Grenfell Tower – fire safety investigation:
The fire protection measures in place on the night of the fire, and conclusions as to:

the extent to which they failed to control the spread of fire and smoke;
the extent to which they contributed to the speed at which the fire spread.

Phase 1 Report – Appendix M

Applicable historic guidance on fire door design, specification and testing

REPORT OF

Dr Barbara Lane FREng FRSE CEng

Fire Safety Engineering

24th October 2018

Specialist Field	:	Fire Safety Engineering
Assisted by	:	Dr Susan Deeny, Dr Peter Woodburn, Dr Graeme Flint, Mr Tom Parker, Ms Danielle Antonellis, Mr Alfie Chapman
On behalf of	:	Grenfell Tower Inquiry
On instructions of	:	Cathy Kennedy, Solicitor, Grenfell Tower Inquiry
Subject Matter		To examine the circumstances surrounding the fire at Grenfell Tower on 14th June 2017
Inspection Date(s)	:	6th October, 1st November, 7-9th November 2017

Dr Barbara Lane
Ove Arup & Partners Limited
13 Fitzroy Street
London W1T 4BQ

Appendix M– Historic requirements for the design, specification and performance of fire doors

CONTENTS

M11 Conclusion regarding the condition of the Grenfell Tower stair door M-74

M1 Applicable historic guidance on fire door design, specification and testing

M1.1 Purpose of this section

M1.1.1 Various parties have requested that I clarify my position on the applicable legislation, regulations and guidance, as they specifically relate to Fire Doors.

M1.1.2 They have also requested that I clarify my opinion on why I conclude in Section 19 of my Phase 1 report:

M1.1.3 They have also requested that I clarify my opinion on why I conclude in Section 19 of my Phase 1 report:

Based on my inspection of the fire doors remaining onsite I have conducted a compliance assessment of the stair door with the available test evidence, in Appendix I. From this inspection and assessment:

(a)The doors to the protected stair enclosure do not appear to have been replaced since the original installation in 1972

(b) The original requirement was for the doors to the protected stair enclosure to achieve 30 mins stability 30 mins integrity to BS 476-1:1953. This is a lower performance than the current benchmark standard of 60 mins integrity and cold smoke leakage performance to ADB 2013 (as the stair would be required to be a firefighting stair).

(c) The current LGA guidance on existing blocks of flats makes no recommendation that stair doors achieve the ADB 2013 standard of 60 minutes integrity fire resistance and cold smoke leakage. It instead refers to doors of 30 minutes fire resistance only stating there is no expectation that an existing building should meet the current 60 minute standard.

(d) One door to the protected stair enclosure (on level 6) was inspected during my site inspection in November 2017. This thickness of the door leaf, 44mm, as typical of an FD30 door as advised by industry guidance. My measurements show the door was not compliant with a CP3 (1971) Type 2 door as the measured rebate was 12mm compared to 25mm. It was also not compliant with the LGA guidance criteria for an upgraded FD30S as no smoke seals were observed. Finally, it would not meet the performance standard for an ADB 2013 stair door which is FD60S.

I can conclude that the non-compliances I have identified did not contribute to the failure to prevent the spread of fire and smoke during the initial fire event in Flat 16. At this time the protected stair was reported as being clear of smoke (Section 14).

M1.1.4 In this new Appendix I address these two points and specifically provide:

M1.1.5 I have tracked the legislation from the 1960s up to the present day to find the historic requirements and guidance for timber fire door construction in the UK. I have used information from the applicable legislation, regulation, statutory and industry guidance to identify how fire door designs have developed over time.

M1.1.6 I have then compared this with the construction of the stair door at Grenfell Tower observed by myself, Prof. Bisby and the Metropolitan Police, to investigate whether the features of the stair fire doors provide any evidence of when they may have been installed. I provide published information on timber fire doors since 1951 and particularly rebate requirements and set out my resulting concerns about performance in fire.

M1.1.7 I have also identified the conflicting evidence available to me regarding whether work has been done to the stair fire doors at Grenfell Tower since they were installed.

M1.1.8 Finally, I provide the updated version of my Conclusions in Section M11.

M1.2 Defined terms

M1.2.1 The following terminology as listed below is relied upon throughout this Section of the report. Please refer to Appendix I for a further list of defined terms applicable to fire door assemblies.

M1.2.2 **Intumescent fire seal**- seal used to impede the flow of heat, flame or gases, which only becomes active when subjected to elevated temperature. Note that Intumescent fire seals are components which expand, helping to fill gaps and voids, when subjected to heat in excess of ambient temperatures. (BS 8214:2016 *Timber-based fire door assemblies* clause 3.13).

M1.2.3 **Smoke seal-** seal fitted to the leaf edge or frame reveal for the purpose of restricting the flow of smoke or hot gases. (BS 8214:2016 *Timber-based fire door assemblies* clause 3.17). (Note ADB 2013 table B1 only requires cold smoke performance at the head and jambs of the door)

M1.2.4 **Integrity**- the ability of a specimen of a separating element to contain a fire to specified criteria for collapse, freedom from holes, cracks and fissures and sustained flaming on the unexposed face (BS 476-20:1987 *Fire tests on building materials and structures. Method for determination of the fire resistance of elements of construction (general principles)* Section 2.9).

M1.2.5 **Insulation**- the ability of a specimen of a separating element to restrict the temperature rise of the unexposed face to below specified levels (BS 476-20:1987 *Fire tests on building materials and structures. Method for determination of the fire resistance of elements of construction (general principles)* Section 2.8).

M1.2.6 **Stability**- Non loadbearing construction. Failure shall be deemed to occur when collapse of the specimen takes place. (BS 476-8: 1972 *Fire tests on building materials and structures. Test methods and criteria for the fire resistance of elements of building construction* clause 1.5.1).

M1.2.7 Fire door - A door or shutter provided for the passage of persons, air or objects, which, together with its frame and furniture as installed in a building, is intended (when closed) to resist the passage of fire and/or gaseous products of combustion and is capable of meeting specified performance criteria to those ends. (It may have one or more leaves and the term includes a cover or other form of protection to an opening in a fire-resisting wall or floor or in a structure surrounding a protected shaft.) (Approved Document Part B vol 2 Appendix E).

M1.2.8 Fire-resisting door- Notional FD30 door- A door assembly that satisfied the current specification, or fire resistance test, for 30 minutes at the time of construction of a block of flats or manufacture of the door. (LGA, 2011, *Fire safety in purpose built blocks of Flats-Glossary)*.

M1.2.9 Fire-resisting door- Upgraded FD30S door- A 'notional FD30' door, fitted with intumescent strips and smoke seals, and with any other necessary work carried out, such that it may reasonably be anticipated that it would satisfy the relevant test requirements for 30 minutes integrity and control of the passage of smoke at ambient temperature. (LGA, 2011, *Fire safety in purpose built blocks of Flats-Glossary)*.

M1.2.10 BS EN 12519:2018 *Windows and pedestrian doors – Terminology* further outlines the various components of a typical door assembly. An excerpt is shown in Figure M.1.

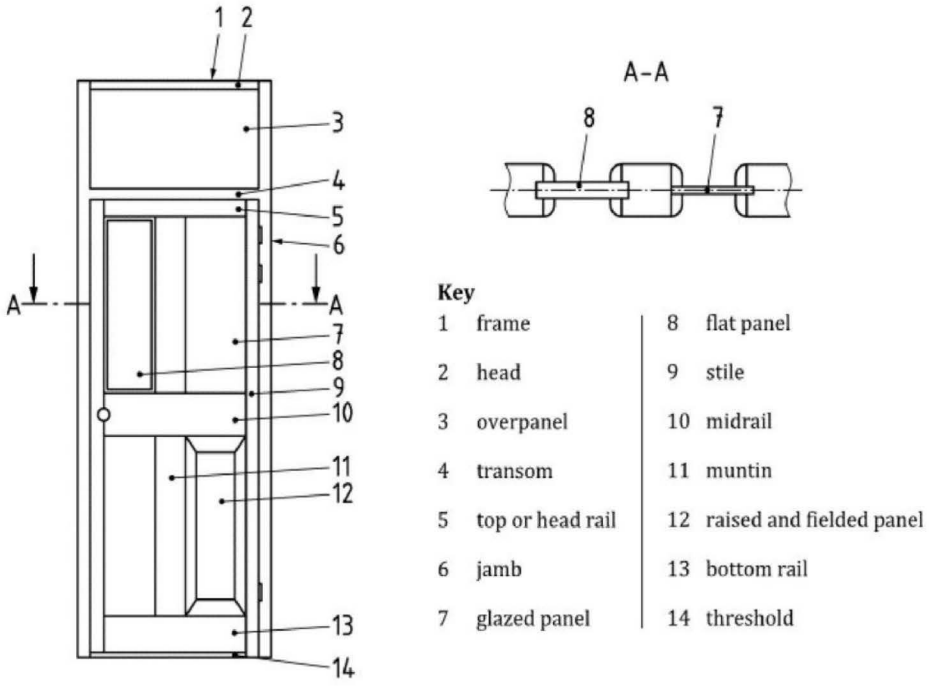


Figure M.1 BS EN 12519:2018 excerpt showing various door terminology

M2 Applicable legislation, regulation and industry guidance for residential fire doors

M2.1.1 In this section, I set out the applicable legislation, regulation and guidance applicable in London between 1972 and the present day. For the period 1972 to 1974 (the time of design and construction of Grenfell Tower), I have already set out the applicable legislation, regulation and guidance applicable in London in Appendix D of my report. My findings are summarised in Figure M.2.

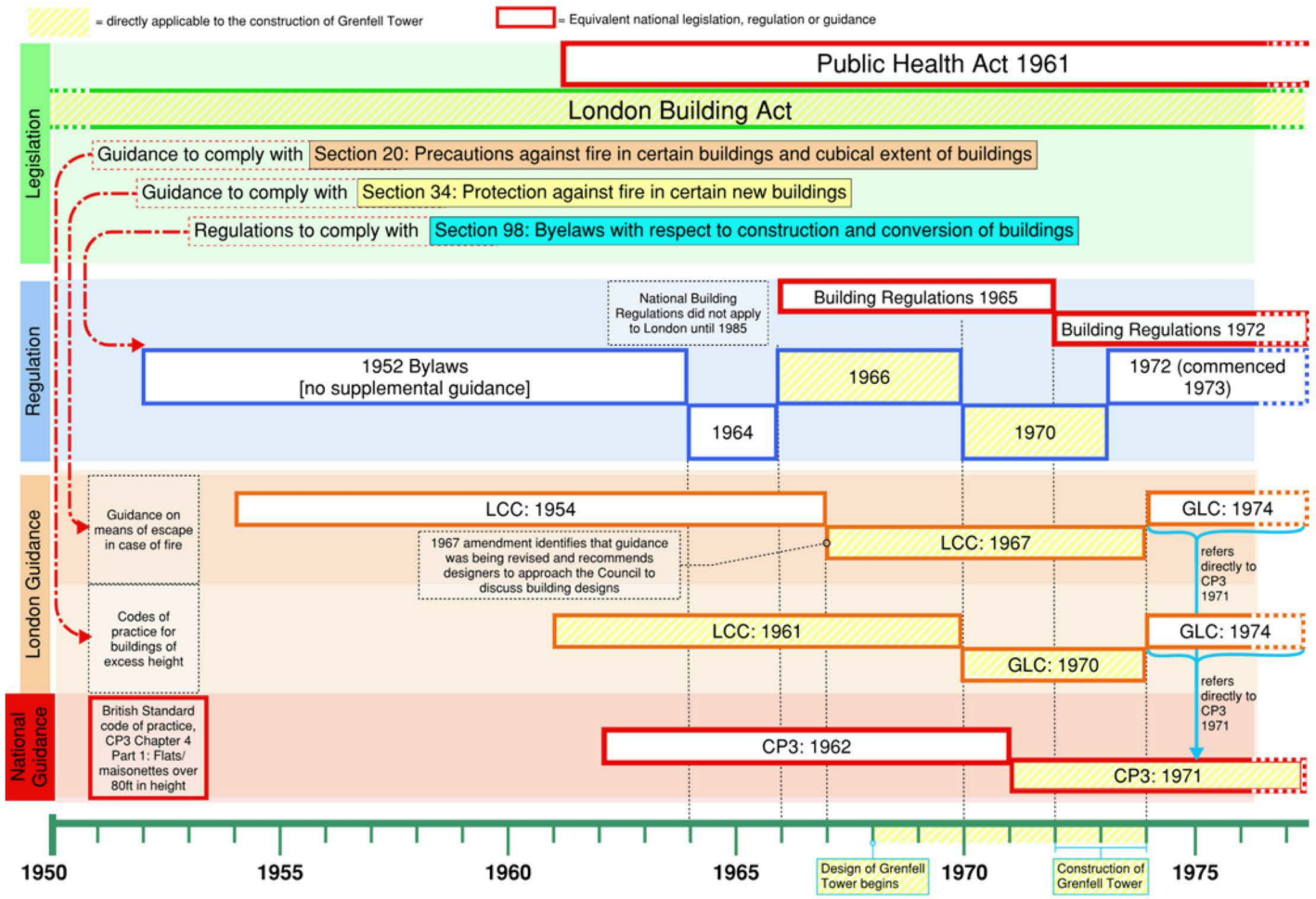


Figure M.2 Legislation, regulations and guidance applicable in London 1950-1975 (references with yellow fill identify the legislation, regulations and guidance in force at the time of the design and construction of Grenfell Tower)

M2.1.2 Based on the timeline in Figure M.2, at the start of construction of Grenfell Tower in 1972, the relevant legislation, regulation and guidance was as shown in Table M-1.

Table M-1 Relevant legislation, regulation and guidance for the design and construction of Grenfell Tower

	London	**National**
Applicable Legislation at time of construction	London Building Acts (Amendment) Act 1939	Public Health Act 1961
Applicable Regulations at time of construction	London (Building) Constructional Amending Bylaws 1952 (as amended 1964, 1966 and 1970)	Building Regulations 1965 and 1972 (commenced 1st June 1972)
Applicable Approved Guidance at time of construction	LCC Guide *Means of escape in case of fire* (1967); GLC *Code of practice for buildings of excess height* (1970);	British Standard CP3: Chapter IV: Precautions against fire: Part 1. Fire precautions in flats and maisonettes over 80ft (1971)

M2.1.3 As shown in Table M-1 the performance of the fire doors (flat and stairs) in Grenfell Tower was required to comply with the *London Building Acts (Amendment) Act 1939*.

M2.1.4 I have identified three sections of the act relevant to the construction of the stair doors. These are *Section 20- Precautions against fire in certain buildings and cubical extent of buildings; Section 34- Protection against fire in certain new buildings; and Section 98- Byelaws with respect to construction and conversions of buildings.*

M2.1.5 To comply with Section 98 of the *London Building Acts (Amendment) Act 1939, compliance with the London Building Constructional Amending Bylaws 1954 (as amended 1964, 1966 and 1970)* was required. The *London Building Constructional Amending Bylaws* make specific provisions for the fire performance of doors which I have set out in Section M3.1.

M2.1.6 To comply with Section 34 of the *London Building Acts (Amendment) Act 1939* the London County Council (LCC) published the code of practice *Means of Escape in case of fire* (1954, amended 1967).

M2.1.7 Section 6.04 of the code of practice states:

"d) Doors to enclosed staircases and to external staircases should be of solid timber not less than 1 ¾ inches finished thickness or having not less than one half hours standard of fire resistance

……

j) Attention is drawn to Table G of Schedule VI of the London Building (Constructional) Bylaws 1952, where these apply"

M2.1.8 Additionally, Fire resisting is defined in Section 3.01 of LCC *Means of Escape in case of fire* (1967) as:

"The standard of fire resistance which for the purposes of this code shall mean one half hours fire resistance to fire as set forth in London Building Constructional Bylaws, 1952, Schedule VI".

M2.1.9 To comply with Section 20 of the *London Building Acts (Amendment) Act 1939*, the Greater London Council published *"Code of practice for buildings in excess height and/ or cubical extent requiring approval under Section 20 of the London Building Acts (Amendment) Act 1939"* in 1970.

M2.1.10 In this code, Appendix A Construction and ventilation of firefighting lobby approach staircases and fire lifts of this code of practice states:

"The doors between the stairs and the lobby and between the lobby and the floor areas should be Class A self-closing doors".

M2.1.11 A Class A door is defined in Section 3.01 of the code of practice as:

"a Class A Door under Table G of Schedule VI of the London Building (Constructional) Amending Bylaws 1966"

M2.1.12 Note the requirements of a Class A door under Table G of the London Building (Constructional) Amending Bylaws is discussed further in Section M3.1.

M2.1.13 The guidance to comply with Section 20 and Section 34 of the *London Building Acts (Amendment) Act 1939* both direct the user to refer to the London Building Constructional Amending Bylaws. Therefore, the Bylaws provided the relevant requirements for fire doors at the time of construction of Grenfell Tower.

M2.1.14 It is also important to understand the national legislation, regulations and associated guidance available at this time Figure M.2 shows that the Public Health Act 1961 was the original legislative vehicle for national building regulations. The first such national regulations came into force in 1965, and were then replaced in 1972.

M2.1.15 The national Building Regulations from 1965 and 1972 did not include any requirements for means of escape. They were concerned with "structural fire precautions" only, i.e. fire resistance of structure, compartmentation and external fire spread over the outside of buildings and between buildings.

M2.1.16 As I have described in Appendix D, British Standards produced recommendations for protection to means of escape in the design of blocks of flats in their Code of Practice CP3: Chapter IV: *Precautions against fire: Part 1. Flats and Maisonettes (in blocks over two storeys) (1971)* (CP3 Chapter IV Part 1 (1971)).

M2.1.17 The London statutory guidance 'LCC Guide Means of escape in case of fire (1967)' states:

M2.1.18 *"This Code of Practice is in the course of revision. Several important principles have been changed.*

...

Pending the publication of the revised Code of Practice applicants are advised to discuss their schemes with the Greater London Council's officers in the earliest stages of design."

M2.1.19 Therefore, until the LCC 1967 guide was superseded in 1974 by the Greater London Council Means of Escape Code of Practice (GLC 1974), there existed a transition period were it was possible for designers to use guidance documents other than the current statutory guidance for means of escape where agreed with Greater London Council officers.

M2.1.20 During this transition period the national statutory guidance for means of escape was CP3 Part 4 (1962 and then later, 1971). Therefore, it is possible that between 1967 and 1974 a designer could use either the LCC 1967, CP3 1962 or CP3 1971 in the design of means of escape in a high rise residential building. From the publication of the statutory guide GLC 1974, CP3 1971 was adopted as the guidance document for means of escape. See section 3.2 for further details.

M2.1.21 I have reviewed the means of escape guidance from these three documents against the original construction of Grenfell Tower. Out of these, only CP3 1971 was consistent with the original design and construction of Grenfell Tower; specifically, its single stair and internal ventilated lobby arrangement. This layout is consistent only with the design principles of a CP3 1971 smoke dispersal ventilated lobby. It is on this basis that I have concluded CP3 1971 was the basis for design of Grenfell Tower – see section 4.2 for further details.

M2.1.22 CP3 Chapter IV Part 1 (1971) was formally recognised guidance for compliance with Section 34 of the London Building Act 1939 on the publication of Greater London Council Means of Escape in Case of Fire: Code of Practice (1974). The introduction of this code states:

"This code of practice does not embrace means of escape in case of fire in respect of flats and/or maisonettes as the Council has, for the time being, adopted the standards contained in the British Standard Code of Practice CP3: Chapter IV: Part 1: 1971".

M2.1.23 It is important to note that there are certain types of Class A door *(London Building (Constructional) Bylaws 1952)* that do not comply with the guidance for an equivalent performance of fire door in CP3. I present the specific details of door construction for the Bylaws in Section M3.1and CP3 in Section M3.2.

M2.1.24 After 1985, the London Building Act Section 34 and 98 were repealed and replaced by the Building (Inner London) Regulations 1985.

