BRITISH STANDARD

BS EN 1366-9:2008

Fire resistance tests for service installations

Part 9: Single compartment smoke extraction ducts

ICS 13.220.50

British Standards

National foreword

This British Standard is the UK implementation of EN 1366-9:2008.

The UK participation in its preparation was entrusted to Technical Committee FSH/22, Fire resistance tests.

A list of organizations represented on this committee can be obtained on request to its secretary.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

Compliance with a British Standard cannot confer immunity from legal obligations.

This British Standard was published under the authority of the Standards Policy and Strategy Committee on 31 August 2008

ISBN 978 0 580 59170 9

Amendments/corrigenda issued since publication

Date	Comments

EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

EN 1366-9

March 2008

ICS 13.220.50

English Version

Fire resistance tests for service installations - Part 9: Single compartment smoke extraction ducts

Essai de résistance au feu des installations de service - Partie 9 : Conduits d'extraction de fumées relatifs à un seul compartiment

Feuerwiderstandsprüfungen für Installationen - Teil 9: Entrauchungsleitungen für einen Einzelabschnitt

This European Standard was approved by CEN on 21 January 2008.

CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration. Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the CEN Management Centre or to any CEN member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the CEN Management Centre has the same status as the official versions.

CEN members are the national standards bodies of Austria, Belgium, Bulgaria, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland and United Kingdom.

EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

Management Centre: rue de Stassart, 36 B-1050 Brussels

Ref. No. EN 1366-9:2008: E

Contents

Page

Foreword

This document (EN 1366-9:2008) has been prepared by Technical Committee CEN/TC 127 “Fire safety in buildings”, the secretariat of which is held by BSI.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by September 2008, and conflicting national standards shall be withdrawn at the latest by September 2008.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN [and/or CENELEC] shall not be held responsible for identifying any or all such patent rights.

This document has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association, and supports essential requirements of 89/106/EEC Directive.

EN 1366 *"Fire resistance tests for service installations"* consists of the following Parts:

Part 1: Ducts

Part 2: Fire dampers

Part 3: Penetration seals

Part 4: Linear joint seals

Part 5: Service ducts and shafts

Part 6: Raised access and hollow core floors (in course of preparation)

Part 7: Conveyor systems and their closures

Part 8: Smoke extraction ducts

Part 9: Single compartment smoke extraction ducts

Part 10: Smoke control dampers (in course of preparation)

Part 11: Protective systems for essential services (in course of preparation)

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland and the United Kingdom.

Introduction

This part of this European Standard has been prepared because a method of test for smoke extraction ducts used in single compartment applications has become necessary. This test exposes a smoke extraction duct to conditions intended to represent the pre-flashover stage of a fire.

Leakage is measured at both ambient temperature and exposure at 600 °C. During the tests, air/gases are drawn through the duct at a differential pressure between the inside and outside of the duct. Leakage is determined at ambient temperature by sealing the openings in the duct located in the furnace and taking flow measurements through a flow measuring device located just before the extraction fan. With respect to determining leakage at 600 °C, oxygen-measuring techniques are used.

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

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

1 Scope

This part of EN 1366 specifies a test method for determining the fire resistance of smoke extraction ducts that are used for single compartment applications only. In such applications, the smoke extraction system is only intended to function up to flashover (typically 600 °C).

This method of test is only suitable for ducts constructed from non-combustible materials (euro class A1 and A2-s1, d0).

It is applicable only to four sided and circular ducts. One, two and three sided ducts are not covered.

This test has been designed to cover horizontal smoke extraction ducts intended for single compartment applications only.

This test method of part 9 is applicable only to smoke extraction ducts that do not pass through into other fire compartments. It represents fire exposure of a developing fire (pre-flashover). For smoke extraction ducts that pass through into other compartments, the method of test described in EN 1366-8 should be used.

The smoke extraction duct is part of the smoke extraction system which also includes smoke control dampers and smoke extract fans.

The method described in this test standard is complex and requires sophisticated instrumentation. It is not recommended therefore to try to test multiple assemblies in this test.

2 Normative references

The following referenced documents are indispensable for the application 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.

EN 1363-1:1999, *Fire resistance tests - Part 1: General requirements*

EN 1363-2, *Fire resistance tests - Part 2: Alternative and additional procedures*

EN 1366-1:1999, *Fire resistance tests for service installations - Part 1: Ducts*

EN 1751, *Ventilation for buildings - Air terminal devices - Aerodynamic testing of dampers and valves*

EN 60584-1, *Thermocouples - Part 1: Reference tables (IEC 60584- 1:1995)*

EN 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 5167-1:2003)*

EN ISO 13943:2000, *Fire safety - Vocabulary (ISO 13943:2000)*

ISO 5221, *Air distribution and air diffusion - Rules to methods of measuring air flow rate in an air handling duct*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in EN 1363-1:1999 and EN ISO 13943:2000 and the following apply.

3.1
single compartment smoke control system ducts
ducts for use within single fire compartment application

3.2
suspension devices
the components used for suspending and fixing a duct from a floor soffit or supporting a duct from a wall

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

3.4
single fire compartment
fire area of a single compartment building bounded by fire-resistant walls

3.5
smoke zone (zones)
areas into which a construction work is divided for the extraction of smoke and hot gases. Each zone is served by a SHEV (or sub-system of a SHEV), which is initiated by a signal from a single or group of initiation devices associated with the zone

3.6
smoke barrier
a barrier to restrict the spread of smoke and hot gases from a fire, forming part of the boundary of a smoke reservoir or used as a channelling screen, or used as a void edge boundary

3.7
compensator
a device that is used to prevent damage from the forces generated by expansion

3.8
smoke and heat exhaust ventilation system (SHEVS)
system consisting of products and/or components jointly selected to exhaust smoke and heat. The products and/or components form a system in order to establish a buoyant layer of warm gases above cooler cleaner air

4 Test equipment

4.1 General

In addition to the test equipment specified in EN 1363-1, the equipment in 4.2 and 4.3 is required. The overall test arrangement is shown in Figure 1. Details of instrumentation and other details are shown in Figures 2 to 10.

4.2 Furnace

The furnace shall be capable of subjecting fire resisting smoke extraction ducts to the standard heating and pressure conditions specified in EN 1363-1 and be suitable for testing ducts in the horizontal orientation (see Figure 1).

4.3 Perforated plate

The perforated plate controls the flow through the duct so that the required differential pressure, see Table 1, can be achieved. Depending on the end-use conditions, a pressure level from Table 1 shall be selected. These levels correspond to typical values used in smoke extraction design.

The plate shall be positioned (250 ± 50) mm from where the duct passes through the furnace wall (see Figures 1 and 2).

These plates shall be made from heat resisting steel, 19 % min. Cr content and 11 % min. Ni content. The number of holes and dimensions are given in Tables 2 and 3. The thickness of the plates shall be 2,5 mm.

Table 2 gives details of perforated plates for standard rectangular ducts of size 1 000 mm x 250 mm. For smaller sizes, the number of holes will be reduced proportional to the smaller cross-section.

Table 3 gives details of perforated plates for standard circular ducts of diameter 560 mm. For smaller sizes, the number of holes will be reduced proportional to the cross-section (a change to larger sizes is not accepted; see 6.1.2 and Table 5).

Further details of the plate are shown in Figures 2, 3 and 4.

Table 1 — Differential pressures between inside and outside the duct for smoke extraction ductwork

Pressure Level[1)]	Operating differential pressure at ambient temperature Pa	Differential pressure for the fire test and pre-test calibration Pa
1	-500	-150
2	-1 000	-300
3	-1 500	-500

Table 2 — Details of perforated plates for testing rectangular ducts (see Figure 3)

Specification for perforations	Pressure level[1)]		
	1	2	3
Total number of holes	550	407	324
Number of holes - horizontally	50	37	36
Number of holes - vertically	11	11	9
Diameter of hole (mm)	10	10	10
Horizontal distance from rim e (mm)	15	15	20
Vertical distance from rim c (mm)	15	15	20
Mounting hole separation a (mm)	19,8	26,9	27,4
Mounting hole separation b (mm)	21,8	22	26,3

1) see Clause 5.

Table 3 — Details of perforated plate for testing circular ducts (see Figure 4)

Specification for perforations	Pressure level[1)]		
	1	2	3
Total number of holes	541	403	319
Diameter of hole (mm)	10	10	10
Horizontal distance from rim e (mm)	30	35	35
Mounting hole separation a (mm)		23	25,5

4.4 Inlet nozzles (fire test)

Each nozzle shall have an internal dimension of 160 mm (see Figure 10, suitable for the standard sizes of ducts specified in 6.1) in accordance with EN ISO 5167-1 and ISO 5221, and shall be suitably mounted to the end of the duct with its piezometric ring connected to appropriate differential pressure measuring equipment. The measuring device shall be capable of measuring to an accuracy of ± 5 %.

4.5 Ambient leakage measuring device

Ambient leakage measuring shall be in accordance with EN ISO 5167-1 and ISO 5221 and suitably mounted to the end of the duct, connected to appropriate differential pressure measuring equipment. The measuring device shall be capable of measuring to an accuracy of ± 5 %.

4.6 Pressure sensors for differential pressure control

A tube sensor as specified in EN 1363-1 shall be located at the end of the duct, inside the duct, at the level of its centre line. A second sensor (e.g. an open end of a measuring tube) shall be located on the same level outside the duct.

A flow control damper shall be provided for a fine control for maintaining the required differential pressure. Alternatively, another suitable device such as a variable speed fan may be used. Any flow control damper shall be attached to the extract fan connecting duct (see 4.8).

4.7 Welded connecting tube

A welded connecting tube is a tube designed to provide a suitable gas tight connection between the inlet nozzles and the oxygen measuring probes shall be provided (for details see Figure 6).

4.8 Extract fan connecting duct

An extract fan connecting duct is a duct designed to connect between the test specimen and the extraction fan. An inlet opening may be provided if a flow control damper is used for fine control of the differential pressure (see 4.6).

4.9 Extraction fan

An extraction fan is a fan for extracting gas under test with a suction capacity of at least 2 x V_n where V_n is the required capacity e.g. for a stated cross-section of V_n = 0,25 m x 1 m, 2 x V_n = 0,5 m^3/s.

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

4.10 Thermocouples

1,5 mm sheathed thermocouples shall be provided for measuring the gas temperature adjacent to the nozzles. An alternative thermocouple may be used, provided it can be shown to have equivalent response time.

4.11 Oxygen measuring equipment

Equipment for measuring the oxygen content of gases shall be provided. This system shall consist of paramagnetic cell oxygen analysers together with appropriate equipment for cooling, filtering and drying the gases. Appropriate connecting tubes and probes shall be provided. The 90 % response time of the complete system shall be 20 s maximum. The accuracy shall be better than ± 0,1 vol %.

4.12 Restraint equipment

Restraining equipment shall be applied as for duct B in EN 1366-1:1999.

4.13 Observation window

An observation window shall be provided between the two nozzles and a suitable method of viewing from a safe distance shall be provided (a mirror arrangement may be found suitable). If the reduction in cross-section of the duct can be assessed sufficiently from the outside (see 9.4), then the observation window may be omitted.

