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Smoke sealing of doorway thresholds

Document
Fact Sheet 04

The Intumescent Fire Seals Association (IFSA) is the trade association dedicated to the science and application of intumescent based sealing materials for the passive fire protection industry.

The Association provides technical advice and guidance on all matters relating to fire door seals, smoke seals, glazing seals and all penetration/gap sealing problems.

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Intumescent Fire Seals Association
The home of reactive fire protection systems

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Introduction

Smoke generated from a fire is the product of incomplete combustion and consists of a carrier gas bearing charred particles of combustible material from the burning item. The carrier gas will also contain some toxic gases such as carbon monoxide, carbon dioxide, hydrogen chloride and dioxins. Carbon monoxide is particularly dangerous because it is tasteless and odourless so the potential victim is unaware of its presence and it is a common cause of death in fire accidents. The Building Regulations Approved Document B prescribes which doors need to be smoke resisting in order to minimise the transmission of smoke from the fire to the escape routes. Victims of carbon monoxide poisoning are often asleep in rooms close to the fire and are not awoken by its presence.

Many people assume that a fire door will stop both the spread of flames and of smoke but the two aspects are tested separately. In a fire test there is no failure criterion for smoke production at any time during the test which evaluates the fire resistance only, ie: passage of flames through the doorset, or presence of holes in the doorset. Smoke resistance is tested separately in a rig designed to evaluate air leakage at room temperature in BS 476 Pt 31.1 or either at room temperature or at medium temperature (200^{o}C) in the BS EN 1634-3 test. The pattern of smoke generation in a fire test is usually that smoke starts to leak around the door after 3 or 4 minutes when the exposed side of the door starts to burn and continues for about 15 minutes until the intumescent seals are fully activated. There is very little smoke after this until the intumescent seals begin to break down due to distortion of the leaf towards the end of the test. The amount of smoke varies significantly with doors of different construction.

An outbreak of fire occurs when we have a quantity of fuel; a supply of oxygen; and a source of ignition. A smouldering phase may follow, of variable length of time, and then by growth of flames to the point of “flashover” wherein everything that is combustible will spontaneously ignite, resulting in what is known as a “fully developed” fire. Typically, flashover will take place at around 600^{o}C and rapid growth will then be experienced to the region of 900^{o}C or more until either fuel or oxygen becomes exhausted, at which point there will follow a “decay” phase.

International fire test procedures are intended to represent only a cellulosic fire exposure scenario, post flashover, coupled with the accelerated growth that takes place with the spontaneous ignition of everything that is organic in nature and therefore combustible. This includes all wood; most plastics; and synthetic or natural materials used in furnishings. Not only in the fully developed phase, smoke will be produced at all stages in the fire sequence and may be at any temperature from ambient to more than 900^{o}C.

For example, prior to flashover, a fire door will be exposed to smoke at temperatures rising from ambient to 300^{o}C and at progressively increasing pressure over an indefinite time period.

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Smoke seals are designed to reduce the amount of smoke leaking around a fire door. They are never 100% effective so a smoke controlled fire alarm will still be activated but the amount of smoke will be considerably reduced in escape routes making exit from the building safer.

A weakness in the current regulation is that the threshold is not required to have a seal at all. The permitted gap is reduced to 3mm but as shown later in this document this is insufficient to ensure safe exit conditions in escape routes.

Current Requirements

Approved Document B

The required performance for a smoke control door, specified in Approved Document B (2019) to the Building Regulations (Note 2a in Table C1) is that smoke leakage at ambient temperature should not exceed 3m^3/h/m (head and jambs only) at a pressure of 25Pa when tested in accordance with BS 476 Pt 31 Section 31.1. This means the overall leakage rate (m^3/h/m) of the door is divided by the length of the gap between the leaf and the door head and jambs, but ignoring the leakage at the threshold as this is taped. The calculation is the same if testing in accordance with the European equivalent standard of EN 1634-3.

BS 9999

BS 9999: 2017 (Section 32.1.7), similarly requires that the ambient temperature leakage rate should not exceed 3m^3/h/m (head and jambs only) at a pressure of 25Pa when tested in accordance with BS 476 Pt 31 Section 31.1 or EN 1634-3

BS 9991

BS 9991:2024 has been revised and no longer stipulates “head & jambs only”. Smoke leakage at the threshold will be included in the calculated figure of cubic metres per Hr per M of perimeter.

BS 8214

BS 8214:2016 is currently under revision and expected to be re-published in 2026 – to be further advised.

