International Standard

ISO 6944-1

Second edition
2024-06

Fire containment — Elements of building construction —

Part 1: Ventilation ducts

Endiguement du feu — Éléments de construction —

Partie 1: Conduits de ventilation

Reference number
ISO 6944-1:2024(en)

ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Email: copyright@iso.org
Website: www.iso.org

Published in Switzerland

Contents

Page

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.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO document should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

ISO draws attention to the possibility that the implementation of this document may involve the use of (a) patent(s). ISO takes no position concerning the evidence, validity or applicability of any claimed patent rights in respect thereof. As of the date of publication of this document, ISO had not received notice of (a) patent(s) which may be required to implement this document. However, implementers are cautioned that this may not represent the latest information, which may be obtained from the patent database available at www.iso.org/patents. ISO shall not be held responsible for identifying any or all such patent rights.

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 92, *Fire safety*, Subcommittee SC 2, *Fire Resistance*.

This second edition cancels and replaces the first edition (ISO 6944-1:2008), of which it constitutes a minor revision. It also incorporates the Amendment ISO 6944-1:2008/Amd. 1:2015.

The changes are as follows:

— references to ISO 5221:1984 (withdrawn) have been replaced with references to ISO 5167-2:2022 and ISO 5167-3:2022;

— key element 2 in Figure 2 and key elements 18, 19 and 20 to Figure 4 have been revised.

A list of all parts in the ISO 6944 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

The purpose of this test is to measure the ability of a representative duct or duct assembly that is part of an air-distribution system to resist the spread of fire from one fire compartment to another, with fire attack from inside or outside the duct. It is applicable to vertical and horizontal ducts, with or without branches, taking into account joints and exhaust openings, as well as suspension devices and penetration points.

This document is very similar to EN 1366-1, but includes an alternative arrangement for testing elbows.

The test measures the length of time during which ducts of specified dimensions, suspended as they normally are in practice, satisfy defined criteria when exposed to fire from either inside or outside the duct.

All ducts inside the furnace are fully restrained in all directions. Outside the furnace, ducts exposed to fire from the outside are tested unrestrained, while ducts exposed to fire from the inside (horizontal only) are tested restrained.

The test takes into account the effect of fire exposure from the outside, where a 300 Pa underpressure is maintained in the duct, as well as the effect of fire entering the ducts under conditions where forced air movement is potentially (but not necessarily) present, by maintaining an air velocity of 3 m/s.

Ducts exposed to fire from the inside are supplied with air in a manner that is representative of the “fan off” and “fan on” situations that can arise in practice.

Fire containment — Elements of building construction —

Part 1: Ventilation ducts

CAUTION — The attention of all persons concerned with managing and carrying out this fire resistance test is drawn to the fact that fire testing can be hazardous and that there is the possibility that toxic and/or harmful smoke and gases can be evolved during the test. Mechanical and operational hazards can also arise during the construction of the test elements or structures, their testing and the disposal of test residues.

The duct assembly should be allowed to cool completely after the fire test, before dismantling, to minimize the possibility of ignition of combustible residues.

An assessment of all potential hazards and risks to health shall be made and safety precautions shall be identified and provided. Written safety instructions shall be issued. Appropriate training shall be given to relevant personnel. Laboratory personnel shall ensure that they follow written safety instructions at all times.

1 Scope

This document specifies a method for determining the fire resistance of vertical and horizontal ventilation ducts under standardized fire conditions. The test examines the behaviour of ducts exposed to fire from the outside (duct A) and fire inside the duct (duct B). This document is intended to be used in conjunction with ISO 834-1.

This document is not applicable to:

a) ducts whose fire resistance depends on the fire resistance performance of a ceiling;

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

c) doors of inspection openings, unless included in the duct to be tested;

d) two-sided or three-sided ducts;

e) the fixing of suspension devices to floors or walls;

f) kitchen extract ducts (see ISO 6944-2).

NOTE Annex A provides general guidance and gives background information.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 834-1, *Fire-resistance tests — Elements of building construction — Part 1: General requirements*

ISO 5167-1, *Measurement of fluid flow by means of pressure differential devices inserted in circular cross-section conduits running full — Part 1: General principles and requirements*

ISO 5167-2, *Measurement of fluid flow by means of pressure differential devices inserted in circular cross-section conduits running full — Part 2: Orifice plates*

ISO 5167-3, *Measurement of fluid flow by means of pressure differential devices inserted in circular cross-section conduits running full — Part 3: Nozzles and Venturi nozzles*

ISO 13943, *Fire safety — Vocabulary*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 834-1 and ISO 13943 and the following apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1
fire-resisting duct
duct used for the distribution or extraction of air and designed to provide a degree of fire resistance

3.2
suspension device
components used for supporting and fixing a duct from a floor or supporting a duct from a wall

3.3
supporting construction
wall, partition or floor through which the duct passes during the test

3.4
compensator
device that is used to prevent damage from the forces generated by expansion

4 Apparatus

4.1 In addition to the test equipment specified in ISO 834-1, the following apparatus is required.

4.2 **Furnace**, capable of subjecting ventilation ducts to the standard heating conditions specified in ISO 834-1 and suitable for testing ducts in the vertical (see Figure 1) or horizontal (see Figure 2) orientation.

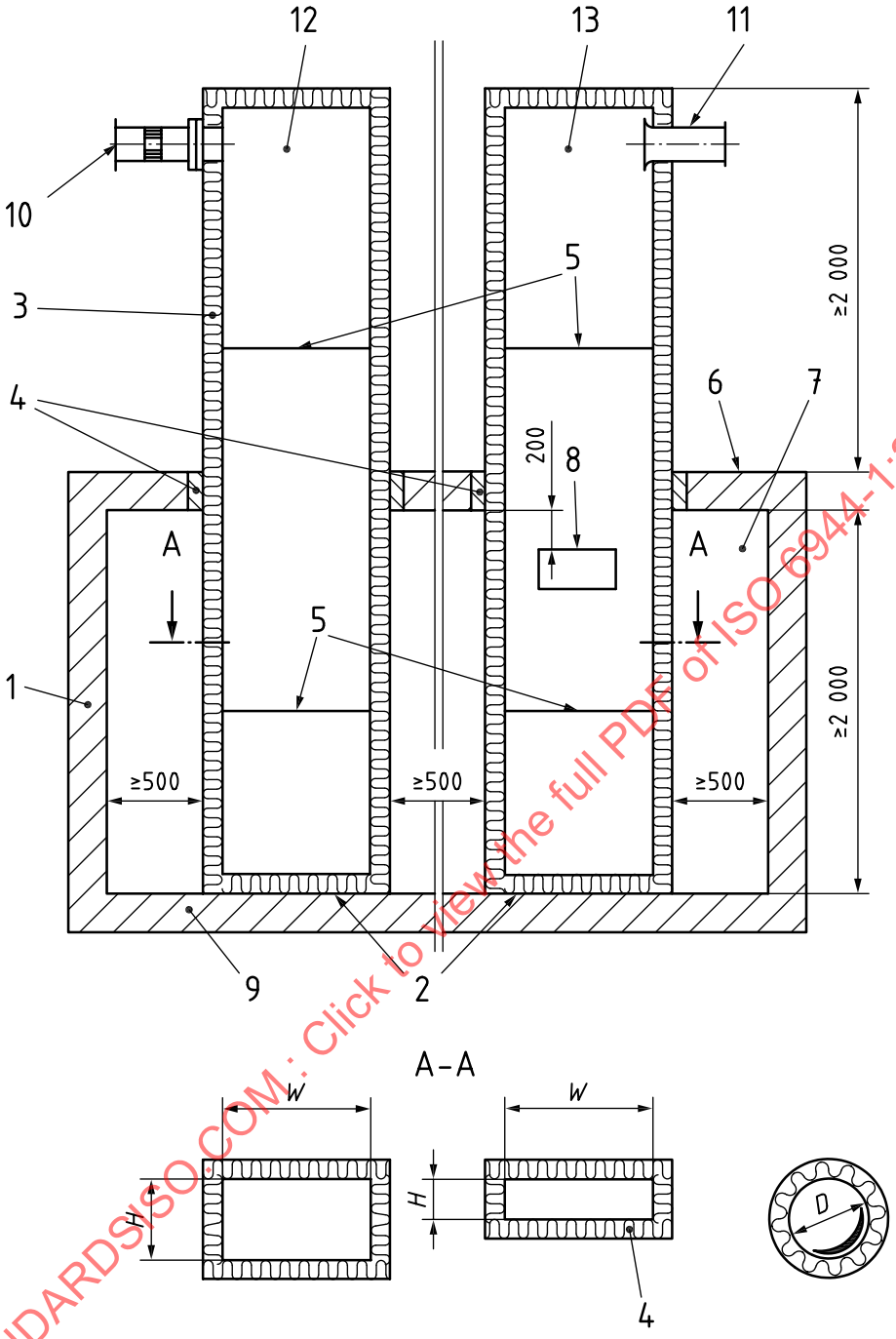
Figures 1 and 2 show two ducts being tested together. When two ducts are tested together, they shall be separated by a minimum of 500 mm. It is also permitted to test each duct singularly in the furnace.

