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Second edition
2021-06

Determination of the resistance to jet fires of passive fire protection materials —

Part 1: General requirements

Détermination de la résistance aux feux propulsés des matériaux de protection passive contre l'incendie —

Partie 1: Exigences générales

Reference number
ISO 22899-1:2021(E)

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Foreword

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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 documents 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).

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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 containment*.

This second edition cancels and replaces the first edition (ISO 22899-1:2007), which has been technically revised. The main changes compared to the previous edition are as follows:

— Corrections to figures;

— Revision of the method of test for penetration seals.

A list of all parts in the ISO 22899 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 test procedure described in this document enables the determination of properties of passive fire protection materials. This test is designed to give an indication of how passive fire protection materials are likely to perform in a jet fire. The dimensions of the test specimen can be smaller than typical structure or plant items and the release of gas can be substantially less than that which can occur in a credible event. However, individual thermal and mechanical loads imparted to the passive fire protection material from the jet fire defined in this document have been shown to be similar to those imparted from large-scale jet fires resulting from high-pressure releases of natural gas.

NOTE Guidance on the applicability of the test is intended to be covered in a future part of the ISO 22899 series.

Although the method specified in this document has been designed to simulate certain conditions that occur in an actual jet fire, it cannot reproduce them all exactly and the thermal and mechanical loads do not necessarily coincide. The results of this test do not guarantee safety but may be used as elements of a fire risk assessment for structures or plants. This should also take into account all the other factors that are pertinent to an assessment of the fire hazard for a particular end use. The test is not intended to replace the hydrocarbon fire resistance test (ISO/TR 834-3/EN 1363-2[3]) but is seen as a complementary test.

Users of this document are advised to consider the desirability of third-party certification/inspection/testing of product conformity with this document.

Determination of the resistance to jet fires of passive fire protection materials —

Part 1: General requirements

1 Scope

This document describes a method of determining the resistance to jet fires of passive fire protection materials and systems. It gives an indication of how passive fire protection materials behave in a jet fire and provides performance data under the specified conditions.

It does not include an assessment of other properties of the passive fire protection material such as weathering, ageing, shock resistance, impact or explosion resistance, or smoke production.

Complete I-beams and columns cannot be tested to this document due to disruption of the characteristics of the jet.

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 834-1:1999, *Fire-resistance tests — Elements of building construction — Part 1: General requirements*

ISO 13702, *Petroleum and natural gas industries — Control and mitigation of fires and explosions on offshore production installations — Requirements and guidelines*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological 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
assembly
unit or structure composed of a combination of materials or products, or both

3.2
critical temperature
maximum temperature that the equipment, *assembly* (3.1) or structure to be protected may be allowed to reach

3.3
Delta Tmax
maximum *temperature rise* (3.18) recorded by any of the installed thermocouples

3.4
fire barrier
separating element that resists the passage of flame and/or heat and/or effluents for a period of time under specified conditions

3.5
fire resistance
ability of an item to fulfil, for a stated period of time, the required stability and/or *integrity* (3.8) and/or thermal insulation and/or other expected duty, reaching the *critical temperature* (3.2) specified in a standard fire-resistance test

3.6
fire test
procedure designed to measure or assess the performance of a material, product, structure or system to one or more aspects of fire

3.7
flame re-circulation chamber
mild steel box, open at the front, into which the *jet fire* (3.10) is directed giving a re-circulating flame resulting in a fireball

Note 1 to entry: Materials other than mild steel may be used when appropriate.

3.8
integrity
ability of a separating element, when exposed to fire on one side, to prevent the passage of flames and hot gases or occurrence of flames on the unexposed side, for a stated period of time in a standard *fire resistance* (3.5) test

3.9
intermediate-scale test
test performed on an item of medium dimensions

Note 1 to entry: A test performed on an item of which the maximum dimension is between 1 m and 3 m is usually called an intermediate-scale test. This document describes an intermediate-scale jet *fire test* (3.6).

3.10
jet fire
ignited discharge of propane vapour under pressure

3.11
jet nozzle
orifice from which the flammable material issues

3.12
outside specimen diameter
specimen diameter measured to the outer surface of the *passive fire protection* (3.13) system on a tubular specimen

3.13
passive fire protection
coating or cladding arrangement or free-standing system that, in the event of fire, provides thermal protection to restrict the rate at which heat is transmitted to the object or area being protected

Note 1 to entry: The term "passive" is used to distinguish the systems tested, including those systems that react chemically, e.g. intumescents, from active systems such as water deluge.

3.14
passive fire protection material
coating or cladding that, in the event of a fire, provides thermal protection to restrict the rate at which heat is transmitted to the object or area being protected

3.15
passive fire protection system
removable jacket or inspection panel, cable transit system, pipe *penetration seal* (3.16) or other such system that, in the event of a fire, provides thermal protection to restrict the rate at which heat is transmitted to the object or area being protected

3.16
penetration seal
system used to maintain the *fire resistance* (3.5) of a separating element at the position where there is provision for services to pass through the separating element

3.17
protective chamber
mild steel box, open at the front and back, which is designed to be attached to the rear of the *flame re-circulation chamber* (3.7) to shield the rear of the flame re-circulation chamber from environmental influences

Note 1 to entry: A protective chamber is not required for tubular section tests but may be used to provide additional stability to the flame re-circulation chamber.

3.18
temperature rise
increase in measured temperature above the initial temperature at a given location

4 Principle

The method presented in this document provides an indication of how passive fire protection materials perform in a jet fire that can occur, for example, in petrochemical installations. It aims at simulating the thermal and mechanical loads imparted to passive fire protection material by large-scale jet fires[4] resulting from high-pressure releases of flammable gas, pressure liquefied gas or flashing liquid fuels. Jet fires give rise to high convective and radiative heat fluxes as well as high erosive forces. To generate both types of heat flux in sufficient quantity, a 0,3 kg s^{-1} sonic release of gas is aimed into a shallow chamber, producing a fireball with an extended tail. The flame thickness is thereby increased and hence so is the heat radiated to the test specimen. Propane is used as the fuel since it has a greater propensity to form soot than does natural gas and can therefore produce a flame of higher luminosity. High erosive forces are generated by the release of the sonic velocity gas jet 1 m from specimen surface.

5 Test configurations

5.1 General

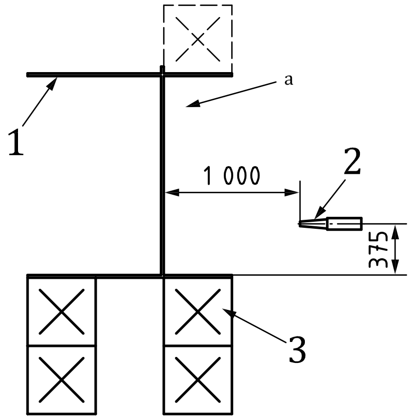
There are two basic configurations under which the test can be operated:

a) an internal configuration where one or more of the inner faces of the flame re-circulation chamber incorporates the test construction;

b) an external configuration where the test construction is installed on supports in front of the flame re-circulation chamber.

These two alternative configurations are shown in Figures 1 and 2.

Dimensions in millimetres



Key

1 protective chamber

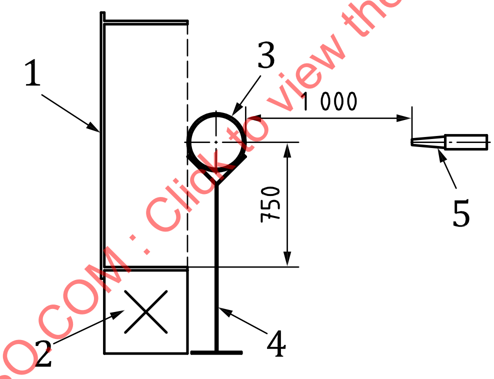
2 jet nozzle

3 supports

[a] Flame re-circulation chamber either with coated inner surfaces or with the rear face replaced by a panel to form the test construction.

Figure 1 — Layout for internal configuration

Dimensions in millimetres



Key

1 flame re-circulation chamber

2 flame re-circulation chamber support

3 test construction

4 test construction support

5 jet nozzle

Figure 2 — Layout for external configuration

5.2 Internal configuration

The internal test configuration is used for determining the jet fire resistance of:

a) protection systems for plane surfaces;

b) protection systems for edge features;

c) fire barriers;

d) penetration systems used in conjunction with fire barriers.

5.3 External configuration

The external test configuration is used for determining the jet fire resistance of protected hollow sections or assemblies mounted on hollow sections.

6 Construction of the test items and substrates

6.1 General

The key items required for the test are the jet release nozzle, the flame re-circulation chamber and a protective chamber. These items are all required for the internal configurations of the test and the test specimen forms all or part of the flame re-circulation chamber. In the external configurations of the test, the flame re-circulation chamber is only used to help produce the fireball and it is not necessary to use the protective chamber.

6.2 Material

The material normally used is 10 mm thick steel plate conforming to ISO 630-1:2011, Grade Fe 430. All-welded construction shall be used and all welds shall be 5 mm fillet and continuous unless otherwise stated. The use of substrates manufactured from other materials or thicknesses other than 10 mm shall be documented in the report.

All dimensions are in millimetres and, unless otherwise stated, the following tolerances shall be used:

— whole number ±1,0 mm

— decimal to point ,0 ±0,4 mm

— decimal to point ,00 ±0,2 mm

— angles ±0’ 30”

— radii ±0,4 mm

6.3 Nozzle

The fuel is released towards the specimen from a nozzle. The tapered, converging nozzle shall be of length 200 ± 1 mm, inlet diameter 52 ± 0,5 mm and outlet diameter 17,8 ± 0,2 mm. Figure 3 shows the details of construction. The nozzle shall be constructed of heat resistant stainless steel. Provisions shall be made for fitting a sighting device.

Dimensions in millimetres

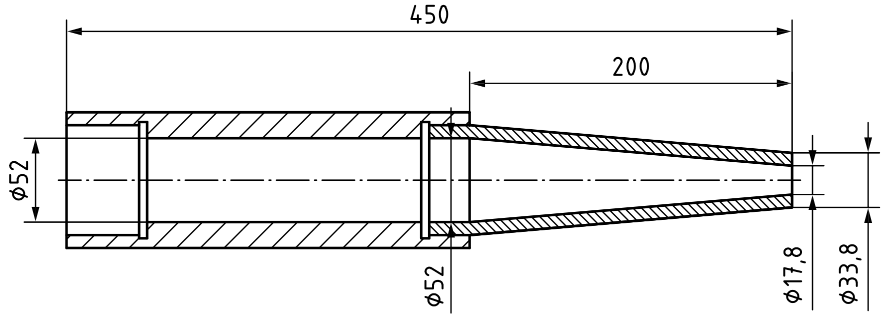


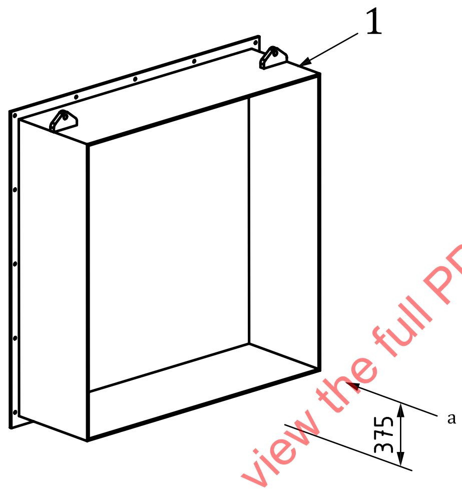
Figure 3 — Nozzle

6.4 Flame re-circulation chamber

The side, top and bottom walls of the flame re-circulation chamber shall be constructed from mild steel of 10 mm thickness. The rear wall of the chamber shall either be constructed of 10 mm thick steel welded to the sides of the chamber or of a panel bolted on to form the rear wall. If the substrate material is not steel or the substrate thickness is not 10 mm, the material and thickness used shall be stated in the test report. The details of construction of the flame re-circulation chamber are given in Figure 5.