Relevant testing standards

BS 476 Part 31 - Section 31.1

Title: Fire tests on building materials and structures
Part 31: Methods for measuring smoke penetration through doorsets and shutter assemblies
Section 31.1: Method of measurement under ambient temperature conditions “Ambient” is defined as 25^{o}C +/- 15^{o}C

Interpretation

The test is carried out by evaluating the rate of leakage through the gaps around the whole perimeter of the door assembly, always including the threshold. Pressures of 5Pa, 10Pa, 25Pa & 50Pa, both positive & negative, are applied on the exposed face of the door leaf and the volumetric leakages measured in cubic metres per hour.

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Classifications: There is no "pass-or-fail" criterion but if the leakage is less than 3 cubic metres per hour per metre of perimeter, a fire door may be classified "S" regardless of its fire integrity rating - e.g. - FD 30S FD 60S etc, as described in Approved Document B.

BS EN 1634-3:2004
Fire resistance and smoke control tests for door and shutter assemblies, openable windows and elements of building hardware - Part 3: Smoke control test for door and shutter assemblies.

Interpretation
This test is carried out by evaluating the rate of leakage of gaps around the whole perimeter of the door assembly, either with or without the threshold being included. Pressures of 10Pa, 25Pa and 50Pa, both positive & negative are applied on the exposed face of the door leaf and the volumetric leakages measured in cubic metres per hour.

There are two separate parts to the test procedure - "Ambient" temperature and an optional continuation under "Medium" temperature exposure.

"Ambient" is defined as 25^{o}C +/- 15^{o}C
"Medium" is defined as 200^{o}C +/- 20^{o}C

Classifications: These are made according to EN 13501-2:2023

Sa_3 - Ambient temperature - Three-sided - Head & jambs only - 25Pa pressure and demonstrating a leakage performance of not more than 3 cubic metres per hour per lineal metre of door leaf perimeter but excluding any leakage across the threshold.

Sa_4 - Ambient temperature - Four-sided - Head / Jambs / Threshold - 25Pa pressure and demonstrating a leakage performance of not more than 3 cubic metres per hour per lineal metre of door leaf perimeter inclusive of any leakage across the threshold.

S_{200} - Medium temperature - Independent of door size - Overall leakage at 50Pa and in terms of cubic metres per hour over the whole area of the test specimen (Not cubic metres per hour per metre of perimeter) must be less than 20 for a single leaf door assembly and less than 30 for a double leaf design.

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The Threshold Gap

Approved Document B to the Building Regulations restricts the threshold gap to 3mm for a smoke-controlled door whereas guidance is given in BS 8214:2016 to fit a threshold seal with the same performance as the head and jamb smoke seals (ie: 3 cubic metres per hour per metre). Recent work carried out by IFSA members has conclusively demonstrated that unless the threshold is properly sealed, the volume of smoke that will be transferred through that area will entirely negate the effectiveness of the seals fitted to the rest of the door assembly.

In 2019, IFSA commissioned a series of tests using the methodology of BS EN 1634-3 and showing the performance of a door assembly as a barrier to smoke in three different modes - (1) with the threshold impermeably taped (2) with a 3mm open gap as allowed by Approved Document B and (3) with the simple expedient of an automatic threshold seal fitted.

The test rig was modified by adding a transparent box around the outer face of the door assembly to represent a corridor, and a smoke generator was placed inside the test chamber to show directly the air leakage. A Fire Exit sign was affixed to the visible face of a normal sized single acting single leaf door and there were other distinguishing features on the face of the leaf so that the obscuration effects of the smoke were readily noticeable to the observer. The pressure was set at 25Pa as required in Approved Document B and the test was run for 2 minutes also as required by the test standard.

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Figure 1:
Test rig

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Figure 2:
Smoke seals fitted
head and jambs
Threshold – Gap 3mm
Leakage 10.5m³/h/m

Test 1

Smoke seals fitted to head and jambs - Threshold has a 3mm gap

The fire exit sign is completely obscured and general visibility in the “escape route” is reduced to less than 1 metre.

Figure 3:
Smoke seals fitted
head and jambs
Threshold – Blanked-off
Leakage <1m³/h/m

Test 2

Smoke seals fitted head and jambs - Threshold has been blanked off

In this artificial condition the door is not operable but the minimal smoke leakage through the perimeter seals can be seen.

Figure 4:
Smoke seals fitted
head and jambs
Threshold – Automatic seal
Leakage <1m³/h/m

Test 3

Smoke seals fitted head and jambs - Threshold - Automatic seal

Obscuration is greatly reduced from test 1 and the effectiveness of the threshold seal is convincingly demonstrated.

Figure 5:
Perimeter smoke seal used in all tests.

Figure 6:
Threshold smoke seal used in test 3.

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Far from the allowable 3 cubic metres per hour per metre of door leaf perimeter at 25Pa pressure, under the strictly controlled conditions of the EN 1634-3 smoke test it has also been verified that a 3mm open gap at the threshold will allow more than 60 cubic metres per hour per metre to pass through at 25Pa pressure.