M2.1.25 Section 2 (1) of the Building (Inner London) Regulations 1985 states*: "The Building Regulations 1985 (b) the Building (approved inspectors etc.) Regulations 1985(c) and the Building (Prescribed fees etc.) Regulations 1985(d) shall apply in inner London.*

M2.1.26 The London Building Regulations therefore required compliance with the National Regulations, the result of this was that after commencement of the Building (Inner London) Regulations 1985 on the 6th January 1986 the applicable Legislation, Regulations and guidance changed.

M2.1.27 There was no requirement to retroactively apply the new regulations to existing buildings such as Grenfell.

M2.1.28 I have produced a time line of the applicable legislation, regulation and guidance in London from 1980 to the present day for any building works undertaken to Grenfell Tower during the operation of the building which was subject to Building Regulations compliance. This is shown in Figure M.3.

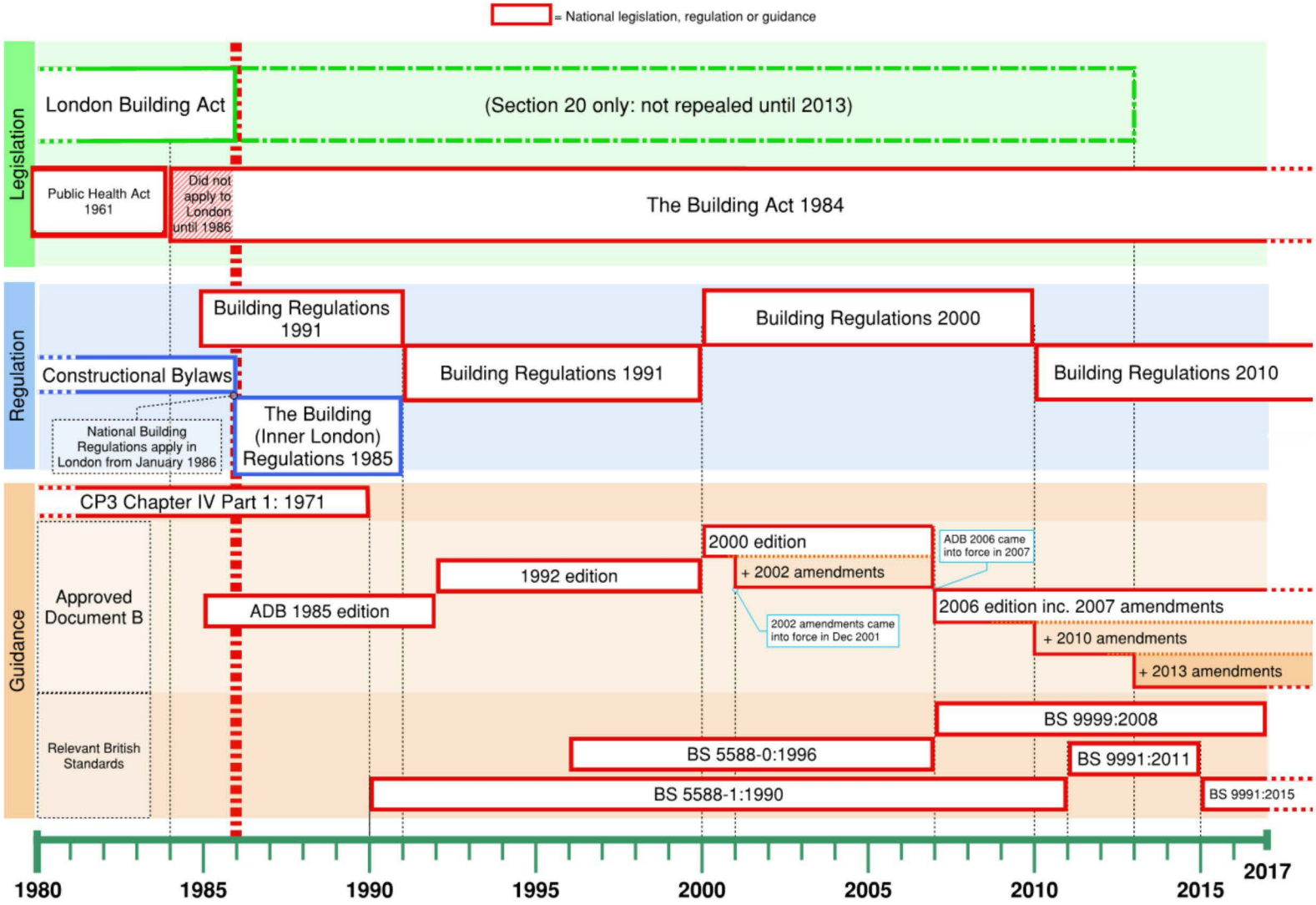


Figure M.3Timeline of the applicable legislation, regulation and guidance in London from 1980 to 2017

M2.1.29 Based on my assessment of the relevant legislation, regulations and guidance above, the specification of new fire doors in London should have complied with the guidance listed in Table M-2 for the relevant year.

Table M-2 Applicable standard for specification of the design and construction of flat entrance and stair doors

Year	Applicable standard for specification of the design and construction of flat entrance and stair doors at Grenfell Tower
1952 -1986	London Building (Constructional) Bylaws 1952 as amended 1964, 1966, 1970 London Building (Constructional) Bylaws 1972
1974 - 1990 (Applied by direct reference from GLC Means of Escape guide 1974)	British Standard CP3: Chapter IV: Precautions against fire: Part 1. Flats and maisonettes (in blocks over 2 storeys) (1971) (Noting that some of the Class A doors permitted by the Bylaws would not comply with the requirements for doors in CP3)
1990 -2011	BS 5588-1: 1990
1992-2000	Approved Document Part B 1992
2000-2006	Approved Document Part B 2000 (as amended 2002)
2006-2018	Approved Document Part B 2006 (as amended 2007, 2010, and 2013)
2011-2015	BS 9991: 2011 *Fire safety in the design, management and use of residential buildings. Code of practice*
2015-2017	BS 9991: 2015 *Fire safety in the design, management and use of residential buildings. Code of practice*

M2.1.30 I will now describe the fire door specification requirements stated in the relevant Legislation, Regulations and Guidance set out in Table M-2in Section M3.

M3 Performance requirements for fire doors 1966 to 2017

M3.1 London Building (constructional) amending bylaws

M3.1.1 During the design and construction of Grenfell Tower there were three revisions of the London Building (constructional) amending bylaws. These were 1966, 1970 and 1972. There is no material difference to the performance of fire doors between these revisions therefore I shall refer to the 1966 requirements for the rest of this section.

M3.1.2 Section 11.07 of the London Building (constructional) amending bylaws states:

"11.07

Openings and doors *(1) Notwithstanding the provisions of By-law 11.06 but subject to the provisions of By-law 7.13, openings may be made in the vertical separations between parts of buildings other than in vertical separations between separate dwellings:*

Provided that

(i) The aggregate area of the openings in a wall or partition forming a separation in any one storey of a building shall not exceed one-half of the overall area of the wall or partition in that storey;

(ii) Where such openings are made in separations between tenancies for similar uses, they each shall be fitted with a self-closing door of not less standard that that of class A in Table G of Schedule VI of these by-laws; and

(iii) Where such openings are made in separations between parts of buildings in different uses, they each shall be fitted with a self-closing door of not less standard that that of class A in Table G of Schedule VI of these by-laws, or of class B in that table if the separation in which the opening is made is required to be capable of resisting the action of fire for a period greater than one hour."

M3.1.3 Table G of Schedule VI of *London Building (constructional) amending bylaws 1966* provides four methods of demonstrating a door achieves a class A performance. Three of these are design specifications and the fourth method is by test. The four methods listed are:

1) Solid timber not less than 1 ¾ inches finished thickness.

2) Laminated timber core solid throughout covered both sides with ply facing and with all edges protected by solid timber capping covering the full thickness of the core and facings, the total thickness of the door not less than 1 ¾ inches.

3) Timber stiles and top and bottom rails not less than 3 ¾ inch wide and a middle rail not less than 6 ½ inch wide rebated to receive 3/8 inch p plasterboard infilling on both sides strengthened by 1 ¾ inch intermediate rails, the whole covered both sides with plywood facings, the total thickness of the door not less than 1 ¾ inches.

4) Doors tested in accordance with the provisions of Section 3 of British Standard 'Fire Tests on Building Materials and Structures' No. 476 : 1953, and certified as being capable of resisting the action of fire for ½ hour.

M3.1.4 Further general guidance is given in Table G of schedule VI of *London Building (constructional) amending bylaws 1966* as stated below:

"Class A doors shall be hung to open in one direction only in solid timber or metal frames with rebates or door stops not less than ½ inch deep, centre opening doors may be in two leaves each hung to the frame with butt jointed meeting stiles where only minimum clearance is allowed at the meeting edges.

Provided that Class A doors which open into a corridor or lobby with enclosures capable of restricting the action of a fire for a period of not less than ½ hour, may open in two directions without rebated frames provided minimum clearance only is allowed at the meeting edges.

Glazing fixed shut may be incorporated in a Class A door if it is capable of resisting the action of fire under the provisions of Table F of this schedule for a period of ½ hour, or if it comprises of a single vision panel of ¼ thick clear glass not exceeding 100 square inches in area in a solid timber frame at least 1 ¾ inches by 1 ¾ inches clear of rebates."

M3.1.5 It does not state in Table G of Schedule VI of *London Building (constructional) amending bylaws 1966* what the expected performance of the number 1-3 doors is. I have explained in full in Section M5 of my Expert Report that a door designed to comply with the no.3 Class A Bylaw specification would achieve less than 30 minutes integrity and 20 minutes stability to BS 476-1:1953, which is a lower performance than that required by a no. 4 class A door, and the performance standard stated for it (30 minutes stability and 30 minutes integrity) at that time.

M3.1.6 I have taken the guidance stated above and produced the drawing in Figure M.4to illustrate the differences between the four types of Class A door specified in Table G of Schedule VI of the *London Building (constructional) amending bylaws 1966*.

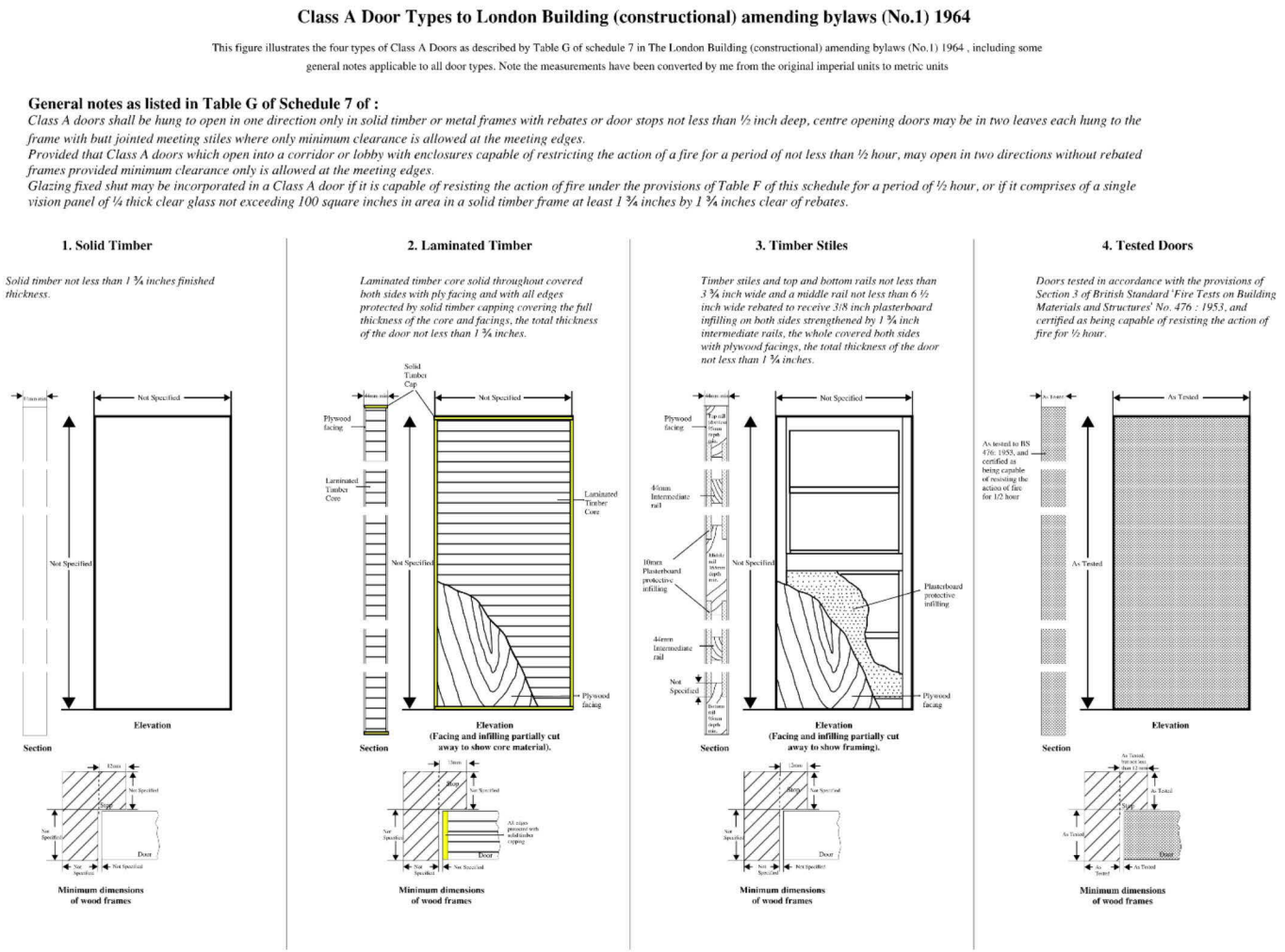


Figure M.4 Four types of Class A door specified in Table G of Schedule VI of the London Building (constructional) amending bylaws 1966 (note units converted from imperial to metric by me)

M3.2 CP3 Chapter 4 Part 1 (1971) for fire doors (stair and flat entrance)

M3.2.1 As I have explained in Section 4 (and supported by calculations in Appendix J), CP3 Chapter 4 Part 1 (1971) was the design standard the means of escape in the Tower was constructed to. I have therefore included the performance specification from CP3 Chapter 4 Part 1 (1971) here.

M3.2.2 I explain in Appendix I that to comply with CP3 Chapter 4 Part 1 (1971) stair fire doors were required to be of Type 2 construction and flat front entrance fire doors were required to be of Type 3 construction.

M3.2.3 CP3 Chapter 4 part 1 (1971) Section 4.3 *Fire Resisting Doors* states:

"4.3.1 General. Fire resisting doors are one of the most important links in the chain of fire safety precautions and care in their selection, to ensure they are adequate for purpose, cannot be over emphasized. Doors used for fire protection purposes should be self-closing and should, except for entrance doors to dwellings and doors within them, be marked with a warning notice that they are provided for fire safety and should be kept closed. Self-closing devices should be of a type that which cannot readily be disconnected or immobilized and should not embody a check retaining action at 90°, and it is essential that a self-closing device of any kind should override any latches fitted to the door or doors. Self-closing devices are particularly important in both double and single swing doors, as the efficiency of doors as a barrier to fire can be negated if the device does not retain the door positively in the closed position.

Fire resisting doors occurring in spaces in common use (other than in dwellings) should be fitted with door closers or spring hinges; rising butt hinges are not considered satisfactory in these situations. Hinges and closers should be check action. Hinges should satisfy BS 1227, provided the melting point of the metal is not less than 800°C. No hinges should have nylon brushes.

In all cases the tests referred to under 4.3.2 are those laid down in BS 476.

4.3.2 Types of fire resisting door. The types of fire resisting door numbered 1, 2 and 3 correspond to the recommendations of CP 3, Chapter IV, Parts 2 and 3. Type 4 is a further type recommended in this Code for places where glazed doors are recommended across corridors."

"4.3.2.2 Type 2 door. The door, or leaf thereof when fixed in a frame with a 25mm rebate (approximately 1in) should satisfy the requirements of test as to both freedoms from collapse and resistance to passage of flame for not less than 30 minutes. The door may be single or double leaf, swinging in one or both directions. Such doors should be fitted with a self-closing device (other than rising butt) and the frame may have either no rebate or a rebate of unspecified depth; meeting stiles should not be rebated.

With any doors fitted in frames without rebates, the clearance between leaf and frame. or leaf and leaf, should be as small as reasonably practicable."

4.3.2.3 Type 3 door. The door, or leaf thereof when fitted in a 25mm (approximately 1in) rebated frame should satisfy the requirements of test as to freedom from collapse for not less than 30 minutes and resistance to passage of flame for not less than 20 minutes. The door should either be a single leaf swinging in one direction only or double leaf with each leaf swinging in the opposite direction from the other leaf, and with rebated meeting stiles. The door should be fitted in frames having a rebate of not less than 12mm (approximately 1/2 inch) and should be fitted with an automatic self-closing device which may (except where otherwise recommended) consist of rising butt hinges"

"4.3.2.5 Glazing. Doors having a half hour fire resistance or one hour fire rating may incorporate fixed glazing so long as the fire resistance in respect of integrity and stability is maintained. For the particulars of fire rated glazing, see CP 153: Part 4."

M3.2.4 *Collapse* and *passage of flame* are defined failure criteria specific to BS 476-1:1953.

M3.2.5 Clause 11 of BS 476-1:1953 states:

"The test result shall be stated in terms of time, in hours and minutes from the commencement of heating, for which the element of structure complies with those of the following three requirements which are relevant to it. Where a test is terminated by agreement, this shall be stated in the report"

*a) **Collapse**. For all elements of structure, it is required that the element shall not collapse*

*b) **Passage of flame**. For all elements of structure whose function is to separate spaces and hence resist passage of fire from one space to another, it is required that cracks, fissures or other orifices through which flame can pass shall not develop.*

M3.2.6 In the later version of the fire resistance standard BS 476-8:1972 the term *collapse* from BS 476-1:1953 changed to be called *stability*. Stability is defined in clause 1.5.1.2 of BS 476-8:1972 for non-loadbearing elements of construction as:

"failure shall be deemed to occur when collapse of the specimen takes place"

M3.2.7 There is therefore no material difference between *collapse* as defined in BS 476-1:1953 and *stability* as defined in BS 476-8:1972.

M3.2.8 Note in the later version of the fire resistance standard BS 476-8:1972 that term *passage of flame* from BS 476-1:1953 changed to be called *integrity*. Where integrity is defined in clause 1.5.2 as:

"failure shall be deemed to occur when sustained flaming exists for an uninterrupted period of not less than 10s on the unexposed face of the specimen or when cracks or other openings exist through which flame or hot gases pass which cause flaming of the cotton wool pad as noted in 1.4.6.2."

M3.2.9 The only material difference between *passage of flame* as defined in BS 476-1:1953 and *integrity* as defined in BS 476-8:1972 is that a defined period of flaming and a method of assessing whether a crack or fissure is large enough to allow the passage of flame by using a cotton pad was introduced.

M3.2.10 For simplicity through the rest of this appendix I shall use the term *stability* instead of *freedom from collapse* and *integrity* instead of *resistance to passage of flame* as later editions of the fire resistance test standards and industry guidance form the time of construction use the terms *integrity* and *stability* (although noting that *stability* was no longer tested for after the introduction of BS 476-22:1987).

M3.2.11 From the text in 4.3.2.2 and 4.3.2.3 of CP3 Chapter 4 part 1 (1971) it can be seen that a Type 2 door requires a higher performance (30 minutes integrity and 30 minutes stability) than a Type 2 door (20 minutes integrity 30 minutes stability). A Type 2 door is specified with a 25mm rebate and a Type 3 door is specified with a 12mm rebate.

M3.2.12 It should be noted that there is one instance where either a Type 2 or a Type 3 door can be installed with no rebate or rebate of unspecified depth as stated below:

"The door may be single or double leaf, swinging in one or both directions. Such doors should be fitted with a self-closing device (other than rising butt) and the frame may have either no rebate or a rebate of unspecified depth; meeting stiles should not be rebated. With any doors fitted in frames without rebates, the clearance between leaf and frame. or leaf and leaf, should be as small as reasonably practicable.""