The flame re-circulation chamber, having nominal internal dimensions 1 500 mm × 1 500 mm × 500 mm, shall be used for each test. The chamber is flanged at the rear to allow bolting on of a panel when required and attachment, by bolting or clamping, of the protective chamber when required. A general view of the flame re-circulation chamber is shown in Figure 4 and details of construction are shown in Figure 5.

Dimensions in millimetres



Key

1 flame re-circulation chamber

[a] Jet position.

Figure 4 — General view of flame re-circulation chamber

Details of the flange construction, apart from the hole spacing, are not given as one of two methods may be used:

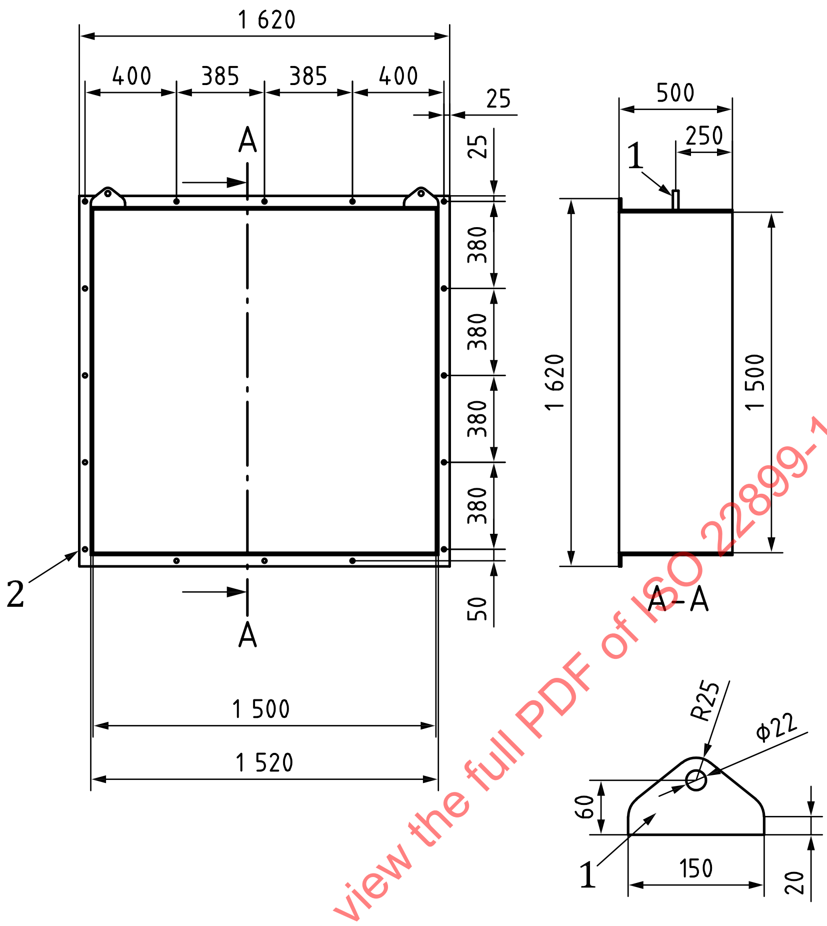
a) The flanges may be constructed by welding L-section steel to the rear of each wall.

b) For structural steelwork specimens, the rear wall may be constructed by continuously welding a 1 620 mm × 1 620 mm plate on to the rear of the flame re-circulation chamber and drilling holes at the appropriate locations in the plate extending beyond the sides of the chamber.

Inner walls that do not form part of the specimen, e.g. the sidewalls in a panel test, shall be protected from distortion by an alkaline earth silicate board or other suitable form of passive fire protection or insulation material.

When testing in the external configuration, the recirculation chamber shall have a rear wall and the recirculation chamber shall be insulated.

Dimensions in millimetres



Key

1 lifting lug, 25 mm thick machined steel

2 sixteen holes drilled, Ø 18

Figure 5 — Construction of flame re-circulation chamber

6.5 Protective chamber

The protective chamber (nominal internal dimensions 1 500 mm × 1 500 mm × 1 000 mm) is used to shield the rear of the flame re-circulation chamber from environmental influences in the internal configuration of the test. It shall generally be constructed from mild steel of 10 mm thickness and shall be open at the front and back and flanged at the front to allow fitting to the rear of the flame re-circulation chamber with no visible air gaps.

A general view of the protective chamber is shown in Figure 6 and details of construction are shown in Figure 7.

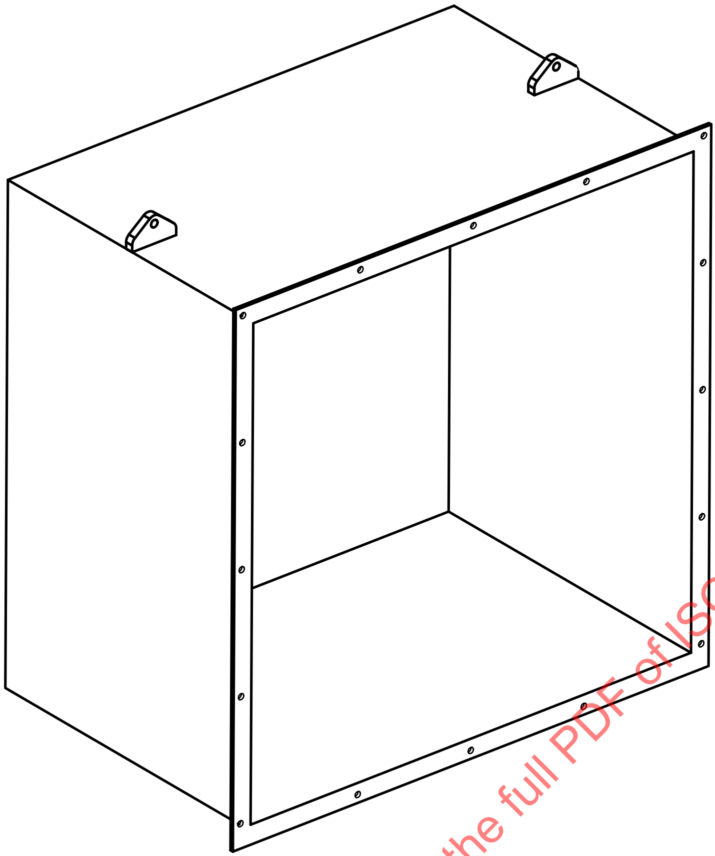
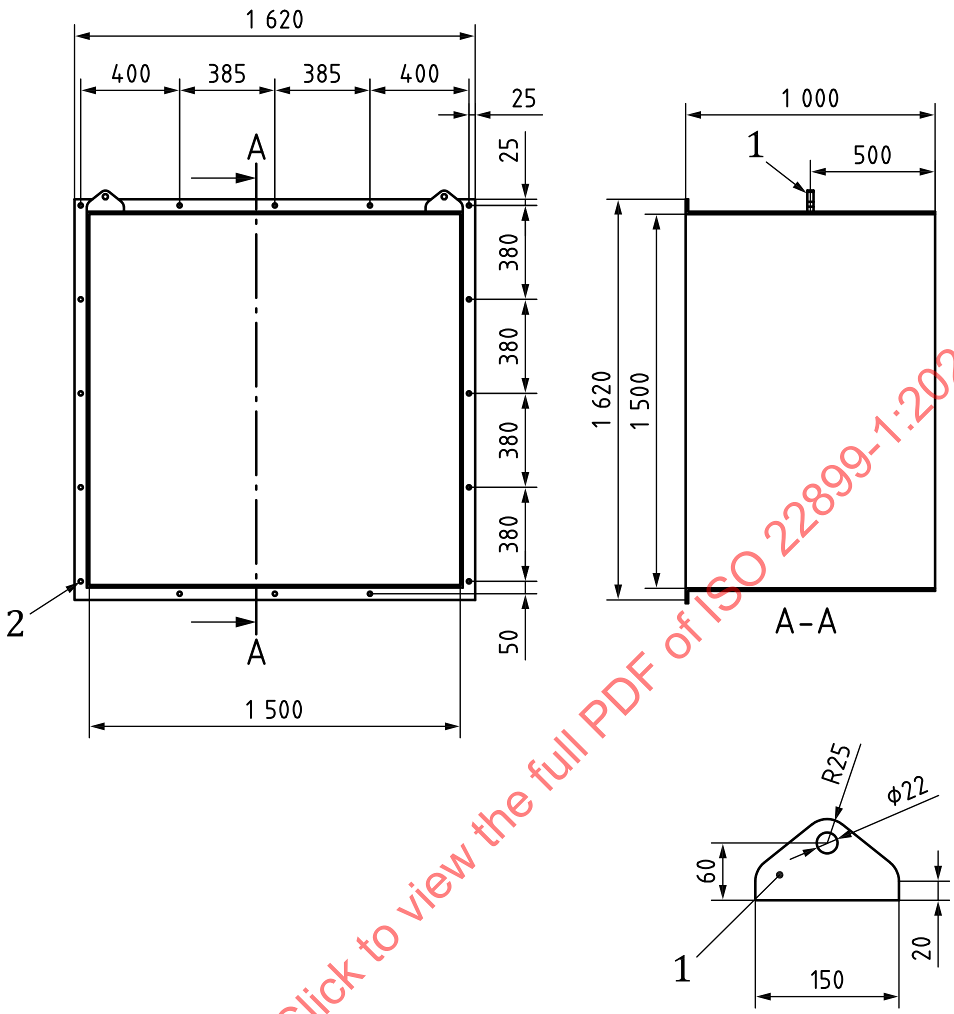


Figure 6 — General view of protective chamber

Dimensions in millimetres



Key

1 lifting lug, 25 mm thick machined steel

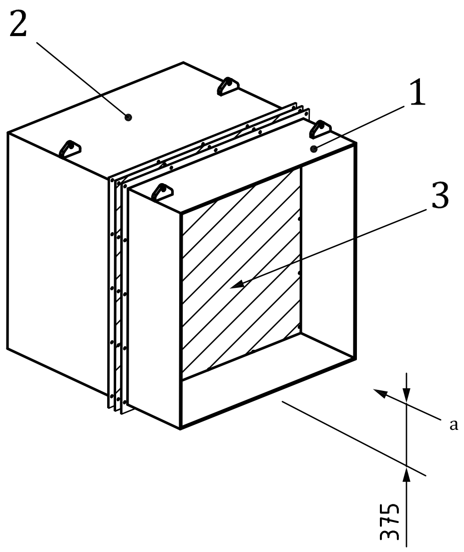
2 sixteen holes drilled, Ø 18

Figure 7 — Construction of protective chamber

6.6 Panel test specimens (internal configuration)

The panel test specimen shall consist of a flame re-circulation chamber, with the rear wall replaced by the panel to be tested. The panel is sandwiched between the flame re-circulation chamber and the protective chamber as illustrated in Figure 8. The connection between the panel and the flame re-circulation chamber shall be gas tight. The method of mounting depends on the type of passive fire protection as described in 7.1.

Dimensions in millimetres



Key

1 flame re-circulation chamber

2 protective chamber

3 Panel

a Jet position.

