THE UNIVERSITY *of* EDINBURGH
School of Engineering

Grenfell Tower Inquiry
Phase 2 – Regulatory Testing and the Path to Grenfell

Professor Luke Bisby

Signed:

Dated: 10th November 2021 (updated 4th December 2021 and 1st June 2022)

Preface

1. "Disasters reveal patterns of risk and vulnerability built into the environment and the technological systems that undergird modern society".[1]

2. The Grenfell Tower fire occurred on 14th June 2017 and resulted in the deaths of 72 people. The aftermath of the fire continues to adversely affect the wellbeing of hundreds of thousands of individuals owing to the ongoing "cladding crisis".

3. The refurbishment overcladding of Grenfell Tower occurred within a fire safety regulatory and testing landscape that had been slowly developing for many decades. After the Grenfell Tower fire the regulatory landscape in fire safety continued to develop – and it will continue to do so in the future in response to social, political, and economic drivers.

4. This report seeks to explain how and why the fire safety regulatory and testing landscape developed as it did. I aim to demonstrate how and why "patterns of risk and vulnerability" came to be embedded within industry practice and within the words of the guidance and its underpinning legislation.

5. In the first part of this report (Part I), I discuss the purpose of regulatory testing, both generally and with respect to fire safety. I aim to explain the reasons why tests may be created and the compromises that are inherent within them. Fundamentally, I aim to demonstrate that it is usually unfair to criticise a test for being too small, too unrealistic, too variable – **a test is just a test; it is what people choose to do with the results from a test that matters.**

6. In the second part of this report (Part II), I have drawn together multiple narrative threads on testing, regulation, fire investigation, and research that, together, allow some of the patterns of risk and vulnerability in fire safety to be revealed. These narrative threads show that by the time of the Grenfell Tower fire there had been numerous opportunities where the statutory guidance and regulatory compliance testing regime *could* have been made simpler or less permissive. However, **in each case there appears to have been powerful commercial and ideological incentives to increase complexity, whilst also increasing flexibility for industry**. I show that the resulting complexity, coupled with widespread incompetence and poor regulatory oversight of built environment professions (and professionals), significantly contributed to the disastrous fire safety outcomes at Grenfell Tower.

7. In the third part of this report (Part III), I offer some closing remarks – based on the main body of this report and its Appendix A – that I hope the Chairman and the Panel might keep in mind as they consider evidence during Module 6 of the Inquiry.

8. Finally, in Appendix A, I present a discussion on the purpose and deployment of regulation. I focus on what I consider to be a topic of central importance

[1] Knowles, S.G. 2012. *The Disaster Experts: Mastering Risk in Modern America*. University of Pennsylvania Press, pp. 5. https://doi.org/doi:10.9783/9780812207996.

when considering the fire safety regulatory and compliance testing landscape leading up to the Grenfell Tower fire, namely "regulatory capture". Appendix A thus provides what I consider to be necessary background context to understand the conflicts, incentives, and compromises that are inherent within any regulatory system and, critically, **how industries must be expected to seek to exploit regulatory systems for their own benefit**.

9. In drafting this report, I have become acutely aware of the challenges that are likely to be faced by the Chairman and the Panel in making recommendations that will not fall victim to, or be diluted by, precisely the same pressures and incentives which have delivered the present – inadequate – fire safety regulatory and compliance testing landscape.

10. It is my hope that this report will help the Chairman and the Panel to ensure that their Phase 2 recommendations are as informed and effective as possible.

Table of Contents

Part III – Closing Remarks

Appendix A – The Purpose and Evolution of (Fire Safety) Regulation

1. Introduction

1.1. Scope and Purpose

The Inquiry's Terms of Reference

11. The Inquiry's Terms of Reference have been approved by the Prime Minister and have been published on the Inquiry's website. The Inquiry has also published on its website a detailed list of issues which identify the matters with which its investigation will be concerned. This provisional list may be revised in due course.

Structure of the Inquiry

12. The Chairman indicated that the Inquiry would be conducted in two phases.

13. *Phase 1 of the Inquiry was intended to investigate the development of the fire itself, where and how it started, how it spread from its original seat to other parts of the building and the chain of events that unfolded during the course of the hours until it was finally extinguished. Phase 1 also examined the response of the emergency services and the evacuation of residents. The Chairman has noted that it was necessary to address these questions first for two reasons*:

14. *(1) there was an urgent need to identify what aspects of the building's design and construction played a significant role in enabling the disaster to occur; and*

15. *(2) until the chain of events was understood, it would not be possible to pinpoint the critical decisions that had a bearing on the fire.*

16. The Chairman asked (me) to provide a report(s) for Phase 1 on:

17. ***(1) ignition of the façade materials; and***

18. ***(2) preliminary conclusions on fire spread to and on the exterior of the building.***

19. *Phase 2 of the Inquiry [is] concerned with the balance of issues identified in the provisional List given on the Inquiry's website. For Phase 2, the Chairman asked (me) to provide [reports] addressing the following issues:*

20. *(1) Final conclusions on fire spread to and on the exterior of the building;*

21. *(2) Performance of the materials which formed part of the exterior of the building and contribution (if any) to spread of fire, including: (i) a review of testing by BRE and any other relevant bodies, and (ii) a review of the standard testing regime;*

22. *(3) Any issues relating to the mechanical response of the reinforced concrete structural frame (if deemed relevant following further investigation); and*

23. *(4) Recommendations about what, if any changes could be made to the regulatory regime and industry practice to prevent a similar incident from happening in the future.*

24. The above instructions were supplemented (on 25th July 2019) with additional Phase 2 instructions, specifically to prepare reports at Phase 2 on:

25. *(1) The performance and respective contributions of the materials and products which formed part of the exterior of the building and contribution to initiation, growth and spread of fire, including:*

26. *(i) a programme of experimentation*[2] *aimed at understanding and quantifying the respective roles of the various materials and products that made up the cladding system at Grenfell Tower under a range of relevant fire conditions and system geometries. This work is to be undertaken with a team from the School of Engineering at the University of Edinburgh including Dr Angus Law and Dr Rory Hadden in collaboration with Professor Jose Torero. The experimental work will be developed in on-going consultation with Professor Torero and will aim to establish the manner and extent to which each component of the cladding system contributed to rate and extent of fire spread during the Grenfell Tower fire;*

27. *(ii) a review of the standard compliance testing regime for cladding materials and products; and*

28. *(iii) a review of large scale cladding tests, including a review of extended applications developed on the basis of such large scale cladding tests; and*

29. *(2) [My] final conclusions on the relative contributions of the cladding design and materials to the fire spread to and on the exterior of the building taking account of the findings made in the Phase 1 report, reports submitted by other instructed experts to the Inquiry, and work at (1) above.*

30. This document was prepared at the request of the Solicitor to the Inquiry and represents my responses to instructions noted above in Paragraph 21 (items 2(i) and 2(ii)), Paragraph 23, and Paragraph 27.

1.2. Sources of Information

31. The opinions and analysis presented in this report are based on a variety of sources of evidence, some of which has been provided to me by the Inquiry team, and some of which I have obtained independently via publicly available print, online, media, or archive sources. All sources of evidence are referenced within the body of this report.

1.3. Structure of Report

32. The body of this report contains four main sections. These are summarised below to orientate the reader:

33. **Part I: The Purpose of Testing** – describes the purpose of regulatory testing in general terms, and with specific reference to the tests that are of relevance to

[2] As described in a Technical Addendum to a letter from the Inquiry to Core Participants dated 23 April 2019. {INQ00014941}

the regulatory regime for external cladding that was in place at the time of the Grenfell Tower Fire. I am aware that other experts have given detailed descriptions of specific test apparatuses and procedures[3]; I have attempted to minimise repetition, and have focused my evidence on the fundamental technical underpinnings of the various test methods and on the roles that each of these tests performs (or ought to perform) within the regulatory system. Of particular relevance for the Grenfell Tower fire is how tests were perceived, used, and interpreted by industry and by government.

34. **Part II: The Path to Grenfell** – describes the gradual development of the regulatory environment in which the Grenfell Tower refurbishment took place. Many of the ideas that manifest within the current regulatory system have their genesis in the early- and mid-20th century. To understand the current state of the regulatory system, and to make recommendations that avoid the pitfalls of previous generations, it is necessary to try to understand as much of this context as possible. The narrative in this report includes reference to regulations, industry practice, testing methods, real fire events, and fire investigations. I have drawn together these narrative threads in an attempt to allow the patterns of risk and vulnerability to be revealed.

35. **Part III: Closing Remarks** – I have presented some closing remarks for the Chairman and the Panel to consider based on the information contained within this report.

36. **Appendix A: The Purpose of Regulation** – describes a much broader background for the reader to elucidate questions around how and why regulation of fire safety exists. Drawing on the social science literature, and co-authored with my colleague and academic collaborator Dr Graham Spinardi, this Appendix provides the background context necessary to understand the conflicts, incentives, and compromises that are inherent within any regulatory system; it also shows how industries may (and invariably do) seek to exploit regulatory systems for their own benefit. The evidence presented in this Appendix underpins some of my interpretation of the evidence that I present in parts I and II; however I have placed it in an appendix because I do not hold myself out as an expert in the socio-technical study of regulation, despite having considerable experience in academic thinking, and writing, about such issues.

37. Each part of this report is referenced independently.

38. I am grateful to the Chairman, the Panel, and Inquiry team for allowing me to undertake this work for the Inquiry. I hope that the need for (and value in) drawing together so many narratives becomes self-evident for all readers.

1.4. About the Author

39. I am Professor of Fire and Structures and Head of the Research Institute for Infrastructure and Environment within the School of Engineering at The University of Edinburgh. I was formerly Arup Chair and Royal Academy of Engineering Research Chair. I am Co-Editor-in-Chief of the technical journal *Fire Safety Journal*.

---

[3] Lane, Oral evidence to the Inquiry, 10th November 2020.

I have extensive experience of engineering research and consultancy, university teaching and administration, promotion of public understanding of science and engineering, and wide-ranging professional community activities. I am a Chartered Structural Engineer (FIStructE, UK) and a Licensed Professional Engineer (PEng, Ontario, Canada). I have received numerous awards for my commitment to high quality engineering research and education, and for my dedication to the broader academic and research communities.

40. My core research to date has focused on the thermal and structural performance of both conventional and innovative structural materials, products, and construction systems when exposed to high temperatures and fire. On-going fire safety and structural fire engineering research is being undertaken in collaboration with various groups internationally. My current research is focused on building and infrastructure materials at elevated temperatures, polymer composite-confined concrete columns, fire-safe structural strengthening and rehabilitation materials, definitions of design fires, explosive spalling of concrete in fire, passive fire protection coatings, the fire behaviour of concrete structures, fire performance of bio-based building materials and products (including structural laminated timber and engineered bamboo), fire performance of external cladding materials, products, and systems, as well as work on social and regulatory aspects of fire safety and structural engineering.

41. I have advised both industrial and government fire safety research organisations in the UK, USA, Canada, France, Switzerland, and Germany. I am involved in design code/guide development internationally (American Concrete Institute (ACI), American Society of Civil Engineers (ASCE), British Standards Institution (BSI), European Committee for Standardization (CEN), and Canadian Standards Association (CSA)).

42. I have related interests in sustainable building design, fire safety in informal settlements, and engineering education, with published peer-reviewed articles also in these areas.

43. I am an active member of the UK Standing Committees on Structural Safety (SCOSS) and Collaborative Reporting on Structural Safety (CROSS), and a Fellow of the Royal Academy of Engineering (RAEng), the Institution of Fire Engineers (IFE), the Institution of Structural Engineers (IStructE), the Royal Society of Edinburgh (RSE), the International Institute for FRP in Construction (IIFC), and the Institution of Engineers in Scotland (IES).

44. A more detailed curriculum vitae is provided in Appendix E of my *Final Phase 1 – Expert Report*.[4]

1.5. Assisted By

45. I was assisted in the production of this report by the following individuals:

[4] {LBYS0000001}

46. Dr Angus Law – Lecturer in Fire Safety Engineering at the University of Edinburgh. Dr Law has assisted by preparing the first drafts of Parts I, II, and III, and by reviewing and commenting extensively on all parts of this report.

47. Dr Graham Spinardi – Visiting Research Fellow at the University of Edinburgh. Dr Spinardi has assisted by preparing the first draft of Appendix A, providing text for Part I (particularly the early sections), and providing review and comment on Part II. Dr Spinardi has also spent considerable time in the National Archives at Kew, gathering and reviewing primary evidence in support of this report.

48. Dr Rory Hadden – Senior Lecturer in Fire Investigation at the University of Edinburgh. Dr Hadden has assisted by reviewing and commenting extensively on Part II of this report.

1.6. Statements

49. I confirm that I have no conflict of interest of any kind, other than any which I have already set out in this report or disclosed to the Inquiry. I do not consider that any interest which I have disclosed affects my suitability to give expert evidence to the Inquiry on any issue on which I have given evidence and I will advise the Inquiry if, between the date of this report and the Inquiry hearings, there is any change in circumstances which affects this statement.

50. I confirm that I have made clear which facts and matters referred to in this report are within my own knowledge and which are not. Those that are within my own knowledge I confirm to be true. The opinions I have expressed represent my true and complete professional opinions on the matters to which they refer.

51. I confirm that I understand my duty to assist the Inquiry on matters within my expertise, and that I have complied with that duty. I also confirm that I am aware of the requirements of Part 35 and the supporting Practice Direction and the Guidance for the Instruction of Experts in Civil Claims 2014.

52. I reserve the right to alter my opinions and conclusions in light of any further evidence or relevant information of which I am currently unaware. I will immediately inform the Inquiry should such a situation arise.

