INTERNATIONAL STANDARD

ISO 9806-2

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Test methods for solar collectors —

Part 2:
Qualification test procedures

Méthodes d'essai des capteurs solaires —

Partie 2: Méthodes d'essai de qualification

Reference number
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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 voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

International Standard ISO 9806-2 was prepared by Technical Committee ISO/TC 180, *Solar energy*, Subcommittee SC 5, *Collectors and other components*.

ISO 9806 consists of the following parts, under the general title *Test methods for solar collectors*:

— *Part 1: Thermal performance of glazed liquid heating collectors including pressure drop*

— *Part 2: Qualification test procedures*

— *Part 3: Thermal performance of unglazed liquid heating collectors (sensible heat transfer only) including pressure drop*

Annexes A and B form an integral part of this part of ISO 9806. Annex C is for information only.

Introduction

It is widely recognized that the durability and reliability of solar collectors and solar collector systems are of great importance when the overall quality of a solar heating system is being assessed.

Collectors are required to resist a number of influences which can be clearly identified and quantified, such as high internal fluid pressures, high temperatures and rain penetration. Tests to establish the extent to which a collector is able to resist these influences are commonly called "qualification tests".

Test methods for solar collectors —

Part 2:
Qualification test procedures

1 Scope

1.1 This part of ISO 9806 establishes test methods for determining the ability of a solar collector to resist the influences of degrading agents.

1.2 This part of ISO 9806 applies to all types of solar collectors, including integral collector storage systems but excepting tracking concentrating collectors.

1.3 This part of ISO 9806 defines procedures for testing collectors under well-defined and repeatable conditions, but does not include pass/fail criteria for the test results.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this part of ISO 9806. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this part of ISO 9806 are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 9060:1990, *Solar energy — Specification and classification of instruments for measuring hemispherical solar and direct solar radiation.*

ISO 9459-1:1993, *Solar heating — Domestic water heating systems — Part 1: Performance rating procedure using indoor test methods.*

ISO 9459-2:1995, *Solar heating — Domestic water heating systems — Part 2: Outdoor test methods for system performance characterization and yearly performance prediction of solar-only systems.*

ISO 9806-1:1994, *Test methods for solar collectors — Part 1: Thermal performance of glazed liquid heating collectors including pressure drop.*

ISO 9806-3:—[1], *Test methods for solar collectors — Part 3: Thermal performance of unglazed liquid heating collectors (sensible heat transfer only) including pressure drop.*

1) To be published.

3 Definitions

For the purposes of this part of ISO 9806, the definitions given in ISO 9806-1 and the following definitions apply.

3.1 collector, evacuated: Collector in which the space between the absorber and the cover is evacuated to a pressure < 3 kPa.

3.2 integral collector storage system: Solar heating system in which the solar collector also functions as a heat (water) storage tank.

3.3 irradiation: Incident energy per unit area of surface, found by the integration of irradiance over a specified time interval.

It is normally expressed in megajoules per square metre.

NOTE 1 The time interval specified is often an hour or a day.

3.4 stagnation conditions (in solar energy systems)**:** Conditions of temperature and pressure existing when the system has attained a quasi-steady state after the flow of the heat transfer fluid has stopped, but the absorber continues to receive significant solar radiation.

3.5 steady-state: Status of a solar collector when the heat removal rate (including losses) is equal to the solar energy input rate.

4 General

The tests in this part of ISO 9806 shall be carried out in the sequence shown in table 1, using three collectors (A, B and C) of any given type.

Tests may be omitted from the sequence upon agreement of all parties involved or at the discretion of the test laboratory. Changes in the test sequence shall be reported with the test results and the reasons for deviation shall be given.

For some qualification tests, a part of the collector may have to be tampered with in some way, for example a hole may have to be drilled in the back of the collector to attach a temperature sensor to the absorber. In these cases care should be taken to ensure that any damage caused does not affect the results of subsequent qualification tests, for example by allowing water to enter into a previously raintight collector.