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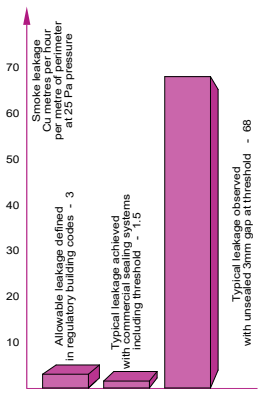

Figure 7:
Door assembly undergoing smoke testing at an independent laboratory

Figure 8:
Definitive results from actual smoke tests

With these alarming illustrations to hand, it is easy to see that an unsealed threshold gap on a fire door is completely ineffective as a barrier to smoke, yet, on the other hand, the simple expedient of fitting an automatic threshold seal enables a vast improvement and life safety is greatly enhanced.

These products consist of a flexible sealing element within a compact aluminium housing and are designed to press against the threshold surface when the door is closed but instantly retract as soon as the door leaf is opened by a few millimetres. In this way, there is no friction from contact with the floor and the seal is also not affected by floor levels perhaps being uneven as the leaf swings through its' arc of operation. The automatic movement of retraction, and subsequent sequence of pressing against the threshold as the leaf is closed once more, is entirely mechanical and no electrical connections are required. The everyday function of the doorway is not impaired by any increased resistance to opening or closing and, furthermore, without a trip hazard at the threshold through the presence of any upstand to assist with the sealing.

Ease of operation

Experience on the test chamber additionally shows that a balance has to be maintained between effective smoke sealing and ease of operation of the door assembly in everyday service. A properly adjusted automatic threshold seal provides that optimum balance.

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Figure 9:
Type T1

Figure 10:
Type T2

Type T1 - Surface mounted fixed seal
The sealing element is in contact with the floor over the whole arc of swing. It may be formed from either brush filaments or a flexible blade.

Low cost and easy to fix but will drag across the floor when the door is opened and will be subject to excessive wear in service.

Type T2 - Surface mounted fixed seal with threshold bar or plate
The sealing element is in contact with the floor only when the door leaf is in the closed position. It may be formed from brush filaments, a flexible blade or a resilient “bulb” profile

The additional threshold bar also allows carpet to be fitted up to it whilst the sealing element fitted to the door leaf is able to move clear as the door opens

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Figure 11:
Type T3

Figure 12:
Type T4

Type T3 - Surface mounted automatic
The moveable sealing element is contained within a compact fixed aluminium housing. It is in contact with the floor only when the door leaf is in the closed position and automatically lifts clear as soon as the leaf is opened by a few millimetres.

Normally suitable for sealing gaps of up to 12mm with some models capable of even 20mm. Self-levelling on sloping floors

Surface mounted location requires no machining of the bottom rail. Provides optimum performance when used in conjunction with perimeter seals mounted on the door stop but highly effective with other perimeter sealing arrangements as well.

Type T4 - Concealed automatic
The moveable sealing element is contained within a compact fixed aluminium housing. It is in contact with the floor only when the door leaf is in the closed position and automatically lifts clear as soon as the leaf is opened by a few millimetres.

Normally suitable for sealing gaps of up to 12mm with some models capable of even 20mm. Self-levelling on sloping floors.

Central location makes it compatible with most perimeter seals of the combined intumescent and smoke control type.

Generally supplied with neat end-plates, the seal is visually unobtrusive but requires a channel to be machined into the bottom rail of the leaf to enable installation.

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Myth Busters

1. Smoke always logs at ceiling level and the threshold is unimportant.

   Away from the room-of-origin of any outbreak of fire, smoke will quickly cool and descend to floor level meaning that a door assembly in another location will be under pressure over its whole face, including the threshold.

2. A gap of up to 3mm is OK at the threshold.

   Apart from the complete impracticality of maintaining a gap of less than 3mm between the bottom of the leaf and the floor level, the potential smoke leakage through this gap has been shown to be entirely unacceptable.

3. Crawling along close to the floor will maintain safety.

   As per myth 1, once in the escape route, smoke will quickly cool and descend to floor level. The cool smoke, however, will threaten life safety by seriously impairing visibility and also leading to disorientation, while still remaining highly toxic.

4. Some smoke is more toxic than other smoke.

   By definition, all smoke is the product of incomplete combustion, meaning that large quantities of deadly carbon monoxide will inevitably be present, irrespective of whether the smoke has been generated from burning substances known to emit other dangerous toxins.

Get in touch

Visit ifsa.org.uk for more information and expert technical guidance on fire door seals, smoke seals, glazing seals, and solutions for penetration and gap sealing.

Together, we're raising standards in fire safety - working to maximum safety and compliance across the fire protection industry.

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