Signed: [signature] Dated: 10th November 2021

Part I: The Purpose of Regulatory Testing

2. Introduction

53. The purpose of testing is to allow an individual or an organisation to use the results of a test to make a claim about how a material, product, or system will perform in a real "in-service" situation.[5] A key issue with any test is therefore "the problem of inference from test performance to actual use", and the tension that exists between tests that are more realistic and those that are carefully controlled and highly instrumented.[6] Tests can never exactly mimic operational use of a technology because test designers seek to minimise uncontrolled variables and introduce instrumentation that would not normally be present. The differences between a test and operational use means that: "Tests get engineers closer to the real world but not all the way."[7]

54. The key issue therefore is not whether a test is "realistic" – because it can never be completely so – but rather whether it is sufficiently "representative". As Downer argues: "Since even the most 'realistic' tests will always differ in some respects from the 'real thing', engineers must determine which differences are 'significant' and which are trivial if they are to know that a test is relevant or representative."[8]

55. Nevertheless, one approach to claiming that a test is sufficiently representative is to seek to make it as realistic as practical. MacKenzie focuses on this form of testing (exemplified by his case study of missile accuracy) where complete systems are tested in scenarios that are chosen to be similar to operational usage. These are thus what Sims refers to as "proof tests" designed "to test a complete technological system under conditions as close as possible to actual field conditions to make a projection about whether it will work as it is supposed to."[9] Proof tests can always be questioned by a determined critic with regard to whether they are sufficiently realistic, with the credibility of knowledge claims based on such tests depending on "similarity judgements" between the test and the intended use conditions.[10]

56. Proof testing can be central to the development of a new technology, as prototypes and then operational designs are refined through increasingly realistic testing. Aircraft designs progress from wind tunnel to flight tests, drugs from animal to human trials, and so on. There are two key characteristics to proof testing. First, a technological artefact is tested in conditions that are intended to replicate, insofar as is practicable, the intended operational use. Second, instrumentation is used to

---

5 Throughout this report, it is important to keep in mind the potential differences between a "material", which one would assume to be relatively uniform and homogenous in composition, and a "product", which may be uniform and homogenous in composition – but which might also be composed of distinct layers of substantively different materials, with correspondingly different reaction-to-fire properties.
6 Mackenzie 1989, 414.
7 Pinch 1993, 26.
8 Downer 2007, 9.
9 Sims 1999, 492.
10 MacKenzie 1996.

LBYP20000001_0013

measure the aspects of performance in the test that are considered relevant, typically to enable judgements to be made as to whether the technology provides a desirable balance of efficacy and safety, and to obtain the knowledge needed to feed back into remedying poor performance. Thus, the purpose of the missile testing described by MacKenzie was not only to characterise performance (specifically as regards accuracy), but also to gain detailed information (through onboard instrumentation and telemetry) that could be used to improve performance.[11]

57. However, the proof test approach is not suitable for all technologies for two reasons. First, even where it is possible to test a complete system, much testing focusses on components and materials in order to enable their substitution and to facilitate the design process. Although it is possible to design (and test) bespoke components, the cost of so doing would usually be prohibitive, and most components are tested according to standardised methods that facilitate their use by a system integrator. As Smith notes: “Testing is essential to standardization.”[12] Testing of components and materials is therefore typically geared towards standardised metrics rather than any specific societal function. For example, a material such as a particular aluminium alloy could be rated for properties such as strength and stiffness; it is then up to a system designer to make appropriate use of such materials and components.

58. Second, “realistic” testing of complete systems may be impractical. In the case of built environment fire safety, full-scale destructive testing of building prototypes would be expensive, certainly excessively so if carried out for a range of likely scenarios (in terms of user behaviour and building contents). In any case, many buildings are bespoke in nature, and so judgements about overall fire safety performance must in practice rely on knowledge of the performance of the component parts.

59. Whether focused on proof testing of complete systems or standardised testing of components, the overall aim of regulatory testing is to assess performance. This does not *necessarily* require an understanding of the fundamental processes involved. The extent to which a test builds on and potentially adds to an existing scientific body of knowledge will depend on the chosen instrumentation and performance metrics. In principle, a test can be useful even if purely empirically based, although it would be rare for any test developed in the last few centuries not to draw on some theoretical concepts.

60. Conceptually, one can distinguish between *technological testing* that focusses on whether something “works” and *scientific testing* where one seeks to understand the mechanisms that are involved. In practice, most testing falls somewhere on a spectrum that encompasses both approaches.

61. However, the extent to which a test enables scientific understanding can be important. Although a test does not need to be theoretically rich to be useful, understanding of the relevant scientific principles may help not only in designing a

---

[11] MacKenzie 1989.
[12] Smith 1985, 17.

test, but crucially also in interpreting test results, particularly if seeking to *extend* the test results to a different instance from precisely that tested. This "extension" of test results poses a particular problem for similarity judgements. Rather than just seeking to claim that a test is sufficiently similar to the conditions of operational use of a technology, the claim is now made that the test results can be applied to a technology used in conditions that are *known to be dissimilar* to that tested.

2.1. Fire Safety Testing

62. Because it is not practical to test prototypes of buildings to demonstrate fire safety performance, regulatory approval typically relies on testing focused on the properties of materials, products, and elements of structure (e.g. columns, beams, and doors) rather than on complete buildings. Whereas proof tests can seek to mimic the specific use scenario for a particular new technology, with testing consistency required only from test to test of the system in question, component testing requires more standardisation if the test data are to be widely useful.

63. However, such standardised tests can still seek to be representative of real building fires in some respects. Although they only test part of a building, choices can be made as to the extent to which any test seeks to mimic "realistic" conditions. But real fires involve many complex phenomena, and greater realism is likely to mean greater complexity in test design. The challenge is to find a test design that captures the key phenomena without too much complexity, but as Downer argues "it is impossible to make the test simpler without making it less realistic: we are *trading representativeness for reproducibility*".[13] Common-sense might suggest that more realism is always a good thing, but it is important to consider the trade-off between representativeness versus reproducibility when considering what it is that any specific test is intended to achieve in practice.

64. Testing for fire safety needs to achieve two main purposes. First, and most importantly, it should enable regulation that achieves societal objectives with regard to safety. Second, it needs to be practical in operation, providing reasonably consistent results without being overly burdensome in cost and time.

65. The first of these purposes hinges on attaining a useful correspondence between test results and real-world performance. In principle, it does not matter whether a test is *realistic* so long as it is *useful* in this regard. This is critical because even the most rigorous attempts at a proof test can *never* be the same as real-world usage, and in fire safety testing the focus on materials, products, and elements of structure means that most regulatory fire tests *intentionally* sacrifice realism (or representativeness) for the sake of simplicity and reproducibility.

66. Although concerns about realism mean that it is always possible to question the credibility of knowledge claims derived from tests, in practice "the result of most testing is routinely accepted as fact".[14] This "acceptance-as-fact" happens because consensus typically emerges around the value of a testing methodology and its application to a real-world challenge (whether it be focussed primarily on design optimisation or regulation). Agreement over the value of a testing approach, and

[13] Downer 2007, 19, emphasis added.
[14] MacKenzie 1989, 415.

lack of powerful opposition, results in what Constant calls a "tradition of technological testability".[15] A central consideration in the emergence of such a tradition is not whether a test is realistic but whether it is useful; whether the test result can be seen as a useful metric in measuring performance, and, in the case of fire safety, in aiding regulation.

67. Thus, Downer argues that the utility of technological testing can be assessed from the real-world performance of technologies developed based on that testing, so long as the technology in question and the test procedure have not been subject to radical change.[16] The results of such tests can be seen as "yardsticks, significant because of their uniformity rather than because they reflect any inherent or 'natural' properties" … "What is important is not that the test represents a 'natural' measure but that it is constant, allowing us to measure one thing against another".[17] For example, the validity of testing of aircraft and their components can be judged to be generally adequate because airliner disasters are rare (especially those linked to mechanical failures), and innovation in civil airliner technology is incremental in nature.[18]

68. Structural fire resistance testing provides another such testing tradition. Standard fire testing was originally introduced to provide ratings for the "fire resistance" of elements of structure. Although fire resistance testing can be critiqued as unrealistic in many regards,[19] the resulting ratings are (largely on the basis of their apparent historical effectiveness at preventing adverse consequences from fires) widely accepted as qualitatively credible metrics for application via prescriptive regulation, when used appropriately. Fire resistance testing, now deeply embedded in fire safety regulations, has thus endured almost unchanged for more than a century.[20]

69. Fire resistance testing has proved enduring because *it has been seen to be useful* in providing a metric that enables prescriptive structural fire safety design. Real world experience of buildings designed according to prescriptive rules based around fire resistance ratings is seen to provide the necessary evidence base that this testing approach, and the regulatory framework that it underpins, is "working". However, there are serious concerns when practitioners seek to apply fire resistance ratings to scenarios that have not been "validated" by such a historical record – for example, in using "fire resistance" ratings based on standard furnace testing to assess the fire safety of massive timber elements of structure.[21]

70. A consensus may thus emerge (as it has over more than a century with fire resistance testing) that a test is useful, albeit plainly and widely acknowledged as unrealistic in its representation of structural response in real building fires.

71. However, if the regulations based on this testing approach constrain building design and prevent the use of innovative architecture, materials, and products, then the

---

15 Constant 1983.
16 Downer 2017.
17 Downer 2007, 21.
18 Downer 2017.
19 For expert critiques, see, e.g., Harmathy and Lie 1970; Law 1981; Lane 2000.
20 Law and Bisby 2020.
21 Law and Hadden 2020.

question arises (or should do) as to whether a change in regulations requires a reappraisal of the utility of the associated tests. Radical innovation in architecture, in materials, in products, or indeed in the regulatory approach, may all to some extent invalidate the historical correlation between a testing approach and adequate, acceptable fire safety outcomes.[22]

72. Some of the challenges associated with managing "innovation risk" when using a testing-based regulatory system have been highlighted by Brannigan, who notes:

73. > "Technological innovation poses the greatest challenge to any test based regulatory system since the ability to create a new product is not always connected with the ability to understand its risks and therefore to develop an appropriate test. Regulatory standards also can fail to capture the risk inherent in materials or processes which did not exist when a regulatory standard was adopted."[23]

74. Innovation risk constitutes "a risk in any type of performance testing", where there is "the ability to create a product that meets the technical requirement of a regulation but represents a novel hazard".[24]

75. Brannigan suggests that the normal way to address "innovation risk" is "to have a regulator with adequate discretion and expertise examine each innovative product or situation to determine whether the regulatory test is adequate to describe the risk arising from the new product." He goes on to note, however, that "such an approach conflicts directly with the political philosophy of a performance based test for approving products"[25], and that "this is not easy."[26]

76. Brannigan also warns, with respect to innovation risk, that "gaps in the current system can be exploited and grow if proper attention is not paid to the overall regulatory system."[27]

77. The second purpose of testing for fire safety – that fire tests should not be overly burdensome – is interrelated with judgements about their credibility and utility. Regulation seeks to achieve a *societally acceptable balance of benefits versus risks*. Although it is rarely explicit, or even acknowledged, society routinely makes cost-benefit choices as to whether a test is "good enough". If there is a historical correlation between the use of a test along with a set of regulations and a reduction in serious relevant fire incidents, then the test may be judged as useful (although deriving cause-and-effect claims from such correlations is notoriously difficult).

[22] For example, concerns about environmental impacts, as well as changing aesthetic values, may justify a shift towards the use of engineered timber in high-rise buildings; however, it is (or should be) recognised that this may require a change in fire testing approaches. Moreover, because such tall mass timber buildings are novel, there is no track record to demonstrate a correlation between the testing approaches and adequate safety outcomes.
[23] Brannigan 2008, 1.
[24] Brannigan 2008, 25.
[25] Brannigan 2008, 26.
[26] Brannigan 2008, https://youtu.be/G6f0NwqG9ms.
[27] Brannigan 2008, 26.

78. Alongside such considerations of whether a testing approach remains valid, are also pragmatic issues of usability. Relative simplicity of operation may also be important to the utility of a fire testing approach. The expense of carrying out a test is a consideration of course, but perhaps more important is the extent to which any test fits within the existing regulatory approach and levels of expertise amongst the relevant practitioners. A test that is seen to provide highly accurate representations of real-world performance when carried out by research scientists in a state-of-the-art laboratory may not be considered a "good" test if its results are less accurate or prone to misinterpretation when used in more typical testing facilities by individuals who lack any real understanding of the intent of a test, or of its physics.

79. The balance of pragmatism and "innovation risk" has particular significance when test results are extended beyond the context of the original test. Once a material, product, or system has been tested, a statement can be made about whether the results represent a *pass* or a *failure* (or, in some cases, a more granular *classification* of performance).

80. However, because material and product manufacturers are constantly producing new or modified products, there is a need (or ought to be) to regularly re-test. In some cases, the new product may be very similar to a previous version. For example, an original product may be 80 mm thick, and a new product may be 100 mm thick. This immediately raises questions about whether a new test result is required or whether it is possible (based on the results of previous tests and/or an individual's knowledge of the relevant physical parameters) to predict the test behaviour *without actually conducting* a new test.

81. This type of extrapolation is known as an "extended field of application"; or, more colloquially, a "desktop study". The extended field of application constitutes a particular extreme with regards to making knowledge claims about how a material, product, or system will perform in a real fire. All tests are laden with unavoidable ambiguities; the relationship between performance in the test and performance in the real world is normally unspecified; and an extended field of application is based on an assumption that one can remove the need to even run the (ambiguous) test.

82. This section analyses some of the regulatory fire tests that are relevant to the Grenfell Tower fire, and seeks to begin to identify and explain their context. What role was each test intended to play? How did any given test become seen to be appropriate as a means to evaluate or adjudicate on the fire performance of complete systems (buildings), as inferred from such standardised tests on component materials and products?