NOTE 2 This sequence has been determined with a view to minimizing test costs while ensuring that the possible effects of each degrading influence are likely to be evaluated in a later test. (For example, rain penetration may result if a collector is distorted by exposure to high temperatures.)

5 Internal pressure tests for absorbers

5.1 Metallic absorbers for liquid heating collectors

5.1.1 Objective

The absorber is pressure-tested to assess the extent to which it can withstand the pressures which it might meet in service.

5.1.2 Apparatus and procedure

The apparatus, shown in figure 1, consists of a hydraulic pressure source (electrical pump or hand pump), a safety valve, an air-bleed valve and a pressure gauge with an accuracy of 5 % of the actual reading. The air-bleed valve shall be used to empty the absorber of air before pressurization.

The metallic absorber is filled with water at room temperature and pressurized to the test pressure for the test period. This pressure is maintained while the absorber is inspected for swelling, distortion or ruptures.

Table 1 — Test sequence

Sequence	Clause	Test	Collector
1	5	Internal pressure	A
2	6	High-temperature resistance[1)]	A
3	7	Exposure	A, B and C
4	8	External thermal shock[2)]	A
5	9	Internal thermal shock	A
6	10	Rain penetration	A
7	11	Freeze resistance	A
8	5	Internal pressure (retest)	A
9		Thermal performance[3)]	A
10	12	Impact resistance (optional)	A or B
11	13	Final inspection	A, B and C

1) For organic absorbers, the high-temperature resistance test shall be performed first in order to determine the collector stagnation temperature needed for the internal pressure test.

2) The external thermal shock test may be combined with the exposure test.

3) The thermal performance test shall be carried out in accordance with the procedures given in ISO 9806-1 or ISO 9806-3 for glazed or unglazed liquid heating collectors and ISO 9459-1 or ISO 9459-2 for integral collector storage systems.

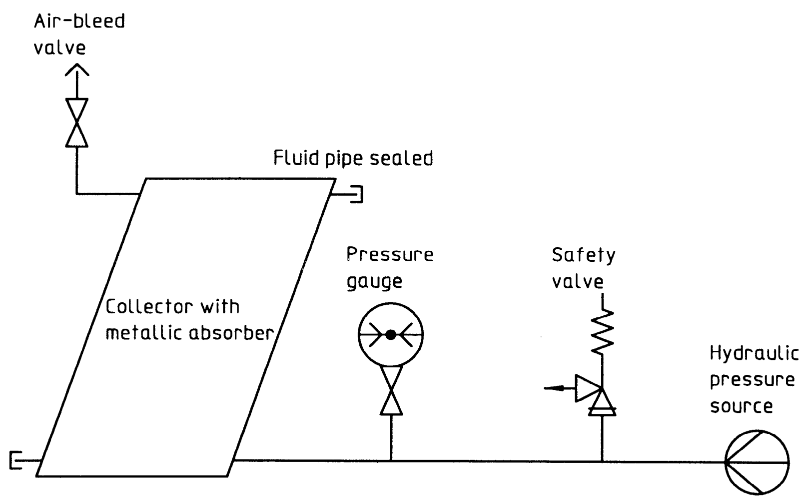

Figure 1 — Schematic for internal pressure test of metallic absorbers for liquid heating collectors

5.1.3 Test conditions

5.1.3.1 Temperature

Metallic absorbers are pressure-tested at ambient temperature within the range 5 °C to 30 °C.

5.1.3.2 Pressure

The test pressure is either the manufacturer's stated maximum test pressure or 1,5 times the maximum collector operating pressure specified by the manufacturer, whichever is lower.

The test pressure is maintained for 10 min.

5.1.4 Results

The collector shall be inspected for leakage, swelling and distortion. The results of this inspection shall be reported together with the values of pressure and temperature used and the duration of the test. If the applied test pressure was less than 1,5 times the maximum collector operating pressure specified by the manufacturer, this shall be reported.