4.3 **Fan A**, capable of producing an underpressure of (300 ± 15) Pa within duct A (see Figure 3) at the start and throughout the test, and which shall be connected, either directly or by a suitable length of flexible ducting, to the volume flow-measuring station (4.5).

4.4 **Fan B**, capable of producing an air velocity when extracting gas from duct B (see Figure 4) of at least 3 m/s measured at ambient temperature in the duct before the test.

It shall be connected, either directly or by a suitable length of flexible ducting, to the velocity-measuring station (4.8). The fan shall be provided with a by-pass vent that can be opened prior to shutting the damper (4.7).

Dimensions in millimetres



Key

1	furnace wall	7	furnace chamber
2	sealed end	8	openings providing a total area of 50 % of duct cross-section
3	fire-protection system	9	furnace floor
4	location for fire stopping (normal practice)	10	leakage-measuring station (see Figure 3 for details)
5	joint in fire-protection system	11	gas-velocity-measuring station (see Figure 4 for details)
6	furnace roof	12	duct A
		13	duct B

W width

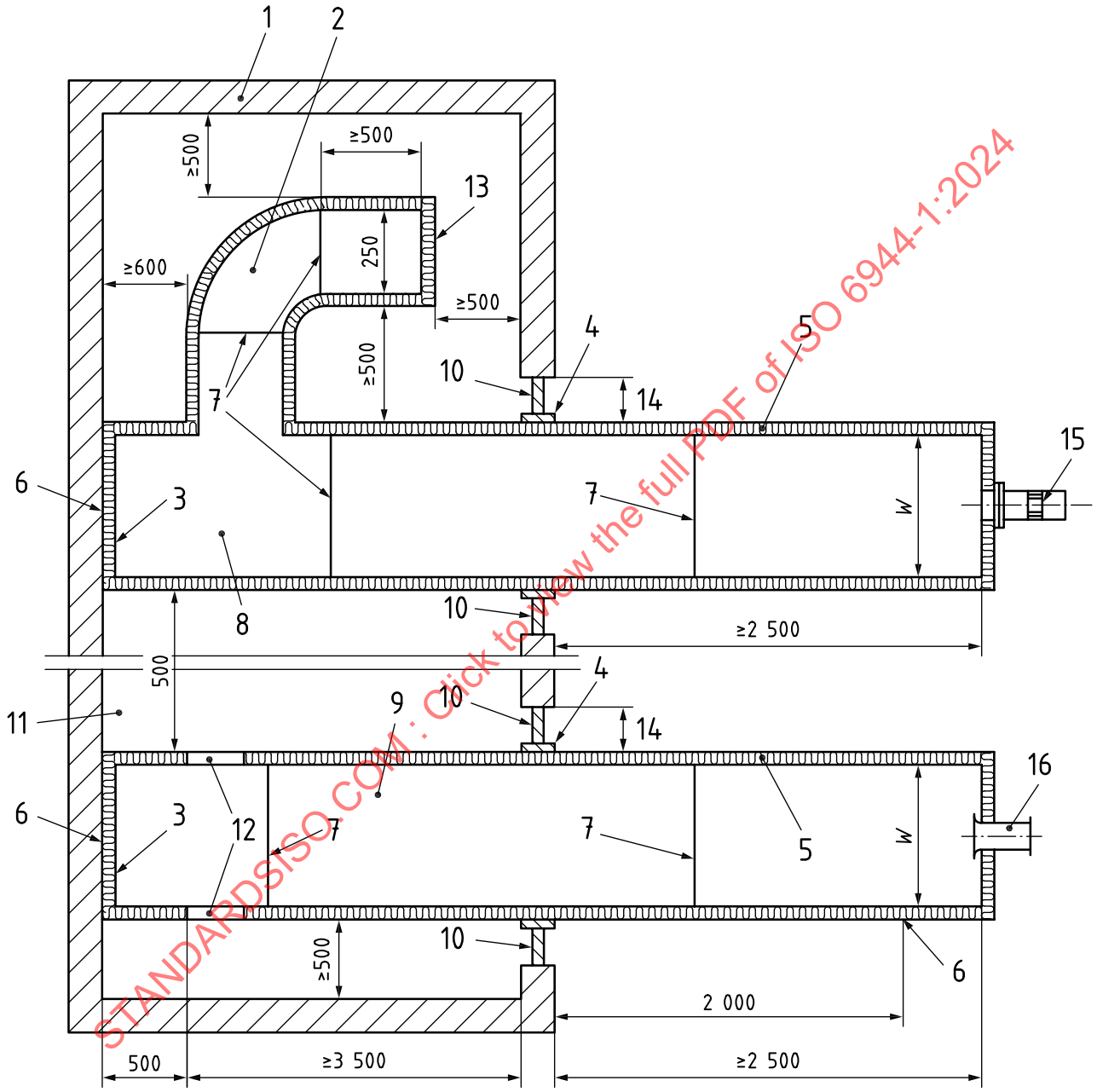
H height

D diameter

See 4.2.

Figure 1 — Test arrangement for vertical ducts

Dimensions in millimetres

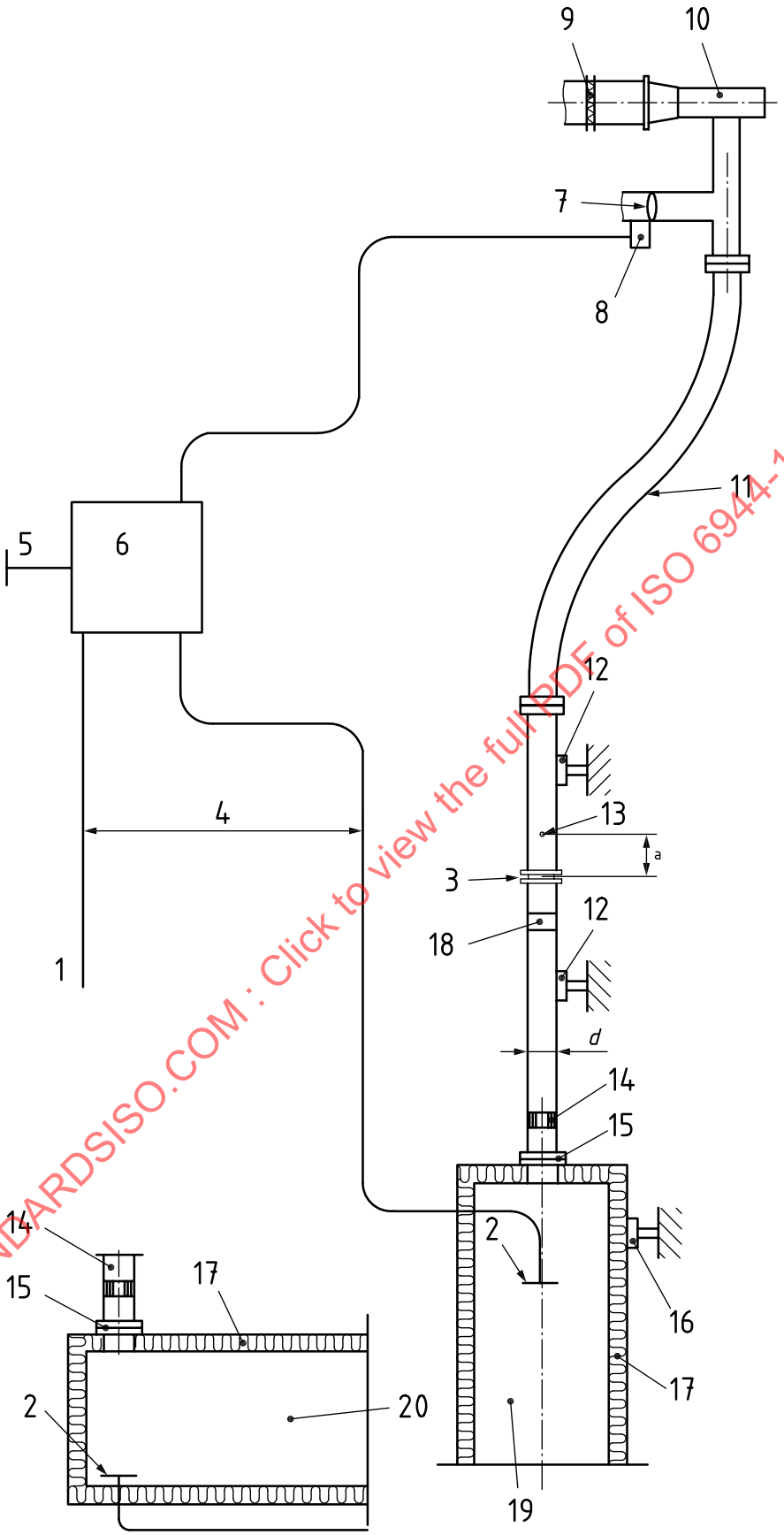


Key

1	furnace wall	9	duct B
2	duct with 90° elbow	10	supporting construction
3	sealed end	11	furnace chamber
4	location for fire stopping (normal practice)	12	openings providing a total area of 50 % of duct cross-section
5	fire-protection system	13	sealed end of elbow
6	location of restraint positions	14	200 mm minimum supporting construction
7	joints in fire-protection system	15	leakage-measuring station (see Figure 3 for details)