Figure 8 — Position of panel

For cases that simulate steelwork with no corners or edge features; or cylindrical vessels, pipes and tubular sections of outside diameter greater than 500 mm, a 1 620 mm × 1 620 mm panel shall be constructed from 10 mm thick steel. The details of construction are shown in Figure 9.

6.7 Structural steelwork test specimens (internal configuration)

The structural steelwork test specimen shall consist of the flame re-circulation chamber with the addition of a 20 mm thick central web, 250 mm deep, to simulate corner or edge features such as stiffening webs or edges of "I" beams. A general view of the test specimen is illustrated in Figure 10.

Dimensions in millimetres

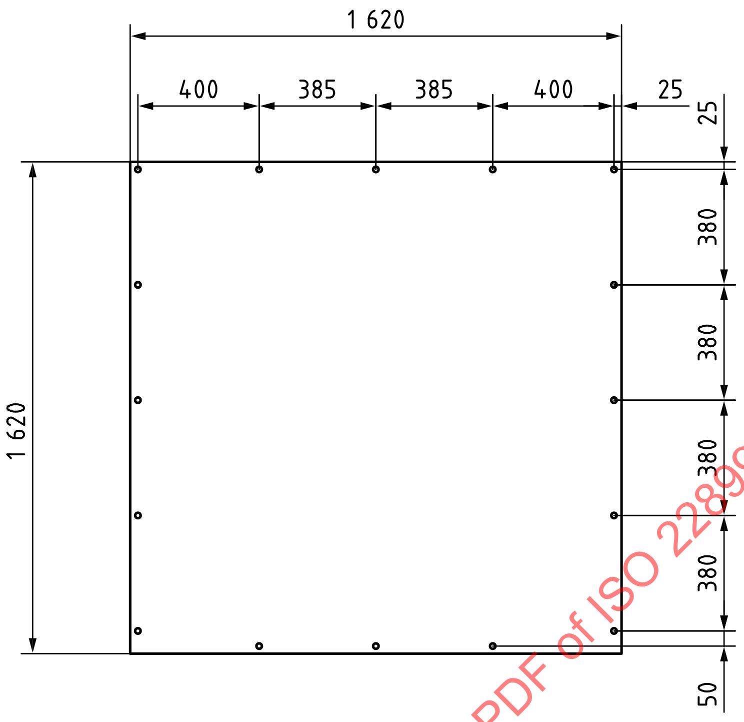
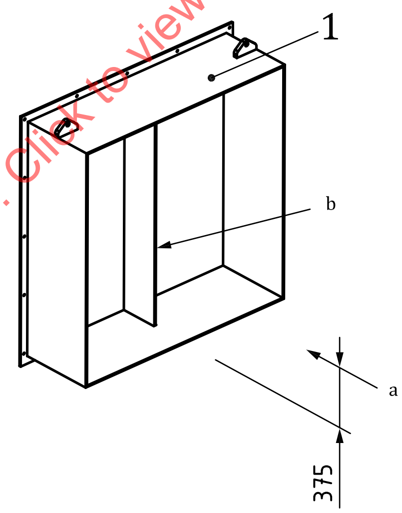


Figure 9 — Construction of panels

Dimensions in millimetres



Key

1 flame re-circulation chamber

a Jet position with web.

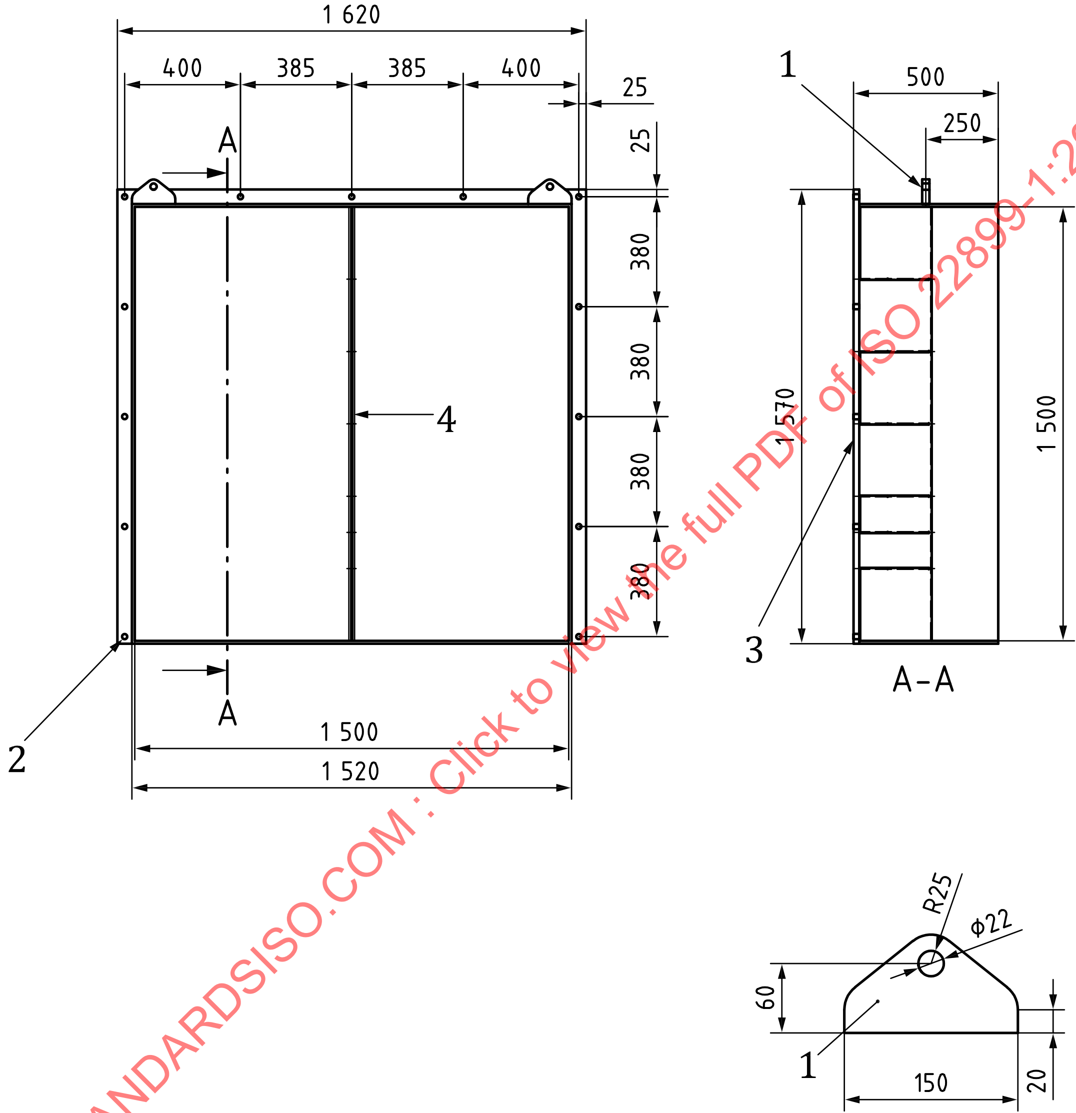
b Simulated corner or edge feature of "I" beam.

Figure 10 — General view of structural steelwork test specimen

Details of the construction of a structural steelwork specimen are given in Figure 11. For a structural steelwork test, the rear wall shall be constructed of 10 mm thick steel. The bottom flange may be omitted if desired. The web shall comprise two 10 mm thick steel plates, which are slotted before being welded together, to have thermocouples inserted and fixed in accordance with the methods given in Annex A. Holes shall be drilled in the rear wall of the flame re-circulation chamber to match the slot positions. Details of construction of the web are given in Figure 12. If the substrate material is not steel or the steel thickness of the web and rear wall is different from 20 mm and 10 mm respectively, the material and thickness used shall be stated in the test report.

When testing passive fire protection materials used to protect structural sections with substrates other than steel or when the thickness of the corner or edge feature on the structural section is different from 20 mm, the central web and rear wall of the flame re-circulation chamber may be constructed from the relevant substrate material and may be of the relevant thickness.

Dimensions in millimetres



Key

1 lifting lug, 25 mm thick machined steel

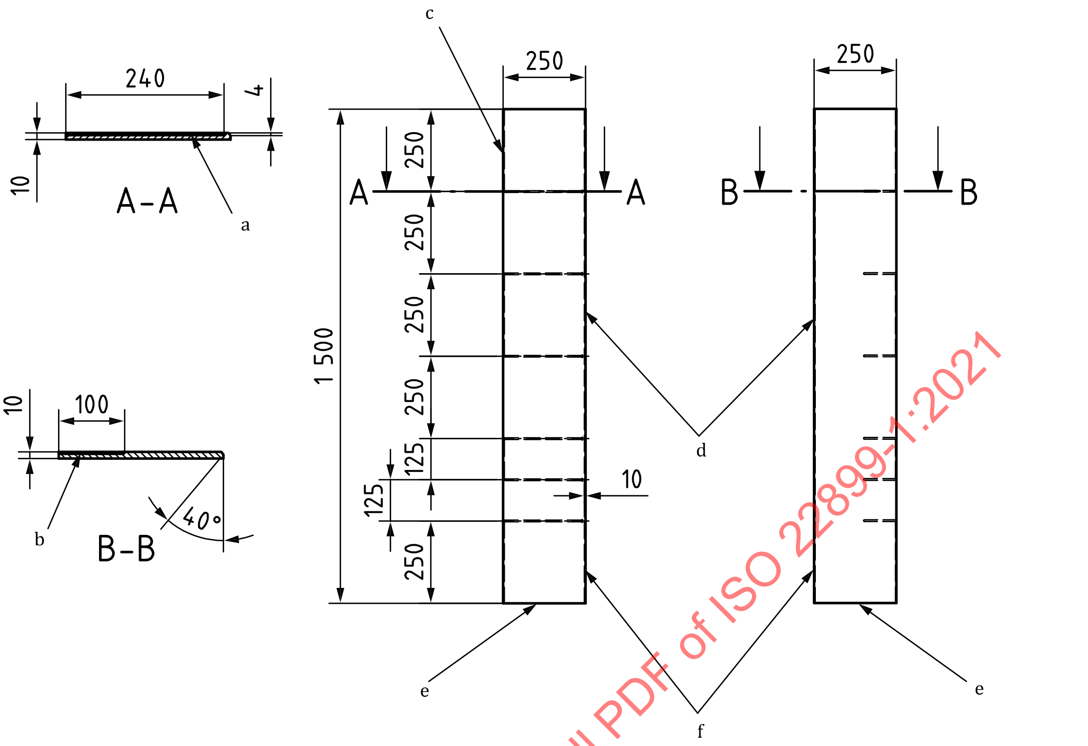
2 thirteen holes drilled, Ø 18

3 six holes drilled and taped in bulkhead to match machined holes in central web; threads to be similar to 1/8 British Standard Pipe Thread

4 central web

Figure 11 — Construction of structural steelwork specimen

Dimensions in millimetres



Key

a Groove machined 3,3 mm deep using 5,0 mm diameter ball nosed cutter.

b Groove machined 3,0 mm deep using 5,0 mm diameter ball nosed cutter.

c Weld preparation, four positions along this edge.

d Weld preparation, full length along these edges.

e Weld plates together after machining with a single V-butt weld; weld to be intermittent and ground flush.

f Weld plates together after machining with a single continuous V-butt weld.