5.2 Liquid heating absorbers made of organic materials (plastics or elastomers)

5.2.1 Objective

The absorber is pressure-tested to assess the extent to which it can withstand the pressures which it might meet in service while operating at elevated temperature. The tests are carried out at elevated temperatures, because the pressure resistance of an organic absorber may be adversely affected as its temperature is increased.

5.2.2 Apparatus and procedure

The apparatus consists of either a hydraulic or a pneumatic pressure source, and a means of heating the absorber to the required test temperature.

The characteristics of a solar irradiance simulator shall be the same as those of the simulator used for steady-state efficiency testing of liquid heating solar collectors (see ISO 9806-1).

The test conditions specified in 5.2.3 shall be maintained for at least 30 min prior to test and for the full duration of the test.

The pressure in the absorber is raised in stages as specified in 5.2.3, and the absorber is inspected for swelling, distortion or rupture after each increase in pressure. The pressure is maintained while the absorber is being inspected.

For safety reasons, the collector shall be encased in a transparent box to protect personnel in the event of explosive failure during this test.

5.2.2.1 Organic absorbers for use in unglazed collectors (test temperature < 90 °C)

Where the maximum test temperature is below 90 °C, absorbers may be submerged in a heated water bath and pressure-tested. The pressurized fluid supply to the absorber shall be fitted with a safety valve, air-bleed valve (if required) and pressure gauge having an accuracy of 5 % of the actual reading. Apparatus is shown in figure 2.

5.2.2.2 Organic absorbers for use with oil-based fluids (test temperature > 90 °C)

When the test temperature exceeds 90 °C, the absorber may be connected to a hot oil circuit. The absorber and hot oil circuit are then pressurized. The hot oil circuit shall be fitted with a safety valve, air-bleed valve and pressure gauge having an accuracy of 5 % of the actual reading.

The absorber may be heated by any of the following methods:

a) connecting a heater in the oil circuit (figure 3);

b) heating the whole collector in a solar irradiance simulator (figure 4);

c) heating the whole collector outdoors under natural solar irradiance (figure 4).

Safety measures should be taken to protect personnel from hot oil in the event of explosive failure during this test.

5.2.2.3 Organic absorbers — high-temperature pneumatic pressure test

The absorber may be pressure-tested using compressed air, when heated by either of the following methods:

a) heating the whole collector in a solar irradiance simulator (figure 5);

b) heating the whole collector outdoors under natural solar irradiance (figure 5).

The compressed air supply to the absorber shall be fitted with a safety valve and a pressure gauge having an accuracy of 5 % of the actual reading.

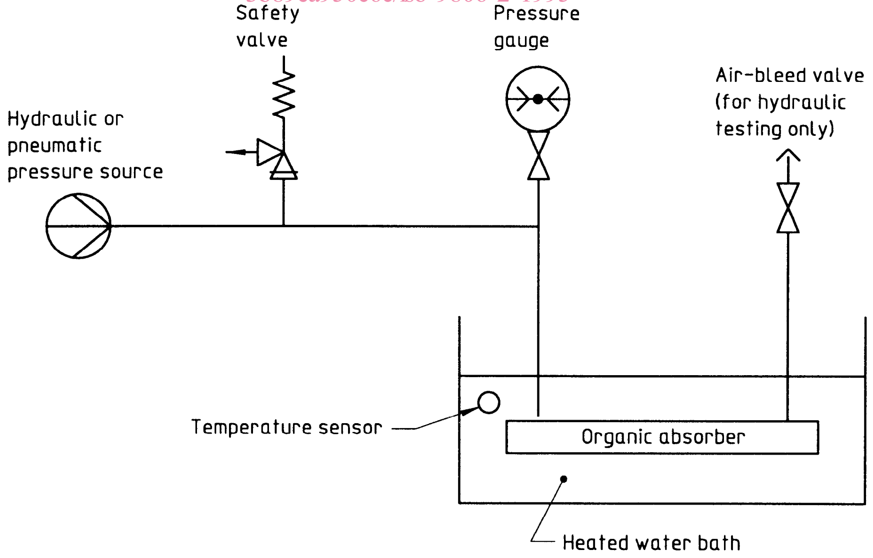

Figure 2 — Schematic for internal pressure test of organic absorbers for use in unglazed collectors