5 Test conditions

5.1 Differential pressure conditions

Depending on the end-use conditions, a pressure selected from Table 1 shall be selected. These levels correspond to typical values used in smoke extraction design.

5.2 Heating conditions

The heating conditions and the furnace atmosphere shall conform to those specified in EN 1363-1 (or, if applicable, EN 1363-2) until 600 °C is reached. The mean temperature of the six furnace thermocouples shall reach 600 °C between 5 min to 10 min from igniting the first furnace burner. After 10 min this temperature shall be maintained between +70 °C, -0 °C for the rest of the test.

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

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

6 Test specimen

6.1 Size

6.1.1 Length

The minimum lengths of the parts of the test specimen inside and outside the furnace shall be as given in Table 5 (see also Figure 1).

Table 4 — Minimum length of test specimen

Orientation	Minimum length (m)	
	Inside furnace	Outside furnace
Horizontal	3,0	4,2

6.1.2 Cross-section

The sizes of duct given in Table 6 shall be tested unless smaller cross-sections are required for specific applications.

Table 5 — Cross-section of test specimen

Rectangular		Circular
Width (mm)	**Height (mm)**	**Diameter (mm)**
1000	250	560

6.2 Number

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

6.3 Design

The test shall be made on a test specimen representative of the complete duct. Each type of duct requires a different approach and an attempt shall be made to reproduce the edge conditions and the method of fixing or support inside and outside the furnace representative of that used in practice. The distance between hangers or supports shall be representative. Where compensators are used in practice, then they shall be incorporated in the test specimen. In this case, the compensator shall be located outside the furnace, approximately 500 mm from the perforated plate.

7 Installation of test specimen

7.1 General

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

The fire-stopping at the penetration through the supporting construction shall be sufficient to prevent leakage of furnace gases.

Parts of the ducts within the furnace shall be exposed to fire from all sides over their whole length.

7.2 Standard supporting construction

A standard supporting construction shall be selected from the specifications detailed in EN 1366-1:1999.

Where the duct passes through an opening in the furnace wall, the opening shall be of sufficient dimensions to allow for the supporting construction to surround all faces of the duct by at least 200 mm.

To ensure that leaking furnace gas does not occur, it is important that the supporting construction and furnace roof is well sealed where it contacts the furnace wall.

7.3 Duct arrangement

7.3.1 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 Figure 1.

7.3.2 Ducts shall be arranged as shown in Figure 1. The end of the ducts within the furnace shall be closed independently of any furnace enclosure by materials and construction similar to the remainder of the duct.

7.3.3 The test arrangement shall include at least one joint or flange connection inside the furnace and at least one joint or flange connection outside it (see Figure 1). Any stiffeners used to maintain the cross-section of the duct shall be arranged at the positions and centres specified by the sponsor. The distance between joint and hangers shall not be less than intended in practice. If the minimum distance has not been specified, hangers shall be arranged so that the joint at mid-span lies midway between them. Centres of the hangers should be specified by the manufacturer and shall be representative of practice.

7.3.4 Two openings shall be provided, one on each vertical side of the duct inside the furnace. The openings shall be positioned (500 ± 25) mm from the furnace wall. Each opening shall have the same breadth/height ratio as the cross-section of the duct and have a total opening area of (50 ± 5) % of the cross-sectional area of the duct. For circular ducts the total opening may be square or circular (Each opening will have an area of (25 ± 5) % of the cross-sectional area of the duct).

7.3.5 There shall be a clearance of (500 ± 50) mm between the top of the duct and the ceiling and at least 500 mm between the underside of the duct and the floor. Similarly, there shall be a clearance of at least 500 mm between the sides of the duct and furnace walls.

7.4 Restraint of ducts

Inside the furnace, the duct will be fully restrained in all directions at the furnace wall or floor remote from the penetration point (see Figure 7). Where there is a possibility of the furnace wall moving, then the fixings shall be made to be independent of the furnace structure. The outside of the duct shall be restrained as shown in EN 1366-1:1999.

7.5 Perforated plate

The perforated plate shall be located (250 ± 50) mm from the external face of the supporting construction. Provision shall be made for the plate to be removed, if necessary during the pre-test calibration described in 10.1.

8 Conditioning

8.1 General

Conditioning of the test construction shall be in accordance with EN 1363-1.

8.2 Water based sealing materials

Conditioning of water base sealing materials shall be in accordance with EN 1366-8.

9 Application of instrumentation

9.1 Thermocouples

9.1.1 Furnace thermocouples (plate thermometers)

Plate thermometers shall be provided in accordance with EN 1363-1 and shall be positioned as shown in Figures 8 and 9. Side A of the plate thermometers shall face the wall of the furnace that is parallel to the longer side of the duct.

9.1.2 Gas temperature within flow nozzles

The gas temperature thermocouples (type K according to EN 60584-1) adjacent to the nozzles shall be arranged with the measuring junction located at the centre line of each nozzle. The distance between the measuring junctions and the inlet of the nozzle is shown in Figure 5 and Figure 6. An alternative thermocouple may be used provided it can be shown to have equivalent response time.

9.2 Pressure

For measurement of the differential pressure between the inside and outside the duct, the pressure probe shall be located horizontally at the end of the duct in the level of centre line of the inlet nozzles as shown in Figures 5 and 6 (Pos. D1).

9.3 Oxygen measurements

Oxygen measurements shall be made using a sensor manufactured from stainless steel tube, having approximate dimensions 6 mm outside diameter and 5 mm internal diameter, which shall be located inside the duct 100 mm upstream from the perforated plate on the centre line of the duct (G1). A second sensor (G2) shall be located after the nozzles at a distance of 100 mm on the centre line of the connecting box (see Figures 5 and 6 for details). Each sensor is connected by suitable pipework to its own single oxygen-measuring instrument.

9.4 Observations of reduction of cross-section

To facilitate observations of reduction of cross-section, an observation window shall be located between the two nozzles or other suitable places.

10 Test procedure

10.1 Pre-test calibration

10.1.1 Oxygen-measuring instrument

Calibrate the measuring instrument just prior to the fire test.

10.1.2 Perforated plate

Switch on the extract fan. Check that both the required differential pressure and air velocity of 2 m/s are obtained under ambient conditions. Ensure the air velocity is within ± 15 % and the differential pressure is within ± 3 %. However, if these values cannot be achieved, switch off the fan, remove the perforated plate and as appropriate, drill additional holes or seal some holes using screws. Replace the perforated plate and repeat the procedure until the required values have been achieved.

NOTE The initial check on the perforated plate should be undertaken on a duct section provided for the purpose and not the test specimen where the removal of the plate may create problems.

10.2 Leakage measurement at ambient temperature

10.2.1 Seal the two openings in the duct that are located inside the furnace.

10.2.2 Switch on the extract fan, making any fine adjustments so that the differential pressure reading is within ± 3 % of the prescribed value given in Table 1 throughout the time over which the leakage measurements are taken.

NOTE The pressure level may be selected by the sponsor. Alternatively it is possible for the sponsor to change to another pressure level depending on the leakage criteria in compliance with 11.2.

10.2.3 Switch on measuring equipment related to the ambient leakage measuring device.

10.2.4 After stable conditions are achieved, for a period of not less than 5 min measure and record the pressure differential through to the ambient leakage measuring device at the selected pressure level. Where information is required on leakage at other pressure levels, repeat the procedure described in 10.1.2 to 10.2.4. Calculate the airflow in accordance with EN ISO 5167-1 and ISO 5221.

10.2.5 Switch off measuring equipment and the extraction fan.

10.2.6 Remove sealing from openings.

10.3 Fire test

10.3.1 Extraction fan

Switch on the extraction fan and make any adjustments to the damper or fan to maintain the differential pressure at the selected pressure level given in Table 5.

10.3.2 Ignition of furnace

Switch on all measuring equipment and ignite the furnace. The time for the evaluation of test data starts in accordance with EN 1363-1:1999, 10.3.

10.3.3 Furnace conditions

Throughout the test, maintain the furnace conditions to comply with the requirements of Clause 5. Make any adjustments necessary to maintain the differential pressure readings inside the duct to within ± 3 % of the appropriate value given in the third column of Table 1 after 5 min of the start of the test.

10.3.4 Temperatures and pressures

Record all temperatures and pressures at the intervals specified in EN 1363-1.

10.3.5 Oxygen measurements

After the first fifteen minutes of the test, start recording the oxygen measurement, readings being taken at the furnace location and then at the nozzle location.

10.3.6 General observations

Take observations on the general behaviour of the duct throughout the test, in particular observe for collapse of any part of the duct inside and outside of the furnace that would effect the liability of function for the purpose for which it is intended.

10.3.7 Reduction of cross-section

Throughout the test, take measurements around the top and bottom outside surface and both sides of the duct outside the furnace to determine any reduction in cross-section of the duct.

These measurements shall be taken at three locations outside the furnace between the perforated plate and the end of the duct. Supplement these measurements by observations. As soon as possible after the end of the fire test, remove sufficient of the apparatus to allow the inside of the tested duct to be examined so that any reduction in cross-section can be verified.

10.3.8 Leakage calculations

Using the values recorded, calculate the leakage from the O_2 measurements as follows:

$$m_L = \frac{C_f \times m_{G2} \times (c_{G2} - c_{G1})}{21 - c_{G1}}$$

where

m_L is the leakage mass flow (kg/s)

m_{G2} is the mass flow at point G_2 near inlet nozzles (kg/s)

c_{G1} is the oxygen content of first sensor (vol-%)

21 is the oxygen concentration of ambient standard atmosphere (vol-%)

c_{G2} is the oxygen content of second sensor (vol-%)

C_f the correction factor, is determined as follows:

C_f = 0,94 for liquid fuel (oil)

C_f = 0,91 for gas

NOTE Gaseous fuel (natural gas H = high and L = low) with approximately 85 to 100 vol-% concentration of methane (CH_4), see Annex B and C.

V_L shall be used to determine compliance with the leakage criteria stated in 11.3 and is calculated as:

$$V_L = \frac{m_L}{\rho}$$

where

V_L is the leakage volume flow (m^3/s)

ρ is the density of dry air at 20 °C/1013 hPa (= 1,2 kg/m^3)

10.3.9 Termination of test

The test may be terminated

a) at the request of the sponsor;

b) at end of classification period (or if a serious failure occurs);

c) when criteria is exceeded leakage (but this may need to be calculated after the test); if duct inside furnace collapses and reduction of cross-section (confirmed after test).

11 Performance criteria

11.1 General requirements

Under the specified pressure conditions given in Table 1, the fire resisting smoke extraction duct shall satisfy the requirements given in 11.2 and 11.3. In addition, smoke extraction ductwork shall be made of non-combustible materials that are classified A1 and A2-S1, d0.

The pressure levels are distinguished for smoke extraction ductwork. In the course of testing smoke extraction ductwork in accordance with Clause 10, the pressure levels defined in Table 5 shall be observed.

11.2 Criteria at ambient temperature

Smoke extraction ductwork of all pressure levels intended for installation remote from the fire zone from which smoke is to be extracted, shall not have a leakage exceeding 10 m^3/h per 1 m^2 of total internal surface area of the complete duct (inside and outside the furnace) when tested in accordance with 10.2.

