International Standard 6944

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Fire resistance tests — Ventilation ducts

Essais de résistance au feu — Conduits de ventilation

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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.

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 6944 was prepared by Technical Committee ISO/TC 92, *Fire tests on building materials, components and structures*.

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.

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Fire resistance tests — Ventilation ducts

0 Introduction

This International Standard has been prepared because a fire resistance test for ventilation ducts has become necessary in order to permit evaluation of ducts designed to prevent fire spread across fire barriers in the absence of fire dampers. It should be read in conjunction with ISO 834.

The annex provides explanatory notes which give important background information, but it does not constitute a mandatory part of this International Standard.

SAFETY WARNING — So that suitable precautions may be taken to safeguard health, the attention of all concerned in fire tests is drawn to the possibility that toxic or harmful gases may be evolved during the combustion of test specimens.

1 Scope and field of application

1.1 This International Standard specifies a method of test and criteria for the determination of the fire resistance of vertical and horizontal ventilation ducts under standardized fire conditions.

1.2 The general purpose of this test is to measure the ability of a representative duct or duct assembly to resist the spread of fire from one fire compartment to another without the aid of fire dampers.

1.3 It is applicable to vertical and horizontal ducts, with or without branches, taking into account joints, air supply and exhaust openings, as well as suspension devices, etc.

1.4 This International Standard is not applicable to:

a) ducts above fire-resisting suspended ceilings (horizontal membranes) in those cases where the ducts rely for their fire resistance on the performance of the ceiling;

NOTE — Other tests are necessary for these ducts.

b) ducts containing fire dampers at points where they pass through fire separations.

NOTE — In order to assess the fire resistance of fire dampers, other tests are required. A method of test for fire dampers is under consideration as a subject for a future International Standard.

1.5 This International Standard is not appropriate for the following ducts unless the further criteria described in the annex are established to the satisfaction of the appropriate authority:

a) ducts of materials which are extremely sensitive to thermal shock;

NOTE — Thermal shock may affect such ducts in a way that would differ from the effect in this test, but the test may still be used where it can be established that sensitivity to thermal shock is within acceptable limits.

b) smoke outlet ducts;

NOTE — These ducts need to retain their integrity and cross-sectional area under fire conditions. Consequently criteria for acceptance additional to those given in this International Standard are required. This International Standard is only applicable, therefore, to smoke outlet ducts if the criteria for integrity failure of a representative smoke outlet duct within the furnace and the loss of retention of cross-sectional area of such ducts are agreed between all parties concerned and are investigated and reported (see the annex).

c) ducts lined on the inside with combustible material or which in practice may accumulate combustible deposits on their inside face (such as kitchen extract ducts).

NOTE — Additional criteria regarding the insulation performance of the duct are required in this case (see the annex).

1.6 This International Standard does not take into consideration the effect of impact shock loading on ducts due to the collapse of supporting or adjacent structural members or other components, or of impact- or thermal shock loading resulting from the application of a water (hose) stream.

NOTE — The method described in this International Standard should be used solely to measure and describe the properties of ducts and their supports in response to heat and flame under controlled laboratory conditions and should not by itself be considered or used for the description, appraisal or regulation of the fire hazard of such ducts or supports under actual fire conditions.

2 Reference

ISO 834, *Fire-resistance tests — Elements of building construction.*

3 Principle

3.1 The test consists of measurement of the length of time for which test specimens, of specified dimensions, satisfy specified criteria under prescribed conditions during the period of exposure to fire.

3.2 If a rigid restraint is not provided (see 7.2.9), measurements shall be made of any elongation or shortening of the duct which occurs during the test, in order to provide an indication of allowances for elongation or shortening which are to be made in the design of the duct system in practice.

3.3 The following measurements are optional and are not to be considered an integral part of this test method.

a) gas leakage rates, to provide an indication of the potential smoke leakage through the duct;

b) the release of smoke from the unexposed face, to provide an indication of smoke generated by duct covering and lining materials;

c) restraint forces at the penetration point in the furnace wall opposing horizontal expansion of the ducts, to provide an indication of potential structural failure of lightweight partitions through which the ducts may pass; however, if the duct specimen at the penetration point is fire-stopped with mineral wool or other flexible fire-stopping, there will not be any full restraint at this point (see 7.2.9 and the annex), and if the duct is restrained outside the furnace (see 7.2.9), it will not be appropriate to measure restraint forces at the penetration point.