Figure 12 — Construction of web for structural steelwork specimen

6.8 Tubular section test specimens (external configuration)

The tubular section test specimen shall consist of a 3 000 mm long tubular section and shall be of the following type depending on the outside diameter:

a) if the outside diameter, including the passive fire protection system, does not exceed 350 mm, the full-scale tubular section shall be used; or

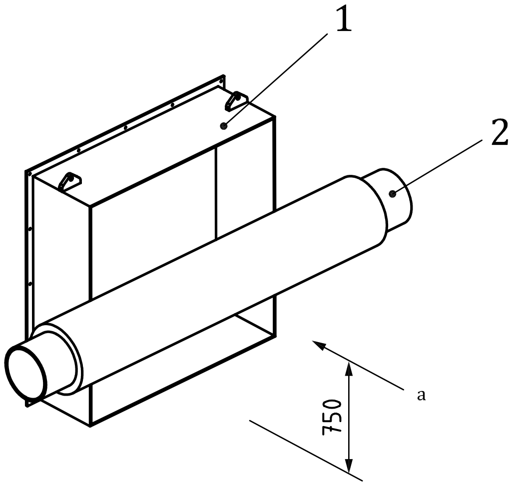
b) if the outside diameter, including the passive fire protection system, exceeds 350 mm, the diameter of the tubular section shall be reduced so that the outside diameter is no more than 350 mm, keeping the wall thickness of the tubular section as close as possible to that to be used in practice.

A general view of a tubular section specimen is given in Figure 13.

The material, diameter and wall thickness of the tubular section used shall be stated in the test report. The tubular section shall be drilled with holes of sufficient diameter to allow thermocouples to be passed down the inside of the tubular section. The access hole for each thermocouple shall be not more than 50 mm longitudinally from the measuring position.

In some cases, e.g. an enclosure for a valve, the outside diameter may exceed 350 mm for a length not exceeding 400 mm.

Dimensions in millimetres



Key

1 flame re-circulation chamber

2 tubular section specimen

a Jet position.

Figure 13 — General view of tubular test

7 Passive fire protection systems

7.1 General

The passive fire protection systems are either coated or mounted onto the substrates described in Clause 6.

7.2 Panel test specimens

When the passive fire protection material is in the form of a panel, the panel shall be fixed to act as the rear wall of the flame re-circulation chamber as shown in Figure 8. The method of mounting shown in Figure 14 depends on the type of passive fire protection and is detailed as follows.

a) For a rigid stand-alone panel, at least one joint shall be included in the panel and this shall be positioned vertically, offset from the centre by 250 ± 50 mm. If the joint is not symmetrically resistant to a jet fire flowing across the front of the rear wall of the flame re-circulation chamber, e.g. a lap joint, the joint shall be oriented to give the most severe exposure to the jet fire as shown in Figure 14.

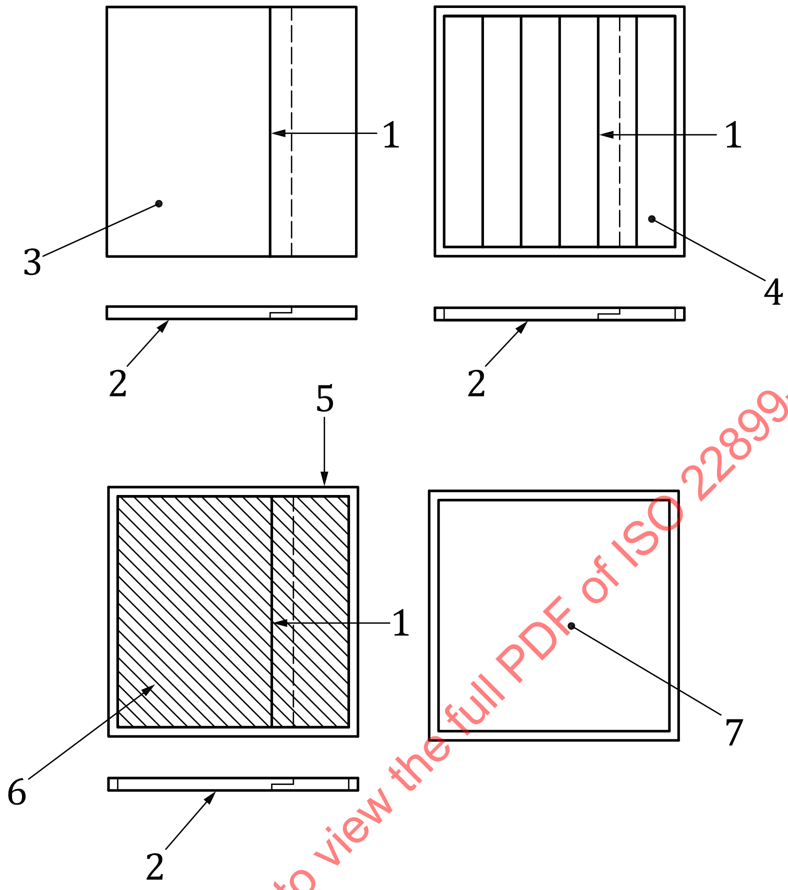
The rigid panel may extend to the full 1 620 mm × 1 620 mm substrate dimensions as discussed in 6.5.

b) If the panel profile is not planar (e.g. trapezoidal), it can be necessary to incorporate a rigid surround around the panel to achieve a gas-tight connection.

c) When the passive fire protection material is in the form of a flexible panel, it can be necessary to incorporate a rigid surround (e.g. 50 mm box section steel) around the panel to achieve a gas-tight connection as shown in Figure 14.

d) When the passive fire protection is in the form of a coating, the joint is omitted as shown in Figure 14.

The connection between the panel and the flame re-circulation chamber shall be sealed to prevent passage of hot gases, e.g. using soft mastic or fibre. In all cases, the side, top and bottom walls of the flame re-circulation chamber shall be protected by an alkaline earth silicate board or other suitable passive fire protection material.



Key

1 joint
2 face exposed to jet fire
3 flat rigid panel
4 profile rigid panel
5 box section surround
6 passive fire protection covering
7 passive fire protection coating

Figure 14 — Different types of panel PFP

7.3 Structural steelwork test specimens

For testing passive fire protection materials applied as coatings, the structural steelwork test specimen shall have passive fire protection material applied directly to all inside surfaces of the specimen. The outside surfaces of the sides, top and bottom of the specimen shall also be coated to a distance of at least 50 mm from the front edge, including any reinforcement.

7.4 Tubular section test specimens

A minimum of 2 500 mm of the central part of the tubular section test specimen shall be covered by the passive fire protection material under test. If the unprotected ends of the tubular section are not protected by PFP they shall be protected by a suitable insulation material.

7.5 Assembly specimens

7.5.1 General

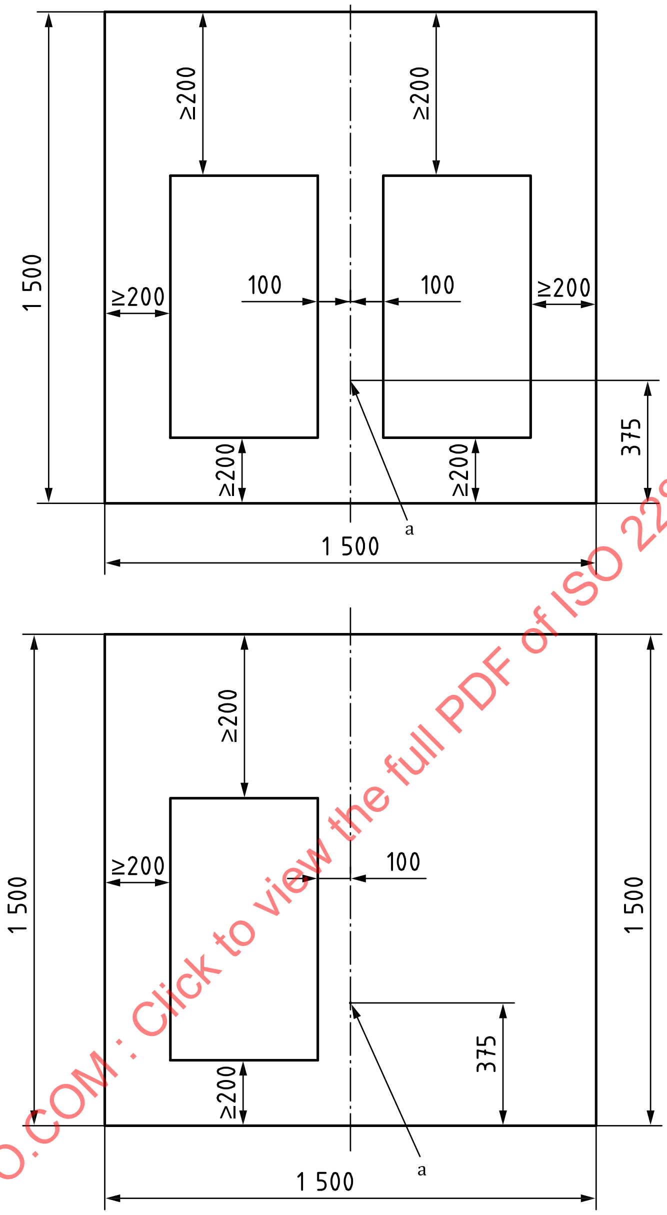
Assemblies can be mounted on a panel (internal configuration) or a hollow section (external configuration). If an assembly is more than 400 mm in width or the geometry sufficiently complex that the flame characteristics are clearly affected, a demonstration at full scale can be necessary, e.g. a 3 kg s^{-1} natural gas jet fire impinging on a full-scale specimen at 9 m from the release point.

For assemblies mounted on panels, the panel shall be fixed to act as the rear wall of the flame re-circulation chamber as shown in Figure 8. The connection between the panel and the flame re-circulation chamber shall be sealed to prevent passage of hot gases, e.g. using soft mastic or ceramic fibre. The side, top and bottom walls of the flame re-circulation chamber shall be protected by an alkaline earth silicate board or other suitable passive fire protection material.

7.5.2 Requirements for assemblies mounted on panels

Assemblies to be mounted in a division (e.g. cable transit systems or pipe penetration seals) should be mounted through an aperture in a panel specimen made from the type of division to be used in the intended application in accordance with 6.6. If the assembly cannot be tested full size without affecting the key features of the test, then a reduced scale assembly can be used provided it reproduces the key features of the intended application. The assembly shall be positioned no closer than 200 mm from exposed edges of the panel. Where more than one assembly are to be tested simultaneously in a panel, the separation between adjacent assemblies shall be 200 mm. If two assemblies are tested simultaneously, they shall be placed symmetrically about either side of the vertical centreline of the panel. The positioning of features that can affect the flow of the jet fire shall be at the discretion of the test laboratory and any third-party certifying body. The position for a single panel mounted assembly should be offset horizontally from the jet impingement point by 100 mm. When two assemblies are to be tested simultaneously both assemblies shall be offset from the jet impingement point by 100 mm. When the size or shape of assemblies prevent this from being achieved with the jet impingement point at a height of 375 mm the nozzle may be raised to a maximum height of 600 mm. The distance from the assemblies to the jet impingement point shall include any insulation which is part of the system. The positions for a single panel mounted assembly and two panel mounted assemblies are given in Figure 15.

Dimensions in millimetres



Key

a Jet position.