11.3 Criteria under fire conditions

11.3.1 General

When tested in accordance with 10.3, smoke extraction ductwork for use in combination with smoke exhaust fans and which is intended to extract smoke from the compartment to outside, without passing through other compartments, shall comply with 11.3.2 to 11.3.4.

11.3.2 Leakage

The duct shall not have a leakage exceeding 10 m^3/h per 1 m^2 of internal surface area. This shall be related to the surface area of the duct from the perforated plate to the end of the duct by the inlet nozzles.

11.3.3 Reduction in cross-section

The internal dimensions (width and height for rectangular ducts, diameter for circular ducts) of the smoke extracting ductwork shall not decrease by more than 10 % during the test inside and outside of the furnace. This shall be by the measurements taken in accordance with 10.3.7.

11.3.4 Mechanical stability

If the duct inside the furnace collapses such that the performance of the duct cannot be maintained, this shall be regarded as failure under this criterion. The critical opening area should be 50 % of the nominal cross section of the duct.

12 Test report

In addition to the items required by EN 1363-1, the following shall also be included in the test report.

a) The method of fixing, support and mounting, as appropriate for the type of specimen, and a description of the method and materials used to seal the gap between the duct and opening provided in the wall to accommodate the duct, the details of the supporting construction.

b) Other observations made during the test including a complete record of the following test parameters as a function of time:

1) furnace temperature;

2) furnace pressure;

3) volume flow measuring station gas temperatures;

4) volume flow measuring station pressure differential;

5) calculated volume flow rate;

6) differential pressure between inside and outside the duct (negative values indicate underpressure);

7) oxygen-concentration.

c) Details of the leakage measured in accordance with 10.2 and 10.3.8. Where the test is terminated before the occurrence of failure under the relevant criteria, this shall be reported.

d) Where steel ducts are used, the thickness, leakage class to EN 1751 and details of any external stiffening or internal stiffeners if incorporated.

e) Full calculations in accordance with 10.3.8.

f) All measurements and observations recorded in respect to reduction in cross-section.

13 Direct field of application of test results

13.1 General

The requirements for direct field of application of test results for all ducts tested to this standard apply to

— all temperatures below 600 °C;

— same time duration;

— same pressure level.

13.2 Duct sizes

A test result obtained for the standard sizes of duct specified in 6.1 is applicable to all dimensions up to the size tested together with a maximum size given in Table 6.

Table 6 — Applicability of duct size tested to other sizes

	Rectangular Width mm	**Rectangular Height mm**	**Circular Diameter mm**
Tested standard size:	1 000	250	560
Maximum sizes up to:	1 250	1 000	1 000
Decrease of size:	No limit	No limit	No limit

For ducts tested with smaller sizes than the specified standard sizes, no extrapolation to larger sizes can be allowed. For sizes larger than the allowable upper limits for extrapolation, no extrapolation rules covering larger sizes are included in this standard. If a circular duct is protected by an independent rectangular protection system, the internal dimensions of the protection system shall be used to validate the field of application.

13.3 Hangers

For larger duct sizes as tested (Table 6) the stress in the vertical rods of the hangers should be less or equal than the calculated values of the test data.

13.4 Pressure difference

The test results of the duct are applicable to ducts with an underpressure or overpressure up to the relevant values as specified in Table 7.

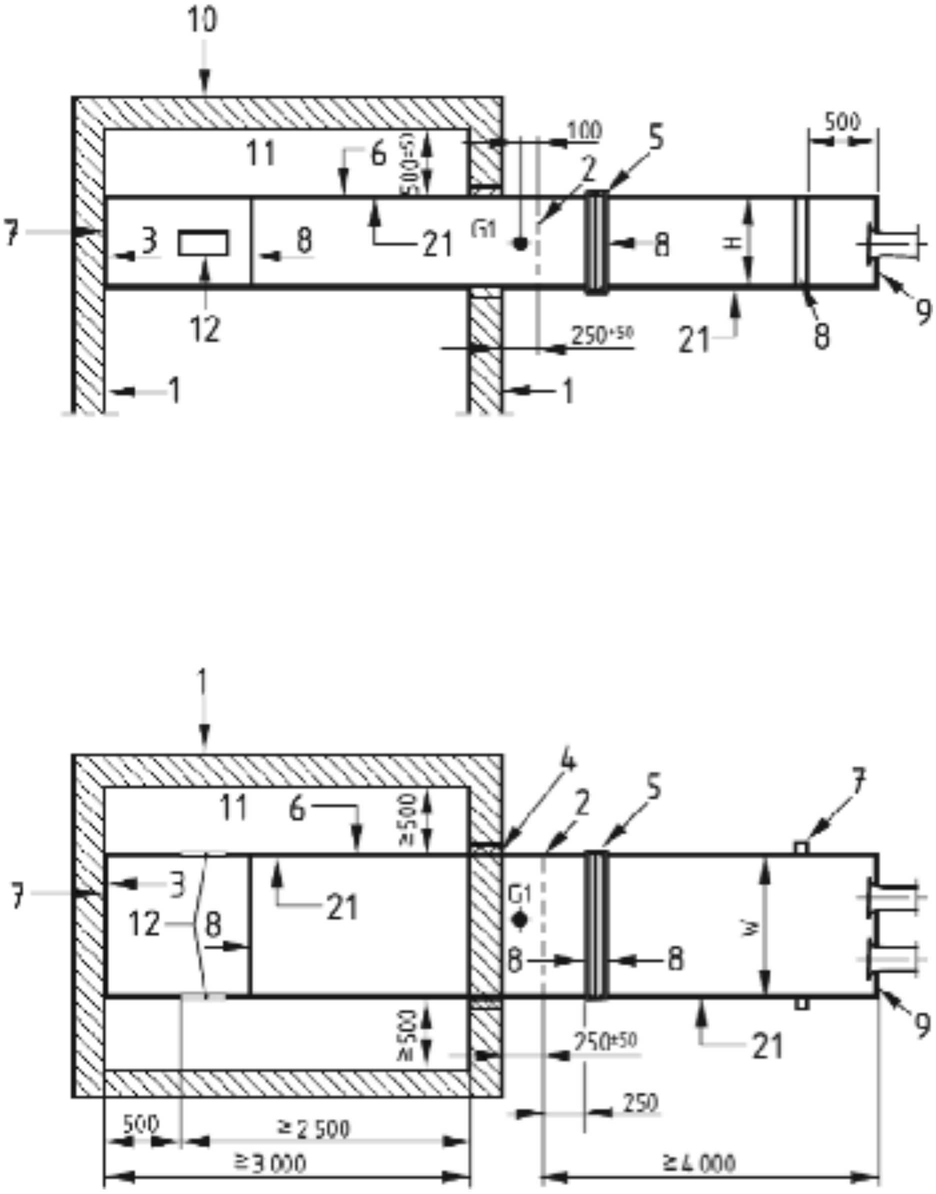
Table 7 — Pressure difference

Tested pressure level (see Table 1)	Underpressure (Pa) up to	Overpressure (Pa) up to
1	- 500 Pa	500 Pa
2	- 1 000 Pa	500 Pa
3	- 1 500 Pa	500 Pa

13.5 Number of sides of duct

No extrapolation to two or three sided ducts is permitted.

Dimensions in millimetres



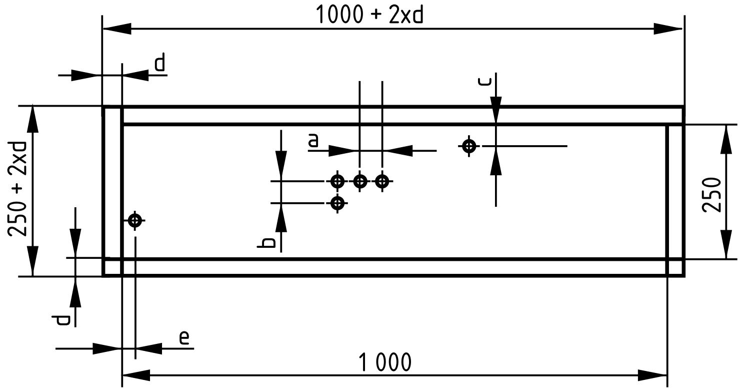
NOTE The sealed end should be independent of the furnace wall.

Key

1 furnace wall
2 perforated plate
3 fixed end of the duct
(May pass through furnace wall)
4 fire stopping as in practice
5 compensator
6 duct surface
7 rigid restraint see Figure 7
8 joints
9 duct end plate
10 furnace roof
11 furnace chamber
12 openings: total cross section
50 % of duct cross section
21 test duct
W width
H height
G1 gas sample sensor at the perforated plate

Figure 1 — Test arrangement for horizontal ducts

Dimensions in millimetres



Tickness: 2,5 mm

Material: Heat resisting steel
Percentage of Chrome minimum 19 %
Percentage of Nickel minimum 11 %

NOTE 1 For installation details see Figure 4.

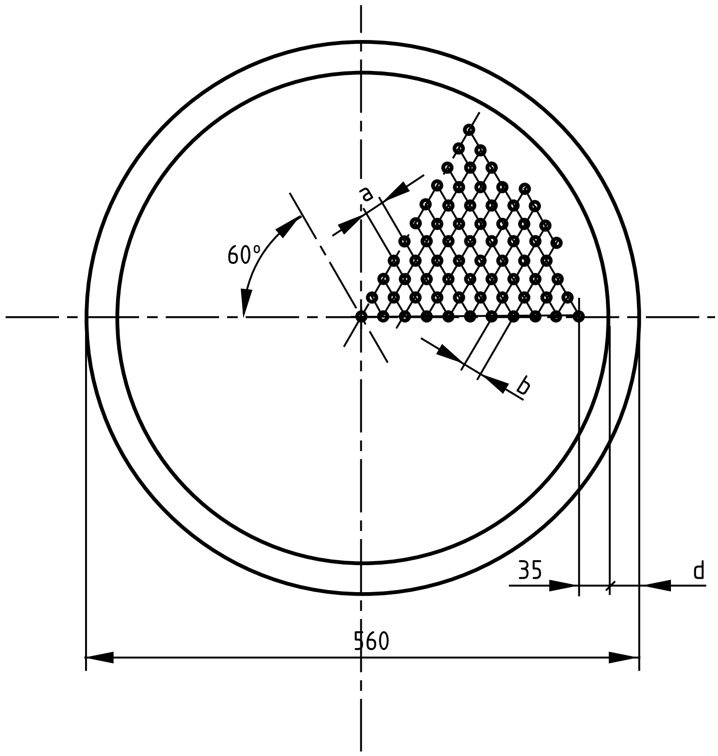
Pressure stage	1	2	3
Pressure differential at ambient temperature (Pa)	-500	-1 000	-1 500
Pressure differential during the fire test (Pa)	-150	-300	-500
Diameter of hole (mm)	10	10	10
Number of holes horizontal (piece)	50	37	36
Number of holes vertical (piece)	11	11	9
Number of holes (piece)	550	407	324
Distance rim horizontal e (mm)	15	15	20
Distance rim vertical c (mm)	15	15	20
Mounting hole a separation (mm)	19,8	26,9	27,4
Mounting hole b separation (mm)	21,8	22	26,3

NOTE 2 The values given in the table apply for standard rectangular duct size 1 000 mm × 250 mm.

For smaller sizes the number of holes will be reduced proportional to the smaller cross section.