3.4 The test takes into account the effect of fire exposure from the outside as well as the effect of fire entering the ducts in conditions where forced air movement may or may not be present.

3.5 The test specimens incorporate the usual joints and exhaust openings and are suspended as they would be in practice. The specimens are supplied with air in a manner which is indicative of the "fan off" and "fan on" situations which could arise in practice.

As the load-bearing capacity of suspension or fixing devices is often critical in a fire, additional separate evaluation of these devices is required. This evaluation may be carried out in a separate furnace. For the suspension and fixing devices, the evaluation procedure may be separated into parts, such as tests for the device for fastening to the floor, ceiling or wall, tests for the device for fastening to the duct and tests for the hangers. After having chosen the correct fastening device and hanger, the complete assembly can be evaluated.

3.6 If specified by the sponsor, part of the test may be omitted if the duct concerned is not required, in practice, to meet all the conditions envisaged by the test; for example a duct designed for use only in the vertical position need not be tested in the horizontal position. Any such deviations from the full test procedure shall be clearly described in the test report.

4 Apparatus

The main items of apparatus are as follows:

4.1 Furnace, capable of subjecting a ventilation duct to the standard heating and pressure conditions specified in clause 5, suitable for testing ducts in the vertical (see figure 1) or horizontal (see figure 2) position.

4.2 Device, if applicable (see 3.3), fixed to the furnace wall, for measuring the forces which restrain thermal elongation in horizontal ducts. A test arrangement for this purpose is shown in figure 3. Details are described in the annex.

4.3 Thermocouples, for measuring the internal temperature of the furnace and internal and external temperatures of the test specimens in conformity with the requirements given in 5.1.2, 5.1.3 and 5.1.4 and, if necessary, a movable thermocouple (see 8.3.1.2).

4.4 Equipment for measuring gas pressures in the furnace and in the ducts.

4.5 Fan, for extracting gas from ducts B in figures 1 and 2 with a suction capacity of at least $2 \times V_n$ (required capacity: $V_n = 3\ m/s \times 1\ m \times 0{,}25\ m = 0{,}75\ m^3/s$), i.e. sufficient to produce an air velocity in the ducts of at least 3 m/s, measured at ambient temperature before the test.

The characteristic curve of the fan shall be horizontal for the actual air flow. The capacity of the fan shall not change by more than 10 % in the event of a drop in pressure of up to 50 Pa.

NOTE — The regulation of the gas flow can be arranged by a flow rate controller, installed just before the fan. This provides a sufficient gas flow even when deformations of the duct reducing its cross-sectional area by not more than 25 % occur. The case where the duct collapses in such a way that its cross-sectional area is reduced by more than 25 % can be disregarded in determining the fan capacity because, before this happens, a stability failure or an integrity failure at the fire-stopping would have already occurred.

For horizontal ducts, a second fan is required to produce and maintain an underpressure of 300 Pa in duct A (see figure 2).

5 Test conditions

5.1 Fire exposure

5.1.1 Temperature rise

The temperature rise shall be controlled in accordance with ISO 834, subclause 4.1.1.

5.1.2 Measurement of furnace temperature

The furnace temperature shall be measured in accordance with ISO 834, subclause 4.1.2.

The positions of the thermocouples shall be as shown in figures 4 and 5.

5.1.3 Tolerances

Tolerances shall be assessed in accordance with ISO 834, subclause 4.1.3.

5.1.4 Measurement of temperature of test specimens

The temperature of the test specimens shall be measured in accordance with ISO 834, subclause 4.1.4.

The positions of the thermocouples shall be as shown in figures 6 and 7.[1)] Thermocouples for estimating average temperature shall be placed in such a way as to give information representative of the normal heat transfer through the walls of the ducts.