M3.2.13 This clause only applies to doors swinging in both directions as if a rebate was fitted the door or doors would not be able to swing in both directions. This interpretation is further confirmed by reference to the 1965 national building regulations Clause E11 (c) which states:

"As to any such door falling into sub paragraph (a)(iii) or (iv), the clearance between the leaf or leaves of the door and the frame and (where there are two leaves) between the leaves shall be as small as reasonably practicable".

M3.2.14 Sub-paragraphs (a)(iii) and (iv) refer specifically to a single leaf door swinging in both directions and a double leaf door, each leaf of which swings in both directions and not to doors swinging in one direction as installed as the stair door in Grenfell Tower.

M3.2.15 I have investigated contemporary test evidence/ industry guidance from the 1970s and I present this in Section M5 of my Expert Report; this shows that

rebate depth has a significant effect on the performance of doors tested to BS 476-1:1953 - The fire resistance test standard that applied at the time of the design of Grenfell Tower (1967 -1972). This evidence shows that a 12mm rebate would not achieve 30 minutes integrity.

M3.2.16 I note that for a Type 2 door one specific dimension is quoted *"The door, or leaf thereof when **fixed in a frame** with a 25mm rebate (approximately 1in)"* [my emphasis]. My interpretation of these dimensions is as follows in Figure M.5.

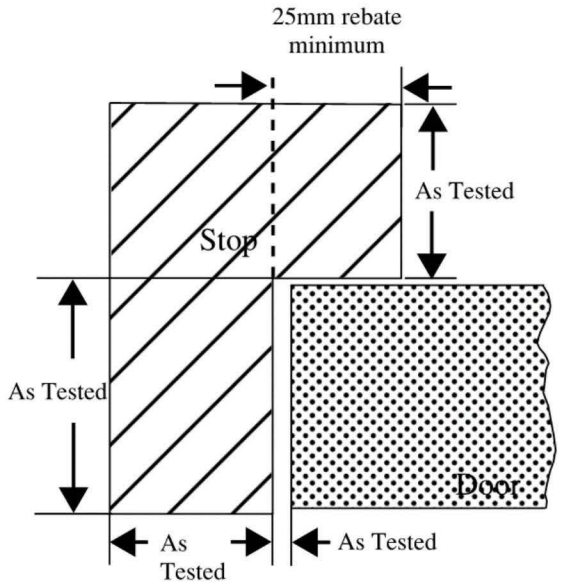


Figure M.5 Minimum dimensions of the rebate and frame of a Type 2 door

M3.2.17 I note that for a Type 3 door two specific dimensions are quoted *"The door, or leaf thereof when **fitted in a 25mm** (approximately 1in) **rebated** frame"* [my emphasis] and *"The door should be fitted in frames having a rebate of not less than 12mm (approximately 1/2 inch)"*. I have taken this to mean that the frame thickness must be at least 25mm with a 12mm rebate overhanging the door as shown in Figure M.6.

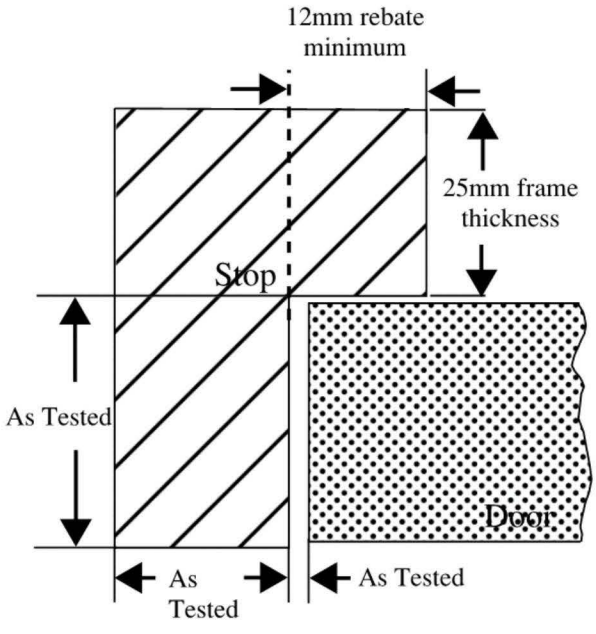


Figure M.6 Minimum dimensions of the rebate and frame of a Type 2 door

M3.2.18 During the design period and just prior to construction, BS 476-1:1953 was replaced with BS 476-8:1972. From my investigation presented in M5 I have shown that under this later test standard the same door leaf construction as the Grenfell Tower stair door even with a 25mm rebate and intumescent strips would not achieve 30 minutes integrity; and would in fact only achieve 20 minutes integrity.

M3.2.19 I have produced the drawing in Figure M.7 to illustrate the differences between a Type 2 and a Type 3 door as specified in Section 4.3.2 of CP3 Chapter 4 part 1 (1971).

CP3 Chapter 4: Part 1: 1971

This figure illustrates the Type 2 and Type 3 doors as described in Section 4.3.2 in Chapter 4: Part1 of CP3: 1971, including some general notes applicable to all door types.
Note I have converted the original imperial measurements to metric.

General notes as listed in Section 4.3.1:

Fire resisting doors are one of the most important links in the chain of fire safety precautions and care in their selection, to ensure they are adequate for purpose, cannot be over emphasized. Doors used for fire protection purposes should be self-closing and should, except for entrance doors to dwellings and doors within them, be marked with a warning notice that they are provided for fire safety and should be kept closed. Self-closing devices should be of a type that which cannot readily be disconnected or immobilized and should not embody a check retaining action at 90°, and it is essential that a self-closing device of any kind should override any latches fitted to the door or doors. Self-closing devices are particularly important in both double and single swing doors, as the efficiency of doors as a barrier to fire can be negated if the device does not retain the door positively in the closed position.
Fire resisting doors occurring in spaces in common use (other than in dwellings) should be fitted with door closers or spring hinges; rising butt hinges are not considered satisfactory in these situations.
Hinges and closers should be check action. Hinges should satisfy BS 1227, provided the melting point of the metal is not less than 800°C. No hinges should have nylon brushes.
In all cases the tests referred to under 4.3.2 are those laid down in BS 476.

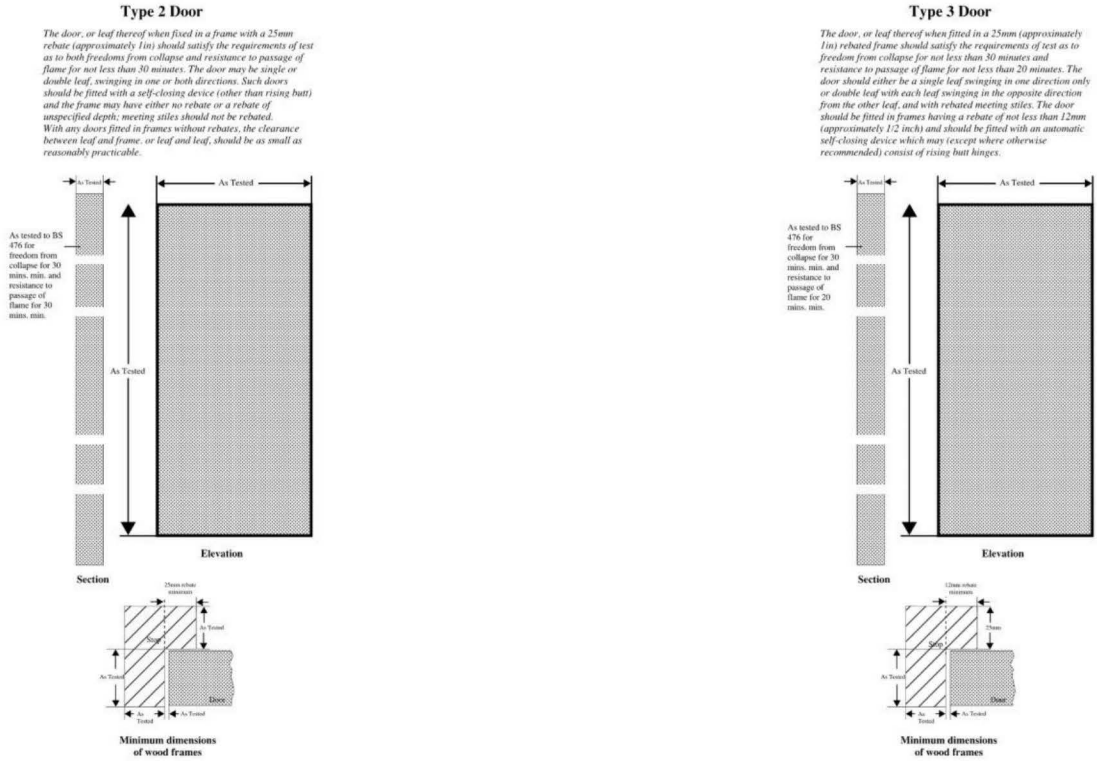


Figure M.7 Type 2 and Type 3 doors as described in Section 4.3.2 in Chapter 4: Part1 of CP3: 1971

M3.3 BS 5588-1: 1990 for fire doors (stair and flat entrance)

M3.3.1 BS 5588-1: 1990 *Fire precautions in the design, construction and use of buildings. Code of practice for residential buildings* was an approved guidance document for the design of new residential buildings from 1990 until it was superseded by BS 9991 in 2011.

M3.3.2 Section 18.6 of BS 5588-1: 1990 provides the recommendations for fire doors. It states:

"18.6.1 Commentary

Fire doors are one of the most important links in the chain of fire safety precautions, and care in their selection to ensure that they are adequate for their purpose cannot be over-emphasized. The failure of doors under fire conditions usually occurs either at the gap between the door and the frame, or at one or more of the points where ironmongery is fixed (particularly at the hinges or lock positions), or, in the case of glazed doors, at the line of the junction between the glazed area and the rest of the door. For this and other reasons it is particularly important to ensure that doors delivered on site comply precisely, in dimensions and workmanship, with the manufacturer's specification for the appropriate fire resistance test report. Doors should also be hung to ensure a good fit to the frame when closed.

The ability of fire doors to perform their designed function will depend upon their being fully closed at the time of fire; they are, therefore, normally required to be fitted with self-closing devices. However, closers ought not to have significantly more force than is necessary to close (and latch if appropriate) the door effectively; latches should be selected and fitted so as not to require an unreasonable closing force. Where a closed door would cause problems to the normal usage of the building, and therefore possibly become wedged or otherwise held open or have the closer disconnected, electromagnetic (or similar) "hold-open" systems may be considered for use except in certain situations. However, because blocks of dwellings contain a sleeping risk, the protection of escape routes is far more critical and, although it is impractical to disallow the use of hold-open devices for cross-corridor fire doors, hold-open devices are not permitted for fire doors protecting vertical escape routes except in sheltered housing and certain mixed user buildings (as these are provided with automatic fire detection systems).

The performance of a fire door when tested in accordance with BS 476-22 is judged by its time to failure (in minutes) for each of the criteria of "integrity" and "insulation"; however, requirements made in connection with regulations and codes of practice do not normally specify any performance for insulation.

For the purposes of this code, fire doors are designated by reference to their required performance (in minutes) for integrity only, e.g. a reference FD 20

implies that the door in that situation should achieve not less than twenty minutes integrity and a reference FD 30 implies not less than thirty minutes integrity when tested in accordance with BS 476-22. Where doors are also required to resist the passage of smoke at ambient temperature, the suffix "S" is added (see 18.6.2). Methods for the evaluation of doors to control the movement of smoke will be published as sections of BS 476-31. The methods take account of three different stages of a fire:

a) ambient temperature;

b) medium temperature;

c) high temperature conditions.

NOTE Further information on the performance and function of fire doors is given in PD 6512-1, on the construction of FD 30 fire doors in PD 6512-2, and on the installation and maintenance of fire door assemblies in BS 8214).

Although the above-mentioned system of designation specifically excludes reference to any performance for insulation (because of problems of radiation through traditional fire-resisting glass), Table 1 recommends limits to the extent of non-insulating glazed areas in fire doors in certain circumstances.

Any reference to performance when tested in accordance with BS 476-8 or BS 476-22 is for the purposes of this code only. Depending upon circumstances, a higher performance may be necessary to satisfy building regulations for structural fire protection.

18.6.2 Recommendations

The following recommendations are applicable.

a) A fire door should be provided to comply with the minimum performance recommended for any of the following circumstances:

1) a fire door forming part of the enclosures of:

i) a protected escape route within a house, FD 20;

ii) a protected entrance hall within a flat (see Clause 9 and Figure 4 and Figure 7), FD 20 (except the dwelling entrance door [see item a)3)i)]);

iii) a protected entrance hall and landing within a maisonette (see Clause 10 and Figure 10), FD 20 (except the dwelling entrance door [see item a)3)i)]);iv) a partition separating living and sleeping accommodation [see Figure 3(b) and Figure 6(b)], FD 20;

v) a protected stairway, FD 30S;

vi) a lobby or corridor approach to a protected stairway, (see 14.7), FD 30S;

vii) ancillary accommodation (see Table 3, items 1 and 2), FD 30S;

viii) ancillary accommodation (see Table 3, items 3 to 9), FD 60S;

ix) a lift well unless within the enclosure of a protected stairway [see 18.4.2a)], FD 30;

x) building services ducts etc. [see 18.4.2b)], FD 30S, unless the duct is fire-stopped at each storey, in which case it should be FD 30;

2) a fire door subdividing a common corridor (see Figure 12, Figure 13 and Figure 17), FD 20S;

3) a fire door affording access:

i) to a dwelling from an internal common corridor or lobby, FD 30S;

ii) to a dwelling from an external balcony or deck, where such balcony or deck is served by only one stair [see Figure 15(b) and Figure 15(c)], FD 20;

iii) on to an external stair, FD 20.

4) a fire door separating at ground or access level a stair and ancillary accommodation in a small single stair building (see 12.3), FD 30S.

b) A fire door (e.g. FD 30) required to resist the passage of smoke at ambient temperature conditions [i.e. those having suffix S in item a)], should be tested complete with smoke seals in accordance with BS 476-31.1.

c) A fire door [except to a cupboard, refuse chamber or service duct, see item f)] should be fitted with a self-closing device that:

1) should be of a type that cannot readily be disconnected or immobilized and does not embody a stand-open action;

2) should override any latches fitted to the door(s) or, in the absence of a suitable latch or other positive device for holding the door shut in its frame, should be of a type that has been shown by test in accordance with BS 476-8 or BS 476-22 to be capable of holding the door closed in the frame for a sufficient period of time for the closing role to be taken over by a thermally activated sealing device (such as an intumescent seal), or throughout the full period of exposure if such seals are not incorporated.

d) Fire doors within dwellings should either comply with item c) or should be fitted with rising butt hinges. NOTE Cupboard doors within dwellings need not be self-closing.

e) Unless shown to be satisfactory when tested in accordance with BS 476-8 or BS 476-22, no part of a hinge on which any fire door is hung, and that provides the sole means of support at the hanging edge, should be made

either of combustible material or of non-combustible material having a melting point of less than 800 °C.

f) Unless within a dwelling, a fire door to a cupboard or refuse chamber or service duct, in lieu of being self-closing, should have means to enable it to be kept locked shut when not in use and be so marked on both sides with the appropriate sign complying with BS 5499-1.

g) Doors to common stairs [other than in sheltered housing and certain mixed user buildings, see item h)], protected lobbies and ancillary accommodation should not be provided with any means for overriding their self-closing mechanisms.

h) Hold-open systems complying with 18.7 may be provided for holding open fire doors, or for overriding their self-closing devices, in the following situations:

1) across any corridor;

2) to a protected stairway in:

i) sheltered housing; or

ii) a mixed user building provided with an automatic fire detection and alarm system. Such doors should be suitably marked on both sides, at about eye level, with the appropriate sign complying with BS 5499-1.

i) All fire doors except doors to and within dwellings, doors to cupboards [see item f)], or doors held open by a hold-open device [see item h)], should be marked on both sides, at about eye level, with the appropriate sign complying with BS 5499-1 to the effect that they should be kept closed when not in use.

j) Fire doors on common escape routes should not be fitted with threshold upstands."

M3.3.3 The requirement for a fire door forming part of the enclosures of a protected stairway (other than a firefighting shaft) for compliance with BS 5588-1:1990 is that they achieve 30 minutes integrity when tested to BS 476-22.

M3.3.4 It is also required that the door is tested with its seals to BS 476-31.1 for cold smoke leakage performance.

M3.3.5 Section 35 *Access for firefighting of* BS5588-1:1990 Section 35.3 *Recommendations* states:

"a) Buildings or parts of buildings of height (see 2.27) exceeding 18 m or depth (see 2.13) exceeding 9 m should be provided with firefighting shafts (each incorporating a firefighting lift) complying with BS 5588-5, except that the size of the firefighting lobby may be larger than that recommended in BS

5588-5. However, the distance between the firefighting lift landing doors and the door to the firefighting stair should not exceed 7.5 m."

M3.3.6 New buildings with a height exceeding 18m constructed to this standard therefore required Firefighting shafts.

M3.3.7 In terms of the fire resistance of firefighting shafts BS 5588-5:1991 *Section 2 planning and construction 9 Construction of the firefighting shaft 9.3 Fire resistance 9.3.2 Recommendations states:*

The following recommendations are applicable.

a) Fire resistance, where recommended in this code, implies the following:

1) for walls and partitions, compliance for loadbearing capacity (where appropriate), integrity and insulation;

2) for glazed elements, compliance for the appropriate criteria (see 9.5);

b) Construction separating a firefighting shaft from other parts of a building or areas of risk should have a fire resistance of not less than 2h for the sides remote from the firefighting shaft and not less than 1h for sides internal to the firefighting shaft."

M3.3.8 To comply with BS 5588-5:1991 Section 9 the wall of a firefighting shaft must therefore achieve 120 minutes' integrity and insulation to BS 476-22.

M3.3.9 In terms of the fire resistance of doors in firefighting stairs, BS 5588-5:1991 *9.4 Fire doors states:*

"9.4.1 Commentary

The performance of a fire door when tested in accordance with BS476-22 is judged by its time to failure (in minutes) for the criteria of "integrity" and "insulation"; regulations and codes of practice do not normally, however, specify any performance for insulation. For the purposes of this code, fire doors are designated by reference to their required performance (in minutes) for integrity only, e.g. a reference FD60 implies that the door in that situation should achieve not less than 60min integrity when tested in accordance with BS476-22, and a reference FD30 implies not less than 30min integrity. Where doors are also required to retard the passage of smoke the suffix "S" is added.

9.4.2 Recommendations

The following recommendations are applicable.

a) Fire doors protecting openings in fire-resisting structures should have a fire resistance of at least one-half of that required for the structure, but in no case less than 30min. In the early stages of fire, it is unlikely that the door between the firefighting lobby and the accommodation would be directly attacked by fire, although the wall separating the firefighting shaft and the

accommodation might well be. The main function of the door at this point is to ensure that the firefighting lobby remains relatively smoke free. During firefighting operations, the door between the firefighting shaft and the accommodation at the fire floor would be open and therefore its level of fire resistance is relatively unimportant, as is the fire resistance of the doors between the firefighting shaft and the accommodation at levels not affected by fire.

b) Fire doors (except lift landing doors and doors to and within pressurized firefighting shafts) should, when tested in accordance with BS476-31.1 with the threshold taped and subjected to a pressure of 25Pa, have a leakage rate not exceeding 3m3/h per metre. When installed, the threshold gap should be sealed by a seal either with a leakage rate not exceeding3m3/h per metre at 25Pa or just contacting the floor; where this is impracticable the threshold gap should not exceed 3mm at any point."

M3.3.10 Fire doors in construction separating a firefighting shaft from the rest of the building must therefore achieve 60 minutes integrity when tested to BS 476-22 and cold smoke leakage of leakage rate of less than 3m3/hour per metre under 25Pa of pressure when tested to BS 476-31.1.

M3.3.11 I have taken the guidance stated above and produced the drawing in Figure M.8 to illustrate the differences between a fire door *forming part of the enclosures of a protected stairway*; a fire door *affording access to a dwelling from an internal common corridor or lobby*; and a fire door in a firefighting shaft.