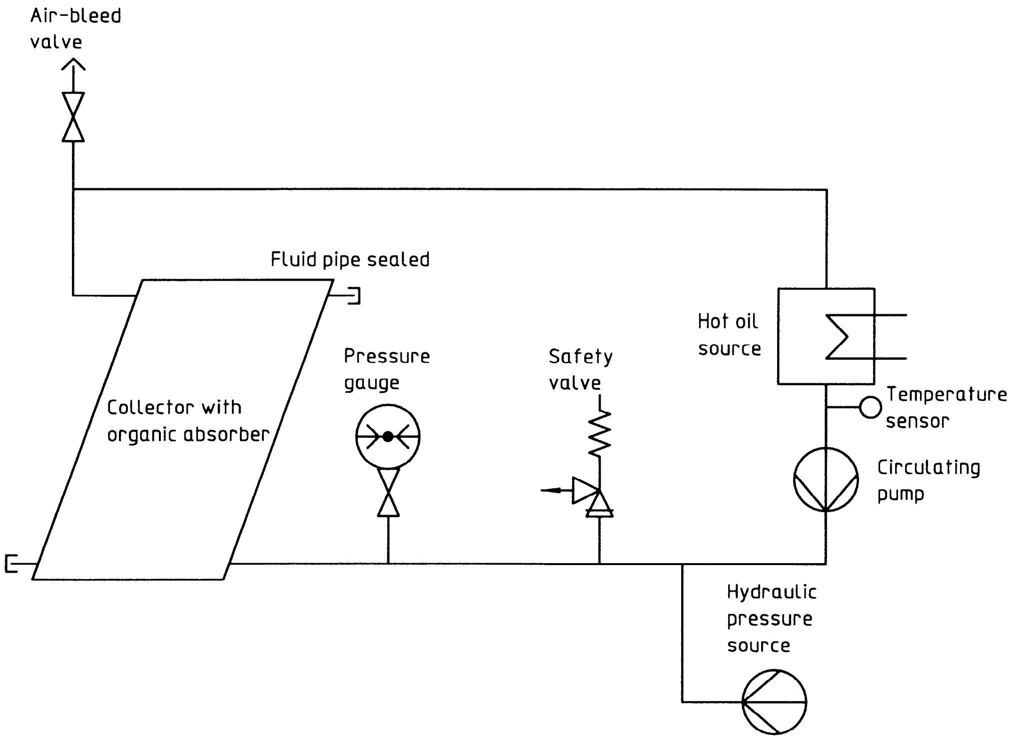

Figure 3 — Schematic for internal pressure test of organic absorbers for use with oil-based fluids (hot oil source)