5.1.5 Measurement of temperatures of flue gases

The gas temperatures inside the ducts shall be measured at the locations shown in figures 6 and 7. The hot junctions of the thermocouples shall be placed centrally in the ducts and at the centre of the top edge of the opening in the vertical duct A (see figure 6). Further details are given in ISO 834, subclause 4.1.2.3.

5.2 Pressure conditions

The furnace pressure shall be maintained according to ISO 834, subclause 4.2.

The neutral plane shall be below the horizontal specimen. The pressure inside horizontal duct A (see figure 2) shall be 300 ± 10 Pa below the ambient (laboratory) pressure at the beginning of the test, and during the test the fan setting shall not be altered. The underpressure shall be continuously recorded to provide a measure of air leakage.

5.3 Air velocity

The air velocity in duct B (see figures 1 and 2) shall be 3 m/s measured at ambient temperature at the start of the test and thereafter the fan velocity shall not be readjusted. The measuring point shall be located inside the tube connecting the test specimen to the fan. The measurements shall then be corrected by the ratio of the cross-sectional areas.

6 Preparation of test specimens

6.1 Dimensions

6.1.1 The test specimens shall normally be full size.

6.1.2 If compliance with the requirements of 6.1.1 is not possible, the following shall be the minimum dimensions of the parts of test specimen exposed:

a) in the furnace (see figures 1 and 2 and clause A.5):

1) horizontal ducts:	length 3,0 m,
2) vertical ducts:	length 2,0 m;

b) outside the furnace:

1) horizontal ducts:	length 2,5 m,
2) vertical ducts:	length 2,0 m.

6.1.3 If applicable, specimens having a ratio of shortest side to longest side of 1/4 shall be tested. The longest side shall be 1 m or as near to 1 m as the dimensions of the furnace allow (see the annex).

6.2 Conditioning

Test specimens containing hygroscopic materials, or other materials which can be affected by moisture, shall be conditioned to equilibrium with the prevailing conditions in the laboratory, which shall be within the following limits:

— temperature (dry bulb): 25 ± 15 °C;

— relative humidity: 40 to 65 %.

7 Test arrangements

7.1 Details of test specimens

The test shall be made on a test specimen representative of the complete duct assembly, including integral or intended insulation, on which information is required. Each type of duct requires a different approach and an attempt shall be made to reproduce the boundary conditions and the method of fixing or support inside and outside the furnace representative of that used in practice.

The fire-stopping shall be as used in practice following established manuals of good practice for field installation, and shall be specified by the manufacturer. If the width of the gap for fire-stopping around the duct at the furnace penetration point is not specified, a width of 20 mm shall be used.

The furnace wall which is penetrated by duct B (see figure 2) shall, for a distance all round the duct of at least 300 mm, be constructed of lightweight concrete blocks not more than 100 mm thick or shall have a similar lightweight construction having a level of fire resistance appropriate to the duct being tested.

7.2 Duct arrangement

7.2.1 A single duct may be tested in the furnace, or alternatively, two or more ducts may be tested in the same furnace, provided that there is sufficient space to do so, in accordance with the dimensions shown in figures 1 and 2.

1) Additional bare wire thermocouples may be placed on supports or in other positions on the ducts to obtain additional data for use in assessments.

7.2.2 Ducts shall be arranged as in practice (see figures 1 and 2). Both horizontal ducts shall abut against the furnace wall at one end and shall penetrate the furnace wall at the other. Both the end of the horizontal duct A (see figure 2) within the furnace and the end of the branch duct attached thereto shall be closed independently of any furnace enclosure by materials and construction similar to the remainder of the duct.

7.2.3 Vertical ducts (see figure 1) shall be tested standing on the furnace floor and penetrating the furnace roof slab; the ducts shall be fixed at the furnace roof level as they would be fixed in practice when penetrating a floor.

7.2.4 For horizontal ducts, the test arrangement shall include at least two joints inside the furnace and at least one joint outside it. One joint shall be at the centre of the span between the supports both inside and outside the furnace, if this is possible in practice.

7.2.5 For vertical ducts, the test arrangement shall include at least one joint inside and one joint outside the furnace (see figure 1).