8 duct A
16 gas-velocity-measuring station (see Figure 4 for details)
W width (rectangular duct) or *D*, diameter (circular duct)
See 4.2.

Figure 2 — Test arrangement for horizontal ducts



Key

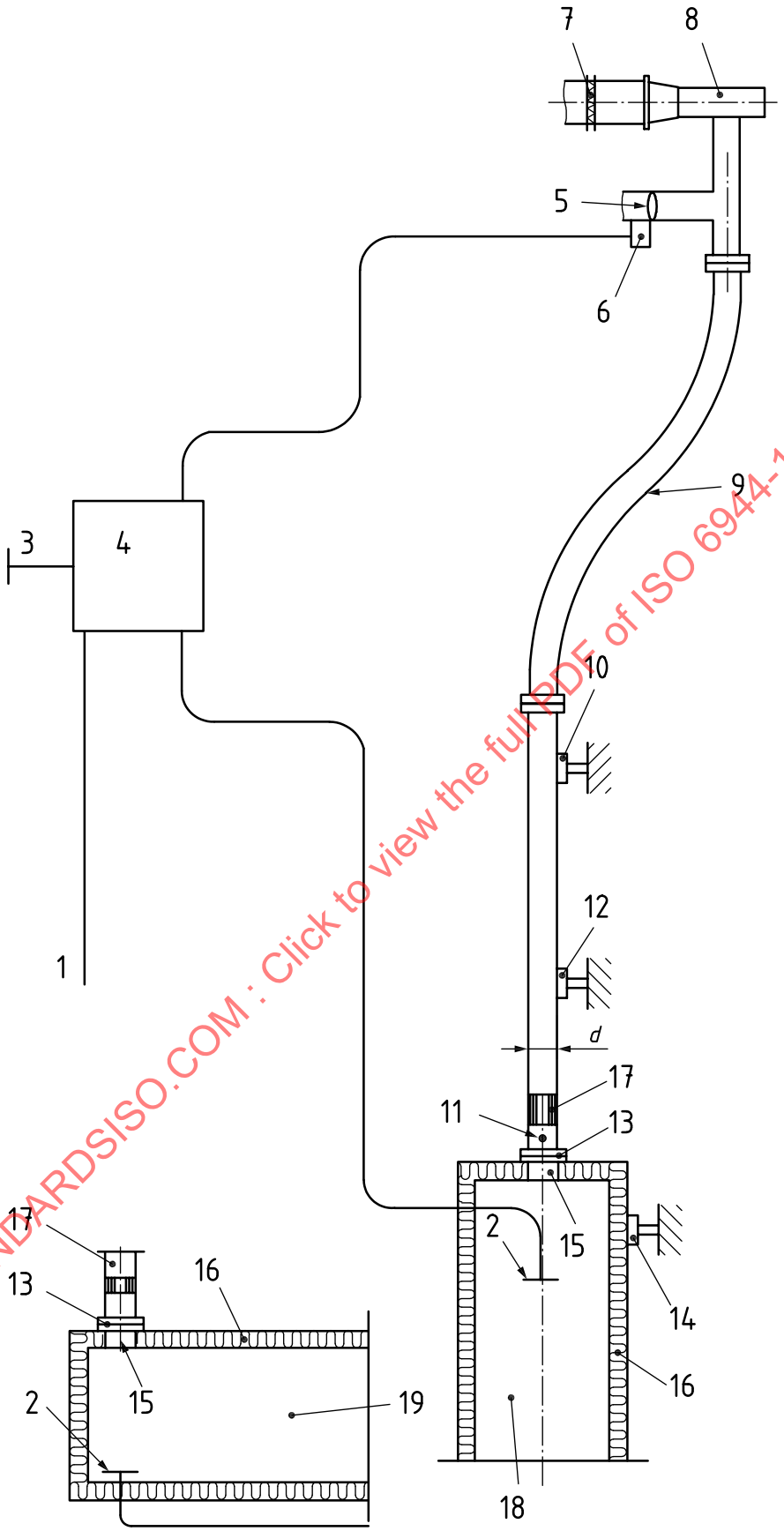
1	pressure sensor to furnace	11	flexible connecting duct
2	pressure sensor on centre-line of duct	12	support for flow-measuring system

3	office plate, venture or similar	13	thermocouple, 1,5 mm diameter
4	pressure differential of 300 Pa	14	flow straightener (where necessary)
5	pressure sensor in laboratory	15	flange
6	pressure-differential control box	16	support for duct outside furnace
7	pressure-control dilution damper	17	test duct
8	pneumatic-actuator manual control	18	condensing device
9	balancing damper	19	horizontal duct A
10	fan	20	vertical duct A

[a] Thermocouple located 2*d* from key item 3; see Note.

NOTE *d* is the diameter of the measuring duct downstream from the flow-measuring device.

Figure 3 — Leakage-measuring station for duct A



Key

1 pressure sensor to furnace
2 pressure sensor on centre-line of duct
11 thermocouple, 1,5 mm diameter
12 support for velocity-measuring station near duct

3 pressure sensor in laboratory
4 pressure-differential control box
5 pressure-control dilution damper
6 pneumatic-actuator manual control
7 balancing damper
8 fan
9 flexible connecting duct
10 support for velocity-measuring station near flexible duct
13 flange
14 support for duct outside furnace
15 inlet nozzle
16 test duct
17 flow straightener (if required)
18 horizontal duct B
19 vertical duct B

Figure 4 — Gas velocity station for duct B

4.5 Volume flow-measuring station, consisting of a venturi, orifice plate or other suitable device and (where necessary) an air-flow straightener, installed in straight lengths of pipe, all sized to ISO 5167-1, ISO 5167-2 and ISO 5167-3.

It shall be connected to the end of duct A outside the furnace to determine the volume flow rate of gas passing through duct A during the test. The measuring device shall be capable of measuring to an accuracy of ±5 %. Regardless of whether vertical or horizontal ducts are being tested, the volume flow-measuring station shall always be used in a horizontal orientation.

4.6 Condensing unit, installed between the end of duct A and the flow-measuring device and which shall allow for drainage.

The gas temperature adjacent to the flow-measuring device shall be measured by a 2 mm sheathed thermocouple with an insulated hot junction, arranged pointing downwards to allow the moisture to drain. Its measuring junction shall be located at the centre-line of the measuring duct and at a distance, *d*, equal to twice the diameter of the measuring duct downstream from the flow-measuring device. The temperature measured by this thermocouple shall not exceed 40 °C.

4.7 Damper, installed between the fan and the velocity-measuring station to shut off the air flow in duct B during evaluation of integrity in the "fan off" condition.

4.8 Velocity-measuring station, to determine the air velocity in duct B and which shall consist of one or two inlet nozzle(s), or another suitable device, installed in a straight length of pipe sized to ISO 5167-1, ISO 5167-2 and ISO 5167-3.