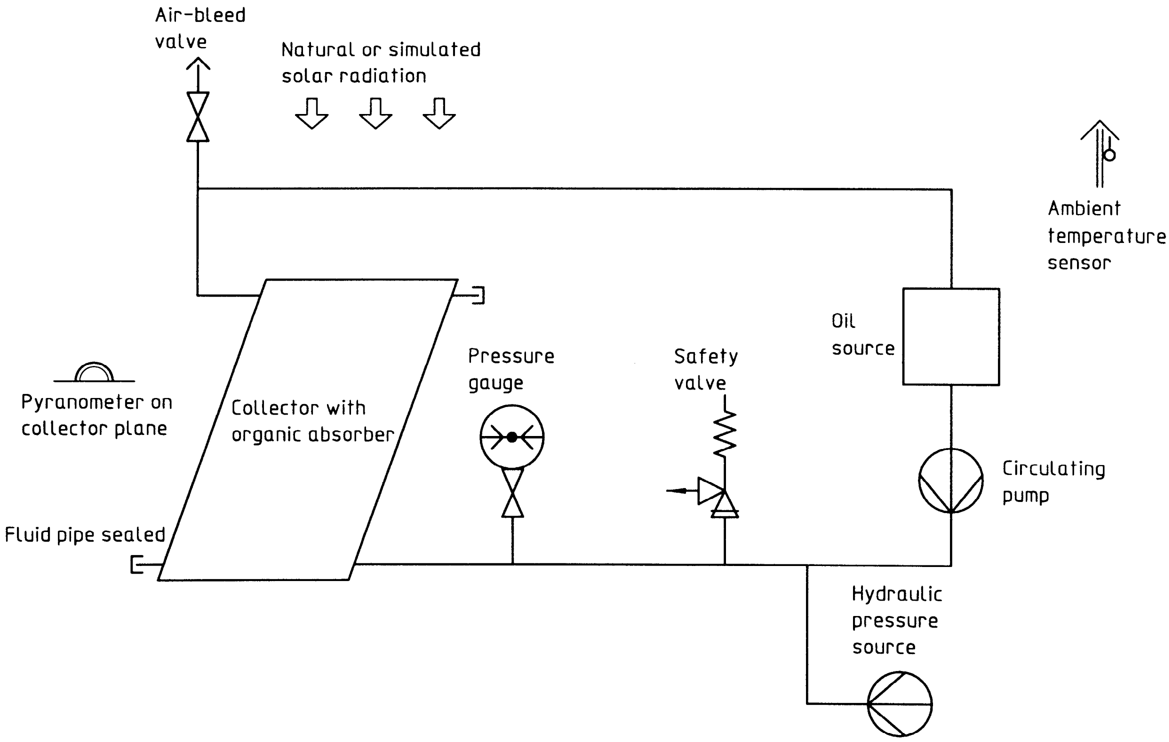

Figure 4 — Schematic for internal pressure test of organic absorbers for use with oil-based fluids (test under solar irradiance)

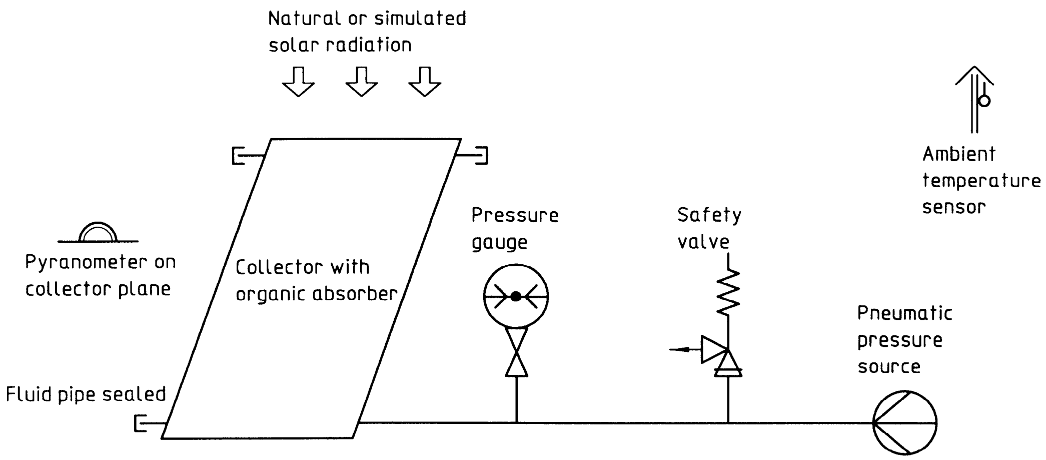

Figure 5 — Schematic for internal pressure test of organic absorbers (pneumatic test under solar irradiance)

5.2.3 Test conditions

5.2.3.1 Temperature

For absorbers made of organic materials, the test temperature is the maximum temperature which the absorber will reach under stagnation conditions.