7.2.6 The openings of all ducts shall have an area which is at least half the cross-sectional area of the ducts. Such openings shall be in the positions shown in figures 1 and 2.

7.2.7 The horizontal duct A (see figure 2) shall include one sharp bend of the same cross-sectional area as the main duct and a T-piece to form a short branch duct. All specimens including this branch shall be mounted with the suspension or fixing devices as would be provided in practice.

7.2.8 There shall be a clearance of 500 ± 50 mm between the top of the horizontal duct and the ceiling, and also at least 500 mm between the underside of the horizontal duct and the floor. Similarly, there shall be a clearance of at least 500 mm between the sides of ducts and the furnace walls, except in the case of assemblies of ducts as shown in figures 1 and 2.

7.2.9 When, in practice, horizontal ducts and/or the applied fire protective insulation outside the fire compartment is likely to be subject to rigid restraint against elongation forces, either from building works (walls, etc.) against which the duct abuts, or where the rest of the duct assembly outside the fire compartment could afford such rigid restraint (such as may be afforded by ducts with short, rigid supports), full restraint shall be produced in the specimen at points 2 000 ± 50 mm from and outside the furnace enclosure.

Such restraint shall be full in the direction of the duct, so as to resist all expansion forces in this direction, but there shall be no restraint (at ambient temperature) to movement in the vertical direction.

In these cases, the measurement of restraint forces and elongations are not applicable. In other cases, the parts of specimens outside the furnace shall be unrestrained.

7.3 Materials and workmanship

The materials and standard of workmanship of the test specimens shall be representative of good practice, as defined by national codes and standards.

8 Procedure

8.1 Test conditions

Parts of ducts within the furnace shall normally be exposed to fire from all sides over their whole length. Ducts shall only be exposed on less than four sides if this is likely to occur in practice. Tests can be performed on assemblies of ducts (see figure 1). Alternatively, tests can be performed with a duct positioned close to a wall or floor if it is desired to represent this condition in practice.

8.2 Control of conditions to permit assessment of integrity

Twenty minutes after the start of the test, stop the fan in duct B (see figures 1 and 2) and, where it is intended to evaluate the "fire outside duct" situation with the duct only in the horizontal position (see 3.6), stop the fan in horizontal duct A (see figure 2) for about 5 min to enable an assessment of integrity of the duct assembly outside the furnace to be carried out under stable conditions in the "fan off" situation. Then start the fan in duct B and, where applicable, in horizontal duct A, and stop it for a 5 min period 10 min before the completion of every 30 min period of the test. Make assessments of integrity in the "fan on" situation at all other times.

8.3 Test measurements and observations

8.3.1 Assessment of fire resistance

Make the following measurements and observations to enable the criteria of stability, insulation and integrity (see clause 1) to be assessed.

8.3.1.1 Stability

Record the time when the suspension or fixing devices can no longer retain a duct in its intended position or when sections of the duct collapse.

8.3.1.2 Insulation (temperature of unexposed face)

Measure the average and maximum temperatures of the unexposed faces of the test specimens as specified in 5.1.4 and ISO 834, subclause 6.2.2.1, using a movable thermocouple to locate points of high temperature.

8.3.1.3 Integrity

a) Record any cracks and openings which indicate loss of integrity.

b) Determine the time at which the passage of flames or of hot gases outside the furnace occurs according to ISO 834,

subclause 6.2.3.1, the cotton pad being applied to the openings outside the duct, if provided, and to any crack or hole which develops.

c) Measure and record the temperature of the gases issuing from openings in the ducts outside the furnace and at penetration points inside the ducts. (See figures 6 and 7; thermocouples 1 and 2 are used.)

8.3.2 Restraint forces and thermal elongation or shortening

If applicable, measure and record the restraint force in duct B (see figure 2) at the penetration point [see 3.3 c)].

Measure and record the thermal elongation or shortening of ducts A (see figures 1 and 2) at the penetration point, where no rigid restraint is provided in accordance with 7.2.9.