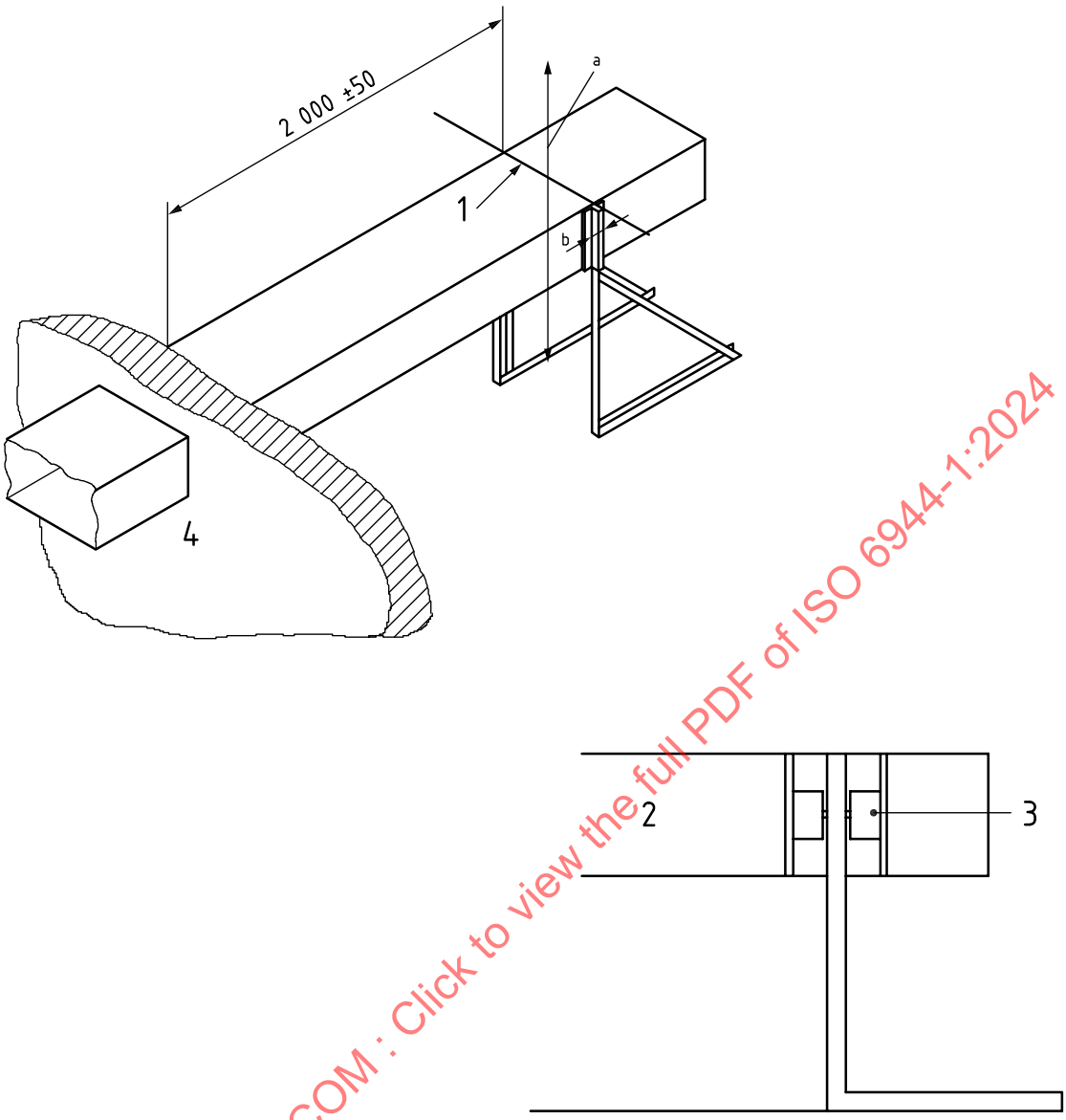
It shall be connected to the end of both the vertical and horizontal ducts B outside the furnace.

4.9 Equipment for measuring gas pressure, located in the furnace and inside duct A.

4.10 Thermal-movement-measuring device, for measuring the expansion or contraction of duct A, accurate to ±1 mm.

4.11 Force-measuring device, for measuring forces at the point of applying the restraint in duct B (see Figure 5).

Dimensions in millimetres



Key

1 location of device measuring the restraining forces
2 duct
3 stiff load cells (used for applying and measuring restraint)
4 furnace
a Allow movement in both directions.
b Resist movement in both directions.

Figure 5 — Restraint of duct B outside the furnace

5 Test conditions

The heating conditions and the furnace atmosphere shall conform to those given in ISO 834-1.

The furnace pressure shall be controlled to (15 ± 3) Pa throughout the test at the mid-height position of the ducts.

Details of test conditions within the ducts during the test are given in Clause 10.

6 Test specimen

6.1 Size

6.1.1 General

Ducts of sizes other than those given in Tables 1 and 2 have restricted the field of direct application (see Clause 13).

6.1.2 Length

The minimum lengths of the parts of the test specimen inside and outside the furnace shall be as given in Table 1 (see also Figures 1 and 2).

Table 1 — Minimum length of test specimen

Orientation	Minimum length m	
	Inside the furnace	Outside the furnace
Horizontal	4,0	2,5
Vertical	2,0	2,0

6.1.3 Cross-section

The standard sizes of ducts given in Table 2 shall be tested unless only smaller cross-sections are used.

Table 2 — Cross-sectional dimensions of test specimen

Duct	Rectangular		Circular
	width mm	height mm	diameter mm
A	1 000 ± 10	500 ± 10	800 ± 10
B	1 000 ± 10	250 ± 10	630 ± 10

6.2 Number

One test specimen shall be tested for each type of installation being evaluated.

6.3 Design

6.3.1 General

The test shall be performed on a test specimen representative of the complete duct assembly on which information is required. The edge conditions and the method of fixing or support inside and outside the furnace shall be representative of those used in normal practice.

Ducts shall be arranged as shown in Figures 1 and 2.

6.3.2 Minimum separation

There is no limit to the number of ducts that may be tested simultaneously in the same furnace, provided that there is a minimum space of 500 mm between the ducts, in accordance with the dimensions shown in Figures 1 and 2.

There shall be a separation of (500 ± 50) mm between the top of a horizontal duct and the ceiling. A minimum separation of 500 mm shall be provided between the underside of a horizontal duct and the floor. Similarly, there shall be a minimum separation of at least 500 mm between the sides of ducts and the furnace walls.

6.3.3 Configuration of duct A (horizontal only)

The horizontal duct A shall include one sharp bend, a T-piece and a 500 mm long length of duct forming a short branch duct having a cross-section of 250 mm × 250 mm and shall be arranged as shown in Figure 2. All specimens, including this branch, shall be mounted with the suspension or fixing devices as intended in normal practice.

An alternative test arrangement where the elbow in horizontal duct A is replaced by a vertical section of duct, which passes through the furnace roof and is then connected to the measuring system and the fan, is illustrated in Figure 6.

6.3.4 Openings in duct B

Two openings shall be provided, one on each vertical side of the duct inside the furnace. For horizontal ducts, the openings shall be positioned (500 ± 25) mm from the furnace wall. For vertical ducts, the openings shall be positioned (200 ± 10) mm below the furnace roof. (See Figures 1 and 2.)

In both vertical and horizontal ducts, the openings shall have the same breadth-to-height ratio as the cross-section of the duct and a total opening area of (50 ± 10) % of the cross-sectional area of the duct, i.e. each opening shall have an area of (25 ± 5) % of the cross-sectional area of the duct.

6.3.5 Joints in horizontal ducts

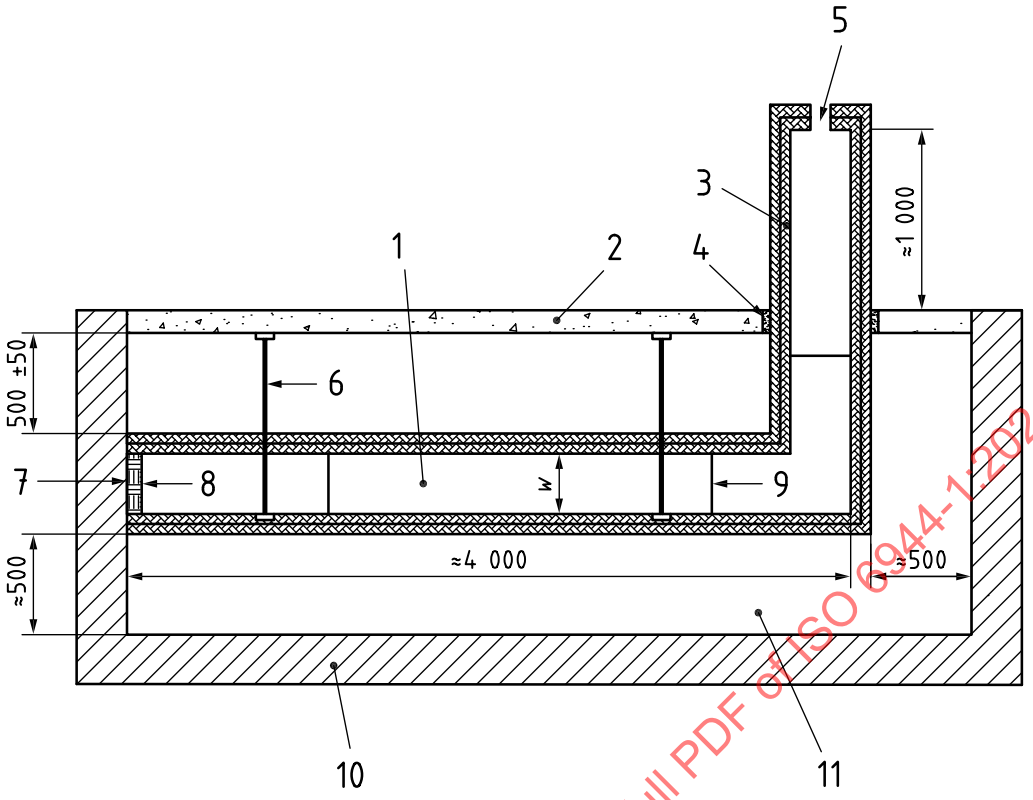
The test configuration shall include at least one joint inside and at least one joint outside the furnace.