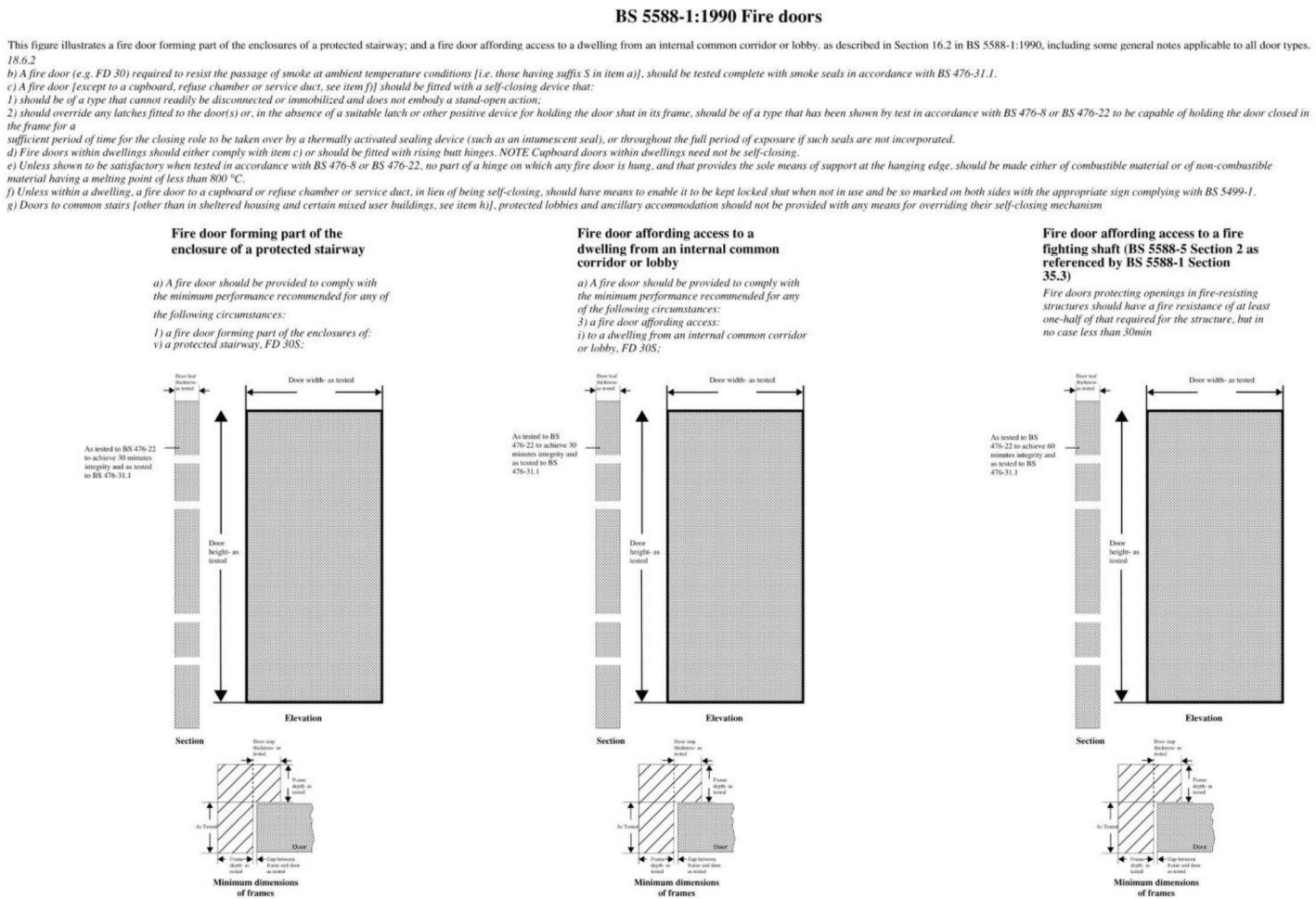


Figure M.8 Stair door and flat front entrance door as described in BS 5588-1:1990

M3.4 Requirements of Approved Document Part B

M3.4.1 Approved Document B 1992 was an approved document that was applicable to the design requirements of new buildings from 1992 to 2000.

M3.4.2 Appendix B of Approved Document B 1992 provides the recommendations for fire doors. It states:

"B1 All fire doors should have the appropriate performance given in Table BI. In the table doors are identified by their performance under test to BS 476: Part 22, in terms of integrity for a period of minutes, e.g. FD30. A suffix (S) is added for doors where restricted smoke leakage at ambient temperatures is needed.

The method of test exposure is from each side of the door separately, except in the case of lift doors which are tested from the landing side only.

B2 All fire doors should be fitted with an automatic self-closing device except for fire doors to cupboards and to service ducts which are normally kept locked shut.

B3 Where a self-closing device would be considered a hindrance to the normal approved use of the building, self-closing fire doors may be held open by:

a. fusible link (but not if the door is fitted in an opening provided as a means of escape unless it complies with paragraph 84); or

b. an automatic release mechanism if the door can also be closed manually and it is not to

i. the only escape stair serving a building (or part of a building), or

ii. a firefighting stair, or

iii. an escape stair serving a building in any Residential purpose group; or

c. a door closure delay device.

B4 Two fire doors may be fitted in the same opening so that the total fire resistance is the sum of their individual fire resistances, provided that each door is capable of closing the opening. In such a case, if the opening is provided as a means of escape, both doors should be self-closing, but one of them may be fitted with an automatic self-closing device and be held open by a fusible link if the other door is capable of being easily opened by hand and has at least 30 minutes fire resistance.

B5 Unless shown to be satisfactory when tested as part of a fire door assembly any hinge on which a fire door is hung should be made entirely from materials having a melting point of at least 800°C.

B6 Hardware used on fire doors can significantly affect performance in fire. Guidance is available in a "Code of practice for hardware essential to the optimum performance of fire resisting timber doorsets" published by the Association of Builders' Hardware

Manufacturers in 1983.

B7 Except for doors identified in B8 below, all fire doors should be marked with the appropriate fire safety sign complying with BS 5499: Part 1 according to whether the door is:

a. to be kept closed when not in use,

b. to be kept locked when not in use, or

c. held open by an automatic release mechanism

Fire doors to cupboards and to service ducts should be marked on the outside; all other fire doors on both sides.

B8 The following fire doors are not required to comply with B7 above:

a. doors within dwelling houses,

b. doors to and within flats or maisonettes,

c. bedroom doors in 'Other-residential' premises, and

d. lift entrance doors.

B9 Tables AI and A2 set out the minimum periods of fire resistance for the elements of structure to which performance of some doors is linked. Table A4 sets out limitations on the use of uninsulated glazing in fire doors."

M3.4.3 Table B1 of ADB 1992 states the minimum fire resistance of door in terms of integrity (minutes) for a *"door in a compartment wall if it separates a flat or maisonette from a space in common use*, or *a door forming part of the enclosures of a protected lobby approach (or protected corridor) to a stairway"* should achieve 30 minutes integrity to BS 476-22 and unless pressurization techniques complying with BS5588: *Part 4 are used these doors should also have a leakage rate not exceeding 3m3/m/hour (head and jambs only) when tested at 25 Pa under BS 476: Section 31.1*.

M3.4.4 In the case of a fire door forming part of the enclosures of a firefighting shaft Paragraph 17.11 of ADB 1992 states:

Firefighting shafts should be designed and constructed, and installed in accordance with the recommendations of BS 5588: part 5 in respect to the following:

a) Section 2: Planning and construction

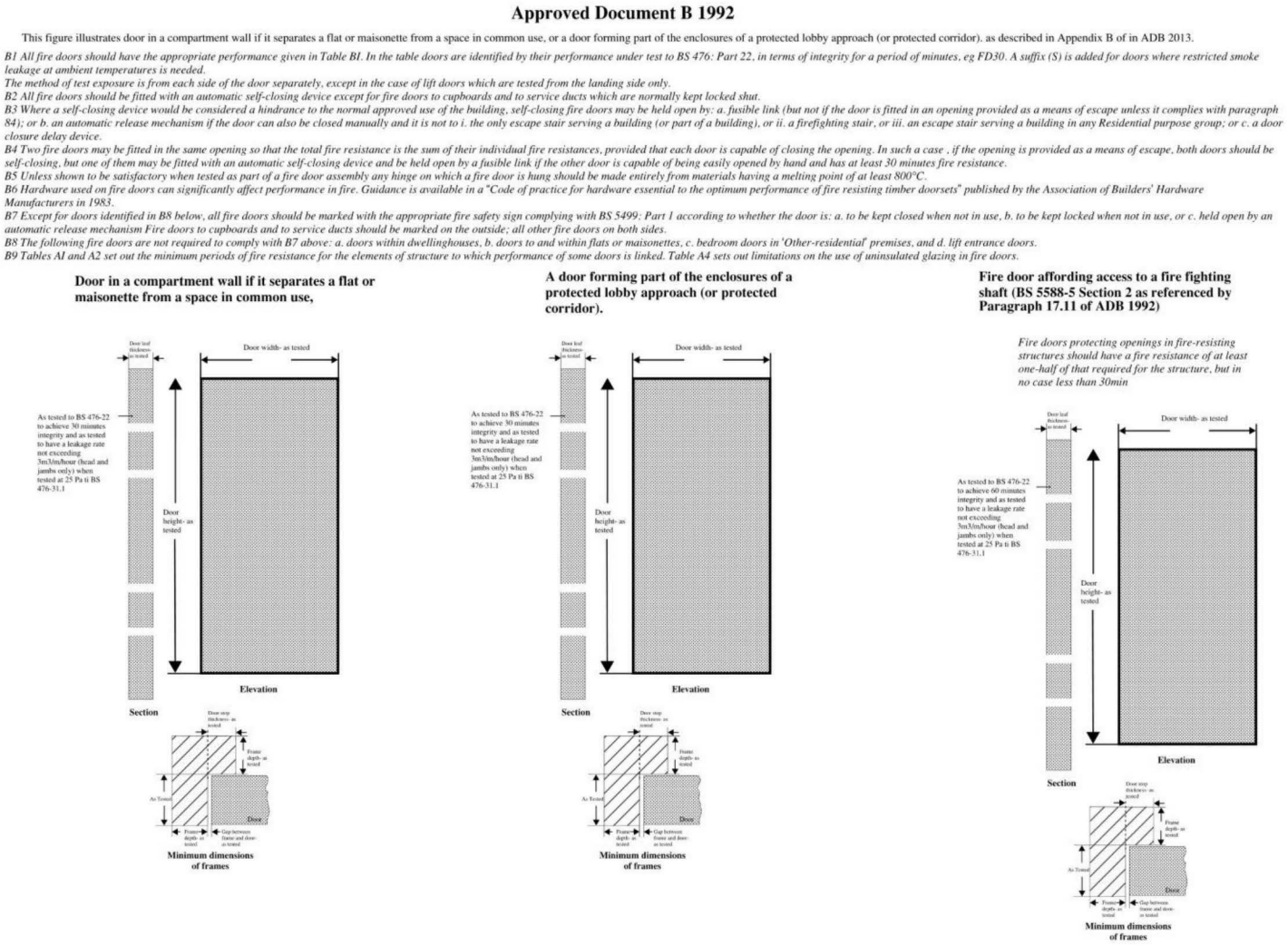
b) Section 3: Firefighting lift installation

c) Section 4: Electrical services

M3.4.5 As I explained in section M3.3.8 of this chapter, doors in construction separating a firefighting shaft from the rest of the building must therefore achieve 60 minutes integrity when tested to BS 476-22 and cold smoke leakage where the rate of leakage is less than $3m^3$/hour per metre under 25Pa of pressure when tested to BS 476-31.1 as defined in Table B1 of ADB 1992.

M3.4.6 My review of all subsequent revisions of ADB (namely 2000 edition (as amended 2002) and 2006 edition (as amended 2007, 2010, and 2013) has found no material difference in the performance specification of a "*door in a compartment wall if it separates a flat or maisonette from a space in common use*, or *a door forming part of the enclosures of a protected lobby approach (or protected corridor) to a stairway"* compared with ADB 1992.

M3.4.7 I have taken the guidance stated above and produced the drawing in Figure M.9to illustrate the differences between a fire door *forming part of the enclosure of a protected stairway*; a fire door *affording access to a dwelling from an internal common corridor or lobby*; and a fire door in a firefighting shaft.



Approved Document B 1992

This figure illustrates door in a compartment wall if it separates a flat or maisonette from a space in common use, or a door forming part of the enclosures of a protected lobby approach (or protected corridor). as described in Appendix B of in ADB 2013.

B1 All fire doors should have the appropriate performance given in Table BI. In the table doors are identified by their performance under test to BS 476: Part 22, in terms of integrity for a period of minutes, eg FD30. A suffix (S) is added for doors where restricted smoke leakage at ambient temperatures is needed.
The method of test exposure is from each side of the door separately, except in the case of lift doors which are tested from the landing side only.
B2 All fire doors should be fitted with an automatic self-closing device except for fire doors to cupboards and to service ducts which are normally kept locked shut.
B3 Where a self-closing device would be considered a hindrance to the normal approved use of the building, self-closing fire doors may be held open by: a. fusible link (but not if the door is fitted in an opening provided as a means of escape unless it complies with paragraph 84); or b. an automatic release mechanism if the door can also be closed manually and it is not to i. the only escape stair serving a building (or part of a building), or ii. a firefighting stair, or iii. an escape stair serving a building in any Residential purpose group; or c. a door closure delay device.
B4 Two fire doors may be fitted in the same opening so that the total fire resistance is the sum of their individual fire resistances, provided that each door is capable of closing the opening. In such a case , if the opening is provided as a means of escape, both doors should be self-closing, but one of them may be fitted with an automatic self-closing device and be held open by a fusible link if the other door is capable of being easily opened by hand and has at least 30 minutes fire resistance.
B5 Unless shown to be satisfactory when tested as part of a fire door assembly any hinge on which a fire door is hung should be made entirely from materials having a melting point of at least 800°C.
B6 Hardware used on fire doors can significantly affect performance in fire. Guidance is available in a "Code of practice for hardware essential to the optimum performance of fire resisting timber doorsets" published by the Association of Builders' Hardware Manufacturers in 1983.
B7 Except for doors identified in B8 below, all fire doors should be marked with the appropriate fire safety sign complying with BS 5499: Part 1 according to whether the door is: a. to be kept closed when not in use, b. to be kept locked when not in use, or c. held open by an automatic release mechanism Fire doors to cupboards and to service ducts should be marked on the outside; all other fire doors on both sides.
B8 The following fire doors are not required to comply with B7 above: a. doors within dwellinghouses, b. doors to and within flats or maisonettes, c. bedroom doors in 'Other-residential' premises, and d. lift entrance doors.
B9 Tables AI and A2 set out the minimum periods of fire resistance for the elements of structure to which performance of some doors is linked. Table A4 sets out limitations on the use of uninsulated glazing in fire doors.

Door in a compartment wall if it separates a flat or maisonette from a space in common use,

A door forming part of the enclosures of a protected lobby approach (or protected corridor).

Fire door affording access to a fire fighting shaft (BS 5588-5 Section 2 as referenced by Paragraph 17.11 of ADB 1992)

Fire doors protecting openings in fire-resisting structures should have a fire resistance of at least one-half of that required for the structure, but in no case less than 30min

Figure M.9 Stair door and flat front entrance door as described in ADB 1992

M3.5 Summary of significant changes in the requirements for stair fire doors

M3.5.1 Based on my review above I have summarised the key construction specification features that would distinguish stair doors designed to comply with London Building Constructional Amending Bylaws and British Standard CP3: Chapter IV: Precautions against fire: Part 1. Fire precautions in flats and maisonettes over 80ft (1971). Noting there is no material difference between the door specifications for the versions of the Bylaws in force during the design and construction of Grenfell Tower.

M3.5.2 Whilst CP3 was not formally recognised in London until 1974, I note the introduction of this code states in 1972:

M3.5.3 "This code of practice does not embrace means of escape in case of fire in respect of flats and/or maisonettes as the Council has, for the time being, adopted the standards contained in the British Standard Code of Practice CP3: Chapter IV: Part 1: 1971".

M3.5.4 I have already explained in Section 4 of my Expert Report, by a process of elimination, supported by analysis in Section 4, and Appendix J of my Expert Report, CP3 1971 appears to have been used as the design basis for the Tower for the critical means of escape features.

M3.5.5 I have summarised the requirements of BS 5588-1: 1990 Approved Document Part B 1992 and all subsequent revisions thereof which may have applied at the time of any alterations to fire doors any alterations to the fire doors, after the original construction of the Tower. I explain in Section M9 I have found no reliable evidence if such alterations occurred, nor any evidence about when such works occurred nor why.

M3.5.6 As a result, I can confirm the key differences in requirements for fire doors during the life time of Grenfell Tower are:

1. The London Building Constructional Amending Bylaws 1952 as amended 1964, 1966, 1970, 1972 in force, prior to 1986, permitted Class A doors, which were either a door which achieved 30 minutes stability and 30 minutes integrity to the fire resistance test standard BS 476:1953 or three different door construction specifications, noting these required a minimum rebate of 12mm.
2. From 1986 onwards, the approved guidance documents do not provide a specific design specification for stair fire doors (i.e. thickness, construction materials) only that fire resistance of all fire doors had to be demonstrated by test.
    a. From 1974 – 1990 British Standard CP3: Chapter IV: *Precautions against fire*: *Part 1. Fire precautions in flats and maisonettes over 80ft* (1971) required the stair door to be a Type 2 fire resisting door

as defined in Section 4.3.2.2 of the standard. The fire performance of a Type 2 door was specified as 30 minutes integrity and 30 stability to BS 476. Prior to 17/08/1972 (and as referenced in the 1965 and 1972 National Building Regulations) the relevant standard was BS 476-1:1953. Between 17/08/1972 and 29/05/1987 the relevant standard was BS 476-8:1972.

b. From 1990- 2018 – BS 5588-1; ADB 1992; ADB 2000 as amended 2000; and ADB 2006 as amended 2007, 2010, and 2013 required this to be 30 minutes integrity to BS 476-22:1987 or 60 minutes integrity to BS 476-22:1987 if the stair was a firefighting shaft. Both types of door were required to achieve a smoke leakage performance when tested to BS 476-31.1

3. Four test standards for the fire resistance of elements of construction (which were used to test the fire resistance of fire doors) were published and in use at various times between the time of design and construction of the Grenfell Tower between 1967 to 1974 and the night of the fire in 2017.
4. Significant changes were made to the conditions under which tests were performed and the criteria used to measure performance. Significantly, the test standard BS 476-8:1972 and subsequent editions of this test standard required a positive pressure to be applied to the exposed face of fire doors resulting in a more onerous test of the door construction. To mitigate this, **intumescent** seals were installed in door specifications since at least 1972.
5. I have investigated these changes and their effect on fire door construction in Section M7. [Please note I explain the lack of evidence at this stage regarding the presence of intumescent seals on the stair doors at Grenfell Tower in Section M10 of my Expert Report; for absolute clarity the nylon brushes as I observed in Appendix I5.6 are not intumescent seals but I have not yet been able to identify whether there may be intumescent materials below the brush seal].
6. In terms of rebate depth of the stair door frame, the following guidance was applicable:
    a. From 1952 – 1974 London Building Constructional Amending Bylaws 1952 as amended 1964, 1966, 1970, 1972 required a minimum rebate of 12mm.
    b. From 1974 -1990 CP 3 1971 required a minimum rebate of 25mm for a Type 2 stair door (unless the door swings in both directions which is not the case of the Grenfell Stair door). This differs from the lower requirement of a12mm rebate for a Type 3 door used on flat entrances as part of a frame with a minimum frame thickness of 25mm as I discussed in Section M3.2.
    c. After 1990, a minimum rebate depth was no longer stated as a mandatory requirement in the relevant guidance of BS 5588-1;

ADB 1992; ADB 2000 as amended 2000; and ADB 2006 as amended 2007, 2010, and 2013. The rebate size required was that tested.

7. After 1990, fire doors were required to be installed with the frame in which they were tested which may have included a rebate/ door stop.
8. However, from 1990 stair fire doors were additionally required to meet a new performance standard – "*leakage performance*" to BS 476-31.1. To mitigate this **cold smoke seals** were added to fire doors. [These are a different installation to the intumescent seals referenced above; but can be sold in a combined system for installation on a fire door. See Section M3.6 below.]