8.3.3 Additional observations

Throughout the test, make observations of all changes and occurrences which do not affect the performance criteria but which could create hazards in a building, including, for example:

a) deflections;

b) the emissions of smoke or noxious fumes from the unexposed face of a duct, for example attributable to its coverings and/or lining;

c) a decrease in cross-sectional area of the ducts (in order to provide information on the ability of the ducts to serve as smoke extraction ducts).

8.4 Duration of the test

8.4.1 Normally, the test specimen shall be heated in the prescribed manner until failure occurs under any one of the relevant performance criteria, namely

a) stability (see 9.2.1);

b) insulation (see 9.2.2);

c) integrity (see 9.2.3).

8.4.2 In tests other than those on test specimens judged only by the criterion of stability (see 9.2.1), testing may be continued after failure under either of the other two criteria (see 9.2.2 and 9.2.3) by prior agreement between the sponsor of the test and the testing authority, until failure occurs under the other criterion, provided that collapse of the specimen has not already occurred.

8.4.3 Alternatively, the test may be concluded after a period determined by prior agreement between the sponsor and the testing authority, even if no failure under any of the criteria has occurred at the end of that period.

8.4.4 The length of time from the commencement of heating for which the test specimen complies with the relevant requirement(s) shall be expressed in minutes.

8.5 Calibration

The instrumentation used for measuring temperature, pressure, air velocity and force shall be calibrated, using established reference standards, and instrument readings shall be corrected as appropriate. Any measurement uncertainty shall be reported.

9 Performance criteria for expression of fire resistance

9.1 General

The fire resistance of test specimens shall be the duration, in minutes, of heating in accordance with 5.1.1 until failure occurs according to one or more of the performance criteria, i.e. stability, insulation, integrity, or until the test is terminated, whichever is the shortest time.

In expressing the test result, the words "stability", "insulation" and "integrity" shall be followed by the time expressed in minutes, denoting the period of successful compliance under each of these headings.

9.2 Performance criteria

9.2.1 Stability

Stability failure shall be deemed to have occurred in duct A within the furnace and in ducts A and B outside the furnace when the duct collapses in such a manner that the duct no longer fulfils its intended function.

9.2.2 Insulation

Insulation failure shall be deemed to have occurred when the temperature rise above initial ambient temperature in the laboratory on the unexposed surface of the test specimen outside the furnace exceeds either

a) 140 °C as an average value (see 5.1.4); or

b) 180 °C as a maximum value read by any surface thermocouple.

NOTE — See also the annex, clause A.1 d) in respect of insulation failure of ducts A in figures 1 and 2 within the furnace where such ducts contain combustible materials, clause A.7.1, regarding the need for care in siting openings into ducts close to fire separation walls.

9.2.3 Integrity

The presence and formation in the test specimen of cracks, holes or other openings outside the furnace through which flames or hot gases can pass shall constitute integrity failure.

Integrity failure shall also be deemed to have occurred when the cotton pad referred to in ISO 834, subclause 6.2.3.1, is ignited

or when sustained flaming, of duration at least 10 s, appears on the unexposed face of the test specimen outside the furnace.

9.3 Precision and accuracy

No quantitative data for precision and accuracy are available at present.

10 Test report

The test report shall include the following information:

a) name of testing laboratory;

b) name of sponsor;

c) date of test;

d) name of manufacturer and the trade name (if any) of the product;

e) details of construction and conditioning of the test specimens, including detailed information on the relevant physical and mechanical properties of the materials used, together with drawings illustrating the essential features and including the number of sides of the test specimens exposed to fire in the furnace (see 8.1);