There shall be at least one joint per layer of fire-protection material, both inside and outside the furnace and in any steel duct.

Outside the furnace, the joint in the outer layer of the fire-protection material shall be no further than 700 mm from the supporting construction and no nearer than 100 mm to thermocouples T2; see Figures 10 to 12. Inside the furnace, the joint in the outer layer of fire-protection material shall be located at approximately mid-span.

The distance between joints and suspension devices shall not be less than that used in practice. If the minimum distance has not been specified, suspension devices shall be arranged so that the joint at mid-span lies midway between them. Centres of the suspension devices shall be specified by the manufacturer and shall be representative of practice.

Dimensions in millimetres



Key

1	duct with vertical elbow	7	location of restraint positions
2	furnace roof/supporting construction	8	sealed end
3	fire-protection system	9	joints in fire-protection system
4	location for fire stopping (normal practice)	10	furnace wall
5	connection of elbow to measuring system and fan as shown in Figure 3	11	furnace chamber
6	duct supports (normal practice)		

Figure 6 — Alternative arrangement for duct A with vertical elbow

6.3.6 Joints in vertical ducts

The test configuration shall include at least one joint inside and one joint outside the furnace (see Figure 1).

There shall be at least one joint for every layer of fire-protection material, both inside and outside the furnace and in any steel duct.

Outside the furnace, the joint in the outer layer of the fire-protection material shall be no further than 700 mm from the supporting construction and no nearer than 100 mm to the thermocouples T2; see Figures 10 to 12. Inside the furnace, the joint in the outer layer of fire-protection material shall be located at approximately mid-span.

6.3.7 Support for vertical ducts

Vertical ducts shall be supported on the furnace floor and shall penetrate through the furnace roof slab/supporting construction (see Figure 1); the ducts shall be fixed at the furnace-roof level as they are normally fixed in practice when penetrating a floor. This shall be as specified by the sponsor.

6.3.8 Compensators

Only where compensators are normally used in practice shall they be incorporated in the test specimen. Where a compensator is being tested, it shall be located within the furnace for duct A and, for duct B, outside the furnace approximately 500 mm from the wall or floor.

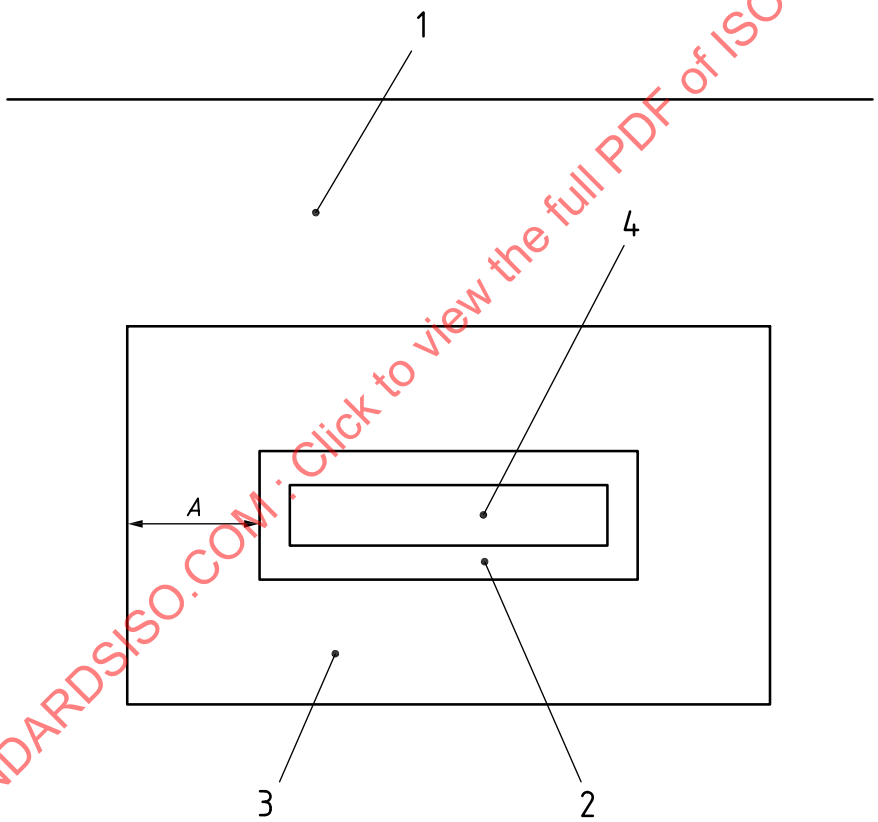
7 Installation of test specimen

7.1 General

The test specimen shall be installed, as far as possible, in a manner representative of its use in normal practice.

The supporting construction selected shall be a wall, partition or floor of the type used in normal practice and shall have a fire resistance greater than the required fire resistance of the duct being tested.

Where the duct passes through an opening in the furnace wall or roof, the opening shall be of sufficient dimensions that the minimum distance between the edge of the fire stopping (see 7.4.5) adjacent to the supporting construction and the outside perimeter of the supporting construction is 200 mm (see Figure 7).



Key

1 furnace wall or furnace roof
2 fire stopping
3 supporting construction
4 duct

Dimension *A* shall be a minimum of 200 mm.

Figure 7 — Details of duct passing through an opening in the furnace wall or roof

7.2 Standard supporting construction

Where the type of supporting construction used in normal practice is not known, then one of the standard supporting constructions described in Tables 3 to 5 shall be used.

Table 3 — Standard rigid-wall constructions

Type of construction	Thickness mm	Density kg/m³	Test duration t h
Normal concrete/masonry	110 ± 10	2 200 ± 200	$t = 2$
	150 ± 10	2 200 ± 200	$2 < t \leq 3$
	175 ± 10	2 200 ± 200	$3 < t \leq 4$
Aerated concrete [a]	110 ± 10	650 ± 200	$t = 2$
	150 ± 10	650 ± 200	$2 < t \leq 4$

[a] This supporting construction may be made from blocks bonded together with mortar or adhesive.

Table 4 — Standard flexible-wall constructions (gypsum plasterboard)

Fire resistance min	Wall constructions			
	Number of layers on each side	Thickness mm	Insulation [a] D/ρ	Thickness [b] mm
30	1	12,5	40/40	75
60	2	12,5	40/40	100
90	2	12,5	60/50	125
120	2	12,5	60/100	150
180	3	12,5	60/100	175
240	3	15,0	80/100	190

[a] D is the thickness in mm of mineral wool insulation inside the wall; ρ is the density in kg/m³ of mineral wool insulation inside the wall.

[b] Tolerance of ±10 %.

Table 5 — Standard floor constructions

Type of construction	Thickness mm	Density kg/m³	Test duration t h
Normal concrete	110 ± 10	2 200 ± 200	$t = 1,5$
	150 ± 10	2 200 ± 200	$1,5 < t \leq 3$
	175 ± 10	2 200 ± 200	$3 < t \leq 4$
Aerated concrete	125 ± 10	650 ± 200	$t = 2$
	150 ± 10	650 ± 200	$2 < t \leq 4$

7.3 Non-standard supporting constructions

When the test specimen is intended for use in a form of construction not covered by the standard supporting constructions, it shall be tested in the supporting construction intended for use.

7.4 Restraint of ducts

7.4.1 Inside the furnace

All ducts shall be fully restrained in all directions at the furnace wall or floor remote from the penetration point. Where there is a possibility of movement of the furnace wall, the fixings shall be made independent of the furnace structure.