83. Later in this report it is shown how, during the past century, UK legislation has elevated the status of the regulatory fire tests. The regulatory systems that evolved in parallel sought to achieve societally acceptable outcomes; the means of achieving these outcomes was that building designers would ensure that the materials and products that they used within their buildings were able to achieve certain *performance* standards via regulatory tests. "Acceptable" was expressed by defining both a test method *and* the result(s) that any building material or product was required to achieve.

84. Over the period 1932 to 2017 various fire test were developed and deployed within the British fire safety regulatory system; these can be divided into three distinct categories as:

85. (1) unrepresentative tests;

86. (2) model tests; and

87. (3) technological proof tests.

88. The following sections describe each of these categories and the tests which, at various times, were developed and deployed within the relevant regulations and associated guidance.

89. The purpose of this categorisation of fire test methods is to aid the reader in better understanding the intent, context, and credible use and application of the various regulatory fire test methods that may have had a bearing on the tragic outcomes at Grenfell Tower; to highlight some of the complexities and compromises that are inherent in thinking about regulatory testing and its application; and to prepare the reader for some of the ideas that are central to the later sections of this report.

90. The co-evolution of fire testing, fire safety regulation, societal drivers and expectations, and experience of real (sometimes disastrous) fire events does not lend itself to being neatly partitioned so that each of these topics can be described independently from the others. The setting out of ideas and concepts specifically around fire testing in this chapter therefore results, unfortunately but necessarily, in some repetition of ideas and concepts later in this report.

3. Category 1: Unrepresentative Tests

3.1. The Combustibility Test

91. In the late 19th century, attempts to regulate the fire hazards of construction materials and products were based around discriminating between materials and products that were "combustible" and those that were "incombustible". Whether a *material*, or a *product*, or *part of a building* constructed of that material or product burned easily was an important consideration because of a historic concern with conflagrations such as the 1666 Great fire of London.

92. At the time, the field of fire science was undeveloped – reliance, therefore, was placed on interpretation of the meaning of the word "combustible". However, this apparently simple word is laden with hidden complexity.

93. What is meant by *combustible*? Combustibility is the *potential* of a *material* to burn.

94. Seeking regulatory clarity, it became important for architects (and others) to be able to define which materials (and products) were combustible, and which could be considered "incombustible" (i.e. non-combustible). The British Standards Institution (BSI) obliged by creating a test. However, the test that was created was not a measure of a material or product's *potential* to burn. Instead, they created at test that determined whether a given material or product *did* burn under a particular set of circumstances. The subtlety of this distinction is crucially important – a test of *potential* to burn would examine whether (under any circumstances) a product *could* undergo combustion. However, the test that was created only examined whether a flame was formed under a particular set of circumstances.

95. Over the course of the 20th century, the combustibility test methods and the definition of combustibility evolved considerably. An early test apparatus was created by Prince for the Forest Products Laboratory (USA)[28]. However, this apparatus was used to *compare* the responses of different materials (it was developed to investigate the effectiveness of fire retardants), rather than to give a "pass/fail" result for regulatory compliance purposes as regards combustibility. In Prince's test, a sample of the test product was lowered into a small furnace that had been pre-heated to a temperature between 200°C and 450°C with a pilot flame located above the furnace. If flammable vapours were generated in sufficient quantity, these would be ignited by the pilot.

96. In 1932, the BSI essentially copied this testing setup, changing some of the procedures and imposing their own definition of "incombustibility". The BS 476 test began when the furnace was cold, with the sample initially lowered into the furnace and then gradually heated up to 750°C.[29] BSI's definition of "incombustibility" was not met "if at any time during the test period the specimen (i) flames, or (ii) glows brighter than the walls of the heating-tube".

[28] Prince, 1915.
[29] BSI 1932, 12.

97. In 1953, the test procedure was changed again.[30] The furnace was now preheated to 750°C before the start of the test. Similarly, the language was changed to it being called a test of "combustibility" rather than a test of "incombustibility". Combustibility was defined as any sample that "flames, or produces vapours which are ignited by the pilot, or causes the temperature of the furnace to be raised by 50°C or more". This definition is notable in that, by inference, it acknowledges that it would be possible for a specimen to produce vapours which might not be ignited by a pilot – thus implicitly acknowledging that this was a test of whether a product *did* burn in that particular test set-up and conditions, rather than if it *could* burn under some other set of conditions.

98. In the 1970 version of the standard,[31] the testing equipment was adjusted slightly; a new "air flow stabiliser" was introduced below the specimen. The language of the test was (again) reversed so that it was now a test for "non-combustible" materials (or products). The assessment criteria were also adjusted; whereas, previously, any flaming resulted in a material being classed as "combustible", the 1970 version of the standard allowed a material (or product) to be classified as "non-combustible" even if it flamed for *up to ten seconds*. The 50°C furnace temperature criterion was retained.

99. The development of the 1970 version of the non-combustibility test appears to have been influenced by the development of an equivalent testing standard by the International Standards Organisation (ISO) (ISO R1182[32] also introduced in 1970). A paper by Herpol (one of the developers of the ISO standard) highlighted the necessary degree to which some of the parameters were semi-arbitrarily chosen. For example, Herpol noted that the increase in permissible flaming time was semi-arbitrary and represented a compromise between *absolute* and *acceptable* levels of "non-combustibility".[33] He pointed out that:

100. > "as a matter of fact, all materials producing flaming should be declared combustible, but to be sure that there is real flaming inside the furnace the flame has to last for a certain time. Thus the 10 s limit is also arbitrary and no member of [the committee] would probably object to acceptance of another period, for example, 15 s."

101. The 1970 version of the BS 476 standard also introduced a change in nomenclature. Whereas previously all fire tests had been constrained within subsections of BS 476, the new combustibility test was introduced as BS 476 *Part 4* (BS 476-4).

102. In 1982 a further new, but similar, standard was also introduced as BS 476 *Part 11*.[34] The key difference with BS 476 Part 4 was that the sample was changed to

---

30 BSI 1953.
31 BSI 1970.
32 ISO 1970.
33 Herpol 1972.
34 BSI 1982.

cylindrical rather than cuboid – which aligned more closely with the new ISO standard that was being developed in parallel (i.e. ISO 1182[35] introduced in 1979).

103. It is notable that the new BS 476 Part 11 test standard did not provide any definition of "non-combustibility". Instead, Approved Document B (which was introduced three years later) provided the definition (and the criteria); a material (or product) was considered non-combustible if it "does not flame and there is no rise in temperature".

104. Until the introduction of Approved Document B in 1985,[36] the criteria cited by regulations for "non-combustibility" were based on the tests and criteria described above. With the introduction of Approved Document B two important changes occurred. First, there were now two alternative routes to defining "non-combustibility" via a regulatory test – i.e. Part 4, which included a definition and pass criteria within the testing standard, or Part 11, which provided *only* a method of test. Second, Approved Document B introduced another, more general textual description to state that "non-combustible" materials could also be defined as "totally inorganic materials … containing not more than 1 per cent by weight of volume of organic material".

105. These three definitions (as well as a further allowance for concrete blocks) were retained up until the date of the Grenfell Tower fire.

106. In 2002, a further definition for non-combustibility was introduced.[37] This was based on the results from two different tests as defined by a new harmonised European standard.[38] The first was the International Standards Organisation's standard ISO 1182, for which the equipment and test method was fundamentally the same as that presented in BS 476 Part 11. A slight distinction was that to achieve the classification of "non-combustible" via the ISO 1182 test standard, the sample should not sustain flaming for intervals of more than 5 seconds.[39]

107. The European testing and classification system (which is further discussed in Paragraph 120) also required an additional test[40] to be performed on samples of any product.

108. The evolution of the test apparatus for non-combustibility is shown in Figure 1. The evolution of the citations in the relevant regulations and/or guidance is shown in Table 1. Finally, the evolution of the named test standard, and the definitions of "non-combustibility" (or an equivalent variant), is illustrated in Figure 2. Some of these apparatuses have previously been described by Dr Lane during her evidence to the inquiry.[41]

35 ISO 1979.
36 Approved Document B, 1985.
37 Approved Document B, 2002, 112.
38 BSI 2002.
39 Recall the earlier statement by Herpol (1972) discussed in Paragraph 100.
40 This additional test is the ISO 1716 test for the determination of the gross heat of combustion (calorific value). See Paragraph 120.
41 Lane, Oral evidence to the Inquiry, 10th November 2020, {Day68/45:} – {Day68/48:}.

109. What emerges from this brief review is a recognition that, in practice, definitions of "non-combustibility", and measures thereof, are arbitrary. Whether or not a material or product *can* burn is different from whether it *does* burn under a particular set of circumstances. Any material that contains organic content *can* "burn" – and each of the various test methods would allow *some* amount of organic content to be present within a test sample whilst nonetheless classifying a material or product as "non-combustible". Materials or products that did not exhibit flaming could still pyrolyse to produce flammable vapours – even if these did not ignite. Indeed, several of the test definitions for non-combustibility allowed a limited amount of flaming to occur – thereby explicitly acknowledging that materials or products that were classified as "non-combustible" could, and in fact sometimes did, burn under the conditions of the test(s).

110. The available evidence suggests that the thresholds for defining whether or not a material or product ought to be classified as combustible were also essentially arbitrary. Regulators appear to have been seeking a definition for "combustible" that would allow materials or products that "did not burn very much", and employed some flexibility in arriving at the exact definitions that were eventually implemented.

111. This was perhaps most (albeit not very) explicitly acknowledged in the initial, 1985 version of Approved Document B, where a threshold of 1% was set for the allowable organic content in a material (or product); thus burning of up to 1% of the total mass of the material or product was considered permissible. Similarly, the later European classification method (see Paragraph 120) also proposed a definition based partly on how much material *could* burn.

112. A noteworthy challenge in applying the concept of non-combustibility based on any of the above tests is in considering the extent to which any of the above tests applies only to a *material,* or whether it can be assumed to be applicable also to testing *products* made up from one or more materials.

113. Babrauskas has noted that the concept of non-combustibility "arose initially in connection with 'elementary' materials, i.e., materials which are homogeneous on a macroscopic scale".[42] Indeed, the original version of BS 476 (1932) makes no reference whatsoever to "products" and explicitly states that "the term incombustible and its derivatives shall be applied to *materials* only".

114. Babrauskas also notes that "this was satisfactory until about 1950, when paper-faced gypsum wallboard started becoming a popular interior finish material"; the problem being that paper-faced gypsum wallboard is a *product* that consists of core made from the *material* gypsum – which passes tests for non-combustibility – and surface made from the *material* paper – which does not.

115. Strictly speaking therefore, testing the *product* – i.e. paper-faced gypsum board – in any of the non-combustibility tests described above would not be appropriate.[43]

[42] Babrauskas 2016.
[43] The 1970 version of BS 476 Part 4 appears to have got around this problem by removing any statement that its results should be applied "to materials only" by referring to "composite materials" (i.e. products),

116. The concept of non-combustibility and the tests that were and are used to define it exemplify the first category of test. That is, they are tests that are both unrepresentative and at least partly arbitrary. There is no particular reason why the criteria for flaming should be set at zero seconds, five seconds, or ten seconds – these are arbitrary decisions made (typically by committee) on the assumption that the precise value selected does not particularly matter with regard to the expected in-service fire safety outcomes.

117. However, by making – but not necessarily stating – an implicit assumption that the particulars of the test will not affect the fire safety outcome, the potential is generated for such details to significantly affect the kinds of products that are *able* to be classified as "non-combustible". The decisions made in defining the test, and the test criteria, may therefore have profound *commercial* implications for both pre-existing products and for the development of new ones.

and requiring that test samples should be fabricated so that the proportions of the different material components of the product in the specimen "shall be the same as those in the material". In cases where this was not possible – for whatever reason – each of the material components was to be tested and reported *separately*.