Figure 2 — Detail of the perforated plate for test duct with dimensions width × height = (1 000 · 250) mm

Dimensions in millimetres



Material: Heat resisting steel
Percentage of Chrome minimum 19 %
Percentage of Nickel minimum 11 %

NOTE 1 For installation details see Figure 4

Pressure stage	1	2	3
Pressure differential at ambient temperature (Pa)	-500	-1 000	-1 500
Pressure differential during the fire test (Pa)	-150	-300	-500
Diameter of hole (mm)	10	10	10
Number of holes (piece)	541	403	319
Mounting hole a separation (mm)	20	23	25,5

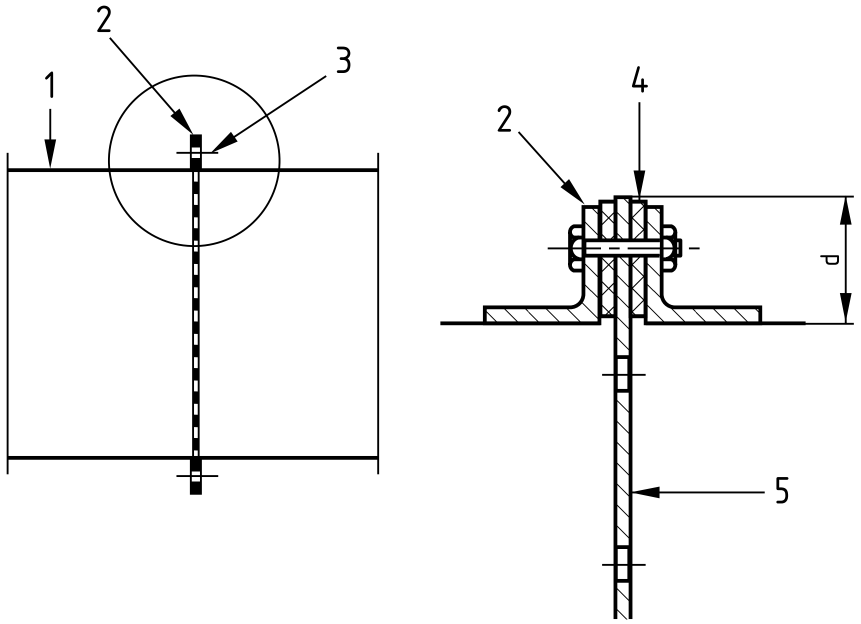
NOTE 2 The values given in the table apply for standard circular duct size diameter 560 mm. For smaller sizes the number of holes will be reduced proportional to the smaller cross section.

NOTE 3 Where d is the width of the flange of the duct.

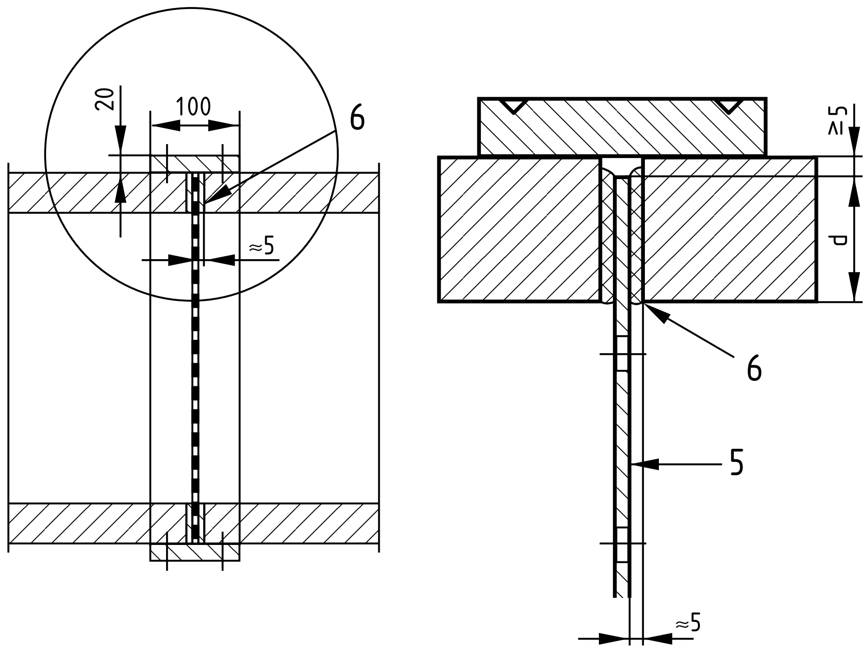
Figure 3 — Detail of the perforated plate for test circular duct with diameter = 560 mm

Dimensions in millimetres

Installation of the perforated plate into the steel sheet duct



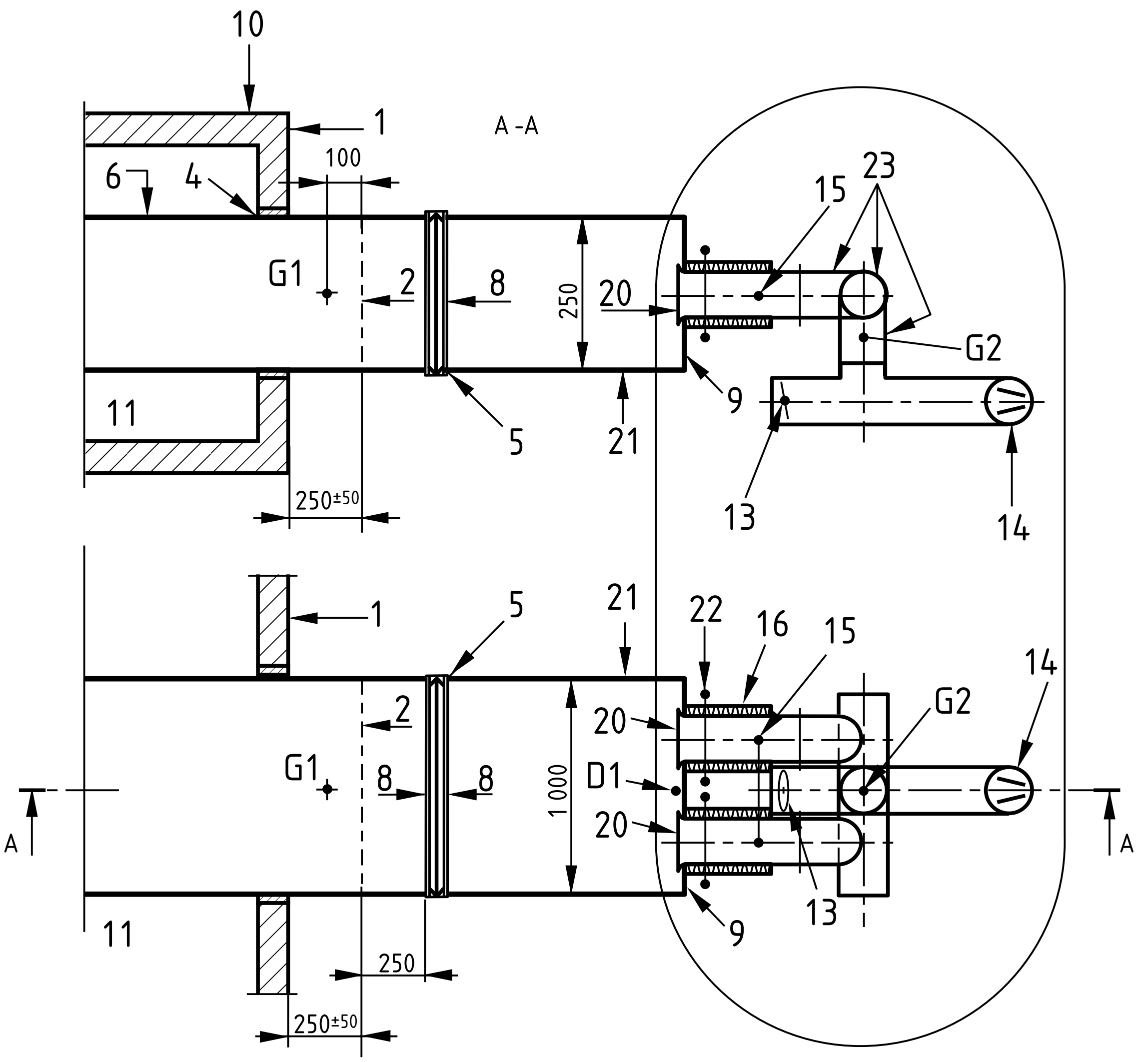
Installation of the perforated plate into the duct of fire resisting boards



1 duct
2 flange
3 screwed
4 ceramic felt strip
5 perforated plate
6 ceramic wool or similar

Figure 4 — Mounting of perforated plate

Dimensions in millimetres



Key

1	furnace wall	14	fan
2	perforated plate	15	thermocouple 1,5 mm diameter type K
4	fire stopping as in practice	16	insulation
5	compensator	20	inlet nozzle
6	duct surface	21	test duct
8	joints	22	piezometric ring
9	duct end plate	23	connecting tube
10	furnace roof	D1	pressure tube
11	furnace chamber	G1	gas-testing probe at the perforated plate
13	flow pressure control damper	G2	gas-testing proble