7.4.2 At the penetration point

Where, in practice, the duct is fixed at floor level, then both vertical ducts A and B shall be fixed where the duct penetrates the furnace roof/supporting construction as specified by the sponsor.

7.4.3 Outside the furnace

Only horizontal duct B shall be restrained outside the furnace. The restraining point shall be located at a position (2 000 ± 50) mm from the furnace wall and shall provide restraint on movement in the horizontal directions but shall allow movement in the vertical directions (see Figure 5). The frame used to apply the restraint shall be rigid and have sufficient strength to resist all horizontal forces. All other ducts shall be unrestrained outside the furnace.

7.4.4 Closure

The end of the ducts within the furnace and the end of any branch duct attached shall be closed independently of any furnace enclosure, by materials and construction similar to the remainder of the duct.

7.4.5 Fire stopping

The fire stopping at the penetration through the supporting construction shall be as intended in practice. If the width of the gap for fire-stopping around the duct at the furnace penetration point is not specified, a width of 50 mm shall be used.

7.4.6 Unsupported vertical ducts

Where, in practice, vertical ducts are not fixed to each floor, then the test specimen shall be suitably loaded to simulate the weight of the remaining height of unsupported ducting.

8 Conditioning

8.1 General

Conditioning of the test construction shall be in accordance with ISO 834-1.

8.2 Hygroscopic sealing materials

Hygroscopic materials used to seal the gap between the supporting construction and the duct where the gap is > 10 mm wide shall be conditioned for 7 days before fire testing.

Hygroscopic materials used to seal the gap between the supporting construction and the duct assembly where the gap is > 10 mm wide shall be conditioned for 28 days before fire testing.

9 Application of instrumentation

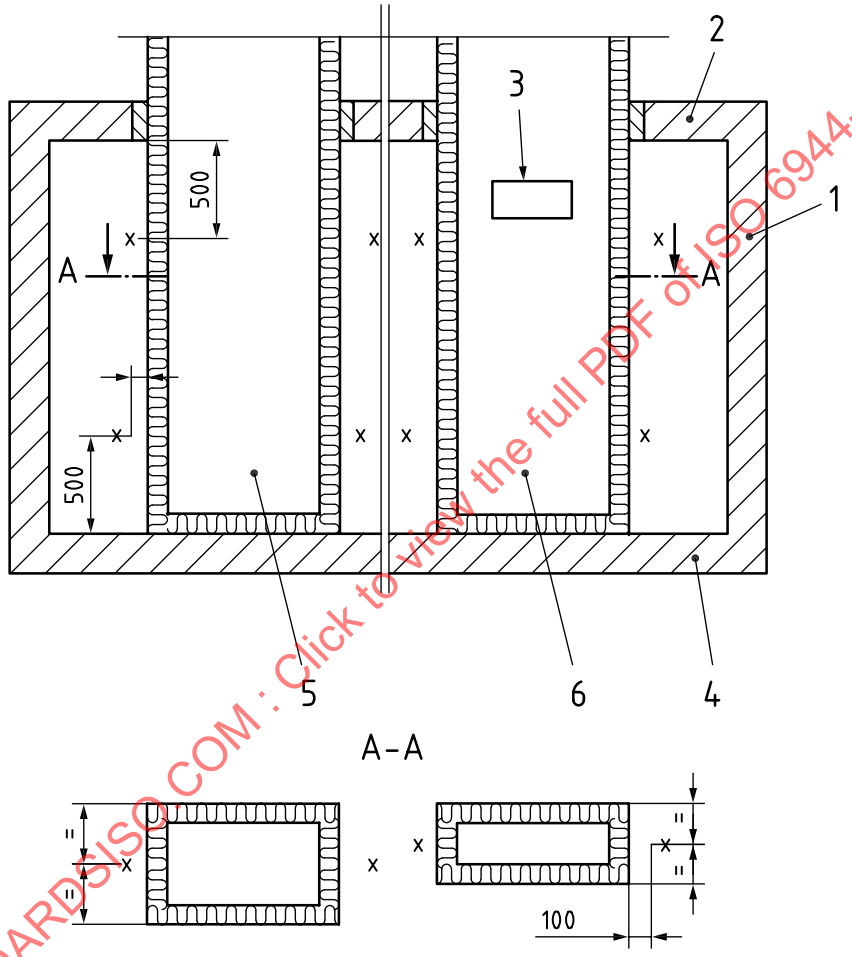
9.1 Thermocouples

9.1.1 Furnace thermocouples (plate thermometers)

Plate thermometers shall be provided in accordance with ISO 834-1 and shall be positioned as shown in Figures 8 and 9.

For all ducts, the plate thermometers shall be oriented so that side "A" faces the walls of the furnace opposite the ducts being evaluated.

Dimensions in millimetres



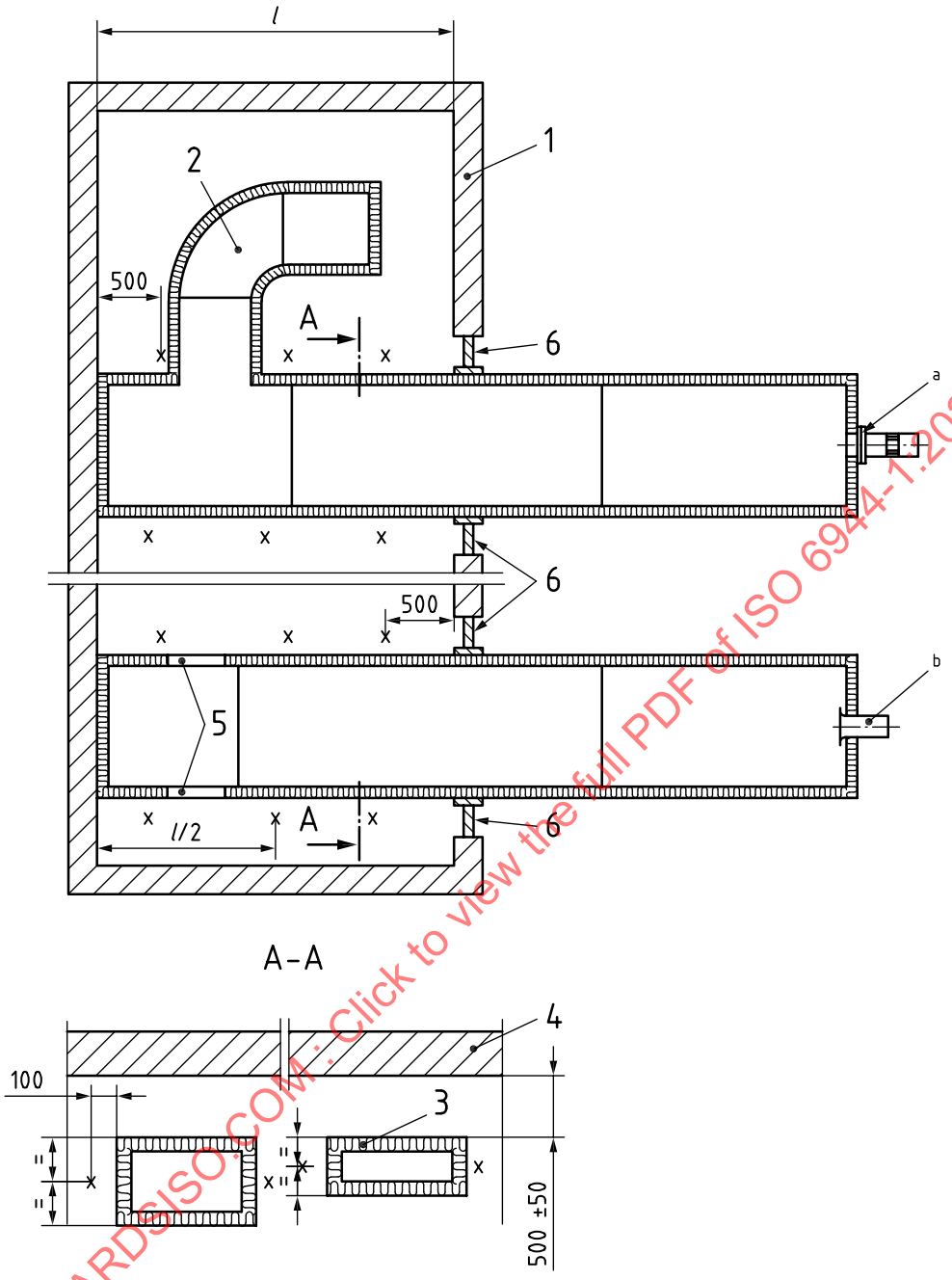
Key

1 furnace wall
2 furnace roof
3 one opening on each side of the duct, providing a total inlet area of 50 % of the cross-section of the duct (see 6.3.4)
4 furnace floor
5 vertical duct A
6 vertical duct B
X furnace thermocouple locations

This figure shows two ducts being tested together. It is also permitted to test each duct singularly in the furnace.