Figure 15 — Positions of panel mounted assemblies

7.5.3 Cable transit systems

A cable transit consists of a metal frame, box or coaming, sealant system or material and the cables, and it may be uninsulated, partially insulated or fully insulated. The metal frame, box or coaming shall be mounted into a panel representative of the fire barrier using the normal method. For example, the frame, box, or coaming, which supports the cable transit system may be incorporated into a fire barrier (typically 830 mm × 740 mm). The frame, box or coaming should be fitted such that it is flush with the front surface of the fire barrier. The fire barrier is then welded into a hole cut into a support panel, e.g. a firewall. This forms the back panel of the flame re-circulation chamber. The transit(s) shall be tested incorporating a range of different types of cable (e.g. in terms of number and type of conductor, type of sheathing, type of insulation material or size) and should provide an assembly which represents a practical situation. No more than 40 % of the inside cross-sectional area of each transit shall be occupied by cables and the distances between the cables and the inside of the transit shall be the minimum which is allowable for the actual penetration sealing system. The cables shall project no more than 250 mm beyond the panel on the exposed side of the panel and 500 mm on the unexposed side. The test results obtained from a given configuration are generally valid for cables of size equal to or smaller than those tested. Requirements for assemblies mounted on tubular sections:

For assemblies fixed to a tubular section, see 6.8.

a) If the assembly (e.g. soft jacket) is intended to protect a tubular section or vessel, a minimum of 2 500 mm and a maximum of 2 700 mm of the central part of the tubular section test specimen shall be covered by the assembly under test.

b) If the assembly is a removable jacket, the fixing method shall be representative of the intended use and joints/fitments shall be oriented to give the most severe exposure to the jet fire.

c) Assemblies to be mounted on a tubular section (e.g. removable jackets or valves) shall be mounted on a tubular section specimen in accordance with 6.8. For assemblies, such as soft jackets, which are applied uniformly, the maximum outer diameter (including the passive fire protection system) shall be a maximum of 350 mm. Asymmetric assemblies, such as valve protection boxes, shall normally be positioned in the centre of the tubular section. However, the positioning of features that can affect the flow of the jet fire shall be at the discretion of the test laboratory and any third-party certifying body. The maximum outside specimen diameter may be up to 400 mm provided that this is for less than a length of 400 mm.

7.6 Pipe penetration systems

A pipe penetration sealing system typically consists of a sleeve or collar mounted in the rear wall of the jet fire rig forming an annulus through which a pipe of smaller diameter passes. The sealing system is designed to provide a fire-resistant barrier for the gap between the sleeve or collar and the pipe to prevent the passage of fire smoke or flames and, where required, ensure the insulation rating of the division is maintained.

These systems generally come in two forms: pack type systems that fill the void between the outer surface of the pipe and the inner surface of the sleeve or collar and wrap type systems that wrap around the outside of the sleeve or collar and the outside of the pipe.

For jet fire testing the penetration(s) shall be mounted onto a jet-fire resistant panel constructed in accordance with 6.6 and 7.2 The inside faces of the flame re-circulation chamber shall be protected by suitable passive fire protection or insulation material.

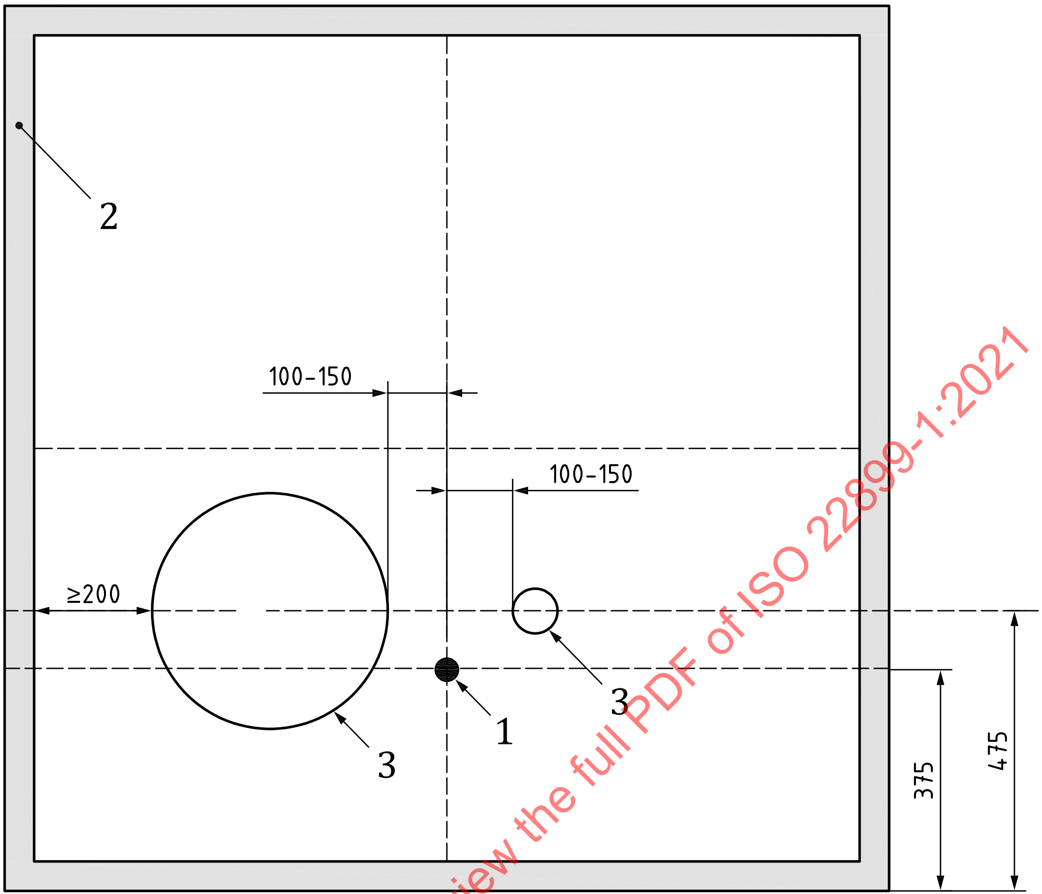
Either one or two pipe penetrations may be installed at a time for testing. When testing a single penetration, the maximum outside dimension, including any PFP, shall not exceed 400 mm in diameter. When testing two penetrations, the aggregate of the two outside dimensions should not exceed 400 mm e.g. a 300 mm diameter penetration may be tested alongside a 100 mm diameter penetration.

When testing a single penetration, either the left or the right position may be used and the other left blank. The pipe penetrations shall be positioned no closer than 200 mm from the insulation on the insides of the flame re-circulation chamber. Each penetration shall be positioned greater than 100 mm and less than 150 mm from the centre line and the centre of each pipe penetration shall be 100 mm above the jet position. The relative positions described are illustrated in Figure 16.

When testing wrap-type penetrations, the longitudinal joint shall be positioned so that it faces the jet impact point.

Where PFP or insulation is added outside the seal onto the sleeve or collar and/or on the pipe, details on the type, thickness and distances of the protection shall be recorded in the test report and are deemed to be part of the sealing system when defining its fire rating.

Dimensions in millimetres



Key

1 jet impingement point

2 passive fire protection or insulation material

3 pipe penetration

Figure 16 — Positions of panel mounted pipe penetration seals relative to the jet

The rear wall of the flame recirculation chamber may be made from 10 mm steel or it may be representative of its practical application, for example a fire barrier welded into a fire wall. If the rear wall is made from steel, then all exposed areas of this plate may be protected with, for example, an alkaline earth silicate board or other suitable PFP coating or insulation to prevent warping and heat transfer. The insulation shall be representative of a system or material that would be used in practice. Alternatively, the test may be carried out without insulation on the rear wall of the flame recirculation chamber or with insulation on the non-fire side of the rear wall.

Whichever arrangement is chosen, the specimen shall be constructed in a manner that is representative of the construction that will be used in practice, as far as is practicable.

The collar is fixed to the rear wall such that it protrudes 50 mm from the front surface of the substrate and either 50 mm from the rear surface for a sleeved seal or a distance sufficient for allowing the normal packing length to be used for a packed seal. The collar shall have a maximum outer diameter of 550 mm.

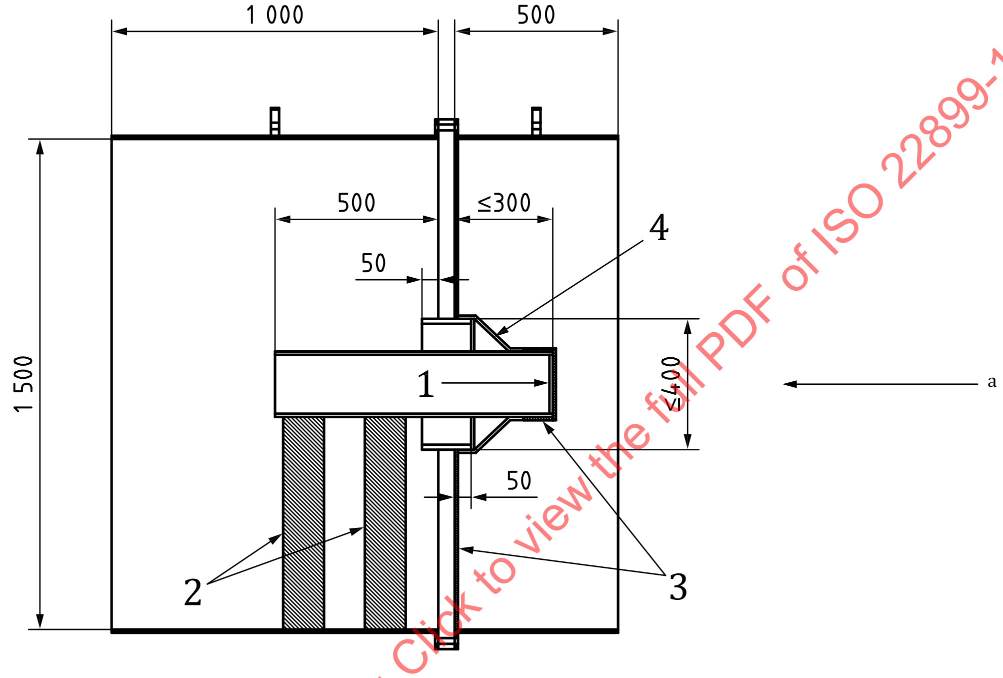
A smaller diameter pipe shall pass through the collar such that it extends a maximum of 300 mm from the front of the panel 500 mm from the rear of the panel. The inner pipe shall have a maximum diameter of 273 mm and at the end shall be capped with a 6 mm steel plate.

The end cap shall be protected using an alkaline earth silicate board or PFP to prevent heat transfer. Other exposed surfaces of the inner pipe may be protected if this is representative of the construction which will be used in practice.

The inner pipe shall be supported centrally within the hole by means of a frame attached inside the protection chamber. The framework shall support the inner pipe such that some movement can occur between pipe and collar.

The pipe penetration seal shall be fitted between the collar and the pipe which penetrates it (see Figure 17). If the seal incorporates a joint, it shall be orientated facing the jet impingement point. General views of the mounting of sleeved and packed seals are illustrated in Figures 17 and 18.