M3.5.7 I have summarised these key changes in Table M-3.

Table M-3 Stair doors – Summary of key changes in stair door requirements as described in Section M3.5

Year	Guidance standard	Door type required	Fire resistance		Smoke leakage performance	Test standard relevant at time guidance standard was in force	Specific guidance provided on a design that would be deemed to satisfy the performance requirement of the approved guidance (i.e. materials, dimensions, construction)	Self-closing requirement
			Integrity	Stability/ collapse				
1964 -1986	London Building Constructional Amending Bylaws 1952 as amended 1964, 1966, 1970, 1972	Class A	Doors tested in accordance with the provisions of Section 3 of British Standard 'Fire Tests on Building Materials and Structures' No. 476: 1953, and certified as being capable of resisting the action of fire for ½ hour noting that BS 476-1:1953 states that doors are tested for stability and integrity		N/A	BS 476-1:1953; or BS 476-8:1972	Yes	Yes
1974-1990	CP3 Chapter 4 Part 1 (1971)	Type 2	30	30	N/A	BS 476-8:1972; (note after 1987 BS 476-8:1972 was superseded by BS 476-22:1987 however the stability measurement was removed from BS 476-22:1987)	No	Yes
1990-2011	BS 5588-1	FD30s (protected stair)	30	N/A	Yes	BS 476-22:1987 & BS 476-31.1:1983	No	Yes

Year	Guidance standard	Door type required	Fire resistance		Smoke leakage performance	Test standard relevant at time guidance standard was in force	Specific guidance provided on a design that would be deemed to satisfy the performance requirement of the approved guidance (i.e. materials, dimensions, construction)	Self-closing requirement
			Integrity	Stability/ collapse				
1990-2011	BS 5588-1	FD60s (Door in firefighting shaft)	60	N/A	Yes	BS 476-22:1987 & BS 476-31.1:1983	No	Yes
1992-2017	ADB 1992; ADB 2000 as amended 2000; and ADB 2006 as amended 2007, 2010, and 2013	FD30s (protected stair)	30	N/A	< $3m^3/m/h$ at 25 Pa	BS 476-22:1987 & BS 476-31.1:1983; or BS EN 1634-1 & BS EN 1634-3	No	Yes
1992-2017	ADB 1992; ADB 2000 as amended 2000; and ADB 2006 as amended 2007, 2010, and 2013	FD60s (Door in firefighting shaft)	60	N/A	< $3m^3/m/h$ at 25 Pa	BS 476-22:1987 & BS 476-31.1:1983; or BS EN 1634-1 & BS EN 1634-3	No	Yes

M3.6 Types of performance seal used in fire door construction

M3.6.1 Cold smoke seal

M3.6.2 BS 8214:2016 *Timber-based fire door assemblies* clause 3.17 states that a smoke seal is a *"seal fitted to the leaf edge or frame reveal for the purpose of restricting the flow of smoke or hot gases"*. Note that ADB 2013 table B1 only requires "cold" smoke performance at the head and jambs of the door when tested to BS 476-31.1. Please refer to Figure M.10for an indicative example of the typical form of this type of performance seal.

Figure M.10 Typical form of a cold smoke seal (nylon brush strip[1])

M3.6.3 Intumescent seal

M3.6.4 BS 8214:2016 *Timber-based fire door assemblies* clause 3.13 states:

"seal used to impede the flow of heat, flame or gases, which only becomes active when subjected to elevated temperature

M3.6.5 *NOTE Intumescent fire seals are components which expand, helping to fill gaps and voids, when subjected to heat in excess of ambient temperatures."*

M3.6.6 Please see Figure M.11for an indicative example of the typical form of this type of performance seal.

[1] [Image online] Available at: https://www.sliding-doorstuff.co.uk/graphics/products/cache/s_800_600_t7035y.jpg Accessed: 18/10/2018

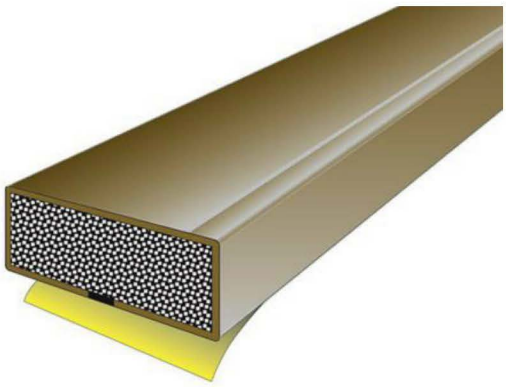


Figure M.11 Typical form of an intumescent seal [2]

M3.6.7 Combined intumescent fire and smoke seal

M3.6.8 Clause 13.2.3 BS 8241:2016 describes combined intumescent fire and smoke seals as *"seals where both intumescent fire and smoke seals are incorporated into one assembly"*. See Figure M.12for an indicative example of the typical form of this type of performance seal.

Figure M.12 Typical form of a combined intumescent fire and smoke seal[3]

[2] [Image online] Available at: https://www.carlislebrass.com/media/catalog/product/cache/1/image/9df78eab33525d08d6e5fb8d27136e95/f/d/fdp104b_1.jpg Accessed: 18/10/2018

[3][Image online] Available at: https://www.jaseals.co.uk/images/webupload/products/15mm-x-4mm-intumescent-fire-and-smoke-seal_227_ze_xlarge.jpg Accessed: 18/10/2018

M4 Grenfell Stair Door Construction

M4.1.1 In this Section of my Expert Report I compare the stair doors I observed installed in Grenfell during my inspection in November 2017 to the specifications I have found in the applicable guidance as discussed in 23.5. and 23.6

M4.2 My site investigation

M4.2.1 As stated in Appendix I, I undertook a detailed inspection of one door to the protected stair enclosure. This was on Level 6. I was very unfortunately unable to carry out a detailed inspection of the other doors due to time constraints imposed on me on site. However, and as demonstrated in my photos in Appendix C, the stair doors in general appear to be of the same type on the other floors - where they were still in place after the fire. At this stage therefore I consider this door to be representative.

M4.2.2 I measured the door leaf as 44mm thick. This is typical of a No.3 Class A door to Table G of Schedule VI of *London Building (constructional) amending bylaws* as discussed in Section M3.1.

M4.2.3 I witnessed a pile brush seal which had been routed into the edge of the door leaf. Based on visual comparison it appears this seal is a cold smoke seal. Please refer to Section M3.6 where I have provided an image of a cold smoke seal for comparison.

M4.2.4 As I found in Section 23.5.1 cold smoke seals were not specified as a requirement in *London Building (constructional) amending bylaws* for Class A doors. My understanding is that these seals are only for cold smoke leakage performance, which was only required after 1990 as I explained in Section M3.1.

M4.2.5 I am aware that there are combined intumescent seals and cold smoke seals available for purchase as I found in Section M3.6.

M4.2.6 It was not possible onsite to determine whether the pile seal I witnessed was a cold smoke seal, or a combined cold smoke seal and intumescent seal.

M4.2.7 Further destructive analysis is therefore required to remove the pile brush (cold smoke seal) and ascertain whether there are any intumescent materials below it. This is discussed further in M10.

M4.2.8 It should be noted that Nylon brush can also be used as a draught excluder therefore their presence does not guarantee that they were intended to restrict cold smoke leakage.

M4.2.9 The BRE state in the fire test they conducted on the stair door on behalf of the Metropolitan police (MET00021780) a “Nylon bristle type smoke strip” was installed on the sides and top of the door. However, the report does not

confirm either way if intumescent materials were present below the nylon brush.

M4.2.10 I have not seen any RBKC and/or TMO records of any such work carried out to the stair door. I discuss this further in Section M9.

M4.2.11 My site inspection determined that the frame rebate depth was 12mm. This is compliant with the minimum requirement of 12mm for a Class A door to Table G of Schedule VI of *London Building (constructional) amending bylaws 1966* as discussed in Section M3.1.

M4.2.12 Figure M.13, Figure M.14, and Figure M.15 show photographs taken of the door to the protected stair enclosure on Level 6 during my site inspections.

Figure M.13 Level 6 stair door

Figure M.14 Level 6 stair door (pile brush seals (potentially for cold smoke leakage) present on door leaf edge highlighted with red dashed line. Unclear whether there are intumescent materials behind the brush seal to restrict hot gas leakage. Edge of door un-planed; original paints visible (yellow and green)

Figure M.15 Level 6 stair door (pile brush seals (potentially for cold smoke leakage) present on door leaf edge highlighted with red dashed line. Unclear whether there are intumescent materials behind the brush seal to restrict hot gas leakage. Blue and the original green paint on the door hinge

M4.3 Metropolitan police investigation - fire resistance testing

M4.3.1 On 05/02/2018, one stair door was tested by BRE on behalf of the Metropolitan police as part of the criminal investigation. Prof. Bisby attended the test on behalf of the Public Inquiry.

M4.3.2 The test report of this is titled *"Fire resistance test in accordance with BS 476: Part 22: 1987 on a single action, single leaf timber doorset with one vision panel, mounted in a block-wall supporting construction" (MET00021780).*

M4.3.3 Table M-4 below shows the measurements of the door leaf frame and associated door hardware that was tested.

Table M-4 *"Fire resistance test in accordance with BS 476: Part 22: 1987 on a single action, single leaf timber doorset with one vision panel, mounted in a block-wall supporting construction"* (MET00021780) testing arrangements

Supporting construction	215mm blockwork wall
Aperture dimensions	Inconsistent: 2.1 states 900mm x 1990mm 2.2 states 900mm x 2100mm
Door frame dimensions	Frame constructed from timber of 40mm depth and 79mm width, giving: Internal dimensions: 742mm x 2021mm (assuming 2.2 is correct)
Door leaf dimensions	825mm x 2035mm x 44mm
Vision panel dimensions	135mm width x 285mm height
No. hinges	Three (150mm from bottom, 1080mm form the bottom, 200mm form the top).
Door closer	Overhead closer installed 240mm form the hinged edge
Seals	Nylon bristle type smoke strip fitted to the perimeter of the door leaf on both side edges and the top but no the bottom of the leaf
Maximum gap between door leaf and frame	10mm

M4.3.4 No information is provided in the BRE test report (MET00021780) for the dimensions of the rebate or the stiles (horizontal members)/ rails (vertical members) that form the internal framing of the door.

M4.3.5 Figure M.16 shows the exposed face of the door after the BS476-22 fire tests. I have used this photo to measure the stile and rail dimensions of the internal framing of the door. I have measured the dimensions from the photo using the height of the door as 2035mm to scale the rest of the measurements.

M4.3.6 In Figure M.16 it can be seen that the bottom rail was measured as 94mm in height. Six intermediate rails can be observed in the photograph. These were measured as between 42 and 59mm. The middle rail was measured as 180mm in height The top rail was measured as 99mm in height. The stile on the closing edge of the door was measured as 70mm in width.

Figure M.16 Exposed face of door after test used to measure stile and rail dimensions (LBY00000192)

M4.3.7 I have summarised the BRE test report findings of the (MET00021780); Professor Bisby's photographs from the test (Figure M.16) and the measurements I have taken from his photographs in Table M-5 below. I have also added the design specification of a No. 3 Class A door in Table G of

schedule VI of *London Building (constructional) amending bylaws* (Refer to Section) for comparison.

Table M-5 Comparison of Level 6 stair door tested by BRE on behalf of the Metropolitan police and BS 459: Part 3: 1951 half hour plywood faced fire check door specification and a No. 3 Class A door in Table G of schedule VI of *London Building (constructional) amending bylaws 1966*

Door set parameter	**Level 6 stair door tested by BRE on behalf of the Metropolitan police**	**Construction specification of a No. 3 Class A door in Table G of Schedule VI of *London Building (constructional) amending by laws 1966*(Refer to Refer to Section M3.1)**
Door leaf height (mm)	2035	Not stated
Door leaf width (mm)	825	Not stated
Door leaf thickness (mm)	44	44
Performance seal	Brush on sides and top. No intumescent strips on door or frame	None
Door leaf construction	Timber (species TBD). Appears to be glued. TBC by destructive analysis of other partially damaged doors in GT.	Timber frame
Top rail depth (mm)	99	95
No. intermediate rails	6	Not less than 2
Intermediate rail depth (mm)	42-59	44
Middle rail depth (mm)	180	165
Bottom rail depth (mm)	94	95
Stile depth (mm)	70	95
Protective infilling	Gypsum board infill	10mm plasterboard
Facings	Not recorded	3mm plywood
Rebate depth (mm)	Approximately 12mm	12mm
Maximum gap between frame and door leaf (mm)	3-7mm	Not specified
No. hinges	3	Not specified
Distance of lower hinge above threshold (mm)	229	Not specified
Marking	None obvious	Not specified
Glazing	Small wire-glazed window	Glazing fixed shut may be incorporated in a Class A door if it is capable of resisting the action of fire under the

Door set parameter	Level 6 stair door tested by BRE on behalf of the Metropolitan police	Construction specification of a No. 3 Class A door in Table G of Schedule VI of *London Building (constructional) amending by laws 1966*(Refer to Refer to Section M3.1)
		provisions of Table F of this schedule for a period of ½ hour, or if it comprises of a single vision panel of ¼ thick clear glass not exceeding 100 square inches in area in a solid timber frame at least 1 ¾ inches by 1 ¾ inches clear of rebates.
Glazing height (mm)	276-281	64516 mm^2 (100 square inches) clear glass
Glazing width (mm)	99-117	
Self-closer	Self-closer installed. Overhead oil-filled type.	Self closing

M4.3.8 It can be seen in Table M-5, the stair door tested on behalf of the MPS would have complied with the construction specification of a No. 3 Class A door in Table G of schedule VI of *London Building (constructional) amending bylaws 1966*.

M4.3.9 The only significant difference between the stair door that Professor Bisby observed under test and a No. 3 Class A door in Table G of schedule VI of *London Building (constructional) amending bylaws 1966* is that a brush seal was installed on the sides and top of the Grenfell Stair door which was not a requirement of a Table G of Schedule VI of *London Building (constructional) amending bylaws 1966.*

M4.4 Comparison of site photos disclosed by the MPS with my site observations/ the fire tested door

M4.4.1 In addition to my site investigations and Prof. Bisby's photos I have reviewed site photographs from the MPS investigation.

M4.4.2 The photograph in Figure M.20, was taken in the lobby of level 19. The closing edge of level 19 stair door contains what appears to be a groove routed into the wood. No seals can be observed in this photo in the closing edge of the door leaf. The internal framing of the door is also noted as stile and rail type consistent with my site investigations and Prof. Bisby's photos of the level 6 stair door. A single vision panel is also noted, again consistent with my site investigations and Prof. Bisby's photos of the level 6 stair door

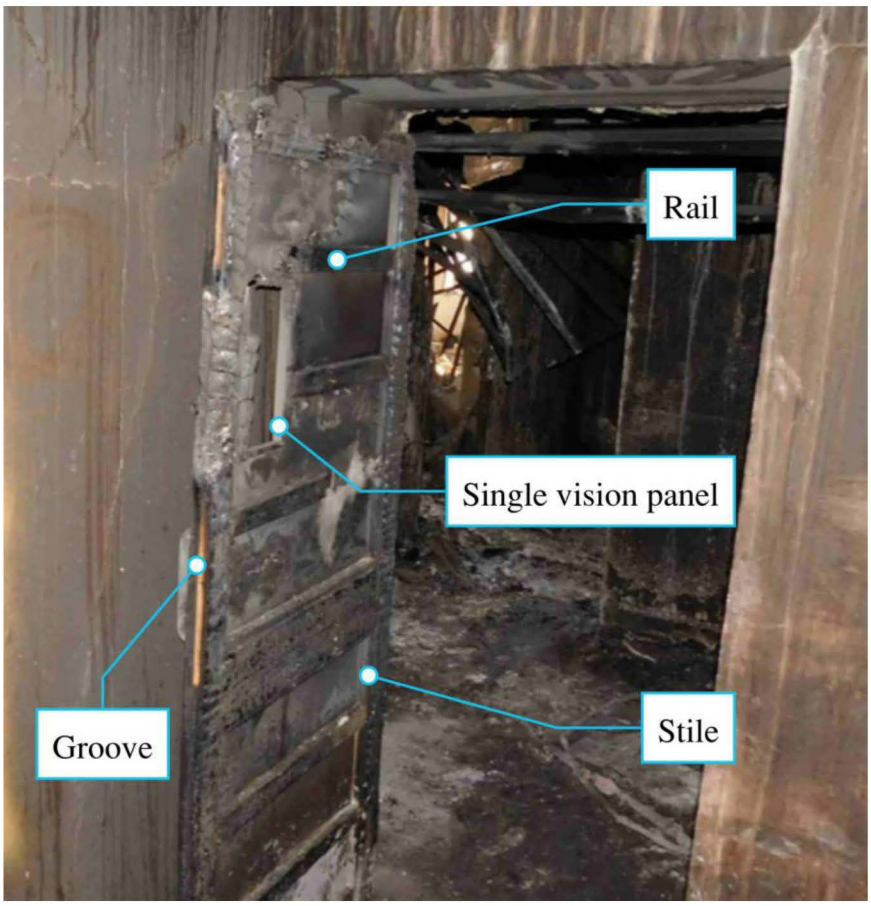


Figure M.17 Level 19 stair door (MET00018975).

M4.4.3 Figure M.18 shows the Level 11 stair door. The closing edge of level 11 stair doors contained what appears a discontinuous brush seal. A single vision panel and an overhead closer can be observed in the photograph. This is consistent with my site investigations and Prof. Bisby's photos of the level 6 stair door.

Figure M.18 Level 11 stair door (MET00018873)

M4.4.4 The photograph in Figure M.19 shows the level 10 stair door. The photograph shows the closing edge of a stair door with what appears to be a groove routed into the wood. No seals can be observed in this photo in the closing edge of the door leaf. A single vision panel and an overhead closer can be observed in the photograph. This is consistent with my site investigations and Prof. Bisby's photos of the level 6 stair door

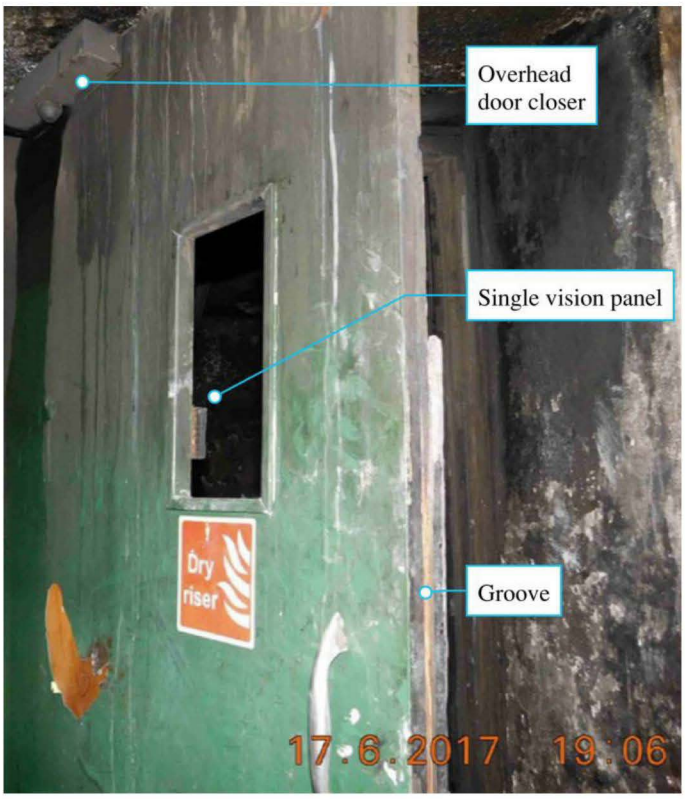


Figure M.19 Level 10 stair door (MET00018829)

M4.4.5 The photograph in Figure M.20, was taken in the lobby of level 16. From this photograph it appears the door is constructed of two timber stiles with a timber middle rail and a single vision panel. This is in accordance with my site investigations and Prof. Bisby's photos of the level 6 stair door. There also appears to be some form of infill material in the door however I cannot determine what the material is from this photo.