Figure 5 — Arrangement of gas-testing probes

Dimensions in millimetres

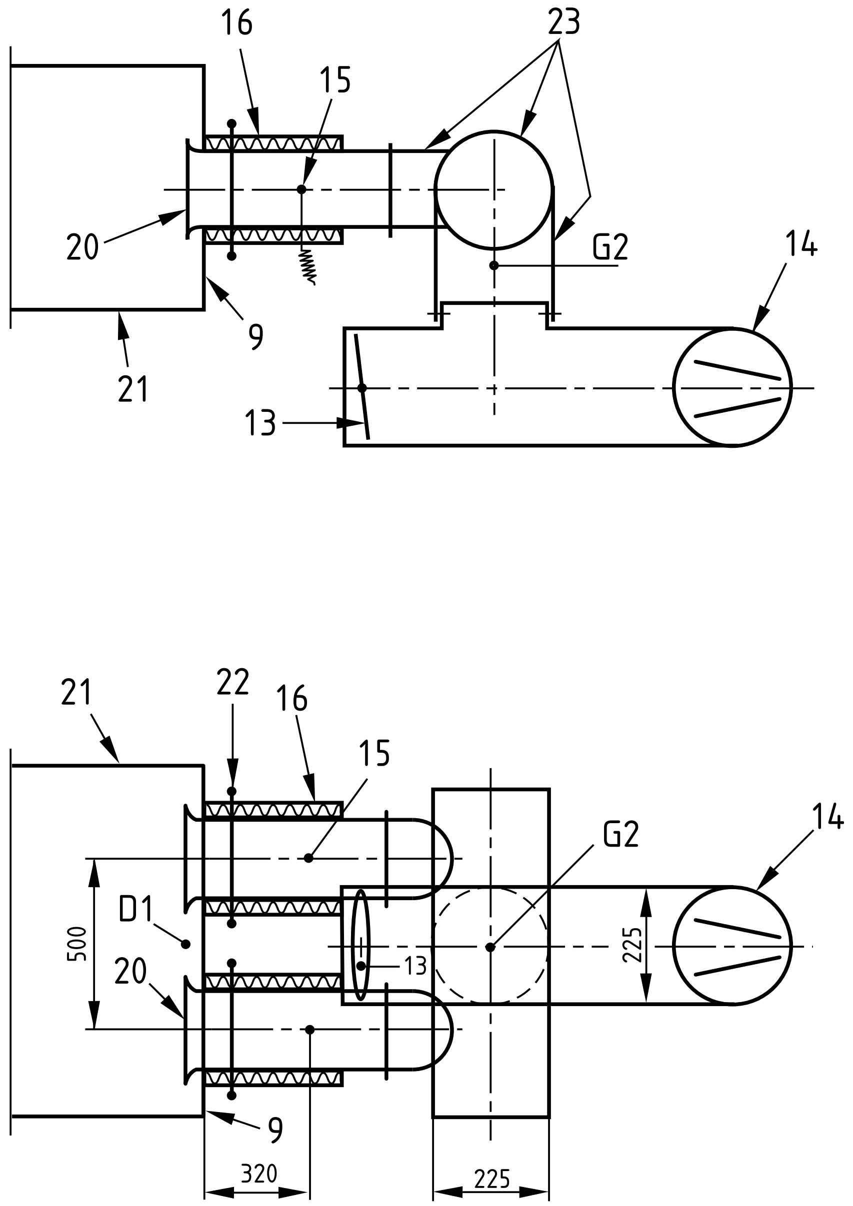
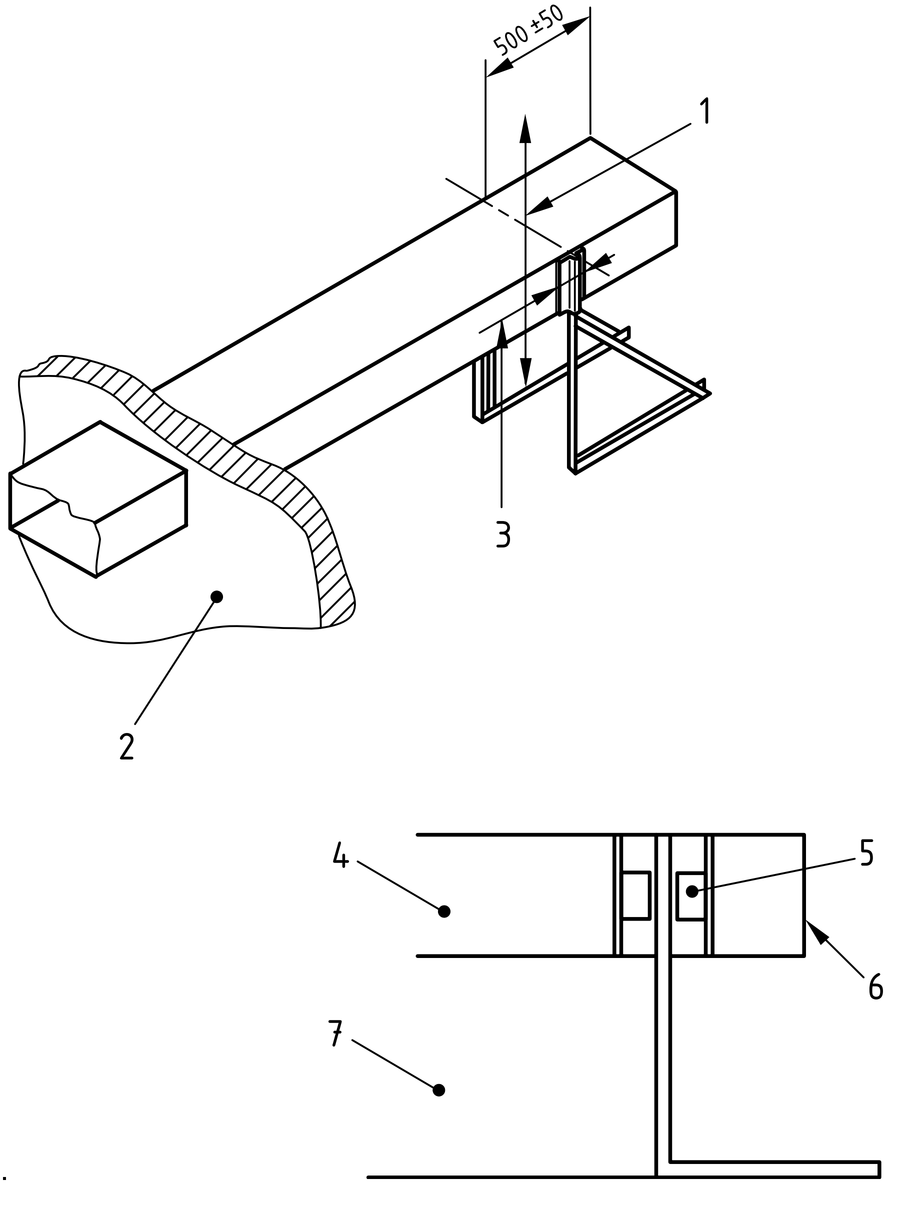


Figure 6 — Detail to Figure 5 (same key as Figure 5)

Dimensions in millimetres

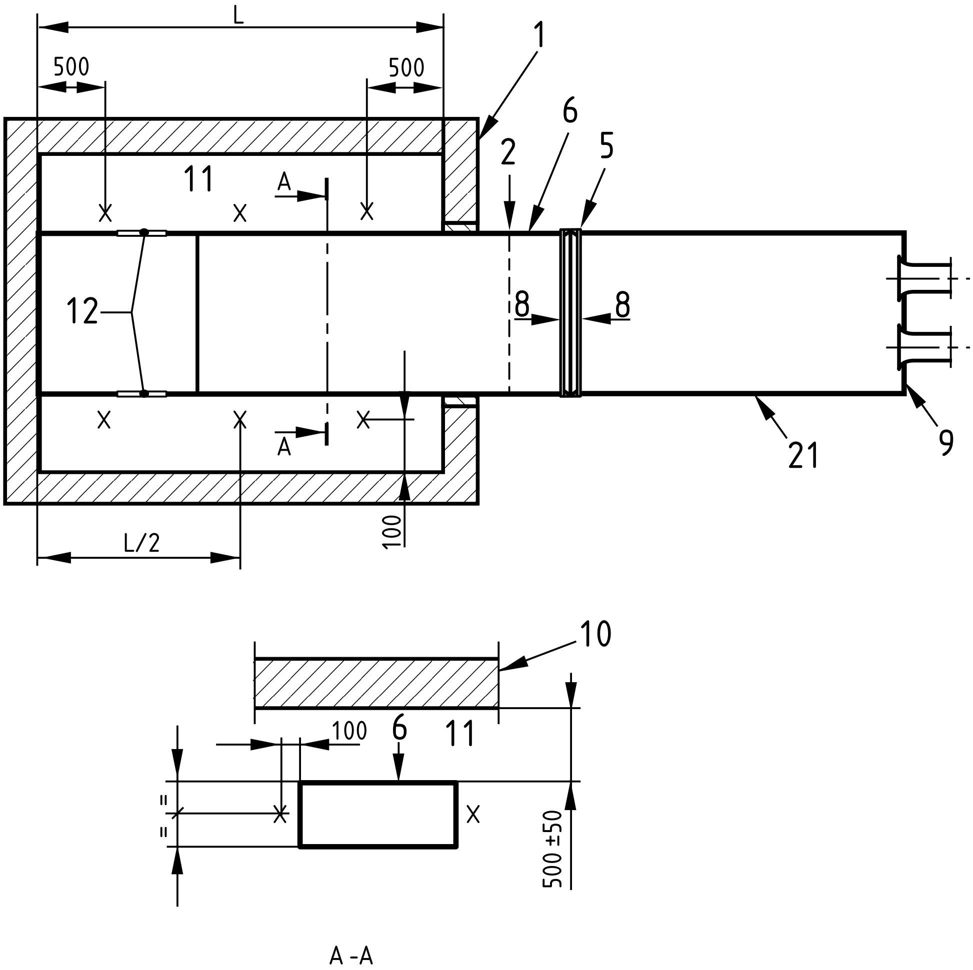


Key

1	allows movement in both directions
2	furnace
3	resists movement in both directions (Location of device for measuring restraint forces)
4	duct
5	stiff load cells
6	duct end plate
7	method of applying and measuring restraint using two pairs of stiff load cells (as example)

Figure 7 — Restraint of Duct C outside the furnace

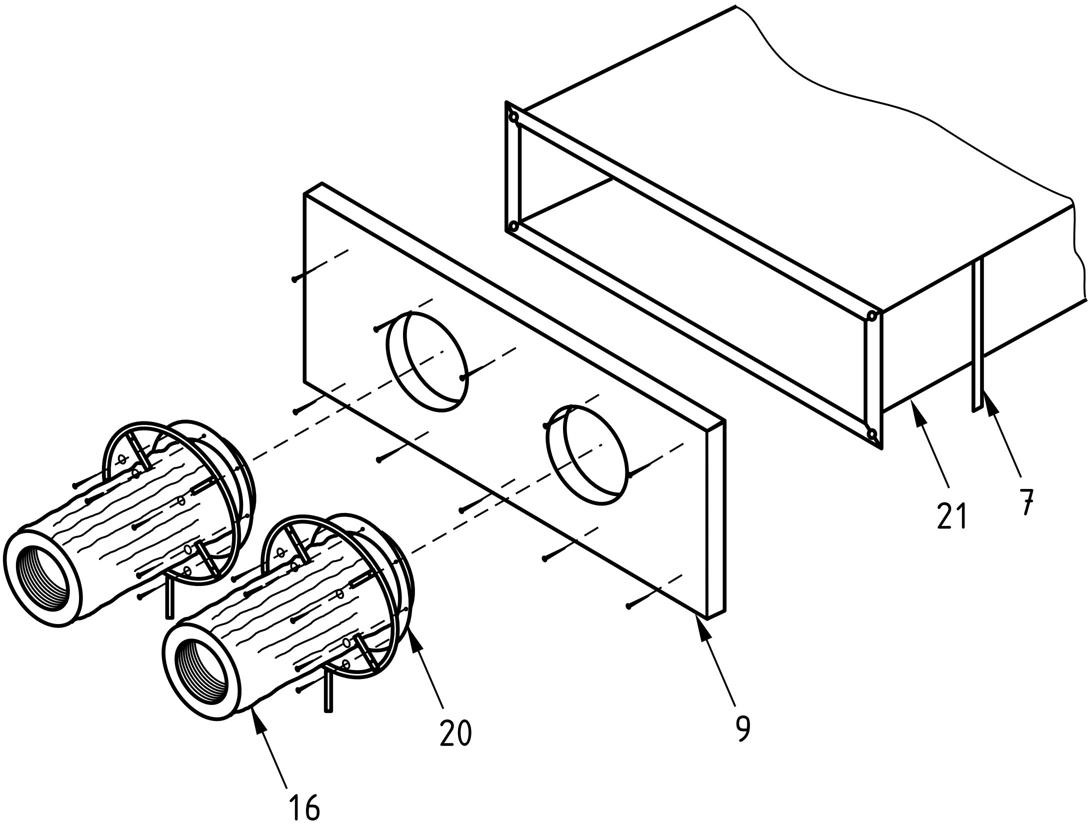
Dimensions in millimetres



Key

1 furnace wall
2 perforated plate
5 compensator
6 duct surface
8 joints
9 duct end plate
10 furnace roof
11 furnace chamber
12 openings: total cross section 50 % of duct section
21 test duct
x furnace thermocouples see EN 1363-1

Figure 8 — Arrangement of furnace thermocouples



Key

7 rigid restraint (see Figure 7)
9 duct end plate
16 insulation
20 inlet nozzle
21 test duct

NOTE 1 For circular ducts use for nozzles mounting adapter from circular to rectangular is suitable (length of adapter L = 1000 mm).