LBYP20000001_0024

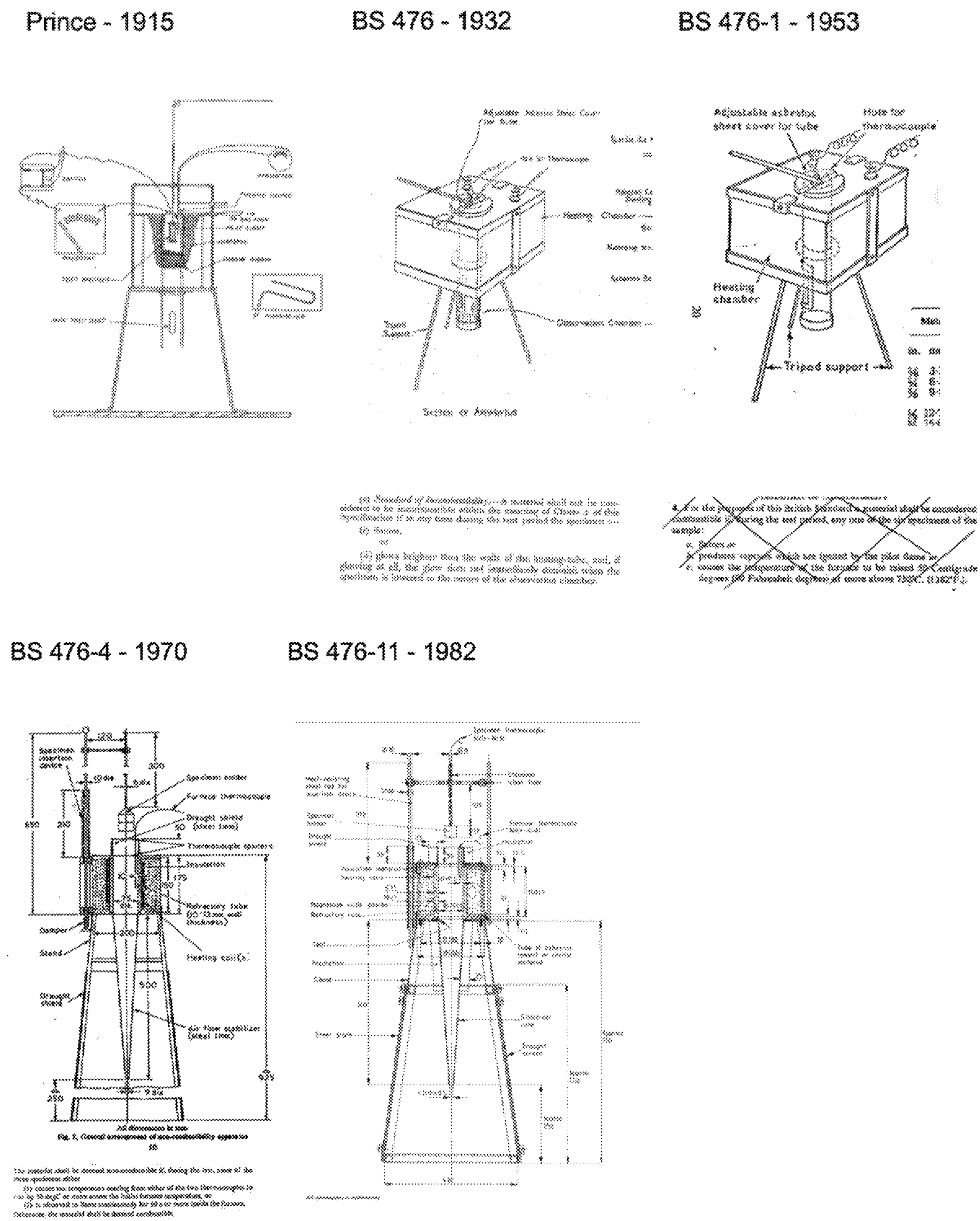


Figure 1 Evolution of test apparatus

Table 1 Citations in regulation

"incombustible material" means material which satisfies the test for incombustibility prescribed in British Standard (Definitions for Fire-resistance, Incombustibility and Non-inflammability) No. 476—1932;	Model bylaws, 1952
"combustible" means capable of being classified as combustible if subjected to the test for combustibility prescribed in BS 476: Part I: 1953; and "non-combustible" shall be construed accordingly;	Building Regulations 1965
"non-combustible" means capable of being classified as non-combustible if subjected to the test for non-combustibility prescribed in BS 476: Part 4: 1970; and "combustible" shall be construed accordingly;	Building Regulations 1972
NON-COMBUSTIBLE means capable of being classified as non-combustible if subjected to the test for non-combustibility prescribed in BS476: Part 4: 1970; and COMBUSTIBLE shall be construed accordingly;	Building Regulations 1976
Notes (a) Any material which when tested to BS 476: Part II does not flame and there is no rise in temperature on either the centre (specimen) or furnace thermocouples. (b) Totally inorganic materials such as concrete, fired clay, ceramics, metals, plaster and masonry containing not more than 1 per cent by weight or volume of organic material. (Use in buildings of combustible metals such as magnesium/aluminium alloys should be assessed in each individual case). (c) Concrete bricks or blocks meeting BS 6073: Part I: 1981. (d) Products classified as non-combustible under BS 476: Part 4: 1970.	Approved Document B 1985

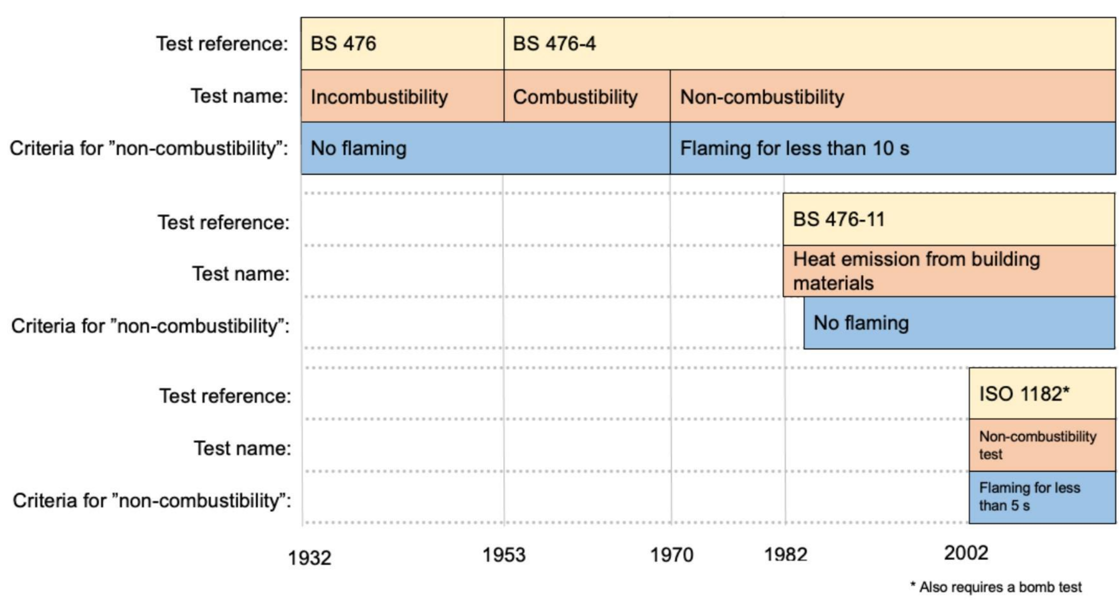


Figure 2 Evolution of test for non-combustibility[44] – temperature criteria omitted.

3.2. Test for Heat of Combustion (Calorific Value)

118. The heat of combustion of a material (sometimes called its "calorific value") is determined using a test method called "bomb calorimetry", within a testing apparatus called a "bomb calorimeter". Unlike the non-combustibility test, which

44 It should be noted that ISO 1182 *existed* before 2002, however it wasn't invoked within building regulation in England and Wales until Approved Document B was adjusted to include the harmonized European reaction-to-fire classification system in 2002.

was created specifically for the purpose of defining regulations, the bomb calorimeter was developed as a piece of scientific equipment to be used across a wide range of technical disciplines; to generate data that represent fundamental properties of materials – their heats of combustion (or calorific value/potential). The bomb calorimeter has been subsequently called into service as testing equipment for fire safety regulatory purposes.

119. The bomb calorimeter test has previously been described by Dr Lane during her evidence to the inquiry.[45] A bomb calorimeter measures a material's "gross heat of combustion" – the amount of energy released from a test sample if all of its combustible content were to burn.

120. A typical test standard for bomb calorimetry (referenced for example within the European reaction-to-fire classification system) is EN 1716. The particulars of EN 1716 are specific to that test standard – and other bomb calorimeter test standards exist that may use slightly different equipment and procedures. However, although the equipment and procedures may vary between standards – the resulting measurement is largely independent of the equipment or methods used.

121. This non-dependence on test standard or specific equipment creates a noteworthy distinction between the previously described non-combustibility test and the bomb calorimeter test. With the non-combustibility test, the result is a function of the particular test equipment and procedure; with the bomb calorimeter, the result should be the same, or at least very similar, irrespective of the equipment used.

122. Although the bomb calorimeter test is highly *reproducible*, the small (often only about 0.5 gram) sample used in a bomb calorimeter test cannot be said to be *representative* of the construction of a real building. The sensitivity of the equipment, however, along with its reproducibility, makes it ideal for differentiating between materials that are not expected to release very much energy (heat) when burnt.

123. The European reaction-to-fire classification system therefore cites the bomb calorimeter (EN 1716), together with the non-combustibility test (EN ISO 1182), as the means of checking whether a material *can be considered* to be "non-combustible" (or the means of demonstrating "limited" combustibility; see Paragraph 124). If a tested product has the *potential* to burn, then the bomb calorimeter *will* detect this potential and return a quantitative measurement (subject to the precision of the instrument used).

124. The test method described in EN 1716 does not define the threshold measurement below which a product tested with the bomb calorimeter could be deemed non-combustible. This value is instead provided within another European standard, EN 13501-1. The threshold value below which a material (or product) is (currently) considered to be non-combustible is 2 MJ/kg (compared to about 46 MJ/kg for polyethylene or about 18 MJ/kg for softwood timber). This means that products that are classed as "non-combustible" may in fact burn, but they would not be "very burny". The value of 2 MJ/kg represents such a low threshold that the code writers

[45] Lane, Oral evidence to the Inquiry, 10th November 2020, {Day68/64:} – {Day68/67:}.

presumably felt that such materials or products presented no meaningful fire hazard. A slightly higher threshold of 3 MJ/kg is (currently) used to define "limited combustibility" – for reasons that are not immediately obvious.

125. Bomb calorimetry suffers from the same challenge as the non-combustibility tests as regards testing of "products" versus "materials". Bomb calorimeter test standards may get around this problem by determining the gross heat of combustion of non-homogenous products using a mass-weighted average of the heats of combustion of the respective component materials, or by dealing only with "substantial components" of composite products.[46] These approaches, when used in isolation, may overlook the potential for certain products with highly combustible outer surface layers and non-combustible cores to generate flame spread hazards.

3.3. Commonalities

126. The bomb calorimeter (i.e. BS EN 1716) and non-combustibility tests (i.e. BS 476 parts 4 and 11, ISO 1182) are *fundamentally* different tests. The latter have evolved in an iterative and semi-arbitrary manner solely for the purposes of regulating materials and products on the basis of their "combustibility". The former is a scientific test that has been appropriated by fire safety science and engineering for regulatory purposes. However, the ways in which the results of these tests are used are very similar; there is an inherent assumption within the fire safety community that the particular (albeit "low") threshold for pass/fail does not materially affect the fire safety outcome in any relevant scenario.

127. In the non-combustibility test, the criteria for flaming could be zero seconds, five seconds, ten seconds, or indeed longer – the exact value is assumed not to particularly matter with regard to the fire safety outcomes. Similarly, the threshold for the bomb calorimeter's heat of combustion value could just as easily be set at 1.7 or 2.4 MJ/kg – again the exact value is assumed to not particularly matter with regard to the fire safety outcomes.

128. However, as noted above, such small changes in the threshold values set by regulators may have very significant impacts on the kinds of products that are able to be classified as "non-combustible" (or as the slightly *more* combustible, "limited combustibility").

129. The selection of a particular threshold value is therefore asymmetric in terms of its impact on fire safety outcomes, as compared to impacts on the products that may be deemed to pass or fail. As such, in the case of the non-combustibility test, small changes to the test setup may have a very significant impact on the products that could be classed as non-combustible. Likewise, for both tests, small changes in the acceptable threshold values could have a significant impact on whether a product can (or cannot) be deemed to be non-combustible.

130. Thus, with each small change in the definition of the non-combustibility test since 1932, and with each small change in the acceptability criteria, there will have been the potential for significant commercial impacts on the products that were (or were not) classified as non-combustible. A small change might cause a product that had

[46] BSI 2009.

previously been classified as non-combustible to be reclassified as combustible (or, more likely, as limited combustibility). This could have potentially serious consequences for product manufacturers. However, as already noted, such a change may have no perceptible impact on the overall fire safety outcomes.

131. Small tweaks to a test made by a code committee for no meaningful fire safety gain could therefore potentially end a company's business. This situation clearly presents a potential problem for any government that has an interest in accommodating the needs of industry.

132. The obvious solution to such a quandary is to allow new standards to be created, whilst retaining legacy standards within the regulatory framework.

133. As noted in Paragraph 126, by 2017 there were *four independent methods* by which a manufacturer could demonstrate that their product was non-combustible. These were:

134. (1) BS 476 Part 4;

135. (2) BS 476 Part 11;

136. (3) BS EN ISO 1182; and

137. (4) BS EN ISO 1716.

138. The oldest of these dated from 1970.

139. This section has described the first category of tests: "unrepresentative tests". Such tests have the following properties:

140. they are unrepresentative of real building situations;

141. they are best used when applied to homogeneous *materials*, and can be applied to *products* only indirectly;

142. the link between test results and building performance is based purely on the *judgements* of the regulators (i.e. the regulatory limits are assumed to have been set so low that the outcomes *will* be acceptable, regardless of the specifics of any given application) with no attempt to quantitatively correlate the test results with real fire behaviours; and therefore

143. small changes in the acceptance criteria are likely to have minimal impacts on fire safety outcomes, but they may have very significant impacts for the products that pass or fail the test.

4. Category 2: Model tests

4.1. Surface Spread of Flame

144. The non-combustibility and bomb calorimeter tests both involve essentially arbitrary judgements about how to define which products could be considered combustible

versus non-combustible. However, beginning in the 1940s a new kind of fire test method began to emerge, both in the UK (and elsewhere). These tests were based around the idea that the fire hazard presented by a product in a real building *could* be represented at least partly by a relatively small-scale test. At first these tests were focussed (in the UK) on the threats posed by incendiary bombs during World War II – it was recognised that materials and products did not have to be non-combustible (in the arbitrary manner by which it had already been defined) in order to provide an "adequate" level of protection from an incendiary bomb. However, attention soon moved towards less militarised applications for fire testing.[47]

145. Prior to World War II there had been an increase in the use of building boards for construction. Many of these were comprised (at least in part) of wood fibres, and were therefore combustible. It was recognised that the existing non-combustibility tests were unable to discriminate between boards over which flame might spread quickly or slowly. In an attempt to discriminate between the hazards presented by different combustible boarding products, a large-scale experimental programme was conducted at the UK's Fire Research Station. Corridors were lined with different types of wall board and the behaviour of fires within the corridors observed. It was concluded that "the rate of growth of a fire was primarily influenced by the assistance given by exposed wall and ceiling surfaces to flame spread."[48] A laboratory test was subsequently devised to mimic this large-scale test, and to provide a measure of flame spread rate.