One of the alternative sets of reference conditions given in table 2 shall be used to determine the test temperature, depending on the climate in which the collector will be used.

The calculations employed to determine the test temperature are included in annex B and shall either:

— use measured collector performance characteristics, or

— extrapolate from average values, measured in the high-temperature resistance test (6.3), of the global solar irradiance (natural or simulated) on the collector plane, the surrounding air temperature and the absorber temperature.

The test temperature for integral collector storage systems shall be 85 °C for class A and class B climate reference conditions and 100 °C for class C.

Table 2 — Climate reference conditions to determine test temperatures for internal pressure test of organic absorbers

Climate parameter	Value for climate class		
	Class A Temperate	**Class B** Sunny	**Class C** Very sunny
Global solar irradiance on collector plane, G (W/m^2)	1 000	1 100	> 1 200
Surrounding air temperature, t_a (°C)	30	40	> 40

5.2.3.2 Pressure

The test pressure shall be 1,5 times the maximum collector operating pressure specified by the manufacturer.

For absorbers made of organic materials, the pressure shall be raised to the test pressure in equal stages of 0,2 bar[2)] (approximately) and maintained at each intermediate pressure for 5 min. The test pressure shall then be maintained for at least 1 h.

5.2.4 Results

The collector shall be inspected for leakage, swelling and distortion. The results of the inspection shall be reported.

Full details of the test procedure used, including the temperature, intermediate pressures and test periods used, shall be reported with the test results.

5.3 Air heating collectors with metallic absorbers

5.3.1 Objective

The collector is pressure-tested to assess the extent to which it can withstand the pressures which it might meet in service, including pressures which may arise when the airflow is blocked on the other side of the collector from the fan.

5.3.2 Apparatus and procedure

The apparatus, shown in figure 6, consists of a controllable air source or suction fan, capable of supplying the specified values of positive or negative pressure at the maximum allowable collector leakage flowrate. An airflow meter having an accuracy of 5 % is installed to measure the rate of leakage, and a pressure gauge having an accuracy of 5 % of the actual reading is installed to measure the pressure in the absorber.

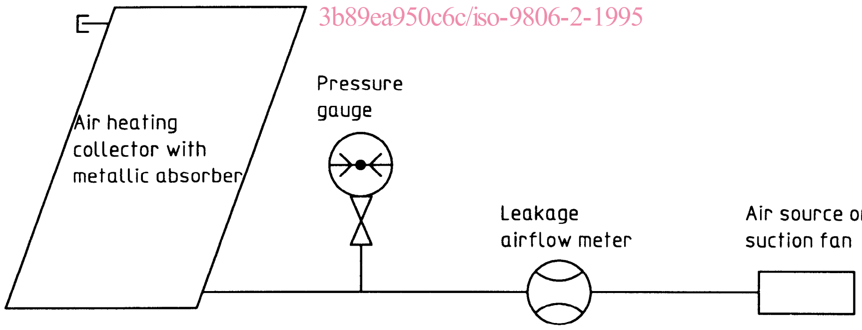

Figure 6 — Schematic for internal pressure test of air heating collectors with metallic absorbers

The air source or suction fan, airflow meter and pressure gauge are connected to the collector, and other pipe connections to the collector are sealed.

The collector is brought to the test pressure with air at ambient temperature, for the specified test period.

The collector is maintained at the test pressure while it is inspected for swelling, distortion or ruptures.

For safety reasons, the collector shall be encased in a transparent box to protect personnel in the event of explosive failure during this test.

2) 1 bar = 100 kPa.

5.3.3 Test conditions

5.3.3.1 Temperature

Air heating collectors with metallic absorbers are pressure-tested at ambient temperature.

5.3.3.2 Pressure

The test pressure is 1,2 times the maximum collector operating pressure difference above or below atmospheric pressure, as specified by the manufacturer.

The test pressure is maintained for 10 min.

5.3.4 Results

The collector shall be inspected for swelling, distortion or ruptures. The results of the inspection shall be reported together with the rate of air leakage, and the values of pressure and temperature and the test period used for the test.