NOTE 2 For sealing of nozzles it is recommended to use suitable products.

Figure 9 — Example of mounting the inlet nozzles to the duct end plate

Dimensions in millimetres

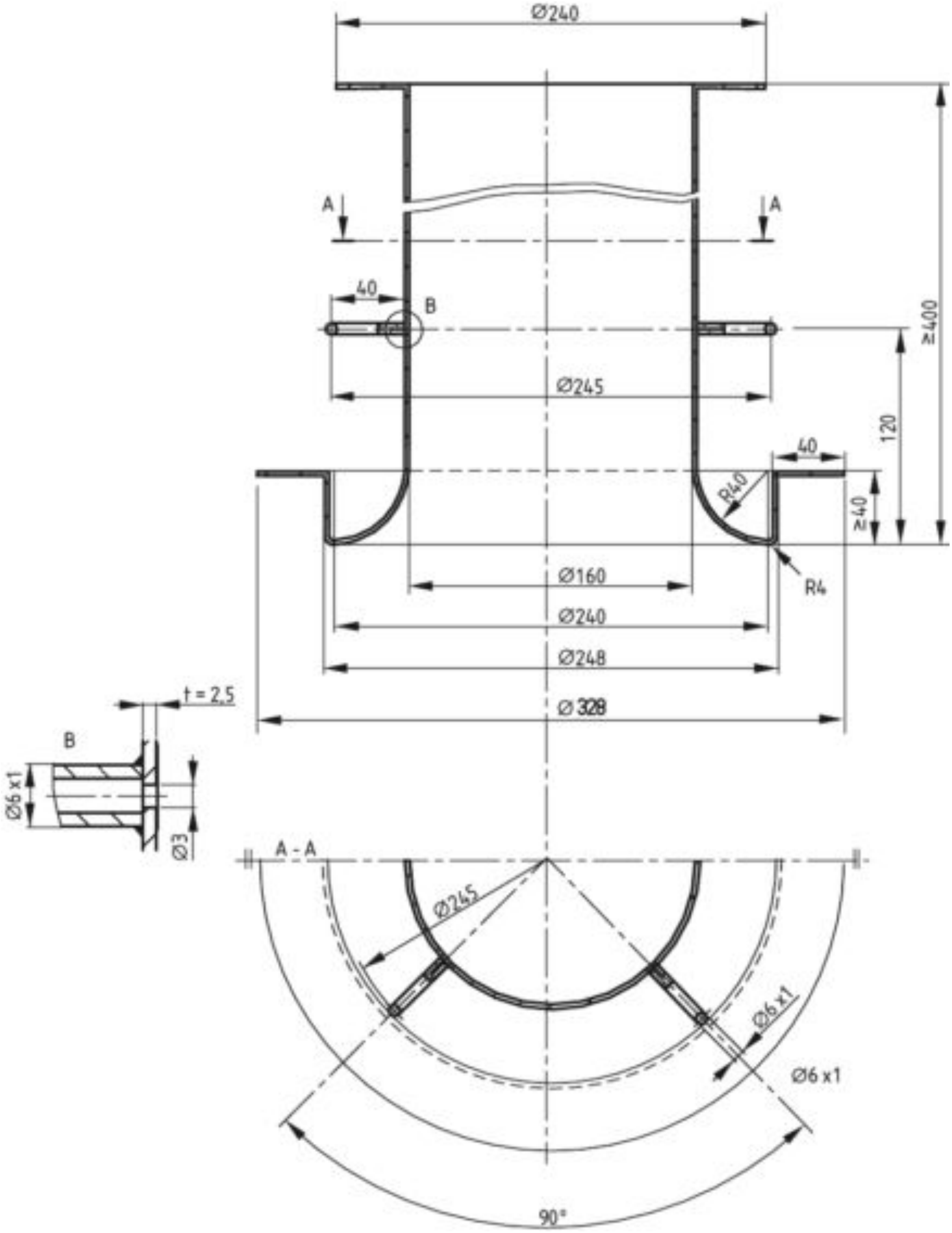


Figure 10 — Inlet nozzle (stainless steel, t=2,5 mm)

Annex A
(informative)

Measurement of volume/mass flow

A.1 Hints on measuring volume flow or mass flow with differential pressure devices

The volume rate of flow or mass rate of flow should be calculated in accordance with EN ISO 5167-1 and ISO 5221 on the basis of pressure differential measurements and temperature measurements, using a suitable pressure differential device and on the basis of the actual physical properties (density, absolute (barometric) pressure, viscosity etc.).

A.2 Density

For the determination of the volumetric flow in accordance with EN ISO 5167-1 and ISO 5221, the actual density of the fluid is needed. The fluid is air or flue gas from a furnace. Flue gas contains N_2 and CO_2 as well as H_2O in unknown concentrations. However, for calculation purposes air and flue gas may be treated as dry air and the density may be calculated from the law of ideal gases:

$$p \cdot v/T = p/(\rho \cdot T) = R = \text{constant} \qquad \text{(A.1)}$$

where

R is the gas constant for air, in J/(kg·K);

v is the specific volume, in m^3/kg;

p absolute pressure, in Pa;

T absolute temperature, in K;

ρ is the density of dry air at absolute pressure and absolute temperature, in kg/m^3.

From this follows:

$$\rho = \rho_0 \times p / \rho_0 \times T_0 / T \qquad \text{(A.2)}$$

where

ρ is the density of dry air at absolute temperature T_0 and absolute pressure p_0.

Generally the condition index "0" is defined as 0 °C (T_0 = 273,15 K) and p_0 = 1013,25 hPa (= 760 Torr), that ρ_0 = 1,293 kg/m^3 shall be used.

A.3 Absolute Pressure (barometric pressure)

The barometric pressure shall be used by means of a barometer.

In cases where a barometer is not available and the level Z (in metres) of the laboratory above sea level does not exceed 500 m, the use of the mean value of barometric pressure according to the following formula is recommended:

$$\rho_a = 1\,013 - Z/8 \quad [\text{hPa}] \tag{A.3}$$

where

Z is the level, in metres, of the laboratory above sea level.

NOTE Common weather conditions may cause deviations of about 1 % related to the mean barometric pressure. In extreme weather conditions, the deviations may rise to about 3 % (e.g. severe winds etc.).

A.4 Viscosity

The actual viscosity is required when the Reynolds number Re needs to be calculated (e.g. when choosing the suitable size or measuring range of a measuring device).

The kinematic viscosity v depends on temperature and pressure. The dynamic viscosity μ is independent of pressure. It only depends on temperature. The relationship between the two viscosities is defined as

$$v = \mu/\rho \tag{A.4}$$

The dynamic viscosity μ is given in the form of a table, a graph and as a formula, in Table 1, Figure A.1 and Equation (A.5).

Dynamic viscosity of dry air versus temperature is calculated using the following polynomial formula:

$$\mu = \sum_{i=0}^{3} \left(a_i \times t^i \times 10^{-3i}\right) \cdot 10^{-6} \qquad [\text{kg/(s} \cdot \text{m)}] \tag{A.5}$$

where

$$\alpha_0 = 17{,}22; \alpha_1 = 48{,}02; \alpha_2 = -24{,}73; \alpha_3 = 7{,}287$$

t is the temperature within the range -50 °C ≤ t ≤ 1000 °C.

A.5 Characteristic data of the inlet nozzles according to Figure 10

The mass flow within the inlet nozzles is

$$\dot{m}_{G2} = \sum_{\text{Nozzle j=1}}^{\text{j=2}} \alpha_j \cdot \varepsilon_j \cdot A_{\text{geom j}} \sqrt{2 \cdot \rho_0 \cdot \Delta p_j \cdot \frac{273{,}15}{273{,}15 + \vartheta_j} \cdot \frac{p_a}{1013{,}25}} \tag{A.6}$$

with

flow coefficient $$\alpha_j = 1 - 0{,}004 \cdot \sqrt{\frac{10^6}{Re_j}} \tag{A.7}$$

expansion coefficient $\varepsilon_{\mathrm{j}} \approx 1 - 0{,}55 \cdot \frac{\Delta p_{\mathrm{j}}}{p_{\mathrm{a}}}$ (A.8)