146. This new "surface spread of flame" test used a gas-fuelled radiant panel[49] to heat the test specimens. This test method and apparatus has previously been described by Dr Lane during her evidence to the inquiry.[50] The specimen and radiant panel were arranged in an L-shaped configuration (Figure 3), and the rate and extent of flame spread across the surface of the specimen was measured. This "lateral flame spread" test supported a more nuanced and complex classification system than the incombustibility test. Where fire spread was observed to be rapid and/or extensive the product was deemed of higher hazard and was "Class 4"; where fire spread was slow and/or confined the product was deemed of lower hazard and was "Class 1", with two intermediate categories of "Class 2" and "Class 3". In the same manner as had been the case for the incombustibility test, the definitions of Class 1, 2, 3, and 4 were directly linked to observed behaviours *in this particular testing configuration* and, also in the same manner, the lines chosen to delineate between the four "classes" were essentially arbitrary.

147. However, unlike the incombustibility test, the classifications were tied (albeit loosely) to the physical phenomena that were considered of relevance in the more representative large-scale tests. This allowed the proposers of the new test method to suggest that the classification obtained during a test could be used to determine the situation in which a given product could be used within a building. They noted that: "The risk which can be permitted will depend largely on the situation. In

---

[47] Hamilton 1958, 47.
[48] Malhotra 1973.
[49] A "radiant panel" is essentially a planar surface which is heated to a very high, and preferably uniform temperature, such that it radiates heat toward a test sample.
[50] Lane, Oral evidence to the Inquiry, 10th November 2020, {Day68/33:} –{Day68/40:}.

passages and on staircases less risk can be tolerated than in a room, and accordingly the kind of material[51] used in the former situations should be less *susceptible to fire*" (emphasis added).[52]

148. In 1944, a UK committee set up to devise a system of building regulation set out a schema for the application of the test "on the basis of these test results and of experience of materials in practice".[53]

149. Class 1 - "May be used in any situation"; Class 2 - "May be used in any situation, except on walls & ceilings adjoining staircases & passages"; Class 3 – "Preferably used only in living rooms and bedrooms as lining to solid partitions. Not on staircases or corridors or in attic bedrooms"; Class 4 – "Only in accessory rooms such, as WCs, bathrooms where there are no open flames".[54]

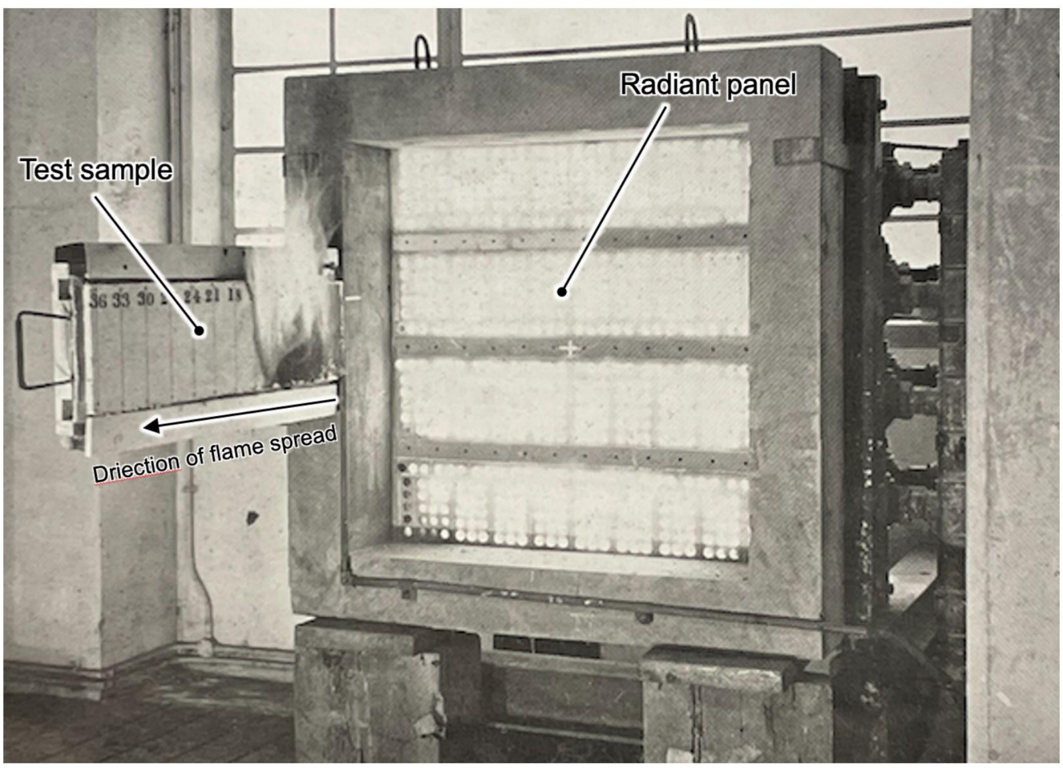


Figure 3 The surface spread of flame test apparatus described in the 1946 update to BS 476[55].

150. The development of the surface spread of flame test represented an important change in the approach to regulatory fire testing. For the non-combustibility test, the link between test results and building performance was based purely on judgement, with no attempt to quantitatively correlate the rest results with real fire behaviours. With the surface spread of flame tests, the link to reality was somewhat stronger –

[51] I note that I consider use of the word "material" to be imprecise in this instance; "product" would have been more appropriate.
[52] DSIR 1944.
[53] DSIR 1944.
[54] DSIR 1944.
[55] JFRO 1947, Plate 6.

the test was inspired by an attempt to mimic a real fire condition, and the results were used to create different classifications that corresponded to perceived acceptable flame spread rates based on the respective hazards that were considered tolerable in different end use conditions.

151. The surface spread of flame test, which became known as BS 476 Part 7, was thus the first of a new breed of fire test. These tests would provide a more robust and quantitative link between the test result and a real-world scenario. They were intended to capture and measure physical phenomena that were also of relevance in particular real-world scenarios. To accomplish this, these tests required underpinning research – and the development of the test and its acceptance criteria were informed by larger, more realistic (and more costly in time and money) experiments that were more representative of the relevant real-world scenarios.

152. For the first British surface spread of flame test, published in 1946, the link between the corridor fire experiments and the resulting test was relatively weak. However, the precedent had been established – and the subsequent decades would see the development of two other classification systems that followed the same logic.[56]

153. The surface spread of flame test sits within a category of tests that can be termed "model tests". This is because the small-scale and inexpensive compliance test was *modelled* on a larger "scenario test" that was the subject of underpinning research involving validation testing at larger scale; this validation testing was in turn modelled on a real-life fire scenario of relevance. Such tests, to borrow from Brannigan, are "models of models".[57]

154. I note that the surface spread of flame test can only be strictly applied to *products*, rather than *materials*; unless of course a product consists of a board or sheet of homogeneous material.

155. The surface spread of flame test was subject to various modifications over the years, but in 2017 it was fundamentally the same[58] as the test that had been created during World War II.

4.2. The Fire Propagation Test

156. During the 1950s the Joint Fire Research Organisation (JFRO) undertook a series of 1/5th scale compartment fire tests at the Fire Research Station wherein different products were used to line the interiors of the compartments. It was found that products that achieved the *same* classification in the surface spread of flame test sometimes resulted in quite *different* fire behaviour in the scaled compartments.[59] Thus, it was decided to develop a new test method which could better represent, and be used to distinguish between, the fire hazards presented by products when used *within* a real compartment. The idea of the new test was that it should be

[56] These being (1) classification based on the "Fire Propagation" test, and (2) classification based on the "Single Burning Item" test (discussed in the following sections).
[57] Brannigan 2008, https://youtu.be/-H0oP5Vzjbw.
[58] One significant modification to this test was that, in 1987, a water-cooled frame was added around the sample in this test method so as 'to improve the ability to classify certain thermoplastic materials' (see BSI (1987), inside front cover).
[59] Hird and Fischl 1954, 8.

possible to correlate its results with the observations from the scaled compartment fires. Moreover, it was intended that the new test method would investigate a range of phenomena that were relevant for the growth of a compartment fire – the impingement of a small flame, along with the heating of the sample by an external radiant source.[60]

157. The resulting test comprised a small gas burner and two electric heaters – situated inside a box with an exhaust flue (Figure 4). This test method and apparatus has previously been described by Dr Lane during her evidence to the inquiry.[61]

158. The test would commence with the ignition of the gas burners – with the reasoning that this would be representative of a localised ignition source. Then, over the course of several minutes, the electrical elements were heated in order to subject the whole surface of the sample to thermal radiation – with the reasoning that this would be more representative of a large source of heat coming from burning of compartment contents in a real fire.[62] The rate of temperature increase in the exhaust flue, as well as the duration of this increase, were measured. The results were then compared against the results from the 1/5th scale compartment tests.

159. Initially, a classification system was proposed where Class A (plasterboard in this case) was the best, and Class D (compressed straw slabs) was the worst.

[60] Hird and Fischl 1954.
[61] Lane, Oral evidence to the Inquiry, 10th November 2020, {Day68/21:} – {Day68/33:}.
[62] Hird and Fischl 1954, 2-3.

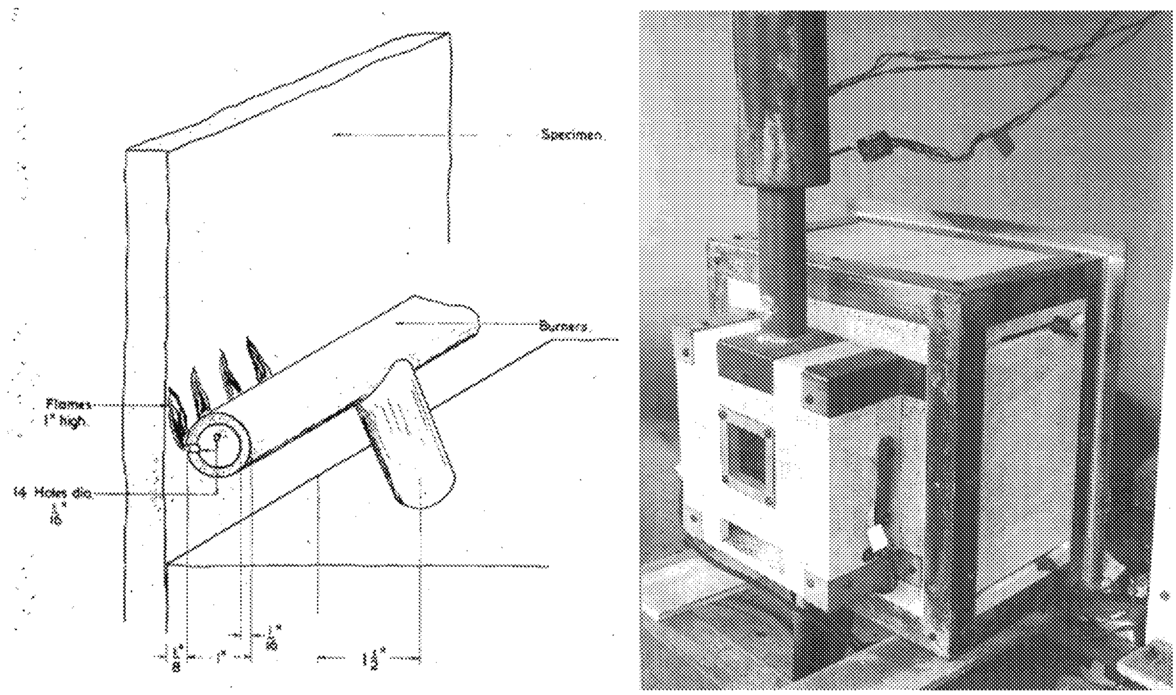


Figure 4 Test configuration that became BS 476-6 1968,[63] images Hird,[64] and Read.[65]

160. Although the test method was originally developed during the mid 1950s, it was not until 1968 that it was formalised as a standalone British Standard test.[66] When the new test was published in 1968, as BS 476 Part 6, the "Fire Propagation Test for Materials",[67] the classification system of Classes A-D had been replaced with a calculation procedure that yielded an "index". A high index was indicative of a short time to flashover[68] and a low index was indicative of a long time to flashover.

161. I note that the fire propagation test can only be strictly applied to *products*, rather than *materials*; unless of course a product consists of a board or sheet of homogeneous material.

---

[63] BSI 1968.
[64] Hird 1955.
[65] Read 1994.
[66] BSI 1968.
[67] I am critical of the title of this testing method on two counts. First, I disagree with the use of the word "propagation" which to me implies travelling of the flame front (as in a surface spread of flame test), rather than the growth of a fire to flashover within a compartment. I would therefore prefer the word "escalation" in this context. Second, I disagree with the use of the word "material", because strictly speaking this test method was being applied to wall covering "products". A more appropriate title might therefore have been, "Fire *Escalation* Test for *Products*". I would also suggest that the title of this test may have led to some of its later misapplication in reaction-to-fire classification testing.
[68] "Flashover" is a term used within fire science to describe a transition that occurs within some fire compartments, from localized burning of one or more items within the compartment to full room involvement, with all combustible items burning. This transition represents a point of no return as regards survivability within the fire compartment. Drysdale (2011) notes that "the enhancement of flame spread by radiant heat is very significant… when the heat flux at floor level reaches 20 kW/m^2 there is an onset of a very rapid change in the character of the fire… [this] requires that the fire has grown beyond a certain minimum size, mainly by flame spread".

162. The research that linked the results of the BS 476 Part 6 test with fire growth behaviour in a real compartment was better developed and more rigorous than for the surface spread of flame test. The test thus *represented* a "model" of the 1/5th scale compartment, which in turn represented a model of a real fire scenario. Notably, the real fire scenario (or "reference scenario") that was under consideration during the development of this test was the growth of a fire within a room, and its transition to flashover.