5.4 Air heating absorbers made of organic materials (plastics or elastomers)

5.4.1 Objective

The collector is pressure-tested to assess the extent to which it can withstand the pressures which it might meet in service, including pressures which may arise when the airflow is blocked on the other side of the collector from the fan. Because the pressure resistance of collectors with absorbers made of organic materials is expected to be significantly reduced at higher temperatures, a pressure test at an elevated temperature shall be used.

5.4.2 Apparatus and procedure

The apparatus (see figure 7) consists of a controllable air source or suction fan, capable of supplying the specified values of positive or negative pressure at the required temperature, and at the maximum allowable collector leakage flowrate. A flowmeter having an accuracy of 5 % to measure the leakage and a pressure gauge having an accuracy of 5 % of the readings taken during the test are also required.

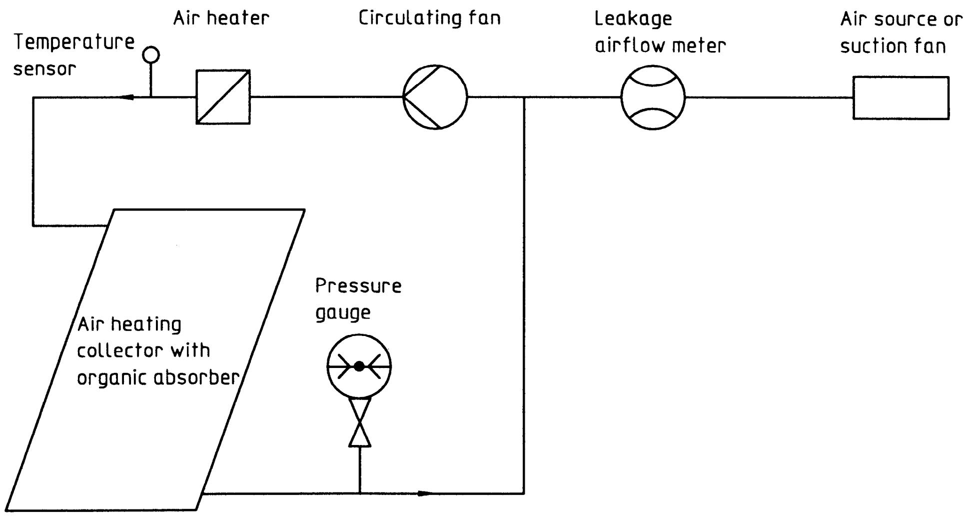

Figure 7 — Schematic for internal pressure test of air heating collectors with organic absorbers

The collector is connected to an air-heating loop in such a way that air flows downwards into the collector. The pressure gauge is connected to the collector either in a separate opening of the collector or in the heating loop close to the outlet of the collector. While circulating air through the collector, the air is heated to the test temperature and maintained there for the test period. The collector and the heating loop are pressurized or depressurized in stages to the test pressure, which is then maintained for the test period.

After the test period, the temperature and pressure are maintained while the collector is inspected for swelling, distortion or ruptures. The collector is also inspected for swelling, distortion or ruptures after each rise in pressure.

For safety reasons, the collector shall be encased in a transparent box to protect personnel in the event of explosive failure during this test.

5.4.3 Test conditions

5.4.3.1 Temperature

For absorbers made of organic materials, the test temperature is the maximum temperature which the absorber will reach under stagnation conditions.

One of the alternative sets of reference conditions given in table 2 shall be used to determine the test temperature, depending on the climate in which the collector will be used.

The test temperature shall be determined from measurements made during the high-temperature resistance test specified in clause 6, using the expression included in annex B.

5.4.3.2 Pressure

The test pressure shall be 1,2 times the maximum collector operating pressure difference above or below atmospheric pressure, as specified by the manufacturer.