geometrical free opening at the nozzle $A_{\mathrm{geom,\,j}}$

density of dry air under standard conditions ρ_0 = 1,293 kg/m³

differential pressure at the nozzle j Δp_{j}

temperature within the nozzle ϑ_{j}

atmospheric pressure p_{a}

Reynolds number $Re_{\mathrm{j}} = \frac{w_{\mathrm{j}} \cdot d}{\nu}$

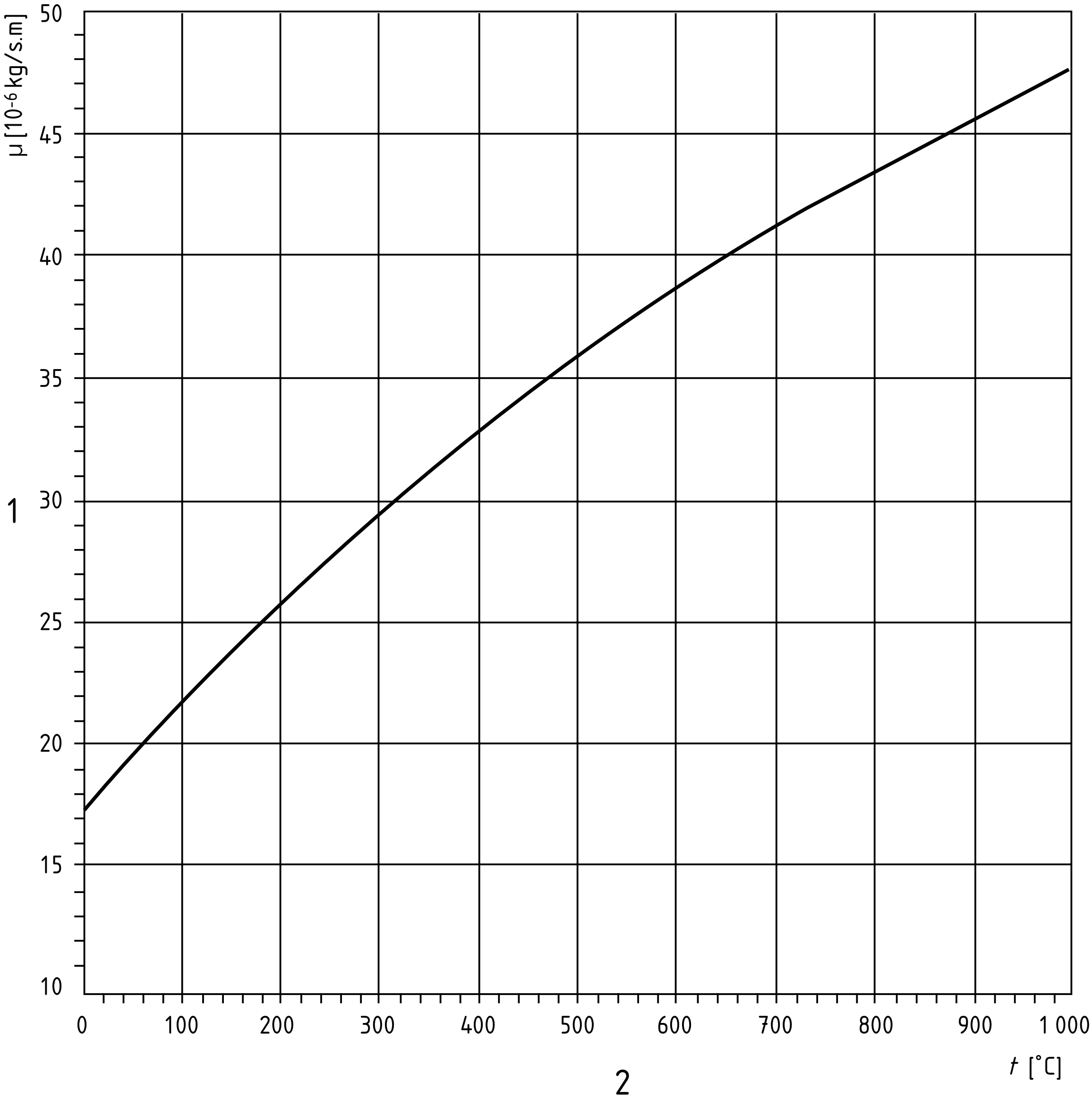
diameter of the nozzle d

flow velocity within the nozzle w_{j}

kinematic viskosity ν, see formulae (A.4) and (A.5)

Table A.1 — Dynamic viscosity of dry air versus temperature(computed from Equation (A.5); maximum deviation from ISO 10294-3, Table 1 is 0,44 %)

Temperature °C	Absolute temperature K	Dynamic viscosity 10^{-6} kg/s.m
-50	223,15	14,8
0	273,15	17,2
20	293,15	18,2
40	313,15	19,1
60	333,15	20,0
80	353,15	20,9
100	373,15	21,8
120	393,15	22,6
140	413,15	23,5
160	433,15	24,3
180	453,15	25,1
200	473,15	25,9
250	523,15	27,8
300	573,15	29,6
350	623,15	31,3
400	673,15	32,9
450	723,15	34,5
500	773,15	36,0
600	873,15	38,7
700	973,15	41,2
800	1 073,15	43,5
900	1 173,15	45,7
1000	1 273,15	47,8
NOTE Interpolation between values is allowed.		



Key

1 dynamic viscosity μ[10^{-6}kg/s·m]

2 temperature

Figure A.1 — Dynamic viscosity of dry air versus temperature

Annex B
(informative)

Measurement of oxygen content

Details on measuring oxygen content with parametric cell analysers

The leakage mass flow is calculated according to 10.3.8 with the formula

$$\dot{m}_{\mathrm{L}} = C_{\mathrm{f}} \cdot \dot{m}_{\mathrm{G2}} \cdot \frac{c_{\mathrm{G2}} - c_{\mathrm{G1}}}{21 - c_{\mathrm{G1}}} \quad \text{(B.1)}$$

c_{G1} and c_{G2} are the O_2 content of the flue gas from the furnace chamber at locations G1 and G2 at the beginning and at the end of the test duct. Besides the mass flow $\dot{m}_{G2}$ and the correction factor C_f, the formula consists of the quotient out of two differences of oxygen content. The possible numerical values during the tests according to this standard are given in Table B.1.

Table B.1 — Limits of operating fields during tests according to this standard

Line	Values to be determined by measurement	600 °C within the furnace	
1	volume flow rate at the end of the test duct in [m³/h] under standard conditions	1 050	1 250
1 a	mass flow rate at the end of the test duct in [kg/h]	1 360	1 615
2	c_{G1} at the begin of the test duct in [vol % O_2]	12,5	13,5
3	$\Delta c = 21 - c_{G1}$	8,5	7,5
4	$\Delta c = c_{G2} - c_{G1}$ throughout the duct in [vol % O_2]		
4a	for criterion S (smoke leakage)	0,45	0,33
4b	for criterion E (integrity)	0,84	0,60

The accuracy of the oxygen measuring devices shall be better than ± 0,1 vol % according to 4.11. In order to receive reliable results with these measuring devices, the following recommendations should be followed.

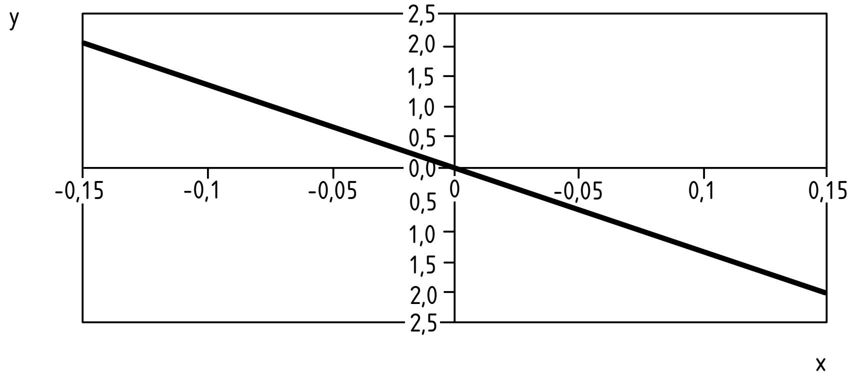
Choice of O_2 measuring devices

Two devices are needed for the O_2 measurements. They should be of the same make and type and have the same characteristics. The digit jump between two readings should not exceed 0,05 vol % O_2. A zero (0 vol % O_2) and end point drift (21 vol % O_2) is not quite avoidable according to experience and should therefore be considered for the evaluation of the measuring results.

Effect of O_2 measuring device errors

Assuming that two exactly the same devices for measuring the oxygen concentration at the points G1 and G2 show approximately the same error of up to 0,1 Vol.-% O_2 with the same sign, the device error will only have an effect on the denominator of formula (B.1).

The biggest error occurs with the smallest possible difference ($21 - c_{G1}$) in the denominator. This will happen with the values according to Table B.1 for $\Delta c = 21 - c_{G1} = 7{,}5$ vol %. Considering the observed oscillation of the measuring results due to the 0,05 Vol.-% digit jumps of such devices, at worst this causes errors as they can occur at 600 °C according to Figure B.1.



Key

x error in measuring the O_2 concentration in Vol-% O_2 for 13,5 % O_2 concentration at the beginning of the duct G1

y resulting Error in Calculating the Leakage in %

Figure B.1 — Greatest effect of the measuring device error at 600 °C within the furnace

The measurements with oxygen concentration measuring devices having the required accuracy at 600 °C within the furnace chamber, afflict the leakage assessment according to Figure B.1 with a maximum error of ± 2,0 %. For the determination of the mass flow $\dot{m}_{G2}$ this standard requires according to 4.4 (inlet nozzles) an accuracy of ± 5,0 %. With the law of error propagation (square root of the total square errors)

$$\text{Error}_{\text{total}} = \sqrt{\text{Error}^2_{\text{Inlet nozzle}} + \text{Error}^2_{\text{O2 measurement}}} \quad [\%] \tag{B.2}$$

follows that the total error can be approximately ± 5,4 %.

Zero and end point drift

The correction of the zero and end point drift should be carried out for each fire test according to this test standard. For this the following steps according to Figure B.2 are necessary for each oxygen measuring device.

1) Starting of the measuring devices at least one day prior to the fire test

2) Adjustment of the zero point with nitrogen and adjustment of the end point (21 vol % O_2) with ambient air approximately two hours prior to the start of the fire test

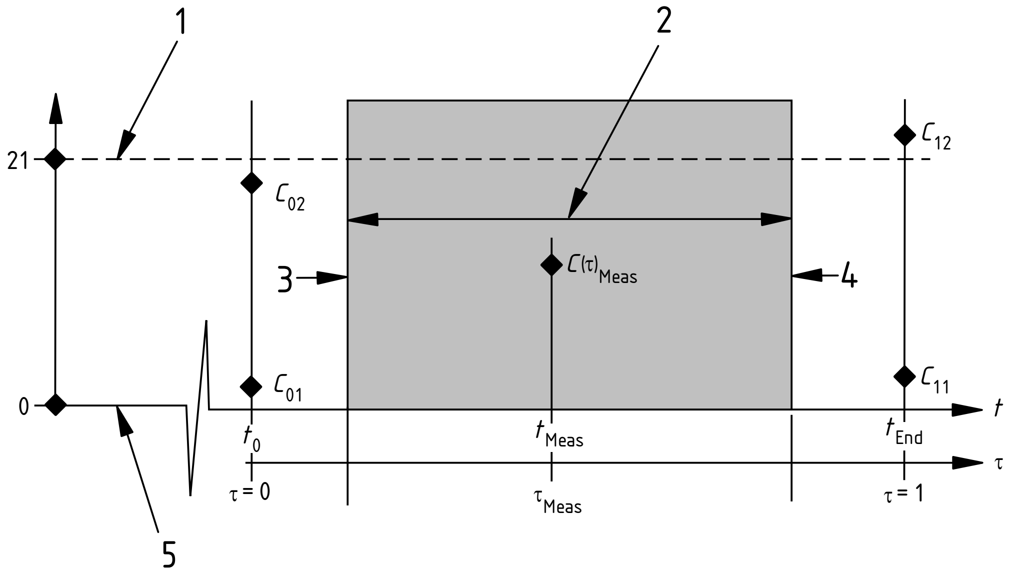
3) Recording of the zero point c_{01} and end point c_{02} control measurements at the moment of t_0 = approximately 20 min prior to the start of the test and for a period of three minutes

4) Recording of the O_2 measurements during the fire tests extending from $t_{\text{Start of fire test}}$ to $t_{\text{End of fire test}}$

5) Recording of the zero point c_{11} and end point c_{12} control measurements at the moment of t_{End} = approximately 10 min after end of the fire test

6) Calculation of the average values of c_{01}, c_{02}, c_{11} und c_{12} during the recording of the control measurements according to item 3. and item 5.

7) Correction of the O_2 concentrations $c(\tau)_{\text{Meas}}$ that have been measured during the fire test with **formula (B.3)** and **formula (B.4)** (assuming a constant drift, the first accolade {...} in formula (B.3) carries out the zero point correction; the second accolade {...} in formula (B.3) carries out the scaling of the measuring range from 0 to 21 vol % O_2).