163. The BS 476 parts 6 and 7 tests became central to the regulation of reaction-to-fire in buildings until 2019. However, although these tests had been developed with an explicit link to fire growth *inside* a compartment (i.e. within a room), the regulations (and later guidance) cited them also as a means to control the *products* that would be used as cladding on the *outside* of a building.

164. A similar leap, from inside a building to outside a building, would later be made during the development of the European reaction-to-fire classification system, as discussed in the next section.

4.3. Single Burning Item and the Euroclasses

165. Although the UK had developed its own national classifications and test standards, the idea of creating a harmonised pan-European set of fire test standards took hold during the 1980s. This was driven by a desire to remove barriers to trade related to construction products within Europe. In 1988, a new reaction-to-fire classification system for products was proposed.[69] This was based on a test where a small gas burner was placed in the corner of a room. The room was lined (again internally) with the construction product of interest, and the growth of the fire and time to flashover were noted. It was proposed to rank construction products based on the heat released during the fire and how quickly the fire grew to flashover. Classifications included Class A (i.e. very limited burning, no flashover), Class B (the room approaching, but not achieving flashover), through to Class E (where flashover occurred after only 2 minutes). The logic of the classification system was based on the relevant hazard being a small (and growing) fire within a room. However, the "Room Corner Test" – as it was known – was large (3.6 × 2.4 × 2.4 metres) and therefore expensive in both time and money. Thus, during the 1990s, a series of research projects were undertaken by the Fire Regulators Group (FRG) and Official Laboratories Group, intended to develop a test that was smaller and less costly, but that would nonetheless give essentially the same information as regards fire hazards.[70]

166. The result was the "Single Burning Item" (SBI) test (EN 13823). This test method and apparatus has previously been described by Dr Lane during her evidence to the inquiry.[71] The SBI test was not an entire room, but rather only the corner of a room with a gas burner situated on the floor in the corner. The gas burner was ignited, and the growth rate of the fire resulting from involvement of the lining products, as well as the total heat released, was measured; the results were then compared against results from tests on the same lining products in the Room

[69] The Herald. 1999. "Man Dies in Tower Block Inferno," June 12, 1999.
[70] Mierlo et al. 2005.
[71] Lane, Oral evidence to the Inquiry, 10th November 2020, {Day68/61:} – {Day68/75:}.

Corner Test. The researchers demonstrated a reasonably good correlation between the fire growth rates in the SBI versus those in the Room Corner Test for many, *but not all*, products (see Paragraph 175). Thus, they concluded that it was possible to use the results from the SBI test to *infer* conclusions about the results that would be expected from an equivalent Room Corner Test.[72] This test was therefore also a model of a model.

167. A new classification system that was fundamentally based on the SBI test was subsequently proposed. However, rather than using the Room Corner Test and its original classifications, the Classes of A to E were coupled to behaviours from the SBI test. The intent was that Class A or B products would not induce a flashover whereas Classes C to E would provide a "grading" of products that *could* induce a flashover *within* a compartment.

168. The threshold for Class A was set to align with products that were perceived to not represent a fire hazard (i.e. totally non-combustible products, mineral wool, and plasterboard). However, it was recognised that some products might make so little contribution to heat release rate that they would not register any reading within the SBI test. To distinguish between these products, Class A was split into Classes, A1 and A2 – wherein A2 represented products such as plasterboard (which invariably has a thin, combustible paper facing), and A1 included products with even less combustible content. The SBI test was, however, insufficiently sensitive to distinguish between these classes – and therefore the bomb calorimeter (EN 1716) and non-combustibility (EN ISO 1182) tests (as described previously) were instead cited as the means to demonstrate that a product was Class A; and also to differentiate between classes A1 and A2.

169. The culmination of this decade-long research activity was a European Commission Decision in 2000,[73] wherein it was decided that the new reaction-to-fire classification system, the "Euroclass system" as it came to be known, would be adopted across the European Union. Member states would be permitted to determine and dictate which classifications would be required for which particular building applications within their own jurisdictions – but the classification method would be harmonised throughout Europe. The implementation of the decision was delayed until 2002, since the SBI testing standard had not yet been published.

170. This new European reaction-to-fire classification system (called EN 13501-1) is notable for several reasons.

171. As with England's pre-existing national reaction-to-fire classification system (i.e. Classes 1 through 4, along with Approved Document B's additional Class 0, see below at Section 9.3), EN 13501-1 is a *composite* classification system that relies on various test methods to construct the full range of classifications.

172. EN 13501-1 was constructed on the basis of a similar logic to the British national classification system; it purported to relate the behaviour of a product in a particular standardised test method and apparatus to the behaviour of the product in a larger,

[72] Messerschmidt 2008.
[73] 2000/147/EC Commission decision of February 2000, European Commission.

more realistic scenario. And critically, as with the BS 476 Part 6 test that had been developed during the 1950s and 1960s, an attempt was made to link the product classification method to the rates of growth of a fire within a room.

173. However, two key differences exist between the British national classification system and the European EN 13501-1 system. First, the room on which the European classification system was based (and calibrated) was a full-scale room, as opposed to the British 1/5th scale model of a room. Second, both the full-scale Room Corner Test and the SBI testing apparatus were equipped with *oxygen consumption calorimetry*[74] – a novel measurement technology that had been unavailable to the British researchers of the 1950s (because it had not yet been invented). The new test methods thus included more direct measurements (i.e. heat release rate[75]) of the fire hazards that might be presented by different products when used within a room. In many respects, the EN 13501 approach can therefore be seen as following the same fundamental logic as the pre-existing British national classification system, albeit with a more advanced quantification of the fire hazards thanks to more advanced diagnostics.

174. Despite the SBI test's implementation via the European Directive of 2000, there was disquiet from some quarters within the fire community due to the fact that the SBI test could not easily (or, some might say, credibly) classify some types of construction products.

175. For example, EN 13501 testing and classification of "exotic" *composite panels with combustible cores and external metal skins*[76] were felt by some to be dangerously misleading. Indeed, Guidance Paper G of the European Commission's decision included provisions to allow the appropriateness of the SBI to be challenged.[77] However, in such cases the onus of proof was placed on the challenger to demonstrate that application of the Euroclass system to the product was not appropriate, rather than on the proposer to demonstrate that it was.

176. Nevertheless, and despite the perceived inadequacies of the SBI test to reflect the true fire hazards presented by some products – in particular by metal faced sandwich panels – the European Decision allowed such panels to achieve European classifications and associated CE marks. Some of the relevant concerns were clearly highlighted by Messerschmidt in 2008, when she characterised such situations as "a very sad example of unsafe classification", and an example of "what happens when [people] forget the basic principles behind the test".

[74] Oxygen depletion calorimetry is a technique that measures the amount of oxygen that has been used by the combustion process to derive the heat release rate. This is based on the knowledge of the amount of heat produced via the relevant chemical reactions, and the mass flow rate of exhaust gases through an exhaust duct collecting all of the combustion products. The advantage of this technique is that the apparatus required for the measurement can be located far from the fire.
[75] The heat release rate (HRR) describes the rate of energy release, per unit time, as a material (or object) burns. It is measured in Watts (W), kilowatts (kW) or megawatts (MW).
[76] Messerschmidt 2008.
[77] 89/106/EEC Guidance Paper G, Concerning the Construction Products Directive, European Commission.

177. Messerschmidt rhetorically asked, "if you make a product that is going to go on a facade, who wants a reference scenario that's a fire in a room?"[78]

178. I note that the SBI test can only be strictly applied to *products*, rather than *materials*; unless of course a product consists of a board or sheet of homogeneous material.

4.4. Commonalities

179. The surface spread of flame test (BS 476 Part 7), the fire propagation test (BS 476 Part 6), and the single burning item test (EN 13823) are, in their setup and arrangements, very different tests. Conceptually, however, they are strongly aligned. The surface spread of flame test established the principle that a regulatory fire test could be a model of a more realistic model scenario, and that the results of the test could therefore (in principle) be used to make inferences about the performance of a product in a real fire. The fire propagation test, and then the SBI test, reinforced this idea and drew upon much larger (albeit always incomplete) datasets in order to support the inferences that were being made.

180. The commonalities between these "model" tests, the second category of tests discussed herein, are therefore that:

181. they are underpinned by research at a larger-scale, based on a more realistic set of "scenario tests";

182. the performance limits therefore may not need to be set[79] quite so conservatively as for the "unrepresentative" tests;

183. they can only be applied to *products*, rather than to *materials*, unless a product consists of a board or sheet of homogeneous material;

184. the "scenario tests" are supposed to be representative of a real fire hazard that might be present in buildings;

185. the measurements in the small-scale tests are intended to correlate with the outcomes observed in the "scenario tests";

186. in each case the scenario test is supposed to represent a real fire; and

187. the real fire of relevance for each of the model tests described in this section was a fire growing *inside* a compartment within a building.

188. As with the Category 1 "unrepresentative tests" described in Section 3, the thresholds used to categorise the outcomes of each of the above tests are essentially arbitrary in terms of the resulting fire safety outcomes. Small changes in the thresholds for the various classifications would likely result in small changes to outcomes in building performance. However, following the same logic as for the "unrepresentative tests", small changes to the precise thresholds may have

[78] Messerschmidt 2008, https://youtu.be/bYuj7KNXi_A
[79] I note that the performance limits are nonetheless "set", and that they therefore involve a degree of judgement and subjectivity from those charged with setting them.

significant impacts in terms of which products may achieve a particular regulatory classification. As with the “unrepresentative tests” there is therefore considerable potential for commercial interest in the threshold values that are used to define each product classification.

189. Three important conclusions can be drawn from the development of the “model” fire tests.

190. First, the tests were created on the basis of *underpinning research* and a body of knowledge at larger, more realistic scale.

191. Second, the classification thresholds are essentially arbitrary in terms of fire safety outcomes, but significant (and therefore likely subject to deliberate manipulation) in terms of the products that may or may not be permitted within each class.

192. Third, all of these tests were developed on the basis that the relevant hazard was a fire growing *inside* a room (or corridor).

193. None of the above test standards was designed (or originally intended) to represent the fire hazards that might be presented by a fire impinging on the external cladding of a building, or its potential for escalation; the “reference scenario” used was (and is) far removed from the circumstances of a cladding fire potentially resulting in promotion of external fire spread.

5. Category 3: Technological Proof Tests

194. The model tests described above prioritised *reproducibility* over *representativeness*. They did not, and did not attempt to, directly mimic real building situations. However, they could be reliably reproduced by eliminating many real world variables, and they used (reasonably) extensive background research to benchmark and underpin the development of the tests, so as to argue that the "model" could be used to make useful inferences about real world behaviour. However, as described within Part II of this report, investigations into the fire hazards that manifested during real cladding fires revealed shortcomings of both the British national (and more recently the European) "model" tests.

195. Much of the criticism (of the British national classifications) focused on the degree to which the existing small-scale tests were fit for purpose for evaluating fire hazards associated with external cladding. After an extensive programme of full-scale fire tests on cladding systems at the Building Research Establishment (BRE), Raymond Connolly concluded (in 1994) that "it is clear that the BS 476 Parts 6 and 7 tests do not accurately reflect the fire hazards that may be associated with cladding systems".[80]

196. As already noted, the model tests were never intended to represent the fire hazards of cladding systems, and the underpinning reference scenarios were small fires growing within rooms rather than the impingement of large fires on external cladding systems. Faced with this realisation, two potential courses of action were available to those responsible for the Building Regulations and associated Approved Document B.

197. One approach would have been to revisit the reference scenario and (re)develop new model tests. A new, more appropriate, reference scenario could have been defined, and the possibly voluminous and costly underpinning research conducted to determine if it was possible to link the results of a new small-scale (and hopefully reproducible) product test to the results in a larger reference scenario. Indeed, it may have been possible, with sufficient underpinning research, to more credibly link the *existing* model tests to reference scenarios involving external fire spread. This is not the course of action that was taken.

198. The alternative approach was to prioritise *representativeness* over *reproducibility* – and to create a more "realistic" test. This second route was the one suggested by Connolly – who was apparently keen (possibly for both technical and commercial reasons) to create a test that included cavity protection, insulation, and external rainscreens. Connolly therefore proposed the creation of an external fire spread "system test".

5.1. Large-Scale Cladding Tests

199. The eventual result, after various iterations described previously by Dr Lane (including Fire Note 3 and Fire Note 9), was BS 8414. This test method and

[80] Investigation of the behaviour of external cladding systems in fire - Report on 10 full-scale fire tests CR143/94 - Fire Research Station, 42 {RCO00000001}.

apparatus was described by Dr Lane during her evidence to the inquiry.[81] This test method and apparatus was generated as an attempt to balance the demand for the use of complex cladding systems and combustible external wall materials and products, with the technical challenges resulting from an absence of underpinning scientific knowledge about how to move from smaller-scale material/product behaviour to large-scale system performance. These cladding system fire tests thus constituted a form of "technological proof test" whereby the test rig and procedures were designed to mimic, as closely as practicable, a real-world use scenario.

200. Those executing a BS 8414 test must design a mock-up of a sufficiently representative cladding system. However, the degree to which something is *sufficiently representative* is open to dispute by individuals with various – potentially very different – claims to fire safety expertise.[82]

201. For example, for rainscreen panels directly fixed to aluminium rails with a gap of 10 mm between the panels, is the gap width a parameter that has an impact on the system behaviour? Could the gap width (within some range) alter the outcome of the tests? If so, what tolerance is allowable during the test: ± 0.5 mm, ± 2 mm? And does someone thereafter need to verify that any contractor who eventually builds the building adheres to these tolerances? To answer these questions, one must have a deep understanding (either scientific or, potentially, empirical) of the relevant processes, and of how the gap between panels may affect the overall *system* performance and the resulting outcomes of the test.