Figure M.20 Level 16 stair door [adapted from METS00016987]

M4.4.6 The photograph in Figure M.21was taken in the lobby on level 17. Again I observe that the door is installed with a single vision panel. This is in accordance with my site investigations and Prof. Bisby's photos of the level 6 stair door.

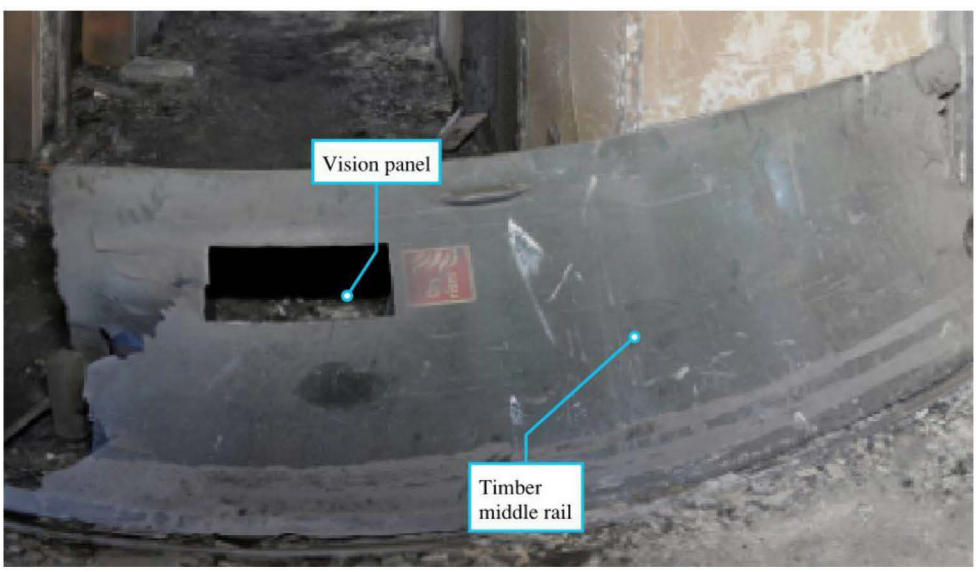


Figure M.21 Level 18 stair door [adapted from METS00017003]

M4.4.7 Based on the above observations the Grenfell stair doors were therefore constructed of stiles and rails, with an infill panel and a facing material. This is also consistent with a No. 3 Class A door in Table G of schedule VI of *London Building (constructional) amending bylaws* as shown in Figure M.4.

M5 The fire performance of *London Building (constructional) amending bylaws 1966* Class A Timber stile and rail doors

M5.1.1 Based on my comparison in M4, the Grenfell Stair doors appears to have been constructed in accordance with the specification of a No. 3 Class A door in Table G of schedule VI of *London Building (constructional) amending bylaws 1966* as I have set out in M3.1 . In this Section of my Expert Report, I review British Standards of fire door construction specification; published industry guidance; and fire test reports to find the notional fire resistance performance of a No. 3 Class A door.

M5.2 Relevant British Standards of fire door construction specification

M5.2.1 The *London Building (constructional) amending bylaws 1966 Table G of Schedule VI* refers to four door types which would be considered as a Class A door (three by reference to their construction, one by reference to a test). A No.3 Class A door is a door constructed of.

"Timber stiles and top and bottom rails not less than 3 ¾ inch wide and a middle rail not less than 6 ½ inch wide rebated to receive 3/8-inch plasterboard infilling on both sides strengthened by 1 ¾ inch intermediate rails, the whole covered both sides with plywood facings, the total thickness of the door not less than 1 ¾ inches."

M5.2.2 Through my literature review, I have found a British Standard from 1951 titled *British Standard 459: Part 3: 1951 Fire check flush doors and frames.*

M5.2.3 It should be noted that this standard is not directly referenced in either *London Building (constructional) amending bylaws 1966* or CP3 Part IV (1971).

M5.2.4 British Standard 459: Part 3: 1951 provides construction details for two types of fire doors: a half hour fire check door and a one-hour fire check door.

M5.2.5 The construction of a half hour fire check door to *British Standard 459: Part 3: 1951 Fire check flush doors and frames* appears to be identical to that of a No. 3 class A door referenced in *London Building (constructional) amending bylaws 1966 Table G of Schedule VI* for the dimensions of the stiles; the top and bottom rails; the middle rail; the plasterboard infilling; and the total thickness of the door.

M5.2.6 The only significant difference between the two specifications appears to be the depth of the rebate where BS 459: Part 3: 1951 requires a 25mm rebate and *London Building (constructional) amending bylaws 1966 Table G of Schedule VI* allows for a minimum rebate depth of 12mm.

M5.2.7 *BS 459: Part 3: 1951* makes no reference to the allowance of glazing in the door leaf nor that the door can be designed to open in two directions both of which are referred to in *London Building (constructional) amending bylaws 1966 Table G of Schedule VI.*

M5.2.8 *London Building (constructional) amending bylaws 1966 Table G of Schedule VI* makes no reference requirements on maximum or minimum door leaf height; maximum or minimum door leaf width; the dimensions of the door frame; the number of hinges required all of which have specific requirements in *BS 459: Part 3 1951.*

M5.2.9 I therefore find that if a door was constructed to the specification of a 30 minute fire check door in BS 459: Part 3: 1951 the door would also comply with the requirements of a No. 3 Class A door in Table G of schedule VI of *London Building (constructional) amending bylaws.*

M5.2.10 It should be noted that the foreword to BS 459: Part 3: 1951 states:

"The standard is not intended to include every type of door that will fulfil the fire-check requirements, but only two types which can be produced under modern conditions with the assurance that they will provide the necessary protection. Any door in its frame, however constructed, which has been shown by test in accordance with BS 476, Part 1 'Fire tests on building materials and structures' to give similar performance to either of the doors described in this standard can be termed a fire check door for the appropriate period"

M5.2.11 Further to this, the scope section to BS 459: Part 3: 1951 states:

"This British Standard gives details of the construction of two types of door and suitable frames which have been shown to provide effective barriers to the passage of fire for the times stated. Since the doors do not comply for the appropriate periods with all of the requirements for fire resistance specified in BS 476: Part 1: 'Fire tests on building materials and structures', they have been termed 'fire-check' doors".

M5.2.12 I have been unable to find specific industry guidance for the fire performance of a No.3 Class A door however I have found through reference to industry guidance from the 1970s that a fire check door compliant with BS 459: Part 3: 1951 was expected to achieve 20 minutes' integrity and 30 minutes' stability. This is discussed further in Section M5.2.18.

M5.2.13 This means that, a No. 3 Class A door in Table G of schedule VI of *London Building (constructional) amending bylaws* is unlikely to achieve the 30 minutes integrity and insulation of a No. 4 Class A door in Table G of schedule VI of *London Building (constructional) amending bylaws* or a *CP3 part 4 (1971)* Type 2 door.

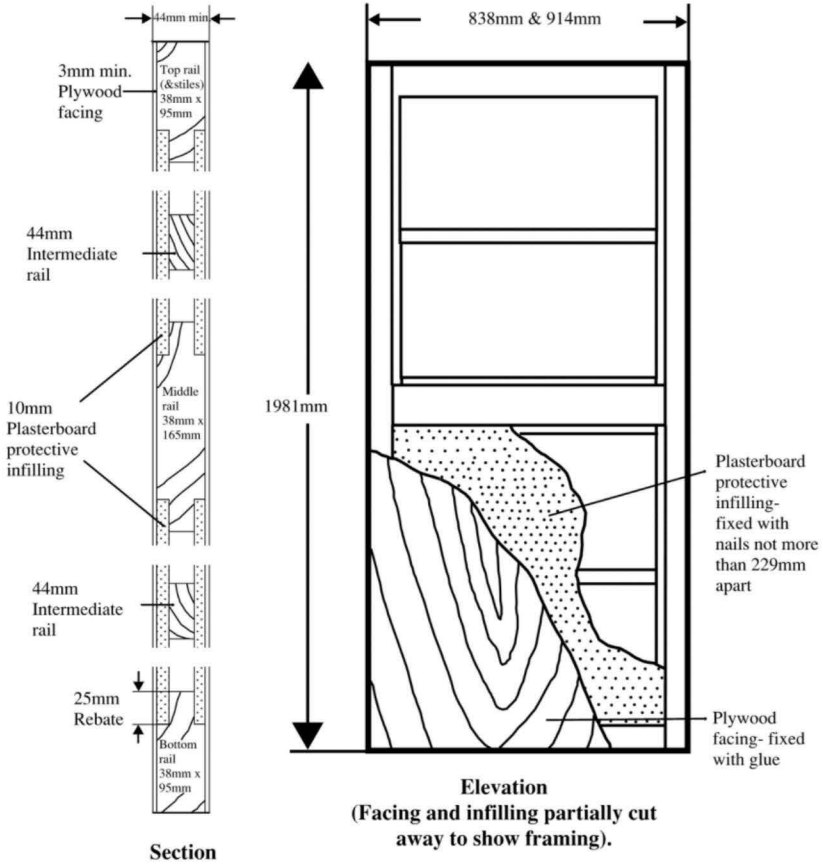
M5.2.14 I have not currently found any test evidence to allow me to find what the expected performance of a No. 1 or a No.2 Class A door in Table G of schedule VI of *London Building (constructional) amending bylaws* therefore

it is unclear if these too are of a lower performance of a No. 4 Class A door in Table G of schedule VI of *London Building (constructional) amending bylaws* or a CP3 part 4 (1971) Type 2 door.

M5.2.15 I have provided a reproduction of the BS 459: Part 3 (1951) construction diagrams in Figure M.22 and Figure M.23 below for the 'half hour fire check door' and a 'one-hour fire check door'. I have converted the original imperial measurements to metric units for clarity.

Half-hour type fire-check flush door to BS 459: Part 3: 1951

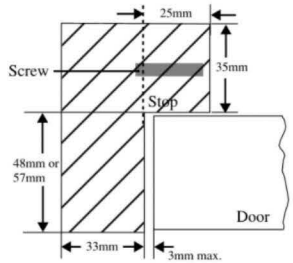
This figure brings together the provisions in BS 459: Part 3: 1951 for a half-hour type fire-check flush door. Figures 1 and 3 from this standard are represented here with dimensions in metric form. Clauses 2, 16 and 18 (describing dimensions, marking and hanging respectively) have been taken directly from the standard.



Section

Elevation
(Facing and infilling partially cut away to show framing).

Reproduction of Figure 1 using metric units



Minimum dimensions of wood frames

Reproduction of Figure 3 using metric units

Clause 2. Dimensions
The standard sizes of doors are:

Width	2 ft. 9 in. or 3 ft. +/- 1/16 in.
Height	6 ft. 6 in. +/- 1/16 in.
Minimum finished thickness	Half-hour type 1 3/4 in. One-hour type 2 1/8 in.

Doors may be of other widths and heights not exceeding 3 ft. wide or 7 ft. high, provided that they comply with all other requirements of this standard.
The width and height measured within the rebates of the wood or metal frames shall be one eighth of an inch greater than the corresponding nominal dimension of the door, subject to a tolerance of plus or minus 1/16 in.

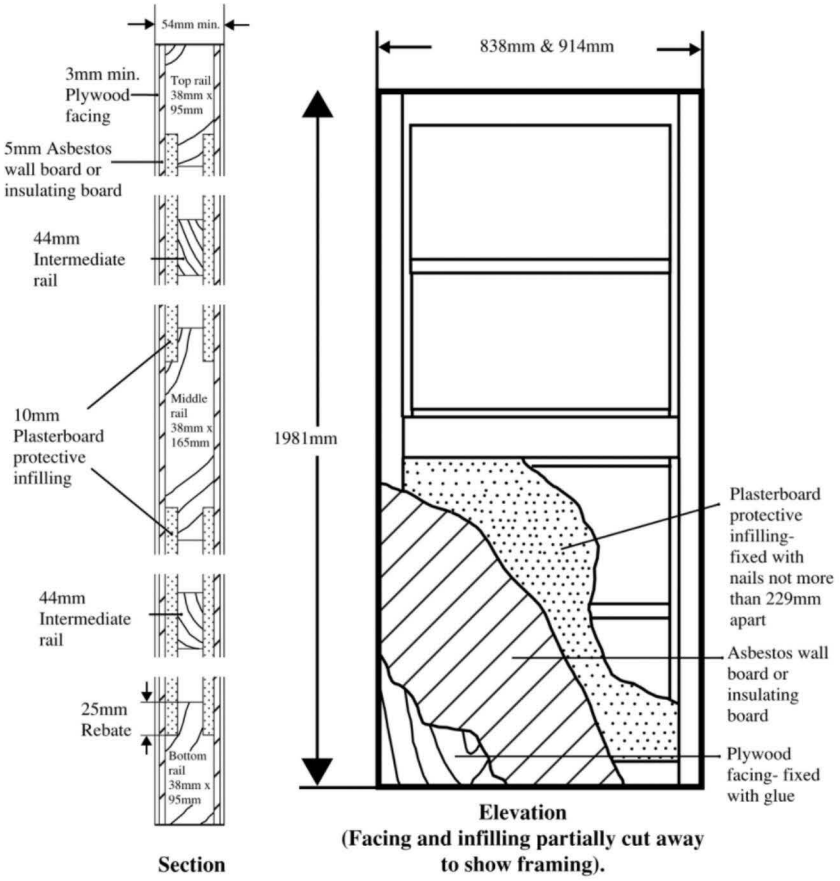
Clause 16. Marking
The doors shall be marked on the hanging stile with the manufacturer's name or mark, the number of this British Standard, i.e. B.S. 459, Part 3, and the reference 1/2H or 1H as may be appropriate.

Clause 18. Hanging, Fastening, etc.
Each half-hour type door shall be hung with not less than one pair of hinges to a frame complying with Clause 9 or 11 of this specification. Each one-hour type door shall be hung with not less than 1 1/2 pairs of hinges to a frame complying with Clauses 10 or 12. The door shall be carefully fitted and hung in the frame in such manner that the gap between the edge of the door and the frame when the door is closed is not more than 1/8 in. wide at any point.

Figure M.22 Reproduction of Figure 1 and Figure 3 of BS 459: Part 3: 1951for the construction of a half hour fire check door

One-hour type fire-check flush door to BS 459: Part 3: 1951

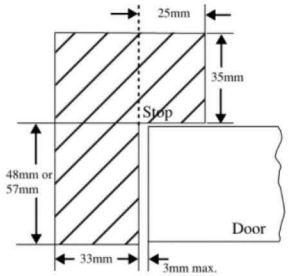
This figure brings together the provisions in BS 459: Part 3: 1951 for a one-hour type fire-check flush door. Figures 2 and 3 from this standard are represented here with dimensions in metric form. Clauses 2, 10, 16 and 18 (describing dimensions, construction of wood frames, marking and hanging respectively) have been taken directly from the standard.



Section

Elevation (Facing and infilling partially cut away to show framing).

Reproduction of Figure 2 using metric units



Minimum dimensions of wood frames

NB: For one-hour type doors the stop shall be worked out of the solid, and the frame impregnated.

Reproduction of Figure 3 using metric units

Clause 2. Dimensions

The standard sizes of doors are:

Width	2 ft. 9 in. or 3 ft. +/- 1/16 in.
Height	6 ft. 6 in. +/- 1/16 in.
Minimum finished thickness	Half-hour type 1 3/4 in. One-hour type 2 1/8 in.

Doors may be of other widths and heights not exceeding 3 ft. wide or 7 ft. high, provided that they comply with all other requirements of this standard.

The width and height measured within the rebates of the wood or metal frames shall be one eighth of an inch greater than the corresponding nominal dimension of the door, subject to a tolerance of plus or minus 1/16 in.

Clause 10. Construction of Wood Frames for One-Hour type Doors

The frames shall be in accordance with Clause 9, except that the stop shall be worked out of the solid and the frames shall be impregnated as follows:-

Impregnation. After the frames have been machined to size they shall be pressure-impregnated with a 15-18 per cent solution of mono-ammonium phosphate in water. The treatment used shall be such as to ensure that the depth of penetration is in no place less than 1/2 in.

Alternatively, the timber may be impregnated before machining, but the depth of penetration shall then be such that, after machining, it is in no place less than 1/2 in.

Clause 16. Marking

The doors shall be marked on the hanging stile with the manufacturer's name or mark, the number of this British Standard, i.e. B.S. 459, Part 3, and the reference 1/2H or 1H as may be appropriate.

Clause 18. Hanging, Fastening, etc.

Each half-hour type door shall be hung with not less than one pair of hinges to a frame complying with Clause 9 or 11 of this specification. Each one-hour type door shall be hung with not less than 1 1/2 pairs of hinges to a frame complying with Clauses 10 or 12. The door shall be carefully fitted and hung in the frame in such manner that the gap between the edge of the door and the frame when the door is closed is not more than 1/8 in. wide at any point.

Figure M.23 Reproduction of Figure 1 and Figure 3 of BS 459: Part 3: 1951for the construction of a one hour fire check door

M5.2.16 I have been unable to find specific industry guidance for the fire performance of a No.3 Class A door however as I found above, a 30 minute BS 459: Part 3: 1951 fire check door would comply with the specification of a No.3 Class A door. For this reason, I have investigated Industry Guidance and test evidence to identify the likely performance of BS 459: Part 3: 1951 fire check doors.

M5.2.17 In the 1970s and 1980s the British Research Establishment (BRE) published several *digests* which provided detailed guidance on timber fire door specifications.

M5.2.18 Table 1 of the BRE Digest 155 Timber Fire doors (1973) states the different fire performance obtained for fire check and fire resisting doors. This has been reproduced in Figure M.24below.

Table 1 Fire-check and fire-resisting doors

Door type	Integrity(1) *Minutes*	Stability(2) *Minutes*
Half-hour fire-check	20	30
Half-hour fire-resisting	30	30
One-hour fire-check	45	60
One-hour fire-resisting	60	60

(1) Integrity Failure is deemed to occur when cracks or other openings exist through which flames or hot gases can pass or when flaming occurs on the unexposed face.

(2) Stability Failure is deemed to occur when collapse of the specimen takes place

Figure M.24 Table 1 of BRE Digest 155 *Timber Fire doors (1973*) therefore states that a *'half hour fire check door'* is expected to achieve 30 minutes stability and 20 minutes integrity.

M5.2.19 Through literature review I have found two instances where *"30 minute fire check doors"* were tested to BS 476:1932 and BS 476:1953 respectively. These are *Webster and Ashton, 1951, National Building Studies Technical Paper No.6 Investigation s on Building fires Part IV Fire Resistance of Timber doors and Morris, 1971, Fire Research Note 855- An Investigation into the Fire Resistance of Timber Fire Doors.*

M5.2.20 Specimen 11 of the *Webster and Ashton (1951)* test series is the basis of a half hour fire check door to BS 459 Part 3:1946.

M5.2.21 Table 2 of *Webster and Ashton (1951)* states that when Specimen 11 was tested to BS 476:1932 it achieved 41 minutes stability and 26 minutes integrity. This aligns with the description of a *"30 minute fire check door"* in Table 1 of BRE Digest 155 Timber Fire doors (1973) as achieving at least 30 minutes stability 20 minutes integrity (refer to Figure M.24) and to the scope section of BS 459: Part 3 which states:

"Since the doors do not comply for the appropriate periods with all of the requirements for fire resistance specified in BS 476: Part 1: 'Fire tests on building materials and structures', they have been termed 'fire-check' doors"

M5.2.22 Later in 1971 W. A Morris undertook an investigation *"into the performance of eighteen timber door sets under the conditions of the British Standard fire test*". Eleven of the eighteen samples tested were forms of fire check doors to BS 459-3. From these tests Morris concluded that:

"From this investigation the following conclusions are drawn:

1. *A door with 12.5mm rebates is not adequate for 'fire check' purposes unless tolerances on fit are controlled to better than 1.5mm*
2. *A door having 25mm rebates will achieve the ½ hour fire check standard with gaps of up to 3mm but will not generally provide a full ½ hour fire resistance unless some additional precautions are taken.*
3. *Doors having no rebated frame, I.e. wing doors, would have a low fire resistance even if very low tolerances are specified.*
4. *The fit of a door is relatively more important than the dimensions of the rebated frame in determining fire performance. A door having clearances in excess of 3mm is likely to fail before 20 minutes even if the rebates are 25mm in depth.*
5. *The use of intumescent strips to seal the edges of a door under fire conditions greatly enhances the performance of timber doors, including swing doors without rebated frames.*

M5.2.23 It is significant that even for the lower standard fire check doors (30 minutes stability 20 minutes integrity), the 12.5mm rebate is deemed not adequate, without specific tolerances of fit.