Key

1 adjustment to 21 vol-% O_2 using Air

2 duration of Fire Test

3 $t_{\text{Begin of fire test}}$

4 $t_{\text{End of fire test}}$

5 adjustment to 0 vol % O_2 using Nitrogen N_2

Figure B.2 — For the correction of the zero point and end point drift (21 vol % O2)

Formula for the elimination of error due to zero point and end point drift of the O_2 measuring devices

$$c_{\text{corr}} = \left\{c(\tau)_{\text{meas}} - c_{01}\cdot(1-\tau_{\text{meas}}) - c_{11}\cdot\tau_{\text{meas}}\right\}\cdot 21\cdot\left\{\frac{1-\tau_{\text{meas}}}{c_{02}-c_{01}} + \frac{\tau_{\text{meas}}}{c_{12}-c_{11}}\right\} \quad \text{(B.3)}$$

with the dimensionless time

$$\tau_{\text{meas}} = \frac{t_{\text{meas}} - t_0}{t_{\text{end}} - t_0} \tag{B.4}$$

Details on the creation of an oxygen content from 12,5 to 13,5 vol % within the furnace

In very tight furnaces and firings with a fixed ratio of fuel and air, oxygen contents of 4 vol % to 4,5 vol % will be reached. The developing flue gases shall then be supplemented by air, in order to achieve a flow through the test duct according to the requirements of this standard. For this the inlet of air shall be ensured near the furnace ground or via controlled air supply.

Annex C
(informative)

The usage of correction factors for the consideration of different parameters

Details for the development of the correction factors and their error limits

In the 1990s a test method for fire resistant smoke extraction ducts according to EN 1366-8 has been developed for

1) temperature within the furnace according to the standard time temperature curve;
2) fluid fuels to heat the furnace;
3) approximately 4 m of test duct outside the furnace;
4) flue gas velocity at least 3 m/s within the duct;
5) failure criterion at a leakage of 10 $m^3/(h, m^2)$.

For the test method for smoke extraction ducts inside a fire compartment according to EN 1366-9 and in the course of the revision of EN 1366-8, it should also be possible to use this method for

1) temperatures of 600 °C within the furnace,
2) gaseous fuels and
3) failure criterion at a leakage of 5 $m^3/(h, m^2)$

The complete formula for the leakage mass flow and the parameters

By means of the complete derived formula for the leakage mass flow

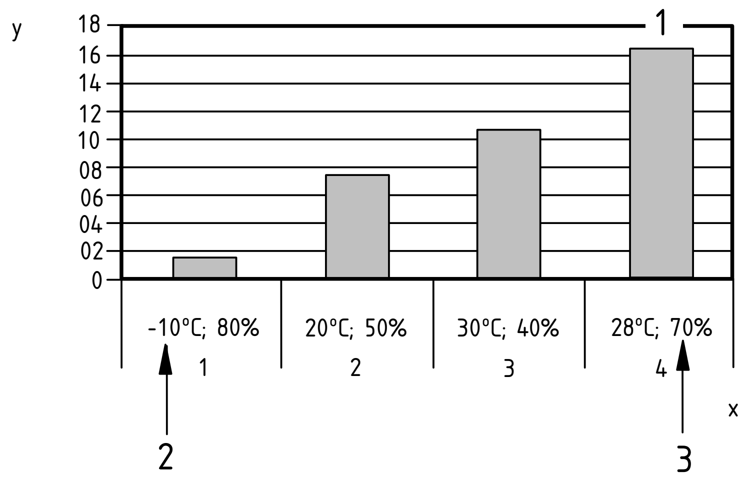
$$\dot{m}_{\mathrm{L}} = \dot{m}_{\mathrm{L,h}} = \dot{m}_{\mathrm{G2,h}} \frac{m_{\mathrm{fl,dr}}}{m_{\mathrm{fl,h}}} \cdot \frac{c_{\mathrm{G2}}/\rho_{\mathrm{G2,dr}} - c_{\mathrm{G1}}/\rho_{\mathrm{G1,dr}}}{21/\rho_{\mathrm{Air,dr}} - c_{\mathrm{G1}}/\rho_{\mathrm{G1,dr}}} \cdot (1 + x_{\mathrm{Air}}) \qquad \text{(C.1)}$$

all parameter according to Table C.1 have been examined.

Table C.1 — Influences on the density

Parameter	Density of air		Density of the flue gas G1		Density of the flue gas G2	
	$\rho_{Air,dr}$	$\rho_{Air,h}$	$\rho_{G1,dr}$	$\rho_{G1,h}$	$\rho_{G2,dr}$	$\rho_{G2,h}$
Weather data						
atmospheric pressure p_a	×	×	×	×	×	×
temperature ϑ	×	×	×	×	×	×
water vapour content x_L of the air / combustion air	--	×	--	×	--	×
Firing						
applied fuel	--	--	×	×	×	×
air ratio number of the combustion	--	--	×	×	×	×
Test specimen						
water vapour set free from the material of the test duct	--	--	--	×	--	×

As limit values for weather data according to Figure C.1, absolutely dry air and very humid air (28 °C and a relative humidity of 70 %) have been used.



Key

x weather conditions

y content of Water Vapour x_L in the Air (g H_2O/kg dry air)

1 extreme Situation $x_{L =}$ g H_2O/kg dry air

2 air Temperature ϑ

3 relative Humidity

Figure C.1 — Water vapour content of the air for different weather situations

Fuel oil EL and natural gas H and L have been tested as fuels. The components of the tested fuels are given in Table C.2 for fuel oil EL and in Table C.3 for two natural gases H and one natural gas L. With increasing water vapour content within the fuel, the water vapour content within the flue gas increases and the density of the flue gas decreases.

Table C.2 — Components of the fuel oil EL

Components	Abbreviated designation	Mass-%
Carbon	c =	86
Hydrogen	h =	13
Sulphur	s =	< 0,5

Table C.3 — Composition and heating and calorific value of natural gas H and L (examples)

Components / property	Chemical symbol	Unit	H gas from STAWA	H gas from MAINOVA	L gas from MAINOVA
Carbon dioxide	CO_2	Mol-%	0,08	1,31	1,71
Nitrogen	N_2	Mol-%	0,79	1,66	9,06
Oxygen	O_2	Mol-%	≤ 0,01	< 0,01	< 0,01
Methane	CH_4	Mol-%	97,77	87,97	85,31
Ethane	C_2H_6	Mol-%	0,92	7,45	3,09
Propane	C_3H_8	Mol-%	0,31	1,23	0,54
iso-Butane	i-C_4H_{10}	Mol-%	0,05	0,15	0,09
n-Butane	n-C_4H_{10}	Mol-%	0,05	0,14	0,10
iso-Pentane	i-C_5H_{12}	Mol-%	0,01	0,03	0,03
n-Pentane	n-C_5H_{12}	Mol-%	0,01	0,02	0,02
Hexane and higher hydrocarbons	≥ C_6H_{14}	Mol-%	0,00	0,04	0,05
Calorific value	$H_{s,n}$	kWh/m^3	11,131	11,670	10,303
Heating value	$H_{i,n}$	kWh/m^3	10,036	10,547	9,299

The release of water vapour from the test specimen has been estimated to be 40 [kg H_2O/h]. At the time of evaluation however, the influence is insignificant. For a conservative evaluation however, at the time of evaluation still 10 % of the water vapour production was expected. This water vapour production was considered as fictive the water vapour content increase of the combustion air.

Application of correction factors in the simple mass flow formulae and achievable accuracy

The simple mass flow formulae according to 10.3.8

$$\dot{m}_{\mathrm{L}} = C_{\mathrm{f}} \cdot \dot{m}_{\mathrm{G2}} \cdot \frac{c_{\mathrm{G2}} - c_{\mathrm{G1}}}{21 - c_{\mathrm{G1}}} \tag{C.2}$$

can be used for fire tests according to this standard at a furnace temperature of 600 °C, if the correction factor

C_f = 0,94 in case of oil firing and

C_f = 0,91 in case of gas firing

is applied. The density of dry air in the standard reference conditions (ρ = 1,293 [kg/m³]) is used for the density of the mass flow m_{G2}. Table C.4 shows the correction factors with their error limits for the criteria S (smoke leakage) and E (integrity) with 5 or 10 [$m^3/(m^2,h)$].

Table C.4 — Statement of the correction factors C_f with their error limits

Furnace temperature	600 °C
Test specimen	Smoke extraction duct within a fire compartment
C_f for fluid fuels	$0{,}94^{+0{,}016}_{-0{,}015}$
C_f for natural gases H	$0{,}91^{+0{,}019}_{-0{,}015}$
C_f for natural gases L	$0{,}91^{+0{,}020}_{-0{,}013}$

With the maximum deviation of +0,020 in Table C.4 and the errors from Annex B we receive with the law of error propagation (square root from the total square errors)

$$\text{Error}_{\text{total}} = \sqrt{\text{Error}^2_{\text{Inlet nozzle}} + \text{Error}^2_{\text{O2 measurement}} + \text{Error}^2_{\text{Cf factor}}} \quad [\%] \qquad \text{(C.3)}$$

total error of up to approximately ± 5,7 %. Thus the total error is only insignificantly higher than the maximum permissible error for the measurement with the inlet nozzle alone.

Bibliography

[1] EN 1366-8, *Fire resistance tests for service installations — Part 8: Smoke extraction ducts*

[2] prEN 12101-7, *Smoke and heat control systems — Part 7: Smoke control ducts*

[3] EN 1507, *Ventilation for buildings - Sheet metal air ducts with rectangular section - Requirements for strength and leakage*

[4] ISO 10294-3, *Fire resistance tests -- Fire dampers for air distribution systems -- Part 3: Guidance on the test method*

This page has been intentionally left blank

BSI - British Standards Institution

BSI is the independent national body responsible for preparing British Standards. It presents the UK view on standards in Europe and at the international level. It is incorporated by Royal Charter.

Revisions

British Standards are updated by amendment or revision. Users of British Standards should make sure that they possess the latest amendments or editions.

It is the constant aim of BSI to improve the quality of our products and services. We would be grateful if anyone finding an inaccuracy or ambiguity while using this British Standard would inform the Secretary of the technical committee responsible, the identity of which can be found on the inside front cover. Tel: +44 (0)20 8996 9000. Fax: +44 (0)20 8996 7400.

BSI offers members an individual updating service called PLUS which ensures that subscribers automatically receive the latest editions of standards.

Buying standards

Orders for all BSI, international and foreign standards publications should be addressed to Customer Services. Tel: +44 (0)20 8996 9001. Fax: +44 (0)20 8996 7001 Email: orders@bsigroup.com You may also buy directly using a debit/credit card from the BSI Shop on the Website http://www.bsigroup.com/shop

In response to orders for international standards, it is BSI policy to supply the BSI implementation of those that have been published as British Standards, unless otherwise requested.

Information on standards

BSI provides a wide range of information on national, European and international standards through its Library and its Technical Help to Exporters Service. Various BSI electronic information services are also available which give details on all its products and services. Contact Information Centre. Tel: +44 (0)20 8996 7111 Fax: +44 (0)20 8996 7048 Email: info@bsigroup.com

Subscribing members of BSI are kept up to date with standards developments and receive substantial discounts on the purchase price of standards. For details of these and other benefits contact Membership Administration. Tel: +44 (0)20 8996 7002 Fax: +44 (0)20 8996 7001 Email: membership@bsigroup.com

Information regarding online access to British Standards via British Standards Online can be found at http://www.bsigroup.com/BSOL

Further information about BSI is available on the BSI website at http://www.bsigroup.com.

Copyright

BSI Group Headquarters 389 Chiswick High Road, London, W4 4AL, UK
Tel +44 (0)20 8996 9001
Fax +44 (0)20 8996 7001
www.bsigroup.com/standards