) the temperature of the heating liquid entering the calorimeter;

g) the temperature of the heating liquid leaving the calorimeter;

h) the mass flow rate of heating liquid circulated;

i) the electrical input to the calorimeter;

j) the mean surface temperature of the calorimeter.

10.6 Determination of refrigerating capacity

10.6.1 The mass flow rate of the refrigerant, as determined by the test, is given by the formula

a) for liquid heating,

$$q_{m_f} = \frac{c\,(t_1 - t_2)\,q_{m_l} + F_l\,(t_a - t_c)}{h_{g2} - h_{f2}}$$

b) for electric heating,

$$q_{m_f} = \frac{\Phi_h + F_l\,(t_a - t_c)}{h_{g2} - h_{f2}}$$

10.6.2 The refrigerating capacity, adjusted to the specified basic test conditions, is given by the formula

$$\Phi_0 = q_{m_f} \frac{V_{ga}}{V_{gl}} (h_{g1} - h_{f1})$$

11 Methods D1 and D2 : Refrigerant vapour flowmeter

11.1 Description

The refrigerant vapour flowmeter is placed in the suction line (method D1) or in the discharge line (method D2) (see figure 4).

The necessary sampling points are installed to measure the pressure and temperature to enable calculation to be made of the specific mass of the refrigerant. The test set-up shall be such that the standard deviation of the final result (i.e. the mass flow rate of the refrigerant) does not exceed 2 %.

The refrigerant vapour flowmeter is installed in the suction or delivery pipeline of a closed circuit which consists of the refrigerant compressor, a means for reducing the refrigerant pressure from the discharge level to the suction level, a means of reducing excessive vapour superheat and a means for returning the conditioned vapour to the inlet (suction) of the compressor. The means for reducing the pressure may be either manually operated or controlled by the suction pressure. The means for removing the heat of compression may be provided by tapping sufficient refrigerant vapour from the high-pressure side of the circuit, liquefying it in a condenser and re-evaporating it in a heat exchanger with superheated refrigerant in the low-pressure side of the circuit, to ensure that the resulting superheated vapour is free from entrained droplets of liquid refrigerant.

11.1.1 The refrigerant mass flow rate q_{m_f} is measured at a point in the suction or delivery pipeline of the compressor where the full refrigerant flow takes place, and means shall be provided to ensure that the superheated vapour at this point is homogeneous and completely free from entrained droplets of liquid refrigerant.

Where pulsating flow occurs in the pipeline, sufficient means of damping shall be provided to reduce or eliminate the flow wave to the meter, for example by the insertion of a surge vessel (see figure 4).

11.1.2 As the calculations for the determination of the refrigerating capacity are based on the measurement of pure vapour, even a small quantity of oil present in the vapour would result in an inaccurate value for the gas flow through the meter and, therefore, for the refrigerating capacity of the compressor. The use of the refrigerant vapour flowmeter is therefore limited to circuits where the gas flow being measured contains less than 1,5 % oil. The oil content is the mass of oil per unit mass of liquid refrigerant-oil mixture (kilogram per kilogram).

11.2 Procedure

Adjust the suction pressure at the compressor by means of the refrigerant flow control device and the inlet temperature by varying the cooling effect. Adjust the discharge pressure by varying the temperature and flow of the condensing medium, or by using a pressure control device in the discharge line.

11.3 Additional information

The following information shall be recorded :

a) the temperature of the refrigerant vapour at the upstream side of the metering device;

b) the pressure of the refrigerant vapour at the upstream side of the metering device;

c) the pressure drop between the upstream and downstream side of the metering device.