202. However, as previously described, this type of test exists *precisely because* this knowledge is not yet (and may never be) available. Thus, the only possible solution is to test every configuration to determine how the outcome of the test varies as a function of the variation of all possible inputs – i.e. to demonstrate that for a given situation, within specified bounds, if all other variables remain unchanged, a given parameter is sufficiently unimportant as regards the fire safety outcomes. This creates a considerable challenge for anybody wishing to apply the results of a large-scale cladding test – however, the challenge is potentially tractable with enough permutations of the various variables interrogated, and most likely with some *interpolation* between test results.

203. More challenging, however, are the relatively inflexible parameters that are defined within the testing standard itself. Although BS 8414 has intentionally been made to be "more" representative, some compromises to reproducibility appear to have been necessary in its design. For example, the BS 8414 testing apparatus does not include any windows. It could, of course, but the window openings in a real building might be situated differently to those in any BS 8414 test arrangement. Would it be necessary to retest for every possible window size, type, and shape? Or every possible window frame material? What if the windows in the real building are *open* at the time of a fire? How open are they? What if they are open in "tilt" versus "turn" mode? The list of potentially influencing parameters has (literally) no end.

[81] Lane, Oral evidence to the Inquiry, 10th November 2020, {Day68/106:} – {Day68/114:}.
[82] The different types of knowledge – and knowledge claims – embodied by various members of the fire safety community are described by Law and Spinardi (2021).

204. Notwithstanding the above-noted compromises to reproducibility, the reproducibility of BS 8414 testing is certainly open to criticism, and BRE's own reports suggest possible concerns in this regard.[83]

205. As another example, BS 8414 includes a "wing wall" oriented at right-angles to the main test wall, but this feature may not be present on many buildings. Should this mean that BS 8414 can only be applicable to buildings with a wing wall? And only buildings with a wing wall with the same projection? What if a building has cladding protrusions at an angle of 135 degrees from the main cladding surface?[84]

206. Approved Document B cited the performance criteria in BR 135 as the means by which it could be judged whether a cladding system tested in accordance with BS 8414 passed or failed. The performance criteria in BR 135 have previously been described by Lane,[85] and are not repeated here. A system that achieved the criteria was said to have been "classified".

207. The extent to which the "pass" criteria in BR 135 represent "conservative" assessments of the performance of external wall and cladding systems as regards the likelihood of such systems leading to unacceptable external upward vertical fire spread when applied on real buildings is (very) difficult to assess quantitatively. As far as I am aware, this question has never been explicitly addressed in any BRE or BSI publications on the matter; this is to say that I am not aware that the real-world rationale for the chosen performance criteria in BR 135 have ever been clearly articulated.[86] My hope is that such questions can be addressed via witness statements and oral testimony from those involved in drafting (and approving) these documents.

208. However, BR 135 (2015) clearly notes that "the classification applies only to the system as tested and detailed in the classification report" and "the classification report can only cover the details of the system as tested". It also notes that "when specifying or checking a system it is important to check that the classification documents cover the end-use application".

209. Thus, BR 135 was *explicit* in highlighting the degree to which the onus was on the end user to ensure that any test result was truly applicable to *any specific end use application*. In essence, application of any cladding system classified to BR 135 *always* implies that a desktop study (see Paragraph 81) has been performed by whoever was deemed to be the designer of the cladding system – whether they realised that they had performed it or not.

210. What emerges from this specific framing of the technological proof test is a realisation that to criticise the BS 8414 test for being "unrealistic" is to reveal the critic's fundamental misunderstanding of the nature and purpose of testing. It

[83] For example, a BRE paper {BRE00000957} demonstrates substantial differences in the burning rates of BS 8414 timber crib fire sources.
[84] As was the case at Grenfell Tower.
[85] Lane, Oral evidence to the Inquiry, 10th November 2020, {Day68/114:} – {Day68/120:}.
[86] This is not to say that the rationale for the performance criteria cannot be *inferred* (see Paragraph 1044).

should be obvious that BS 8414 tests can never be faithful reproductions of anything other than BS 8414 tests.

211. In other words, the test is the test – it is what competent professionals *do* with the test's results that is *most* deserving of scrutiny.[87]

212. It also should be noted that large scale cladding tests – performed in the manner described, for example, in the BS 8414 test specifications – can only be credibly performed on cladding products incorporated within cladding systems; a BS 8414 test cannot be used to study a material or product's reaction-to-fire in isolation.

[87] This is not to say that there is no merit in reconsidering various aspects of the BS 8414 test standards or the BR 135 classification criteria. Clearly, there is always merit in being reflexive regarding compliance testing standards and methods, not least because of the continuous evolution of construction materials, products, and systems – and the potential for this evolution to undermine the technical foundations of existing approaches.

6. Discussion

213. Three different categories of test were relevant for regulation of cladding in high rise residential buildings at the time of the Grenfell Tower fire. The chronology of their development appears to reflect concerns that the tests needed to be made more representative of real building fires, but this resulted in a complex system where the value of tests as “yardsticks”, for consideration by competent professionals, was obscured.

214. **Unrepresentative tests** were used to define the least hazardous *materials* (and, indirectly, products). They did not represent the real behaviours that might manifest during a fire, but the thresholds for acceptance were so conservative that there was reasonable consensus that there was no need for the tests to be representative.

215. **Model tests** were used to differentiate between more hazardous *products*, thus opening up flexibility for more innovation in the construction industry. To have confidence that the result of a model test was relevant to real world applications, these tests were underpinned by significant bodies of more fundamental research – this linked the results of relatively unrealistic but reasonably reproducible tests to more representative fire scenarios.

216. **A technological proof test** was used when there was little physical understanding of how materials or products would behave in a real building situation. This technological proof test was intended to closely resemble a *product’s* application in a real building situation – to allow designers to confidently make judgements about how a particular system would behave in a real fire situation.

217. These three categories of test methods, and the way in which they can and should be used within a regulatory system, are fundamentally different.

218. Unrepresentative tests are the “bluntest tool” in the regulatory toolbox – as such, their results are likely to be valid across the widest range of scenarios. In selecting both the test and the thresholds for pass/fail the test’s designers recognised that, while these may have a significant commercial impact on product manufacturers, there would be minimal impact on fire safety outcomes. Although there is a degree of arbitrariness about test design and acceptance thresholds, the resulting classifications are assumed to have an almost universal validity.

219. This means that much of the responsibility for the test and its application may fall far upstream of a building designer or product manufacturer – a building’s designer or product manufacturer *need rarely think about whether the test is appropriate* for their particular situation. In such cases the onus to ensure that the test is fit for the purpose for which it is used *falls on the test’s designers* – and on those citing the test in regulations or guidance.

220. Model tests are more refined, and the link between the test result and the real world is valid only in-so-far as the tested product does not invalidate the assumptions of the underlying research and reference scenario. The test’s designers must therefore take steps to very carefully define and articulate the test’s limitations – otherwise there is a significant risk that the test may be used for products or

situations for which it was not intended or where it is incapable of highlighting the relevant fire hazards.

221. If such steps are taken, then the test's user must also ensure that the test is not used for products or situations for which it was not intended. In such cases, the implicit onus of responsibly is therefore split. The test's developers, far upstream of a building design process, have a responsibility to clearly define and articulate the limitations of the test method. But the building designer or product manufacturer also has a responsibility to check these limitations and to ensure that the test is not pushed beyond its credible bounds of application.

222. Technological proof tests are different; they *rely almost entirely on similarity judgements made by the end users* about each specific system. The implicit (and, in the case of BR 135, *explicit*) onus of responsibility falls almost entirely on the end user – to make a judgement about whether any particular testing outcome is applicable to any particular real-world situation.

6.1. Implementation

223. The implementation and use of these different kinds of tests within England's regulatory system at the time of the Grenfell Tower fire appears not to have been entirely in accordance with the logic set out above.

224. The "non-representative tests" were used largely as set out above. The thresholds were set at a conservative level, the tests were (relatively) sensitive to detecting the degree to which a material or product may or may not burn. However, the regulatory influence of this category of tests was limited as regards their application to combustible cladding materials and products.

225. The "model tests" were quite clearly *not* being deployed in accordance with the logic set out above. Rather than the classification framework (e.g. BS 476 Part 6, BS 476 Part 7, EN 13823) being set out with its assumptions and limitations, in practice they were implemented within the British regulatory system as more of a "one size fits all" classification system. Thus, so long as the literal rules of the test standards and Approved Document B were "followed", in practice the regulatory system appears to have placed no onus whatsoever on the user to ensure that the particular testing framework applied to any specific situation was suitable for that product, or for its application on a building. The regulatory influence of this category of tests was much more significant as regards the application of combustible cladding products. In particular, classifications of British national Class 0 and European Class B-s3, d2, both of which are based entirely on model tests, appear to be profoundly relevant to what occurred at Grenfell Tower (and to many other UK buildings with problematic cladding, now constituting the UK's "cladding crisis").

226. The "technological proof test" (i.e., BS 8414) was invoked within Approved Document B and BR 135 in accordance with the logic identified above; it was made explicit that the onus was on the user to ensure that a test results was applicable to any particular situation. However, as has been demonstrated in the evidence to the inquiry, the manner in which it was *actually* used in practice was more as a non-representative or model test – where little thought appears to have been given

about the extent to which the tested system was genuinely relevant to the end use situation.

227. In what follows in this report, the above categorisation of test methods, their purpose and the manner of their application in practice, should be borne in mind so as to build a coherent picture of the interrelationships between stakeholder incentives, testing methods, regulatory approaches, and the resulting fire safety outcomes.

7. References for Part I

BSI 2009. *Fire classification of construction products and building elements - Classification using data from reaction to fire tests*, BS EN 13501-1:2007+A1:2009.

BSI 2002. *Fire classification of construction products and building elements, Part 1: Classification using test data from reaction to fire tests*, BS EN 13501-1:2002.

BSI 1987. *Fire Tests on Building Materials and Structures, Part 7. Method for classification of the surface spread of flame of products*, BS 476: Part 7: 1987.

BSI 1982. *Fire Tests on Building Materials and Structures, Part 11. Method for assessing the heat emission from building materials*, BS 476: Part 11: 1982.

BSI 1970. *Fire Tests on Building Materials and Structures, Part 4. Non-combustibility test for materials*, BS 476: Part 5: 1970.

BSI 1968. *Fire Tests on Building Materials and Structures, Part 6. Fire Propagation Test for Materials*, BS 476: Part 6: 1968.

BSI 1953. *Fire Tests on Building Materials and Structures*, BS 476: Part 1: 1953

BSI 1932. *Fire-Resistance, Incombustibility and Non-Inflammability of Building Materials and Structures (Including Methods of Test)*, BS 476:1932.

Babrauskas, V. 2017. Engineering Variables to Replace the Concept of 'Noncombustibility'. *Fire Technology*, 53: 353–373. https://doi.org/10.1007/s10694-016-0570-x.

Brannigan, V.M. 2008. The Regulation of Technological Innovation: The Special Problem of Fire Safety Standards. In *Fire & Building Safety in the Single European Market*, Edinburgh, pp. 20-33.

Constant, E. 1983. Scientific Theory and Technological Testability: Science, Dynamometers, and Water Turbines in the 19th Century. *Technology and Culture*, 24(2): 183-198.

Downer, J. 2007. When the Chick Hits the Fan: Representativeness and Reproducibility in Technological Tests. *Social Studies of Science,* 37: 7-26.

Downer, J. 2017. The Aviation Paradox: Why we can 'know' jetliners but not reactors. *Minerva*, 55: 229-248.

Drysdale, D.D. 2011. *An Introduction to Fire Dynamics*, 3/e, ISBN: 978-0-470-31903-1.

DSIR 1944. *Department of Scientific and Industrial Research Joint Committee of the Building Research Board and Fire Offices' Committee on Fire Grading of Buildings (Working Group), One and Two Storey Houses*, stamped 24 Feb 1944. DSIR 4/272.

Hamilton, S.B. 1958. A Short History of the Structural Fire Protection of Buildings Particularly in England. *National Buildings Studies, Special Report No. 27*. London, pp. 47.

Harmathy, T.Z. and Lie T.T. 1970. Fire Test Standard in the Light of Fire Research, *Fire Test Performance (ASTM STP 464)*. American Society for Testing and Materials, Philadelphia.

Herpol G.A. 1972. Noncombustibility—its definition, measurement, and applications. In *Ignition, heat release, and noncombustibility of materials (ASTM STP 502)*, American Society for Testing and Materials, Philadelphia, pp. 99-111.

Hird, D. and Fischl, C.F. 1954. *National Building Studies Special Report 22, Fire Hazard of Internal Linings*.

Hird, D. and Karas, G.C. 1955. A method for classing the fire hazard of internal linings and their treatments. *Fire Research Note No. 166.*

ISO 1970. *Noncombustibility Test for Building Materials*, ISO Recommendation R 1182.

ISO 1979. *Fire tests—building materials—non-combustibility test*, ISO 1182.

JFRO 1947. *Fire Research 1947 – Report of the Fire Research Board with the Report of the Director of Fire Research for the Year 1947*. Department of Scientific and Industrial Research and Fire Offices' Committee.

Lane, B. 2000. Performance Based Design for Fire Resistance. *Modern Steel Construction*, December.

Law, M. 1981. Designing fire safety for steel – recent work. *Proceedings of the ASCE Spring Convention*. American Society of Civil Engineers, New York.

Law, A.H. and Bisby, L.A. 2020. The Rise and Rise of Fire Resistance. *Fire Safety Journal*, 116: 103-188.

Law, A.H. and Hadden, R.M. 2020. We Need to Talk about Timber: Fire Safety Design in Tall Buildings. *The Structural Engineer* 98(3): 10-15.

Law, A.H. and Spinardi, G. 2021 Performing Expertise in Building Regulation: 'Codespeak' and Fire Safety Experts. *Minerva*. https://doi.org/10.1007/s11024-021-09446-5.