Dimensions in millimetres



Key

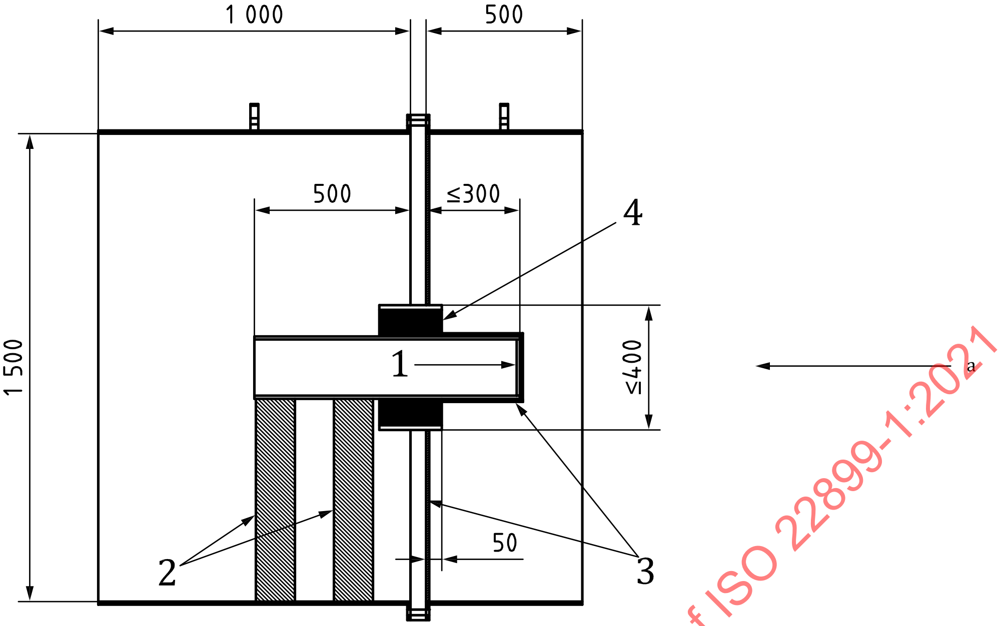
1 end cap
2 supports for inner pipe
3 insulation
4 sleeved penetration seal
a jet fire

NOTE 1 The insulation covering the inner pipe is optional.

NOTE 2 It is recommended that the pipe end cap be insulated.

Figure 17 — General view of panel mounted pipe penetration seal

Dimensions in millimetres



Key

1 end cap
2 supports for inner pipe
3 insulation
4 sleeved penetration seal
a jet fire

NOTE 1 The insulation covering the inner pipe is optional.

NOTE 2 It is recommended that the pipe end cap be insulated.

Figure 18 — General view of packed pipe penetration seal

8 Instrumentation

8.1 General

Thermocouples shall be fastened to all test specimens. The type and fixing shall be in accordance with one of the methods described in Annex A. For tests requiring use of a protective chamber, the air temperature shall be measured inside the protective chamber 500 mm ± 25 mm from the back of the rear wall of the flame re-circulation chamber, in the centre, and 250 mm ± 25 mm from the top.

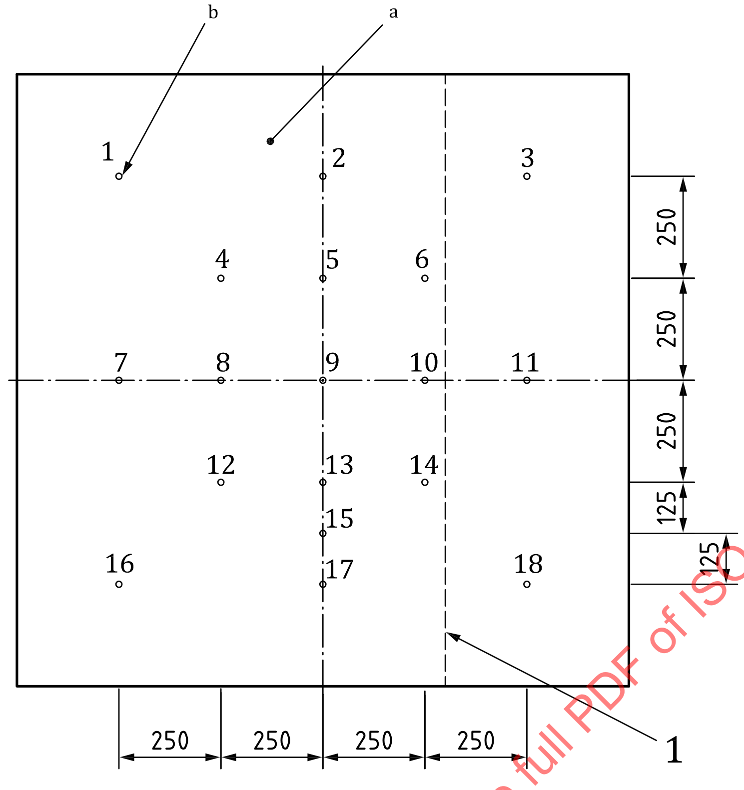
The measuring and recording equipment shall be capable of operating within the limits specified in ISO 834-1:1999, 5.6.

Readings shall be recorded at intervals of not more than 30 s.

8.2 Panel test specimens

Thermocouples shall be fastened to the back of the rear wall in positions as shown in Figure 19 in accordance with one of the methods described in Annex A. Additional thermocouples may be fastened to the rear of the joint at the discretion of the testing laboratory and any third-party certifying body.

Dimensions in millimetres



Key

1 join

a View from rear of specimen.

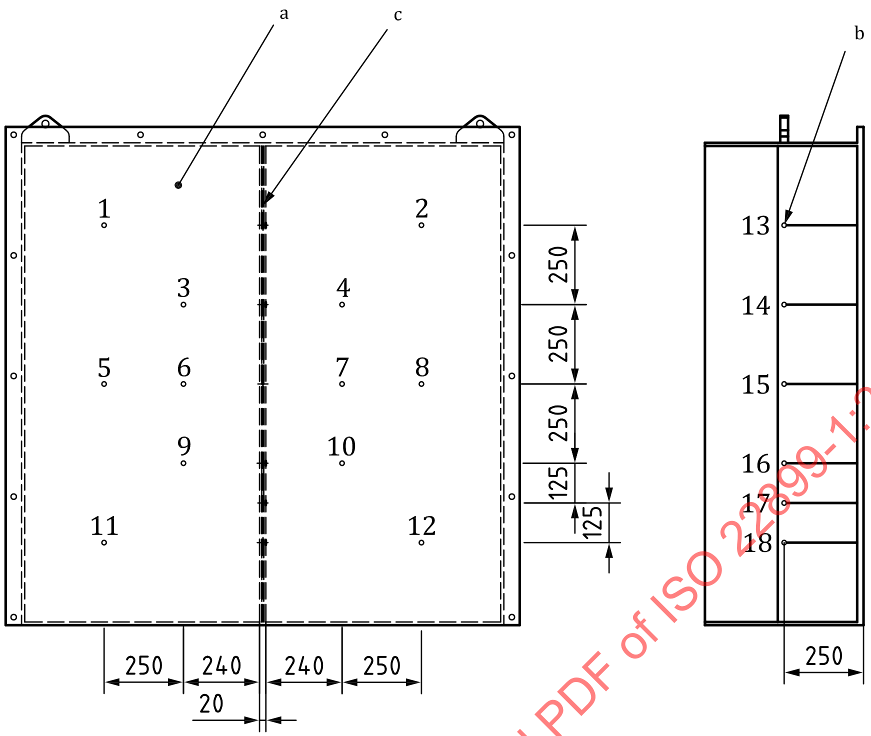
b Thermocouple position.

Figure 19 — Thermocouple positions for panel test specimen

8.3 Structural steelwork test specimens

Thermocouples shall be fastened to the back of the rear wall in positions shown in Figure 19 in accordance with one of the methods described in Annex A. Sheathed thermocouples shall be inserted into the central web as shown in Figure 19 and in accordance with the method described in Annex A.

Dimensions in millimetres



Key

a View from rear of specimen.

b Thermocouple position.

c Simulated corner or edge feature of "I" beam.

Figure 20 — Thermocouple positions for structural steelwork test specimen

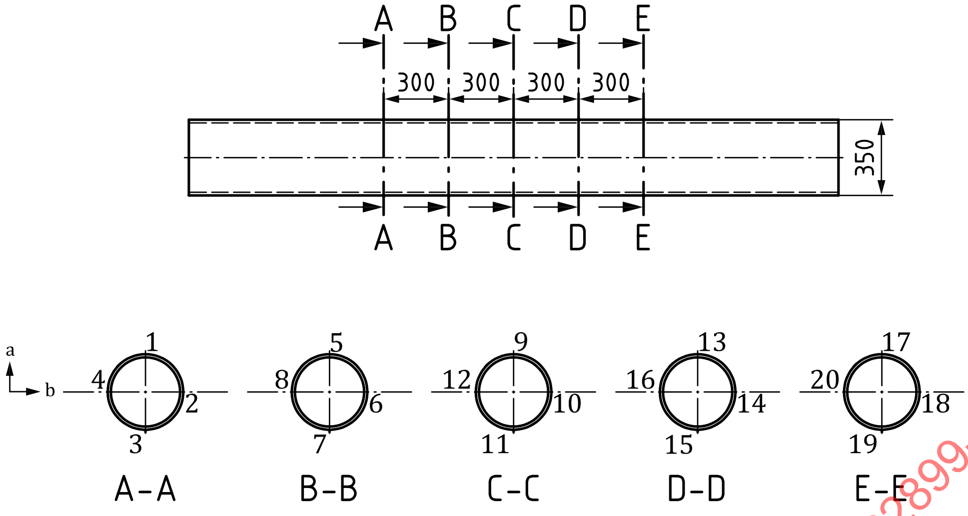
8.4 Tubular section test specimens

Thermocouples shall be fastened to the test specimen at the positions shown in Figure 21, in accordance with one of the methods described in Annex A.

The thermocouples shall be run longitudinally on the outside for no more than 50 mm before being passed through holes to the inside of the tubular section.

NOTE 1 For removable systems, where the thermocouples do not interfere with the fixing of the system to the substrate, the thermocouples can be run longitudinally along the outside of the tubular specimen.

Dimensions in millimetres



a Thermocouple position on top of tubular section.

b Thermocouple position facing towards jet fire.

Figure 21 — Thermocouple positions for tubular section test specimen

8.5 Assembly specimens

8.5.1 General

For panel mounted assemblies, thermocouples shall be fastened to the back of the rear wall in positions shown in Figure 18 in accordance with one of the methods described in Annex A. Where necessary, additional thermocouples shall be fastened to, and inside, the assembly to ensure that the key features of the assembly can be assessed. These thermocouple positions are at the discretion of the testing laboratory and any third-party certifying body.

8.5.2 Panel mounted cable transit systems

For uninsulated cable transit systems, thermocouples shall be fixed on the unexposed face at each of the locations shown in Figure 22.

a) At two positions on the surface of the outer perimeter of the frame, box or coaming at a distance of 25 mm from the unexposed surface of the panel. One thermocouple shall be fixed on the top and bottom faces opposite to each other.

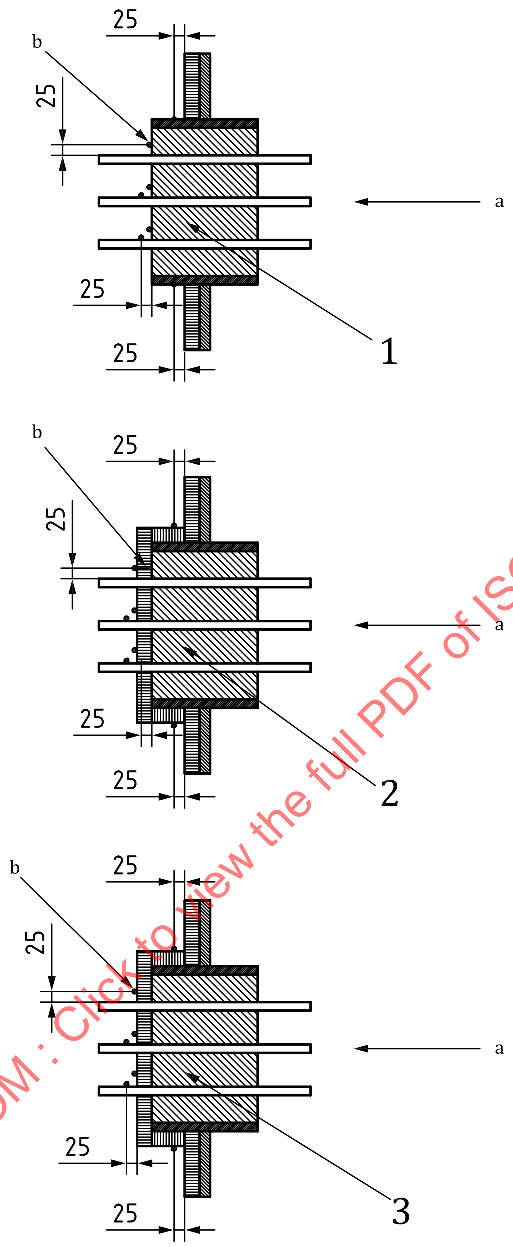
b) At two positions at the end of the transit, on the face of the sealant system or material at a distance of 25 mm from a cable.

c) On the surface of each type of cable included in the cable transit, at a distance of 25 mm from the face of the sealant system of material. In case of group or bunch of cables the group shall be treated as a single cable. The thermocouples should be mounted on the uppermost surface of the cables.