M5.2.24 The fire doors in Morris (1971) therefore confirms that *'half hour fire check doors'* with 25mm rebates will also not achieve 30 minutes integrity and stability to BS 476: 1953.

M5.2.25 As I found in Section M5.2 a half hour fire check door to BS 476: 1953 would be compliant as a No. 3 Class A door referenced in *London Building (constructional) amending bylaws 1966 Table G of Schedule VI*. Based on Morris tests on a half hour fire check door I therefore conclude that a No. 3 Class A door referenced in *London Building (constructional) amending bylaws 1966 Table G of Schedule VI* would also not achieve a 30 minute integrity and stability standard to BS 476-1:1953.

M5.2.26 Regarding the tolerances of fit I note the BRE fire door test for the Metropolitan Police fire test (MET00021780) was apparently designed to replicate the onsite conditions - where the door was tested with a maximum gap between the frame and the door of 10mm exceeding the 3mm limit in the Morris' (1971) tests.

M6 Compliance of Grenfell Tower Stair Door

M6.1.1 In Section M4, I found that the Grenfell stair doors were specified and installed as a No. 3 Class A door to the *London Building (constructional) amending bylaws*.

M6.1.2 In Section M5 I presented my review of the fire performance these doors are likely to obtain.

M6.1.3 Based on this, I now present my review of whether the Grenfell Stair doors were compliant at the time of construction.

M6.1.4 I have reviewed the means of escape guidance from these three documents against the original construction of Grenfell Tower in Section 4 of my Expert Report. As I explain in section 4.2 of my Expert Report, out of these, only CP3 1971 was consistent with the original design and construction of Grenfell Tower. It is on this basis that I have relied on CP3 1971 as the basis for design for means of escape at Grenfell Tower.

M6.1.5 Whilst I am clear the relevant Regulations at the time of construction of Grenfell Tower were *London Building (constructional) amending bylaws*. Under these Regulations the stair door could be of a construction specification listed in *Table G of Schedule VI*.

M6.1.6 However, this was not the standard required for the lobby smoke control system.

M6.1.7 In Section M5 based on test evidence a No.3 Class A door would not achieve the standard of 30 minutes stability 20 minutes integrity to BS 476: 1953 unless the tolerances of fit are controlled to less than 1.5mm.

M6.1.8 CP3 part 4 (1971) requires extract from lobbies and Type 2 doors, as the overall protection feature to the stair.

M6.1.9 As, a door that would comply with the construction specification of a No. 3 Class A door referenced in *London Building (constructional) amending bylaws 1966 Table G of Schedule VI* achieves a lower standard of performance than the 30 minutes stability and integrity required of a Type 2 door in accordance with Section 4.3.2.2 of CP3 Chapter IV Part 1 (1971), it is therefore noncompliant with Clause 4.4.3 of CP3 Chapter IV Part 1 (1971) which states:

"Access to main stairways (other than buy those means described in 3.4.3.3(1)) should be gained through Type 2 doors"

M7 Changes in the BS 476 test standard-its impact on measured fire resistance of doors and door design

M7.1.1 In this section I present my review of the changes that have occurred in the British standard used to measure the fire resistance of doors and the effect this has had on fire door design, namely the introduction of intumescent seals.

M7.1.2 As I have found in Section M3, fire door performance is specified in relation to achieving a set criterion to a given test standard typically integrity, insulation, stability and/ or smoke leakage.

M7.1.3 The fire resistance of a doorset for integrity is measured as part of a standard fire resistance test.

M7.1.4 From the time of the design and construction of Grenfell Tower in 1972 to the night of the fire there have been four main revisions of fire resistance test standards referenced by the approved guidance (not including all amendments to said standard). These are: BS 476-1:1953; BS 476-8:1972; BS 476-22:1987; and BS EN 1634-1.

M7.1.5 My review of BS 476-1:1953; BS 476-8:1972; BS 476-22:1987; and BS EN 1634-1 has found that furnace pressure requirement changes between the revisions. It should be noted that the furnace pressures requirements for BS 476-22:1987; and BS EN 1634-1 testing are actually given in the accompanying guidance in BS 476-20 and BS EN 1363-1 respectively.

M7.1.6 BS 476:1932 and BS 476-1:1953 did not set a pressure requirement for the furnace.

M7.1.7 The later fire resistance test standards BS 476-8:1972; BS 476-20: 1987; and BS EN 1363-1: 2012 applied a furnace pressure to the samples.

M7.1.8 The effect of a higher pressure being applied on doors in a fire resistance test is also described in Section 5.2 of TRADA (2002) *Timber fire resisting doorsets: maintaining performance under the new European test standard* as:

"The second major mode of failure which contributed to 40% of the doorset failures observed was a significantly increased rate of door leaf to frame junction erosion when compared to the BS 476-22 test."

"The mechanism for this increased erosion is likely to be a combination of the increased furnace temperature and the change in pressure. The higher pressure at the head of the doorset results in a higher velocity air flow around the upper perimeter of the doorset. The higher furnace temperature means

that the temperature of the airflow is higher. This hot, high velocity air has a scouring effect on the substrate that it comes into contact with."

M7.1.9 Increasing the pressure applied to a fire door during a fire resistance test therefore reduces its integrity performance.

M7.1.10 This effect is indirectly described in BRE Digest 220 (1978) which states:

The performance indicated above for the two types of door construction in BS 469: Part 3 are in relation to the BS 459: Part 1 test procedure. The use of some form of intumescent protection is normally standard practice for all door now submitted for test and such protection would allow the BS 459: part 3 doors to satisfy the corresponding criteria under part 8.

M7.1.11 Based on the information in the BRE Digest 220 quoted above, intumescent protection was therefore used on doors since at least 1978 specifically to overcome the increased pressure requirements of a BS 476-8: 1972 test compared to that of a BS 476-1:1953 test (noting that there is evidence of the intumescent strips being used previous to this date to generally improve the performance of the door in Morris (1971)

M7.1.12 The presence of an intumescent seal, where original, on a *'half hour fire check'* door therefore could imply that it was intended to achieve 30 minutes stability 20 minutes integrity to BS 476-8:1972.

M7.1.13 A door designed as a 'half hour fire check' without an intumescent seal would imply the door was designed to achieve 30 minutes stability 20 minutes integrity to BS 476-1:1953.

M7.1.14 Note that neither of these performances achieves the required 30 minutes integrity and stability for compliance as a Type 2 door to CP3 Chapter IV Part 1 (1971) or a No. 4 Class A door to *London Building (constructional) amending bylaws*. A 'half hour fire check' with or without an intumescent seal is only compliant with the design specification of a No. 3 Class A door to *London Building (constructional) amending bylaws*.

M7.1.15 Alternatively, the presence of an intumescent strip could be as a result of the responsible person taking general fire precautions to comply with the Regulatory Reform (Fire Safety) Order 2005 (RR(FS)O 2005) as I discuss in the next section.

M7.1.16 As I stated previously, the presence or not of an intumescent strip (for hot smoke leakage) on the Grenfell stair door underneath the pile brush seal (for cold smoke leakage) I observed, is still to be determined as it was not possible onsite to undertake intrusive inspections.

M8 The Local Government Association "Fire safety in purpose built blocks of flats

M8.1.1 As I have explained above, the presence of an intumescent strip, where original at the time of construction, on a *'half hour fire check'* door could imply that it was intended to achieve 30 minutes stability 20 minutes integrity to BS 476-8:1972. Cold smoke seals, were not a requirement until 1990 therefore their presence would indicate the door was installed after 1990 unless their only purpose was as a draught excluder.

M8.1.2 Alternatively, smoke seals and/or intumescent seals could have been fitted retrospectively sometime between the original construction of Grenfell Tower in 1974 and the night of the fire in 2017.

M8.1.3 Since 2005 the fire safety provisions of common parts of blocks of flats in England has been controlled by the Regulatory Reform (Fire Safety) Order 2005. This places duties on the 'Responsible person' to undertake '*general fire precautions'*.

M8.1.4 In 2011 the Local Government Association (LGA) published the guidance document *"Fire safety in purpose built blocks of flats"*. The introduction of the LGA guide states:

M8.1.5 *"This document is intended to assist responsible persons to comply with the FSO and the Housing Act 2004. Accordingly, it is expected that enforcing authorities will have regard to this guide."*

M8.1.6 Page 97 of the LGA guide is the relevant section for fire resisting doors which states:

"62.12 Under current benchmark design guidance, doors forming part of the protected entrance halls and stairways within flats are normally specified as 20-minute fire-resisting doors (designated FD20). Similarly, doors forming part of the protected escape route from the flat entrance door to the final exit, including the flat entrance door itself, are normally specified as 30-minute fire-resisting doors with smoke seals (designated FD30S).

62.13 At the time they were fitted, the vast majority of these doors would have complied with the test standard or specification of the day for a 20 or 30-minute fire-resisting door. In addition, many of these doors have performed satisfactorily in a fire situation and, are likely to continue to do so, providing they remain in good condition.

62.14 A modern (FD30S) fire-resisting door has intumescent strips and cold smoke seals fitted along its side and top edges (or within the frame in these locations). Letter boxes would be of a type incorporating intumescent materials to protect the opening. The door would be fitted with an overhead self-closing device or a concealed closer in the door jamb. The door set, the

complete entity incorporating door hardware and furniture, would be tested for its performance as a whole.

62.15 Original flat entrance doors may lack intumescent strips and cold smoke seals and will not have protected letterboxes. There would have been reliance on 25mm door stops to achieve 'smoke control'. Where older doors were self-closing, this was sometimes achieved by using rising butt hinges.

62.16 Upgrading existing doors simply because they are not fitted with intumescent strips or smoke seals, or fail to meet some other requirement of current standards, should not be made a generic recommendation applicable to all existing blocks of flats. Similarly, upgrading existing letterboxes in flat entrance doors to meet current standards is not always necessary. This will depend on:

- *the location of the letterbox in the door*
- *the location of the flat within the block*
- *the construction of the letterbox.*

62.17 It will not be practicable to test existing doors to confirm their actual fire resistance. Therefore, three options exist in relation to original fire-resisting doors that do not meet current benchmark standards. These are:

- *accept the door as it is, provided it is a good fit in its frame and that it satisfied the standard applicable to fire-resisting doors at the time of construction of the building or manufacture of the door ('notional FD30' door)*
- *upgrade the door by, for example, fitting intumescent strips and smoke seals along the edges, and fitting a protected letter box ('upgraded FD30S' door)*
- *replace the door with an FD30S door ('replacement FD30S' door).*

62.18 An upgraded FD30S door cannot be guaranteed to achieve the same performance as a replacement FD30S door, for which there will be a fire test certificate. This is to be expected and is reasonable provided that the door has sufficient thickness of timber (e.g. 44 millimetres). Simply fitting intumescent strips and smoke seals to a thin door or one with panels will not render it suitably fire-resisting. Specialist advice may need to be sought in order to make an assessment of the likely benefits of upgrading existing fire-resisting doors. Guidance on upgrading fire-resisting doors is also published by the Timber Research and Development Association (TRADA)."

M8.1.7 The Glossary of the LGA guide provides the following definitions:

"Fire-resisting door- Notional FD30 door- *A door assembly that satisfied the current specification, or fire resistance test, for 30 minutes at the time of construction of a block of fats or manufacture of the door.*

Fire-resisting door- Upgraded FD30S door- *A 'notional FD30' door, fitted with intumescent strips and smoke seals, and with any other necessary work carried out, such that it may reasonably be anticipated that it would satisfy the relevant test requirements for 30 minutes integrity and control of the passage of smoke at ambient temperature."*

M8.1.8 As I explain in Section M5 a door of similar construction to a No.3 Class A door would achieve only 12 minutes fire resistance for integrity to BS 476-1:1953.Work by Morris (1971) shows that a door, of similar construction to a No.3 Class A door, upgraded with an intumescent strip could achieve 30 minutes integrity to BS 476-1 (1953) but later evidence from BRE digest 155 and 220 shows that it would fail to achieve 30 minutes to the later more onerous fire resistance standard of BS 476-8 (1972) and would only achieve 20 minutes integrity.

M8.1.9 This means that there is an entire subsection of doors that could have been installed to comply with the *London Building Constructional amending Byelaws* as a Class A No.3 door which cannot achieve 30 minutes integrity to the test standard at the time of construction; and even if upgraded with an intumescent seal cannot achieve 30 minutes fire resistance to any subsequent revision of the fire resistance test standard.

M8.1.10 No warning is provided in the LGA guidance to highlight that these doors exist, are substandard and cannot be retrospectively upgraded.

M8.1.11 The presence of an intumescent strip with cold smoke seals, where not original and installed on an original No.3 class A door, could imply that said door was intended to be an *'Upgraded FD30S door'* as set out in the 2011 LGA guide

M8.1.12 However, as I have explained above, the Grenfell doors could not be *Upgraded FD30S* doors under the LGA Guide because they did not meet the original 30 minute standard.

M8.1.13 No reference is made in the LGA guide that the lower performance is well established with a body of published evidence on the issue, such as fire check doors. All the evidence of the Grenfell stair door indicates that it is in this category of door. I explain this next.

M9 Evidence regarding works to the stair doors in Grenfell Tower

M9.1.1 In my preliminary Phase 1 report I found no evidence the stair doors in Grenfell Tower had been replaced or modified since the buildings original construction in 1972-1974 (Section 4.4.1 - 4.4.2, Appendix I5.4.2 -I5.4.4).

M9.1.2 I can confirm no further evidence has been provided to me that the stair doors have ever been replaced.

M9.1.3 Regarding my photo of the nylon brush on the door at Level 6 (Appendix I), I would need particular documentation to confirm intumescent seals were installed underneath this brush, and why they were installed. I would need particular documentation to confirm the nylon brushes were not for draught exclusion purposes and were for the purposes of a cold smoke seal. I did not have any such evidence at the time of writing my preliminary Phase 1 report, hence my stated opinion.

M9.1.4 I set out in the following sections the evidence available to me about fire safety works to the stair case doors, and the significance of that evidence.

M9.2 Evidence from RBKC regarding works to the Grenfell Tower stair doors

M9.2.1 I have reviewed a letter from DWF on behalf of RBKC to the Inquiry dated 27th September 2018 [RBK00029044]. It states RBKC's view that no replacement or changes were made to the Level 4 to 23 stairwell doors during the 2012-2016 refurbishment.

M9.2.2 This statement from RBKC is consistent with the evidence presented in my Phase preliminary 1 report.

M9.2.3 RBKC also state in their letter of 27 September 2018:

M9.2.4 *"Documents relating to historical works to Lancaster West Estate (i.e. predating 2004) have recently been discovered and are currently being reviewed for relevance and content"*

M9.2.5 I therefore await the outcome of this review which may provide additional evidence regarding any works affecting the staircase doors in Grenfell Tower.

M9.3 Evidence from CS Stokes and Associates regarding works to the Grenfell Tower stair doors

M9.3.1 I had Mr Stokes evidence at the time of writing my Phase 1 report, but it contained many conflicts and gaps, therefore I did not consider it appropriate for me to rely on it.

M9.3.2 I continue to be of this opinion but I have asked for additional evidence to be provided to me if at all possible.

M9.3.3 Mr Carl Stokes wrote to the TMO on 10th April 2015 (RYD00038811) regarding modification of the stair doors. He had been asked to attend Grenfell Tower by the TMO, due to the email exchange set out in CST00000173, where Rydon notified the TMO they had observed someone working on Level 15 *"installing smoke seals to staircase doors"*.

M9.3.4 In the same e-mail chain, the TMO ask internally who is conducting the work and why. No clarification is provided in the e-mail chain.

M9.3.5 This letter records the resulting observations made by Mr Stokes of the stair doors during a site visit on the 9th April 2015. In this letter Mr Stokes provides photographic evidence from an unidentified lobby or lobbies which he considers to allow him to state the following:

a. Stair door leaves removed from their frames – see Figure M.26(a)

b. Evidence of carpentry work within the lobbies – adjacent to the new lobby riser cupboard – see Figure M.26(b)

c. Damage to stair door frame around the hinges – see Figure M.26(c)

d. Evidence of paint removal at the stair door edge – see Figure M.27(a) – (c)

e. Evidence of brush seals being present; and evidence of missing brush seals at the door leaf edge Figure M.27(a) – (c)

M9.3.6 Mr Stokes states an unknown to contractor is responsible for the works (RYD00038811 Page 3).:

"Also the contractor undertaking the work did not inform any TMO employee or any Rydon employees that the work was being undertaken"

M9.3.7 From the supplied evidence Mr Stokes appears to conclude that the stair doors were removed, taken to another level to be *"routed out along the door edges and fitted [with] cold smoke seals into and also fitted new hinges on these doors"* (RYD00038811 Page 1 and 3).

M9.3.8 Mr Stokes also refers to the new fitting as *"intumescent strips and cold smoke seals"* (RYD00038811 Page 5).

M9.3.9 I can see no evidence in his letter (RYD00038811) of Mr Stokes himself observing the stair doors undergoing these works in person, although he took photos of building work in lobbies, and adjacent to stair doors.

M9.3.10 The evidence available also shows that neither the TMO or Rydon have confirmed they either instructed or carried out the work as evidenced by the e-mail correspondence (CST00000173).

M9.3.11 I am concerned about the conflicts this evidence creates. The evidence of carpentry work in the lobbies may for example have been the result of the fitting of a new riser cupboard with its own fire doors within the lobbies as part of the Rydon works 2012- 2016. I can find no evidence to confirm what the carpentry work shown in the photo actually relates to.

M9.3.12 The evidence supplied by Mr Stokes of new hinges being fitted to the re-hung stair doors is included in Figure M.26(c). Green paint, the same as applied to the old form of door is clearly visible on the hinge.

M9.3.13 I have found no evidence the Level 4 -23 stair doors were repainted during the 2012 - 2016 works. The Studio E Stage D design report (CCL00000028 Page

15) contains interior pictures of the Grenfell Tower lobbies prior to the refurbishment works. In these pictures, the doors are painted same shade of green on the lobby interior face as I observed on site.

M9.3.14 Therefore, it is entirely feasible the hinge pictured was in place since the last painting of the stair doors.

M9.3.15 My site investigation photos of the level 6 stair door also show green paint on the hinges indicating that they were in place before that last painting of the door. This is shown in Figure M.25.

Figure M.25 Blue and green paint shown on level 6 stair door hinge

M9.3.16 The evidence supplied by Mr Stokes does clearly show a brush seal (for cold smoke leakage or draught exclusion) along the door edge. The lack of paint on the door edge is evidence the edge of the door has been 'planed' since the doors installation (Figure M.27(a)). I note my own photos clearly show the stair door at Level 6 was not planed on the "handle" side of the fire door.