Figure 8 — Location of furnace thermocouples for vertical duct testing

Dimensions in millimetres



Key

1 furnace wall

2 duct A with 90° elbow (see 6.3.3)

3 fire-protection system

l span inside furnace

X location of furnace thermocouples

[a] See Figure 3 for details of flow-measuring system.

4 furnace roof

5 one opening on each side of duct B providing a total inlet area of 50 % of the cross-section of duct B (see 6.3.4)

6 supporting construction

[b] See Figure 4 for detail of velocity-measuring station.

This figure shows two ducts being tested together. It is also permitted to test each duct singularly in the furnace.

Thermocouples shall be located along the horizontal section of the duct when the L-shaped duct shown in Figure 6 is used.

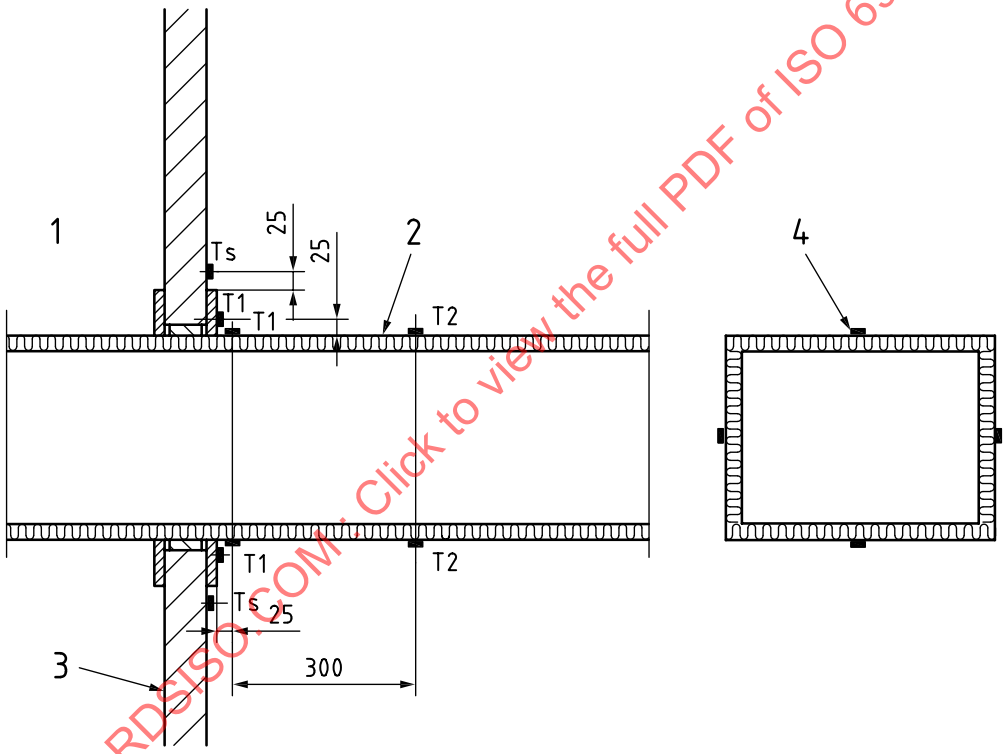
Figure 9 — Location of furnace thermocouples for horizontal ducts

9.1.2 Unexposed surface thermocouples

9.1.2.1 General

The temperature of the test specimens shall be measured with thermocouples as described in ISO 834-1. The position of thermocouples at the point of penetration of the duct through the wall or floor is shown in Figures 10 to 12 for a number of different penetration details. At least one thermocouple of each type shall be positioned on each side of a rectangular duct.

Dimensions in millimetres

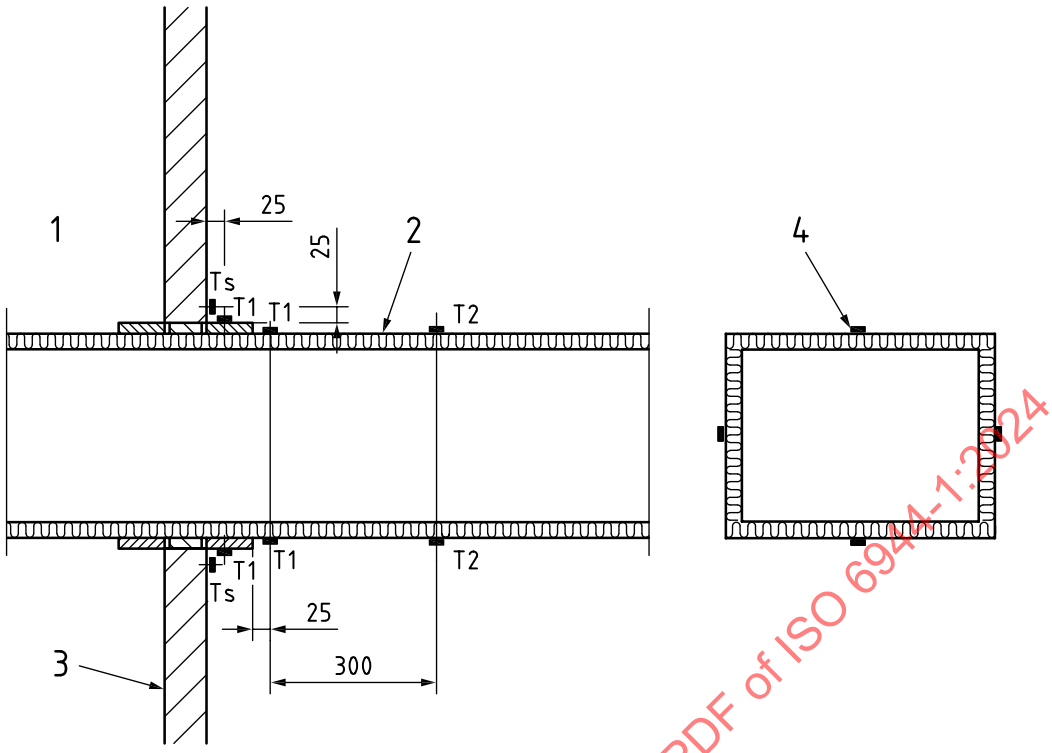


Key

1 furnace
2 fire-resisting duct
3 supporting construction
4 surface thermocouple
Ts position of thermocouple to measure the maximum surface temperature on the supporting construction; minimum of one on each side of the duct
T1 positions of surface thermocouples for determining the maximum temperature; minimum of one on each side of the duct
T2 positions of surface thermocouples for determining the average and the maximum temperatures; minimum of one on each side of the duct

Figure 10 — Location of surface thermocouples where duct penetrates supporting construction — Example 1

Dimensions in millimetres



Key

1 furnace

2 fire-resisting duct

3 supporting construction

4 surface thermocouples

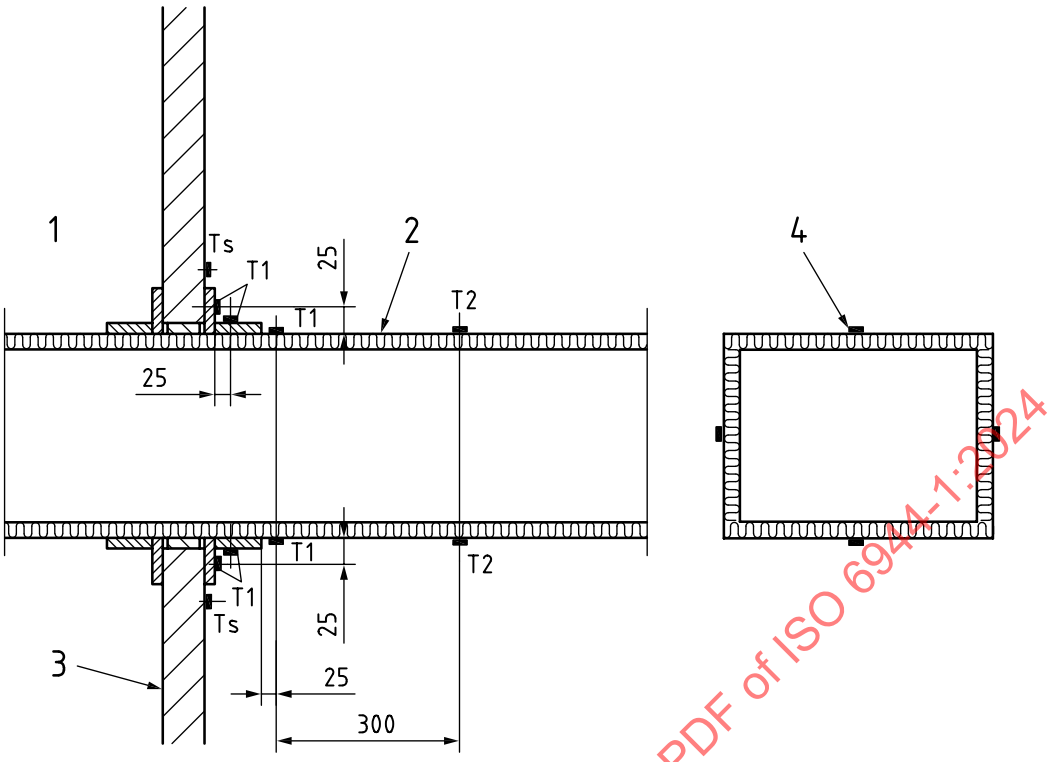
Ts position of thermocouple to measure the maximum surface temperature on the supporting construction; minimum of one on each side of the duct