For each partially insulated or fully insulated cable transit, thermocouples shall be fixed on the unexposed face at equivalent positions to those specified for an uninsulated transit as illustrated in Figure 22.

Additional thermocouples may be fixed depending on the complexity of the cable transit system.

Dimensions in millimetres



Key

1 uninsulated transit

2 partially insulated transit

3 fully insulated transit

[a] Jet fire.

[b] Thermocouple positions.

Figure 22 — Thermocouple positions for cable transit systems

8.5.3 Tubular section mounted assemblies

For tubular section mounted assemblies, thermocouples shall be fastened to the test specimen in accordance with one of the methods described in Annex A. The thermocouples shall be fastened to the tubular section and to and inside the assembly to ensure that the key features of the assembly can be assessed. The thermocouple positions are at the discretion of the testing laboratory and any third-party certifying body.

8.6 Recommended instrumentation of pipe penetration seals

For pipe penetration seals, two thermocouples are recommended to be fixed on the unexposed face at each of the following locations:

— On the surface of the collar at a distance of 25 mm from the centre of the thermocouples to the position where the collar emerges from the rear of the substrate;

— On the surface of the pipe at distance of 25 mm from the centre of the thermocouples to the position where the pipe emerges from the rear of the collar.

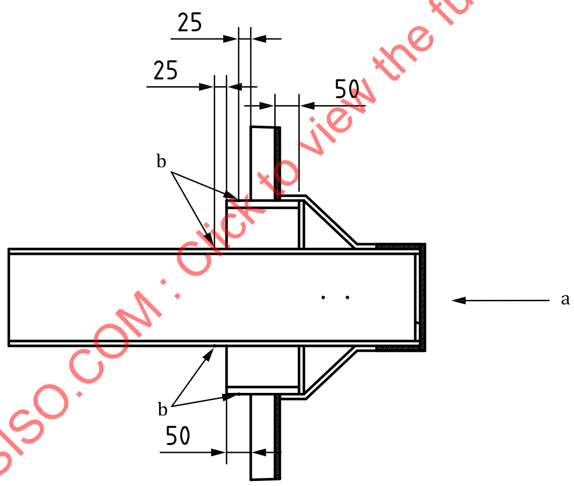
For each of the positions indicated above, one of the thermocouples should be fixed directly above the centre of the collar or pipe and the other thermocouple should be fixed directly below the centre of the collar or pipe.

Two additional thermocouples are recommended at positions dependent upon the type of the pipe penetration:

a) For sleeved seals with a longitudinal join, thermocouples should be mounted on the surface of the pipe behind the join, 25 mm from each end of the seal;

b) For packed seals, on the surface of the rear of the packing, mid-way between the pipe and the collar, one above and one below the pipe.

Additional thermocouples may be needed, dependent upon the complexity of the pipe penetration. The thermocouple positions are illustrated in Figures 23 and 24.

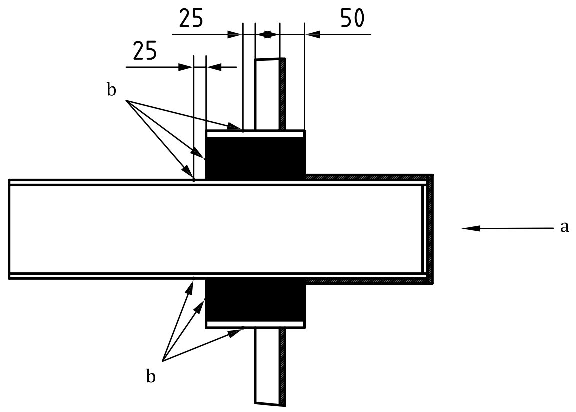


Key

a Jet fire.

b Thermocouple positions.

Figure 23 — Thermocouple positions for sleeved pipe penetration seals



Key

a Jet fire.

b Thermocouple positions.

Figure 24 — Thermocouple positions for packed pipe penetration seals

9 Test apparatus and conditions

9.1 Nozzle geometry and position

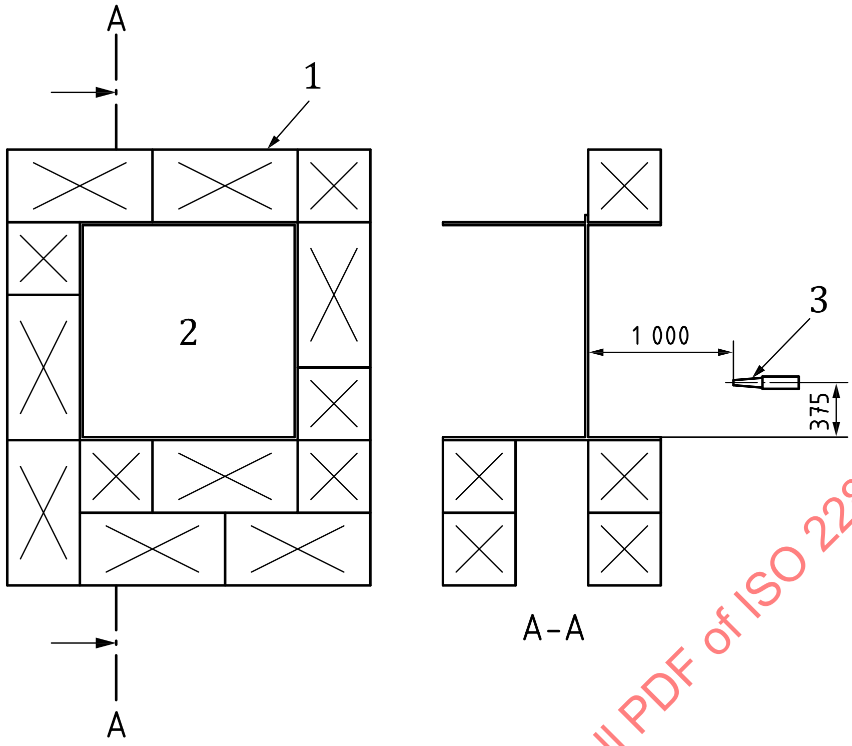
9.1.1 General

Details of construction of the tapered, converging nozzle from which the propane vapour is issued, are given in Clause 6. It is advisable to protect the nozzle and closest part of the fuel line from the flames.

9.1.2 Nozzle position for panel (including panel assemblies) and steelwork tests

The nozzle shall be aimed horizontally and normally to the rear wall of the test specimen. The tip of the nozzle shall be located 1 000 mm ± 50 mm from the front surface of the passive fire protection material or system covering the rear wall of the test specimen. Its centre shall be 375 mm above the inner surface of the test specimen's base excluding the passive fire protection material or system as shown in Figure 25. For assemblies where a feature is not able to be flush with the panel, the tip of the nozzle is located at a distance and angle agreed between the test laboratory and any third-party certifying body.

Dimensions in millimetres



Key

1 lightweight insulation blocks

2 test specimen

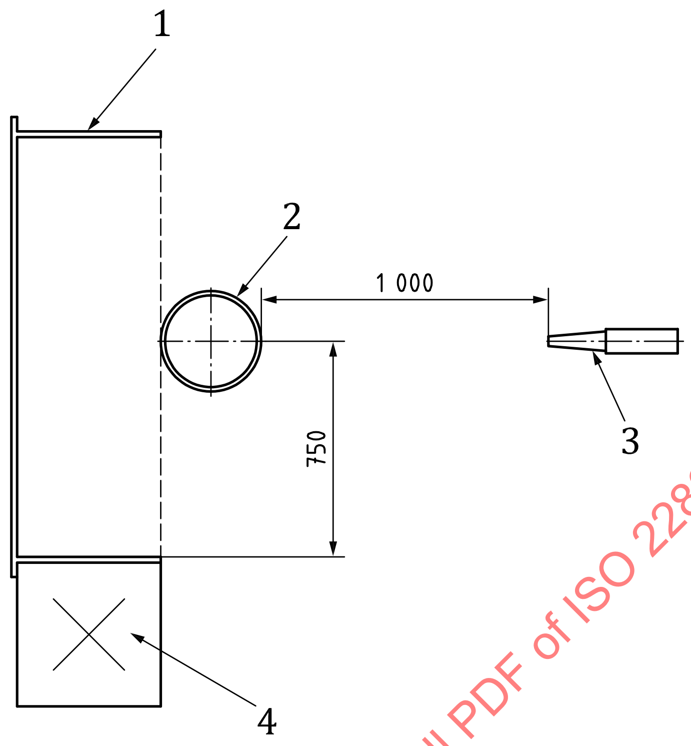
3 jet nozzle

Figure 25 — Layout of test facility with panel or steelwork test specimen

9.1.3 Nozzle position for tubular section (including assemblies) tests

The nozzle shall be aimed horizontally and normally to the rear wall of the flame re-circulation chamber and to intersect the centre of the tubular section test specimen. The test specimen shall be supported horizontally at mid-height across the front of the flame re-circulation chamber, and touching it. The tip of the nozzle shall be located 1 000 mm ± 50 mm away from the front surface of the passive fire protection material or system covering the test specimen as shown in Figure 26.

Dimensions in millimetres



Key

1 flame re-circulation chamber
2 tubular section
3 jet nozzle
4 lightweight insulation block

Figure 26 — Layout of test facility with tubular section test specimen

9.2 Fuel

The fuel shall be commercial propane, delivered as vapour without a liquid fraction at a steady rate of 0,30 ± 0,05 kg s^{-1}. There shall be a means of monitoring the mass flow rate during the test. The total amount (in kilograms) of propane used shall be recorded; for the test to be valid, this shall be 0,3 × duration of test (in seconds) ±5 %. The equipment and method of calculation shall be reported.

9.3 Test environment

The test shall be carried out in an environment in which the effects of the weather do not significantly affect the test. The specimen shall be shielded from the effects of high wind such that the wind speed in the immediate vicinity of the specimen is less than 3 m s^{-1}. The test may be performed if it is raining provided that the prevailing wind does not blow rain directly into the flame re-circulation chamber. The average substrate temperature prior to testing shall be between − 10 °C and + 40 °C.

10 Test procedure

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 toxic and/or harmful smoke and gases can evolve during the test. Mechanical and operational hazards can 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 shall be made and

safety precautions shall be identified and provided. Appropriate training shall be given to relevant personnel.

a) The sponsor shall specify the duration of the test. It may be varied during the test according to how the specimen performs.

b) The sponsor shall provide the specimen for the test in a condition representative of its practical application.

c) For panel or steelwork tests, fix the test specimen to the protective chamber and mount the assembly on a suitable support frame approximately 1,0 m from the ground as shown in Figure 25. The bottom, sides and top of the specimen shall be protected from thermal radiation by fire resistant blocks or boards.