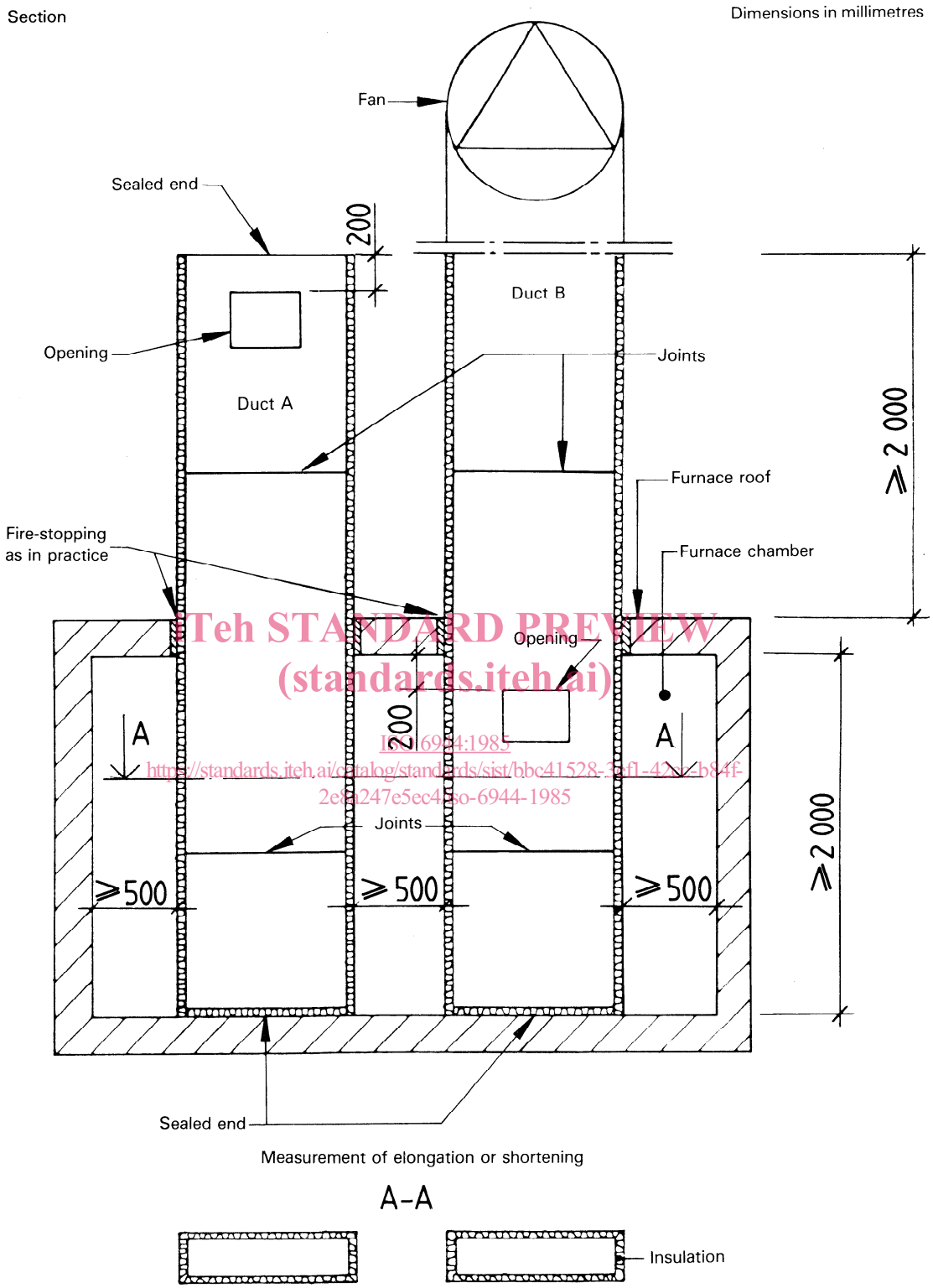
f) whether the duct was considered restrained or unrestrained, including methods of fixing, support and mounting, as appropriate for the type of specimen, and a description of the method and materials used to seal the opening between the duct and cut-out provided in the wall to accommodate the duct;

g) the force (if measured) due to restraint at the furnace penetration point as a function of time, presented as a graph;

h) the thermal elongation or shortening (if measured) of ducts A in figures 1 and 2 (see 8.3.2);

j) other observations made during the test according to 8.3, including a complete record of measured temperatures as a function of time;

k) test results as required by clause 9. Where the test is terminated before the occurrence of failure under the relevant criteria, this shall be reported.



Alternative arrangement for assemblies of ducts

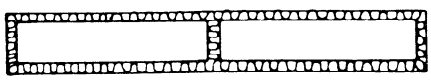


Figure 1 — Test arrangement for vertical ducts