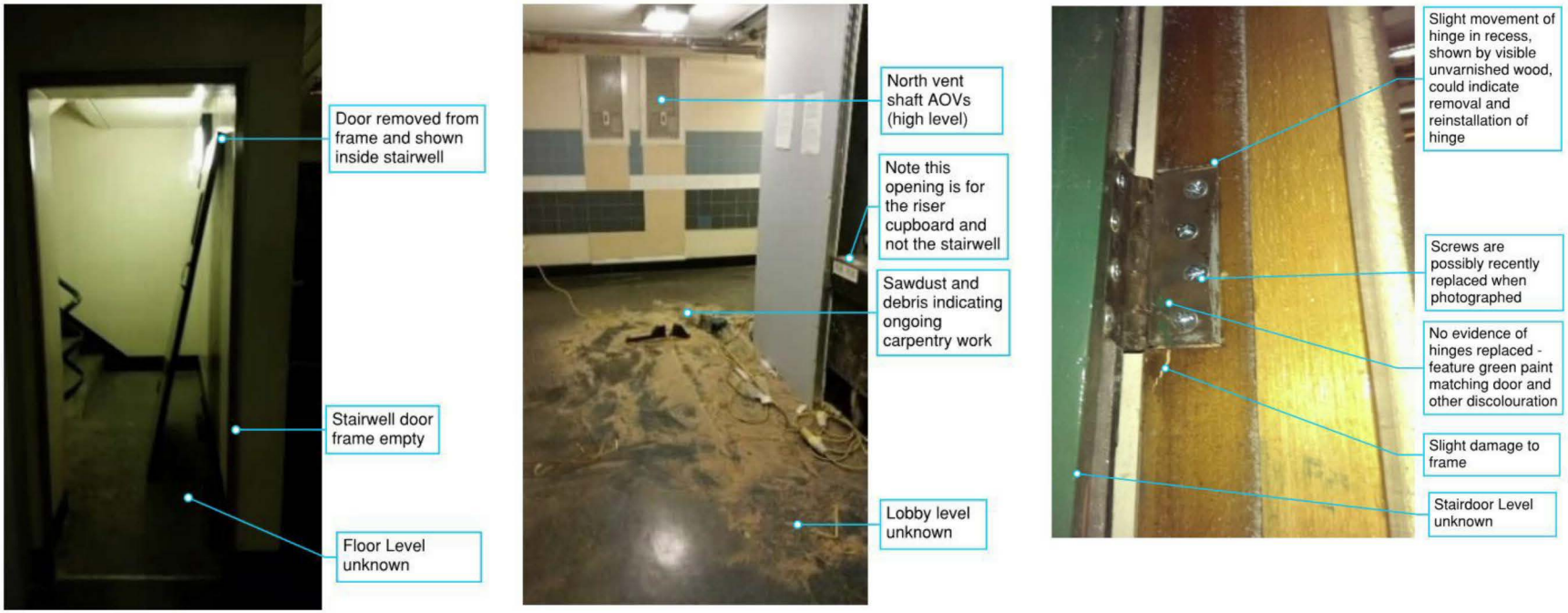
M9.3.17 Mr Stokes refers to the new fitting as either *"cold smoke seals"* or *"intumescent strips and cold smoke seals"*. It therefore appears at the time of writing the letter Mr Stokes may not himself have been able to confirm if one or both types of seals were present.

M9.3.18 I have described the different types of seals in Section M3.6 of this Chapter. From my own on site observations of the stair doors, it was not possible to identify whether the seal was a cold smoke seal only or a combined cold smoke seal and intumescent strip, and I found no information either in the

BRE Global Test Report *"Fire resistance test in accordance with BS 476: Part 22: 1987 on a single action, single-leaf timber doorset with one vision panel, mounted in a block-wall supporting construction"* (MET00021780) as I explained earlier.

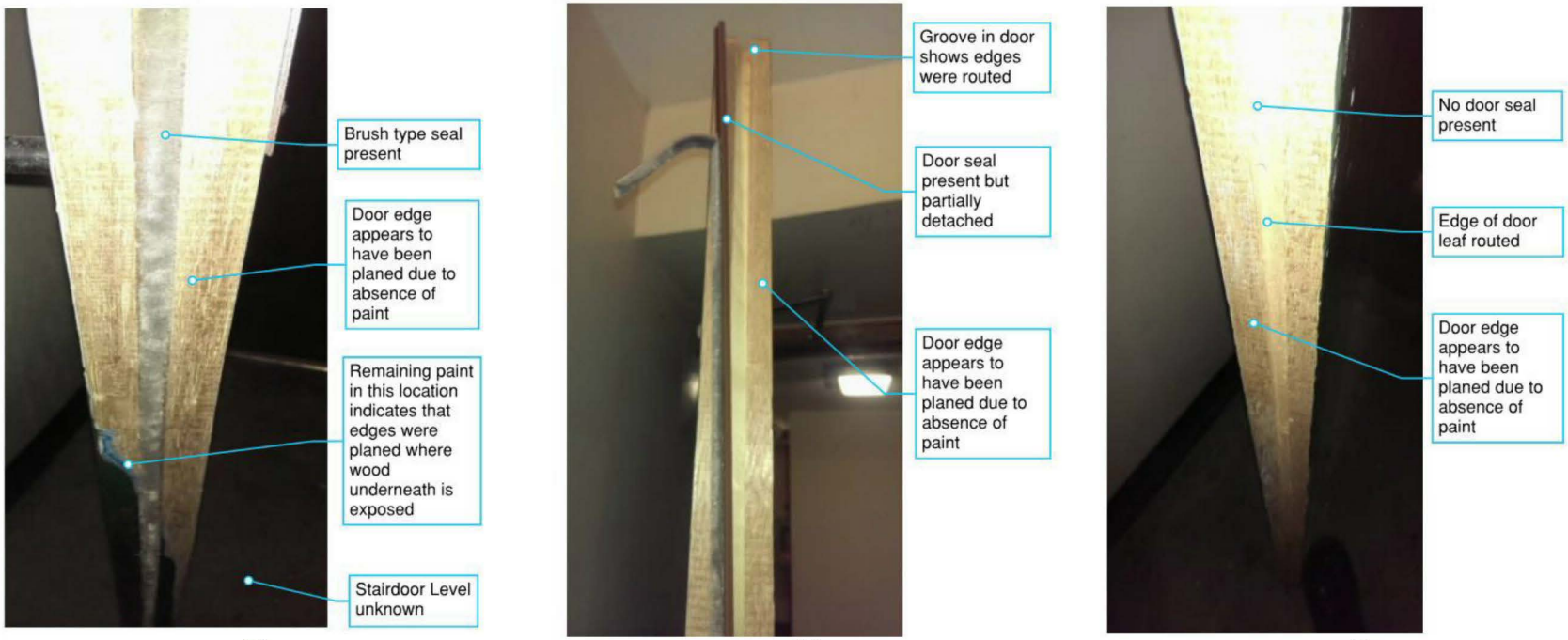
M9.3.19 In Figure M.28 is Mr Stoke's photograph of the seal, where it has partially detached from the door edge and so the base of the seal is visible. I have visually compared this evidence with typical forms of cold smoke seals, intumescent strips and combined cold smoke seals and intumescent strips, available on the market.

M9.3.20 The seal photographed by Mr Stokes is visually similar to a combined cold smoke and intumescent seal. I therefore consider it possible that the installed seal -that Mr Stokes provided a photo of- was a combined cold smoke and intumescent seal.



(a) (b) (c)

Figure M.26 Photographic evidence supplied by CS Stokes and Associates to TMO on 10th April 2015 (RYD00038811) of apparent works to Grenfell Tower stair doors



(a) (b) (c)

Figure M.27 Photographic evidence supplied by CS Stokes and Associates to TMO on 10th April 2015 (RYD00038811) of apparent works to Grenfell Tower stair doors edge

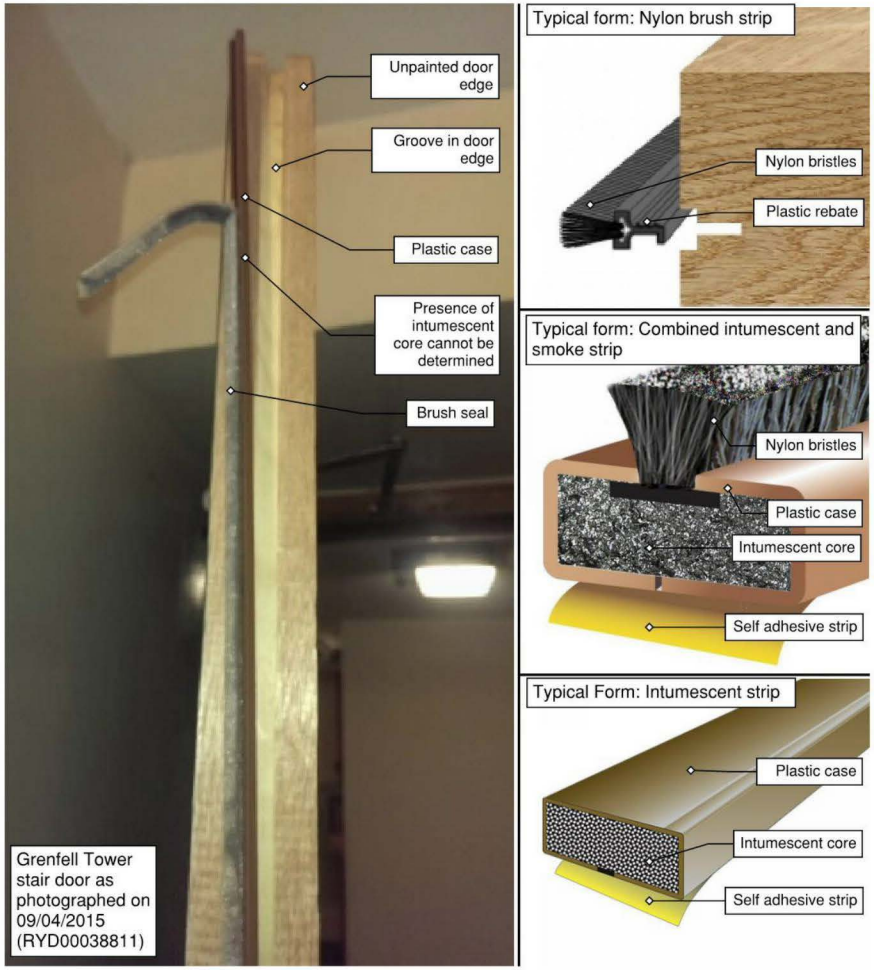


Figure M.28 Comparison of seal observed by Mr Stokes on 9th April 2015 (RYD00038811) and common forms of door seals.

M9.3.21 The stair door I observed on Level 6 within Grenfell Tower was fitted with a brush seal at the sides and top of the door.

M9.3.22 This same door was tested by BRE Global to BS 476 Part 22:1987 and achieved 16 minutes integrity and 3 minutes insulation fire resistance (MET00021780).

M9.3.23 The minimum possible fire door performance from No.3 Class A doors (i.e. fire check door with 12mm rebates) without intumescent strips is 12 minutes integrity fire resistance; and 28 minutes with intumescent strips when tested to original BS 476 Part 1:1953.

M9.3.24 The performance of a fire check door with a 25mm rebate and intumescent strips when tested to the more onerous subsequent standard BS 476 Part 8:1972 reduces to 20 minutes integrity (as stated in BRE digests 155 and 20) a reduction of 8 minutes from the testing undertaken by Morris (1971).

M9.3.25 Despite the difference in rebate it would appear more likely therefore there is an intumescent strip within the stair doors at Grenfell Tower.

M9.3.26 I am satisfied that there is substantial evidence this is a fire check door with a retrospectively installed nylon brush on some levels, with some evidence these are within a combined intumescent seal fitting at an unknown level where Mr Stokes took the photo Figure M.27(a). It concerns me there is no evidence as to who commissioned this work, why, and where.

M9.3.27 The fire resistance test carried out by the BRE, as expected from all the historic testing and guidance provided since the 1950s, clearly demonstrates this fire check door with intumescent strip cannot provide the required 30 minutes fire resistance.

M10 Dating of intumescent strips (for hot smoke leakage) and cold smoke seals

M10.1.1 In the event any party wishes to investigate the presence and form of intumescent strip in the stair doors at Grenfell Tower, I provide the following to assist.

M10.1.2 Please note I am satisfied the stair doors were constructed as a No. 3 Class A door to the *London Building (constructional) amending bylaws* and therefore, based on tests of similar doors as discussed in Section M5, an intumescent seal cannot increase the performance to 30 minutes integrity to BS 476-8; BS 476-22 or BS EN 1634-1.

M10.1.3 The smoke seal attached to the fire check door is only for cold smoke leakage therefore would not increase the fire resistance performance of the door for integrity.

M10.1.4 BRE Digests 155 and 220, published in 1971 and 1978 respectively make reference to a *"smoke control door"* to *"limit the spread of relatively cool smoke"* but state *"There is no standard definition or test method for assessing the performance of doors which are required to restrict the passage of smoke"*. The fire edition of the test standard for the cold smoke leakage performance of doors was BS 476-31.1 which was published in 1987. This was not referenced in an approved guidance document for the design of residential buildings until 1990 (in BS 5588-1:1991). It is therefore unlikely that a cold smoke seal, such as the pile brush I witnessed on the level 6 stair door until after 1990.

M10.1.5 BRE Digests 155 and 220, both refer to intumescent strips (to restrict hot smoke leakage) as being used to improve the fire performance of timber doors.

M10.1.6 Through literature review, the earliest example of intumescent strips being used to improve the fire resistance performance of doors was a paper published by the US Department of Commerce in 1966 titled "*Doors as barriers to smoke*".

M10.1.7 The discussion section of the Department of Commerce report states:

"Preliminary small scale tests at NBS of a commercial intumescent strip for application to door edges and jambs indicated that the product may react more quickly than paint coating. Using the strip, which is available in Europe for building and shipboard installations, a significant decrease was obtained"

M10.1.8 Eight years prior to the construction of Grenfell Tower in 1974, intumescent strips (to restrict hot smoke leakage) were therefore a commercially available product used to improve the fire resistance of fire doors in Europe. It is therefore possible that an intumescent strip installed on a Grenfell Tower stair door was an original feature noting that it is currently unclear whether the brush seal I witness on the level 6 stair door was fitted over the top of intumescent materials as part of a combined cold smoke/intumescent seal. Further intrusive assessment is required to determine this.

M10.1.9 As I found in Section M8, the LGA guidance published in 2011 for purpose built flats recommended that in some circumstances, namely where there is an extended travel distance exceeding current benchmarks, doors compliant at the time of construction of the building could be retroactively *'upgraded'* with intumescent strips and smoke seals.

M10.1.10 I have therefore investigated whether the physical or chemical properties of intumescent strips can be used as evidence whether the seal was from the time of original construction in 1974 or added later.

M10.1.11 To do this I have investigated industry guidance published by Intumescent Fire Seals Association (IFSA).

M10.1.12 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"* as stated on their website[4].

M10.1.13 The IFSA publishes several industry guidance documents on the performance, specification and installation of intumescent seals.

M10.1.14 The IFSA Information Sheet 4 published in April 2014 is titled *"The Ageing Performance of Intumescent seals"*.

M10.1.15 The summary section of Information Sheet 4 states *"Following concerns expressed over the longevity of some intumescent products the Intumescent Fire Seals Association embarked upon a 10 year, real time ageing programme in 1984"*.

M10.1.16 The materials used in this research programme are described in the report as *"At the time of the initiation of the test programme the major intumescent materials were strips or sheets manufactured from mono ammonium phosphate [MAP] or sodium silicate based compounds"*.

M10.1.17 Later in the report in the Section titled *"Materials not included in the IFSA ageing programme"* it is stated that *"Since the programme started in 1984, a number of new intumescent materials have been developed. Several IFSA members now manufacturer or supply intumescent seals made of graphite"*.

M10.1.18 Further to this IFSA Information Sheet 1 The Role of Intumescent Materials in the Design and Manufacture of Timber Doors Section 2.1 states:

"Ammonium phosphate

Intumescent materials of this type were originally based on mono ammonium phosphate (often abbreviated to MAP) but in recent years ammonium polyphosphate (APP) has also been used"

M10.1.19 In summary therefore an intumescent strip formed of Ammonium polyphosphate (APP) or a graphite based material is likely to have been installed at least after 1984 i.e. not part of the original stair door construction from 1974. Intumescent strips manufactured from mono ammonium phosphate [MAP] or sodium silicate based compounds could have been installed as part of the original door construction from 1974.

M10.1.20 Specific intrusive inspection is therefore required to determine whether beneath the cold smoke brush seal I observed on the level 6 stair door there are intumescent materials. If such materials are found, analysis of the chemical composition of those materials will be required. This will allow for an assessment to be made on the date of the intumescent.

[4] https://www.ifsa.org.uk/

M11 Conclusion regarding the condition of the Grenfell Tower stair door

M11.1.1 I have found the following evidence that supports the Grenfell Tower stair door being the original door constructed between 1972-1974:

a) The 'stile and rail' timber plasterboard composite construction of the Grenfell Tower stair door was a common form of construction in the early 1970s, specified in the *London Building (constructional) amending bylaws*. applicable at the time of construction.

b) The frame rebate depth of 12mm is in accordance with the specification of a No.3 class A door in Table G of Schedule VI of *London Building Constructional Amending Bylaws 1966*. This is noncompliant with the higher performance of 25mm required by CP3 Chapter IV Part 1 (1971) which I found in Chapter 4 was used for the design and construction of the lobby smoke control system at Grenfell Tower.

c) After 1986 all doors were required to be fire tested to demonstrate they achieve the required fire performance. Review of fire resistance testing to BS 475-1:1953 from Morris (1971) shows that a door compliant with the minimum requirements of a No. 3 Class A door with a 12mm rebate would not achieve the required fire performance of 30 minutes stability and integrity. This indicates substantially the door was installed prior to 1986.

d) I have reviewed a letter from DWF on behalf of RBKC to the Inquiry dated 27th September 2018 [RBK00029044]. It states RBKC's view that no replacement or changes were made to the Level 4 to 23 stairwell doors during the 2012-2016 refurbishment. This contradicts the limited evidence submitted by Carl Stokes but is aligned with the evidence I have from Rydon and the TMO that they did not instruct such works.

M11.1.2 I have found no evidence that supports the Grenfell Tower stair door having been replaced during the occupation of the building from 1974 to 2017:

M11.1.3 I have found the following evidence that supports the Grenfell Tower stair door having had works done, during the occupation of the building from 1974 to 2017:

a) I observed a nylon brush seal installed in a groove in the edges of the door. Brush seals were not a requirement for compliance with either the *London Building Constructional Amending Bylaws 1966* applicable at the time of construction nor with the *British Standard 459: Part 3: 1951 Fire check flush doors and frames*.

b) Cold smoke performance was not a requirement for stair doors until 1990 by the applicable guidance of BS 5588-1:1990. Therefore, this could provide evidence the brush seal was installed after 1990.

c) Carl Stokes was asked to visit Grenfell Tower on Thursday the 9th April 2015 by the TMO *"to look at the flat/ lift area to staircase fire doors which a contractor has recently routed out along the door edges and fitted cold smoke seals into and also fitted new hinges on these doors"*. The findings from this visit were issued by Carl Stoke to the TMO on 10/04/2015 by letter [RYD00038811]. This could suggest the brush seal observed was retroactively installed on the original door in 2015. But the emails between the TMO and Rydon and the letter disclosed by RBKC show no one was asked to do such work.

d) The Metropolitan Police fire resistance test (MET00021780) describes the presence of a *"Nylon bristle type smoke strip"* which as I have found through review was only required for cold smoke leakage after 1990.

M11.1.4 A destructive survey of any remaining door samples could provide measurements of the top middle and intermediate rail dimensions; door leaf width; door leaf height; ironmongery and presence or not of an intumescent seal to provide further evidence of the door specification however based on the evidence I have to date I am satisfied that the stair door was construction as a No. 3 Class A door from Table G of Schedule VI of the *London Building Constructional Amending Bylaws* applicable at the time of construction however a lower performance than that required by CP3 Part 4 (1971).

M11.1.5 If there are intumescent materials present chemical analysis to determine the age of the intumescent seal as described in M10 however I do not regard this as a significant factor in the performance of the door as relates to the events in Grenfell Tower, the night of the fire.

M11.1.6 I consider the more significant conclusion to be that the LGA guide currently recommends upgrading historic doors, with no advice on the existence of door which would have complied with the *London Building Constructional Bylaws* and yet have a proven lower performance standard in fire. I do not consider this satisfactory.

M11.1.7 There is an entire subsection of fire doors that could have been installed to comply with the *London Building Constructional Byelaws* in the late 60s early 70s which cannot achieve 30 minutes integrity to the test standard at the time of construction and even if upgraded with an intumescent seal cannot achieve 30 minutes fire resistance to any subsequent revision of the fire resistance test standard.

M11.1.8 The LGA guide should be updated to reflect this condition.