NOTE It is usually necessary to protect the specimen-supporting frame from flames.

d) If a tubular section test is carried out, position the test specimen in front of the flame re-circulation chamber (see Figure 26). The support stands and the bare ends of the tubular section shall be protected by thermal insulation.

e) Photographs shall be taken of the test specimen before the test.

f) If the passive fire protection is a coating material, measure the thickness at the positions specified in Figures 27, 28 and 29 for panel, steelwork and tubular section test specimens, respectively.

The measurement positions indicated should be regarded as approximate. If there are clear signs of thinning or thickening at positions away from those indicated for measurement, additional measurements should be taken. The thickness may be measured by drilling a 1,5 mm hole through the passive fire protection material and then using a depth gauge. Care should be taken to ensure that any reinforcing mesh does not lead to a false reading. If the performance of the material may be affected by drilling holes, alternative methods, such as ultrasonic depth gauges, may be used provided they are described in the report and the method of calibration stated.

g) For thermo-setting (e.g. intumescent) materials, hardness measurements (e.g. Shore D) shall be made at a minimum of three positions, selected at the discretion of the test laboratory.

h) Environmental conditions shall be measured immediately before the test and any significant changes during the test noted. Measurements taken shall include ambient temperature and, for tests conducted outdoors, wind speed and direction, and whether there is any precipitation.

i) Ensure that a steady flow rate of propane vapour is provided. When the jet fire first impinges on the specimen, a timer shall be started and the flow rate, temperatures and pressures monitored. Readings of the instruments shall be taken at least once every 30 s. The test shall continue until either the time or temperature agreed with the sponsor is reached.

j) Observations shall be recorded of significant details of the behaviour and appearance of the test specimen during the test and after the jet fire is extinguished. Information on deformation, spalling, cracking or burning of the passive fire protection material and continuance of flaming shall be noted.

k) Photographs of the test specimen shall be taken as soon as is practicable after the jet fire has been extinguished and also approximately 1 h after the jet fire is extinguished. These shall be included in the test report.

l) Continuous visual records shall be made of the test.

Dimensions in millimetres

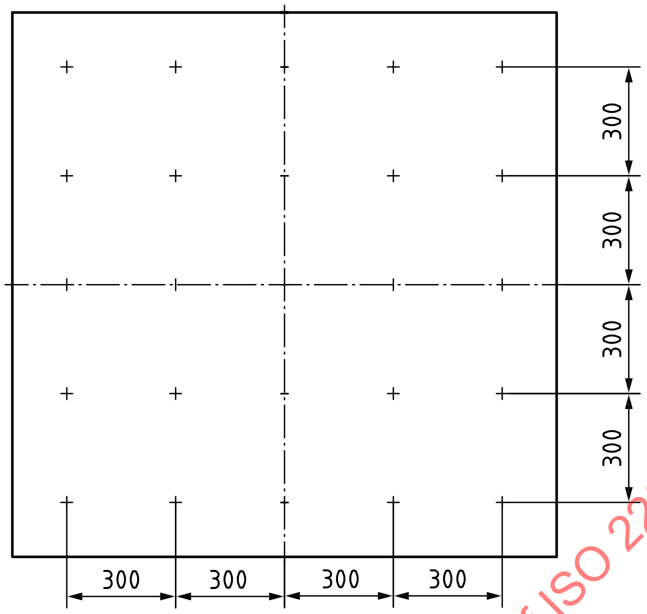
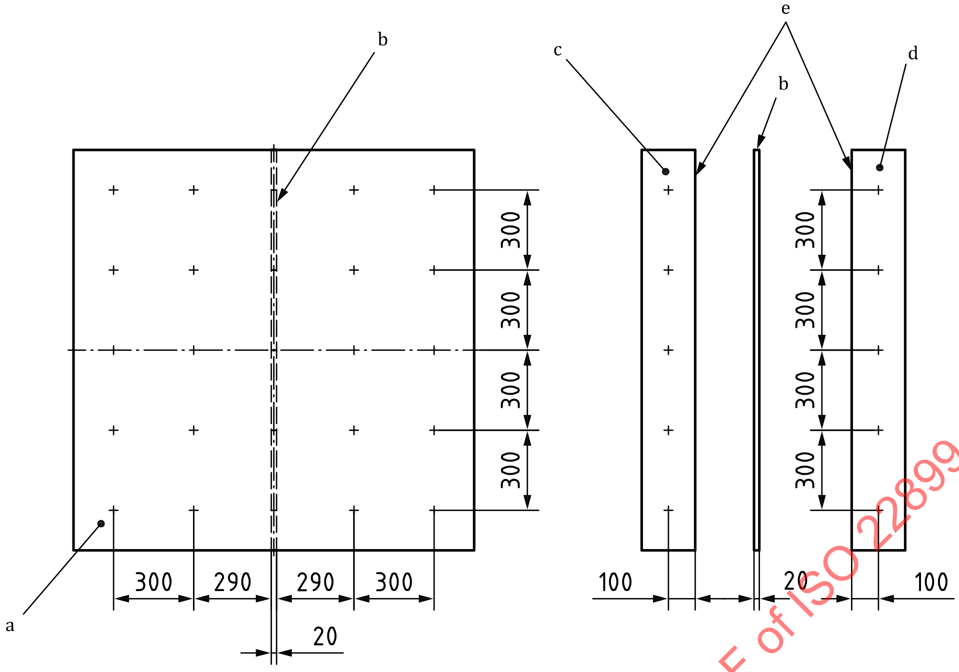


Figure 27 — Passive fire protection thickness measurement locations for panel tests

Dimensions in millimetres



Key

a View of coated steel plate from front of flame re-circulation chamber.

b Simulated corner or edge features of “I” beams.

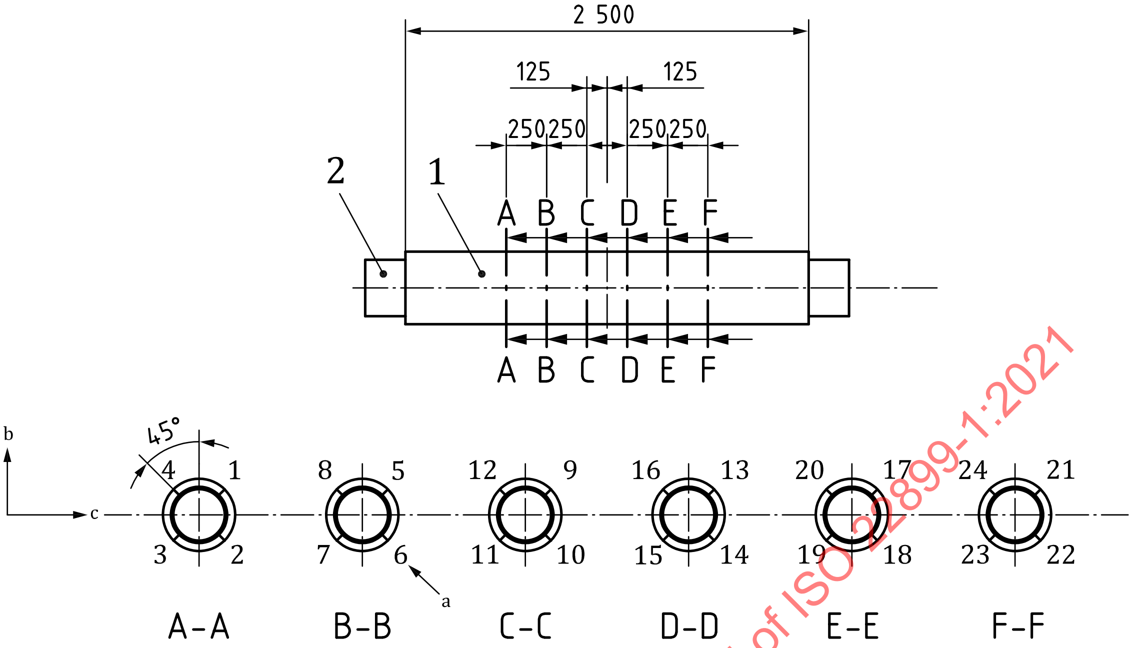
c Left side of simulated corner or edge features of “I” beams.

d Right side of simulated corner or edge features of “I” beams.

e Front edges.

Figure 28 — Passive fire protection material thickness measurement locations for steelwork

Dimensions in millimetres



Key

1 passive fire protection

2 tubular section

a Location of thickness measurement.

b Top of tubular specimen.

c Face of tubular specimen towards jet fire.

Figure 29 — Passive fire protection material thickness measurement locations for tubular section tests

11 Repeatability and reproducibility

For information on reproducibility (between-laboratory variability), see Reference [5].

No direct data on repeatability (within-laboratory variability) are currently available. However, the reproducibility data suggest that the repeatability is acceptable.

12 Uncertainty of measurement

There are many factors that can affect the result of a fire resistance test. The key factors requiring close control are the fuel flow rate and the distance and aiming of the jet release nozzle. Those concerned with the variability of the specimen including its materials, manufacture and installation are not related to the uncertainty of measurement.

13 Test report

The test report shall include the following information:

a) name of the testing laboratory, test date, unique test reference and report identification;

b) names of the sponsor/customer, the manufacturer and the product;

c) documentation on how and when the test specimen was prepared, details of the application of the PFP material or system, the name of the applicator company and, if appropriate, the name of the third-party inspection organization;

d) complete description of the test specimen, including measurements of the thickness of passive fire protection material or system and the hardness, if measured; the mean, standard deviation and range of measurements of thickness should be given as well as details of any joint (if applicable), e.g. position, type, size of overlap and method of fixing;

e) construction drawings of passive fire protection system wherever possible;

f) when appropriate, details of any deviations from the normal test configurations and the reasons for them;

g) record of test details and post fire characterization including:

   1) ambient conditions;

   2) fuel pressure and temperature at least every 30 s throughout the test, where these are used to calculate mass flow rate, and the method of control and calculation;

   3) fuel mass flow rate at least every 30 s throughout the test and total mass of fuel used;

   4) for reacting materials, the thickness of unreacted or partially reacted material left at the end of the test and the char thickness at the positions where the initial thickness was measured, and a statement on the condition of the char;

   5) for materials retained/supported by a reinforcing mesh, the condition of the mesh at the end of the test;

   6) for assemblies, a full inspection following the test to validate construction details and assess fire performance (the assembly should be dismantled so that all components of the system can be checked for flame penetration, integrity and general condition and a visual record made);

   7) for fire protection materials and systems with joints (e.g. transit systems, fire barriers), it is important that the transmission of flame, smoke, hot and toxic gases be prevented, i.e. that their integrity is maintained. Therefore, any breach of integrity during the test should be recorded.

h) the test result, in the format given below:

   1) the behaviour and appearance of the test specimen during and after the test and photographs;

   2) temperature/time graphs and spreadsheets of temperatures at no more than 30 s intervals for each thermocouple;

   3) a table showing the minimum time (rounded down to the nearest minute) for the temperature rise (in 25 °C steps for temperatures below 200 °C and in 50 °C steps for temperatures above 200 °C) above the initial temperature and identification of the thermocouple used to measure it;

   4) notation of test result (optional) according to ISO 13702, e.g. the outcome of a test could be expressed as: JF/type of application/Delta Tmax/time.

For an example report format, see Annex B.