For absorbers made of organic materials, the pressure shall be raised to the test pressure in equal stages of 0,2 bar (approximately) and maintained at each intermediate pressure for 5 min. The test pressure shall then be maintained for at least 1 h.

5.4.4 Results

The collector shall be inspected for leakage, swelling and distortion. The results of the inspection shall be reported. Full details of the test procedure used, including the temperature, intermediate pressures and test periods selected, shall be reported with the test results.

6 High-temperature resistance test

6.1 Objective

This test is intended to assess rapidly whether a collector can withstand high irradiance levels without failures such as glass breakage, collapse of plastic cover, melting of plastic absorber, or significant deposits on the collector cover from outgassing of collector material.

6.2 Apparatus and procedure

The collector shall be tested outdoors, or in a solar irradiance simulator, or in a hot fluid loop of the type described in 5.2.2.2. A schematic for testing outdoors or in a simulator is shown in figure 8.

The characteristics of the solar irradiance simulator to be used for the high-temperature resistance test shall be those of the solar irradiance simulator used for steady-state efficiency testing of liquid heating solar collectors in accordance with ISO 9806-1.

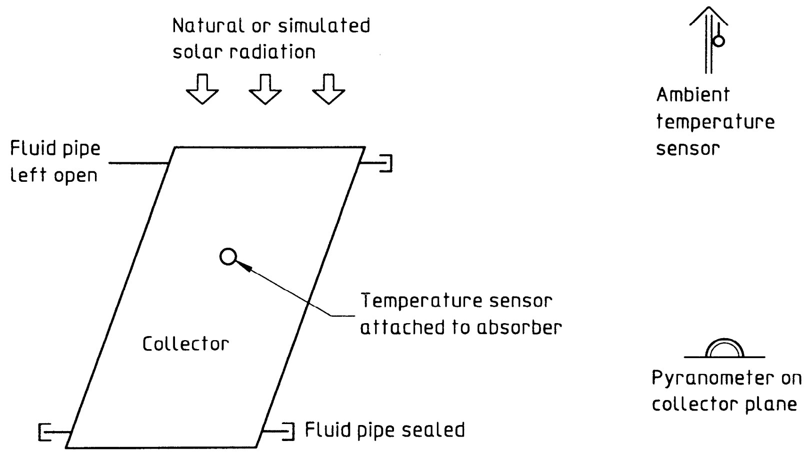

Figure 8 — Schematic for high-temperature resistance test (outdoors or in simulator)

If a hot fluid loop is used, the hot fluid shall be circulated from the bottom to the top of the collector with a constant inlet temperature, using a flowrate similar to that defined for collector efficiency testing (see ISO 9806-1).

NOTE 3 It is recognized that the thermal stresses induced by the hot fluid loop test may not be equivalent to the thermal stresses induced by heating externally using natural or simulated solar irradiance.

The collector is mounted outdoors or in a solar simulator, and it is not filled with fluid. All of its fluid pipes are sealed to prevent cooling by natural circulation of air except one, which is left open to permit free expansion of air in the absorber.

A temperature sensor is attached to the absorber to monitor its temperature during the test. The sensor shall be positioned at two-thirds of the absorber height and half the absorber width. It shall be fixed firmly in a position to ensure good thermal contact with the absorber. The sensor shall be shielded from solar radiation.

NOTES

4 When testing collectors, such as evacuated tubular collectors, for which it is not appropriate to measure the stagnation temperature at the absorber, the temperature sensor should be placed at a suitable location in the collector, and this location should be clearly described with the test results.

5 In some cases, such as evacuated absorbers, it may be difficult to attach a thermocouple to the absorber. In such cases, instead of attaching a thermocouple to the absorber, the testing laboratory may partially fill the absorber with a special fluid, seal the absorber and measure the pressure in the absorber. The relationship between the internal pressure in the absorber and its temperature should be known from the standard vapour pressure/temperature relationship for the fluid.

The test is performed for a minimum of 1 h after steady-state conditions have been established, and the collector is subsequently inspected for signs of damage as specified in 6.5.