T1 positions of surface thermocouples for determining the maximum temperature; minimum of one on each side of the duct

T2 positions of surface thermocouples for determining the average and the maximum temperatures; minimum of one on each side of the duct

Figure 11 — Location of surface thermocouples where the duct penetrates the supporting construction — Example 2

Dimensions in millimetres



Key

1 furnace

2 fire-resisting duct

3 supporting construction

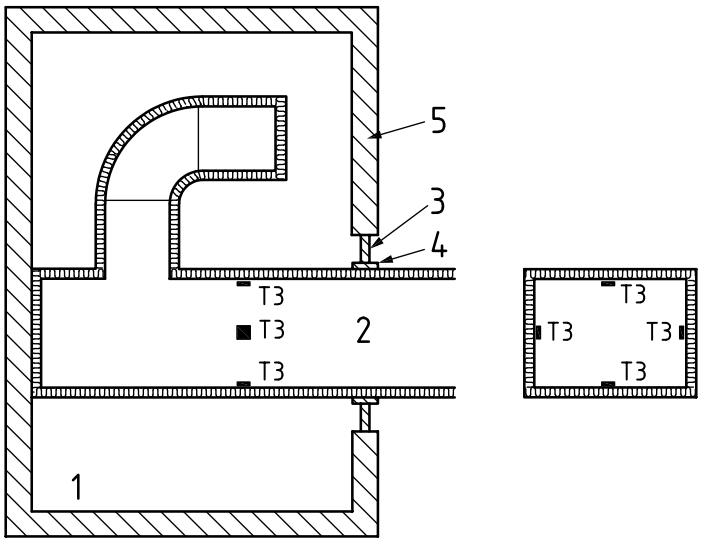
4 surface thermocouples

Ts position of thermocouple to measure the maximum surface temperature on the supporting construction; minimum of one on each side of the duct

T1 positions of surface thermocouples for determining the maximum temperature; minimum of one on each side of the duct

T2 positions of surface thermocouples for determining the average and the maximum temperatures; minimum of one on each side of the duct

Figure 12 — Location of surface thermocouples where the duct penetrates the supporting construction — Example 3



Key

1 furnace
2 duct A
3 supporting construction
4 fire-stopping system
5 furnace wall
T3 location of surface thermocouples for determining the average and the maximum temperatures

Figure 13 — Interior surface thermocouples for ducts with a combustible internal lining

9.1.2.2 Maximum temperature rise

Additional thermocouples, T1, for determining the maximum temperature rise shall be located in positions on the outer surface of the fire-protection material to coincide with all joints, including inner layer joints.

9.1.2.3 Ducts with combustible linings

For ducts where a combustible internal lining is used, four additional thermocouples, reference T3, shall be fixed inside duct A at a position of approximately mid-span within the part of the duct exposed within the furnace. The thermocouples shall be fixed to the inside face of the duct at the locations shown in Figure 13. The thermocouples shall not coincide with joints or cover strips.

9.1.2.4 Compensating devices

Where compensating devices have been incorporated, thermocouples shall be located on the outer surface of the compensator in duct B. These shall be used to check compliance with the maximum temperature rise limits only.

9.1.2.5 Suspension device

Where steel suspension devices are protected, their temperatures shall be measured. A thermocouple shall be positioned on each component of at least two suspension-device systems.

9.2 Pressure

The furnace pressure shall be measured in accordance with ISO 834-1 and the pressure probe(s) located at a position 100 mm below the roof of the furnace and at a position equal to the mid-height of the ducts.

10 Test procedure

10.1 General

The test shall be carried out using the equipment and procedures in accordance with ISO 834-1.

10.2 Control of conditions to permit assessment of integrity

10.2.1 Duct A

Control the underpressure inside duct A (see Figures 1 and 2) to (300 ± 15) Pa below the ambient (laboratory) pressure at the beginning of the test and maintain it at this value throughout the test.

10.2.2 Duct B

Prior to the start of the test, stabilize the air velocity in duct B (see Figures 1 and 2) to 3 m/s. Adjust the fan during the "fan on" parts of the test to maintain the velocity of (3 ± 0,45) m/s.

At 25 min after the start of the test, open the fan bypass vent and then shut the damper, whilst leaving the fan running. Allow 2 min for the conditions to stabilize in duct B.

Make an assessment of the integrity of the duct assembly outside the furnace in the simulated "fan off" situation for a period of 3 min. Then re-open the damper and close the bypass vent. The damper shall be opened or shut in not less than 10 s and not more than 20 s. Check to verify that velocity of the fan is within the limits defined above.

Repeat this procedure 5 min before the completion of every 30 min period of the test. Make assessments of integrity in the damper open position ("fan-on" situation) at all other times.

10.3 Test measurements and observations

10.3.1 Integrity

10.3.1.1 Ducts A and B, including where the ducts pass through the wall or floor

Evaluate the test specimen for integrity as given in ISO 834-1. Table 6 summarizes the evaluation required to assess integrity.

Table 6 — Summary of appropriate integrity evaluation

Duct	Inside furnace	Outside furnace
Duct A (fire outside duct)	Volume flow rate	Volume flow rate Cotton pad Openings Flaming
Duct B (fire inside duct)	—	Cotton pad Openings Flaming

10.3.1.2 Duct A only

Record the pressure differential across the venturi, orifice plate or other suitable device at intervals of not more than 2 min throughout the test.

Calculate the leakage from the recorded pressure differential from the venturi, orifice plate or other suitable device using the equations for volume flow rates given in ISO 5167-1, ISO 5167-2 and ISO 5167-3.

10.3.2 Insulation

Measure the average and maximum temperatures of the unexposed faces of the test specimens as specified in ISO 834-1. Use a roving thermocouple to locate points of high temperature not covered by the fixed thermocouples, at locations where the duct is outside the furnace only.

10.3.3 Restraint forces and thermal elongation or shortening

Measure and record the restraint force in horizontal duct B on the outer surface (see Figure 5) at the point of application of the restraint outside the furnace. Measure and record the thermal elongation or shortening of horizontal duct A (see Figure 2) at the penetration point.

Measure the restraint forces in duct B using the device described in 4.11. In duct A, measure thermal movement using the transducer specified in 4.10.

10.3.4 Additional observations

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

a) deflections; this shall cover the general behaviour of the duct, e.g. the direction in which it is deflecting; precise measurements are not required;

b) the emissions of smoke from the unexposed face of the duct; this can, for example, be attributable to its coverings and/or lining; only limited observations can be possible in view of the highly subjective nature of such observations;

c) 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;

d) the expansion or contraction of each layer of protection material on the duct, at the end of horizontal duct A.

10.4 Termination of the test

Terminate the test for the reasons given in ISO 834-1.

11 Performance criteria

11.1 Integrity

Integrity failure shall be deemed to have occurred if any of the following are observed:

a) integrity failure as defined in ISO 834-1;

b) volume flow rate measured in duct A exceeds 15 $m^3/(m^2 \cdot h)$ at normal temperature and pressure, related to the internal surface area of the duct inside the furnace.

11.2 Insulation

11.2.1 General

Insulation failure shall be as defined in ISO 834-1.

Only thermocouples T2 shall be used to determine the average temperature rise. Thermocouples T1, T2, Ts, and the roving thermocouple shall be used to determine the maximum temperature rise.

11.2.2 Ducts with internal combustible linings only

Insulation failure shall be as defined in ISO 834-1.