MacKenzie, D. 1996. How Do We Know the Properties of Artefacts? Applying the Sociology of Knowledge to Technology. In R. Fox (ed.), *Technological Change: Methods and Themes in the History of Technology.* Harwood, London, 247-263.

Mackenzie, D. 1989. From Kwajalein to Armageddon? Testing and the Social Construction of Missile Accuracy, in D. Gooding, T. J. Pinch and S. Schaffer (eds), *The Uses of Experiment.* Cambridge University Press, 409-436.

Malhotra H. L. 1973. Determination of Flame Spread and Fire Resistance, Lecture given at the *National Fire Protection Association's First European Fire Conference*, Geneva, October 15-17. BRE Current Paper, Fire Research Station, July 1974. AY 21/24.

Messerschmidt, B. 2008. The Capabilities and Limitations of the Single Burning Item (SBI) Test. In *Fire & Building Safety in the Single European Market*. Edinburgh, 70-81.

Mierlo, R. and Sette, B. 2005. The Single Burning Item (SBI) Test Method - A Decade of Development and Plans for the Near Future. *Heron* 50 (January).

Pinch, T. 1993. "Testing – One, Two, Three … Testing!" Towards a Sociology of Testing. *Science, Technology & Human Values*, 18(1): 25-41.

Prince, R.E. 1915. Tests on the Inflammability of Untreated Wood and of Wood Treated with Fire-Retarding Compounds. In *National Fire Protection Association Proceedings of Nineteenth Annual Meeting*, 108-114.

Read, R.H.H. 1994. *A Short History of the Fire Research Station, Borehamwood*. BRE Press, Garston.

Smith, M.R. 1985. *Military Enterprise and Technological Change* (MIT Press).

Sims, B. 1999. Concrete Practices: Testing in an Earthquake-Engineering Laboratory. *Social Studies of Science*, 29(4): 483-518.

Part II: The Path to Grenfell

8. Organisation (1919 to 1947)

228. In May 1919, the Home Office convened an inter-departmental conference to consider problems of fire prevention.[88] At the time, legislation related to fire prevention and fire precautions were contained within a patchwork of local acts and byelaws. Such byelaws were often based on centrally produced documents known as “model byelaws” – but local authorities often adapted these to their local customs. Local authorities and municipal fire services therefore created and enforced their own fire safety provisions – architects and builders had to adapt their building designs to meet these local demands.

229. A key point of debate at the 1919 conference was the need to establish a Central Advisory Board. Proponents of such a board suggested that it could collate information at a national level, initiate technical investigations and research on problems of fire prevention, and disseminate information and advice to departments, local authorities, and firms. Objections from the Fire Brigades Association and Local Authority representatives appeared to be rooted in a fear that such a board would, inevitably, become discontent performing an advisory role and would tend to become a mechanism of supervision and control by central government;[89] these groups feared the “insertion of the thin edge of the bureaucratic wedge”.[90]

230. The creation of a Central Advisory Board, recommended in 1919, was not immediately implemented. This idea received further attention in the early 1920s by Sir Perceval Laurence, a classical scholar and retired judge, who was appointed as chair of The Royal Commission on Fire Brigades and Fire Prevention.[91] In the Commission’s wide ranging final report, dated 1923, there was considerable discussion of the legislative arrangements for fire safety, the administration of – and equipment for – fire brigades, and fire investigation. Sir Perceval revisited the idea of centrally generated fire safety research and advice – proposing a “Fire Advisor” should be attached to the Home Office to lead such an activity.[92] In the years leading up to the 1923 Royal Commission, there had been two main organisations who had undertaken testing and generated outputs that could provide general advice on fire precautions for buildings. These were the British Fire Prevention Committee (BFPC) and the Fire Offices’ Committee.[93] The British Fire Prevention Committee was established by a group of individuals at their own expense as a not-for-profit independent testing body – to verify the performance of various elements of building construction.[94] The Fire Offices’ Committee represented the interests of the insurance industry and, similarly, performed testing on fire safety systems and

88 Laurence 1923, 208.
89 Laurence 1923, 209.
90 Laurence 1923, 210.
91 Laurence 1923.
92 Laurence 1923, 16.
93 Read 1994, 4-5.
94 Wilmore, 1998, 9.

products in order to inform insurance tariffs.[95] Fire tests, at this time, were performed in a largely *ad hoc* fashion – in general there was no standardised approach to fire testing any particular product or system. However, some key principles of testing that were established during this period will be familiar to the modern reader:

231. (1) Tests should be repeatable – in order to provide comparable results between different systems or products.

232. (2) Test procedures and results should be rigorously documented.

233. (3) There should be precision in the language used to describe the qualities of tested systems or products (see Woolson[96]).

234. Whilst the 1923 Royal Commission made many wide-ranging recommendations, there is little evidence that these were acted upon with enthusiasm by government.[97] However, simply the suggestion that a fire advisory role (and associated supporting research) should be undertaken by government was enough to undermine the financial outlook of the independently funded BFPC. The Department of Scientific and Industrial Research (DSIR) provided a grant to enable publication of the BFPC's results from tests that were already completed, and the organisation was promptly wound up in 1924;[98] its testing activities being taken up by the National Fire Brigades' Association.[99]

235. By the end of the 1920s, there had been little overall change in manner of the regulatory systems for fire safety. The manner in which fire testing was undertaken continued much as it had under the BFPC during the preceding decades. Testing was *ad hoc*, and in general there were no standardised procedures between laboratories. The local patchwork of legislation remained the means whereby fire precautions in buildings were prescribed and enforced.

236. During this period, however, there was increasingly a demand from the architectural fraternities to remove some of the more restrictive clauses in the local byelaws. In particular, the limitations on building height in the London Building Act were a source of much debate in the mid 1920s.[100] Height limits on buildings had originally been enacted in response to the construction of Queen Anne's Mansions between 1873 and 1890. The developer of this "monstrous" building was said to be an "expert in testing the borders of legality in his business operations".[101] He was thus able to create a 160 ft building in the heart of London – much to the consternation of the local authorities and members of parliament.[102] The limits on height that had

95 "Testing Station at Elstree for the Fire Offices Committee." 1936. *The Architects' Journal* 84 (2187): 854.
96 Woolson 1904.
97 Read 1994, 5.
98 Hamilton 1958, 31.
99 Read 1994, 5.
100 Joseph 1920.
101 Dennis, 2008, 234.
102 Dennis 2008.

been imposed in response to Queen Anne's Mansions were, by the mid 1920s, proving a barrier to the aspirations of various architects.[103]

237. At this time the London Building Act and its various amendments stipulated a series of fire safety rules that should be followed. Tall buildings (above 60 ft[104] (18.3 metres)) were required to be constructed of "fire-resisting" construction throughout.[105] The legislation provided a *list* of construction materials that were deemed (by London County Council) to be "fire-resisting". For example, "brickwork constructed of good bricks", or "any combination of concrete and steel or iron". Similarly, external walls were required to be constructed of "brick, stone, or other hard and incombustible substances".[106] Other requirements stipulated that "fireproof" materials should be used in various locations (particularly around electrical services). "Fire-resisting" and "fireproof" were not, however, rigorously defined or quantified terms.

238. Under pressure from the Royal Institution of British Architects (RIBA), several changes were made to the regulatory framework during this period.[107] Firstly, the various London Acts and their amendments were consolidated into the London Building Act 1930.[108] Those seeking a repeal on the laws limiting buildings' heights, would be disappointed, no such changes were made. The second notable change was the creation of the United Kingdom's first fire testing standard for building construction (discussed below).

239. A key frustration of practitioners during this period was the poorly defined or quantified terminology used around fire safety. "Fireproof", "fire-resisting", and "incombustible" were all terms that conveyed various desirable qualities. While the early 20th century had seen a move away from the term "fireproof", there was no universal agreement on what elements of construction could be considered "fire-resisting" or "incombustible" (i.e. non-combustible),[109] or on the basis with which such characteristics were to be assessed. For guidance on whether a construction product could be considered to be "fire-resisting", one could (as already noted) refer to the lists of specific materials and products provided within annexes of the London Building Acts – these were updated from time to time – but there was no such guidance on the definition or assessment of "incombustibility"[110].

[103] Ruddock 1996.
[104] Sixty feet was used in the London Building Act 1894 in relation to the height above which additional measures should be required to facilitate egress "at the top of high buildings". At the time, it appears that the logic was that above this height rescue by the fire service would not be possible and that the fire would be difficult to fight given the size of the building. Domestic buildings above this height were also required to be constructed from "fire-resisting materials" (see Law and Bisby 2020).
[105] London Building Act 1894. Section 62
[106] London Building Acts (Amendment) Act 1905. First Schedule.
[107] Hamilton, 1958, 38.
[108] Castleman, 1938, 113.
[109] Law and Bisby 2020.
[110] "The earliest regulators saw virtue in materials that, in lay terms, do not burn. They observed the behaviour of materials in building fires and they nominated particular materials for particular uses knowing that they provided the levels of safety they sought. Then, in an effort to liberalise the regulations by moving from the specific to the generic, they encapsulated their requirement in the word 'non-combustible'" [Fire Code

8.1. Testing for "Combustibility"[111]

240. In 1929, RIBA pressed the British Engineering Standards Association (which shortly afterwards was renamed the British Standards Institution) to produce a standardised method of defining and assessing these various qualities. A committee was established under the chairmanship of Kensington's District Surveyor. The objective of this committee was to define "fire-resistance", "incombustibility", and "non-inflammably", and then to specify procedures for measuring these qualities by test.[112]

241. The result, in 1932, was the publication of the first version of BS 476 – entitled "British standard definitions for fire-resistance, incombustibility and non-inflammability of building materials and structures (including methods of test)".[113]

242. This original version of BS 476 contained four distinct testing methods:

243. (1) "Fire Resistance Tests on Elements of Structures" outlined methods to be used to assess the ability of "certain elements of structure" to "resist the passage of fire for a specified period" of exposure to a standardised heating curve. This test method later became the standalone BS 476 Part 8 (1972),[114] which itself was eventually superseded by BS 476 parts 20 (1987),[115] 21 (1987),[116] 22 (1987),[117] 23 (1987),[118] and 24 (1987).[119] I will not comment extensively on "fire resistance" testing in this report as it has only peripheral relevance to external fire spread.[120]

244. (2) A "Test for Materials for Flues, Furnace-Closings, Hearths and Similar Purposes" provided test methods that could be used to determine if a material was "not only incombustible", as defined by the Incombustibility Test of Materials, but would also have an ability to *retain* its properties *after* being exposed to severe heating. This test method was removed from subsequent versions of BS 476 (i.e. from 1953) and has no direct relevance to the focus of this report.

245. (3) The "Incombustibility Test of Materials" was intended "to lessen the risk of original outbreak of fire by requiring that constructive or decorative material used in certain situations be incombustible". This test method swapped the

Research Reform Program, February 2000, https://www.abcb.gov.au/sites/default/files/resources/2020//FCRC-PR-00-01-Evaluation-non-combustibility-requirements.pdf].

111 The key testing method introduced here would eventually evolve into BS 476 Parts 4 and 11, as well as ISO 1182.
112 Hamilton 1958, 38.
113 BSI 1932.
114 BSI 1972.
115 BSI 1987a.
116 BSI 1987b.
117 BSI 1987c.
118 BSI 1987d.
119 BSI 1987e.
120 In some instances, it is recommended that the external walls of buildings (even non-load-bearing walls) should provide some level of "fire resistance". A detailed discussion of the origins and intent of "fire resistance" is provided by Law and Bisby (2020).

term "combustibility" for "incombustibility" in its title in 1953,[121] and later evolved into the standalone BS 476 Part 4 "Non-combustibility test for materials" in 1970.[122] A more detailed description of this evolution is provided later within this report.

246. (4) A "Test of Non-Inflammability of Materials" was provided due to a recognition that "there may… be cases where the demand of incombustibility is unreasonably severe", but where "it is nevertheless essential that [materials and products] shall not be of such a nature that accidental contact between an exposed surface and, say, a cigarette-end or a match, will lead to a rapid propagation of flame". This test method classified materials and products into four categories, namely (i) non-inflammable, (ii) very low inflammability, (iii) low inflammability, and (iv) otherwise inflammable. The method was deleted in the 1953 version of BS 476 because it "was sometimes found to give anomalous results";[123] I will therefore not discuss this test method in this report.

247. Additional discussion of the structure and evolution of BS 476 testing standards, since 1932, which I consider to be important background for anyone seeking to evaluate, critique, or apply any contemporary BS 476 test, has been provided in Part I of this report.

248. In this initial 1932 version of BS 476, the definition of an "incombustible"[124] material was given as "one which neither burns nor gives off inflammable vapours in sufficient quantity to ignite at a pilot flame *when heated in the manner specified*" (emphasis added). The "manner specified" was a test apparatus whereby a relatively small sample of material (a square prism 50.8 mm to 101.6 mm wide, and with a height equal to twice its width) was heated in vertical tube furnace wherein the specimen was exposed to a temperature that rose from ambient to 750°C at a rate of 500°C per hour[125]. A specimen "passed" – i.e. was deemed to be "incombustible" – if it did not flame or visibly exhibit "glowing combustion" to the extent that the sample "glow[ed] brighter than the walls of the heating tube". The testing assessment was therefore purely visual.

249. The test configuration selected for inclusion within BS 476 (1932) was derived from an earlier test apparatus that had been developed in the United States by Prince (Figure 5 shows these side-by-side)[126] and was, in essence, a glorified toaster.

250. In creating a definition with reference to this testing apparatus, the BS 476 committee had explicitly linked the *word* "incombustible" to the *observed behaviours* when using a specific testing apparatus, procedure, and criteria.

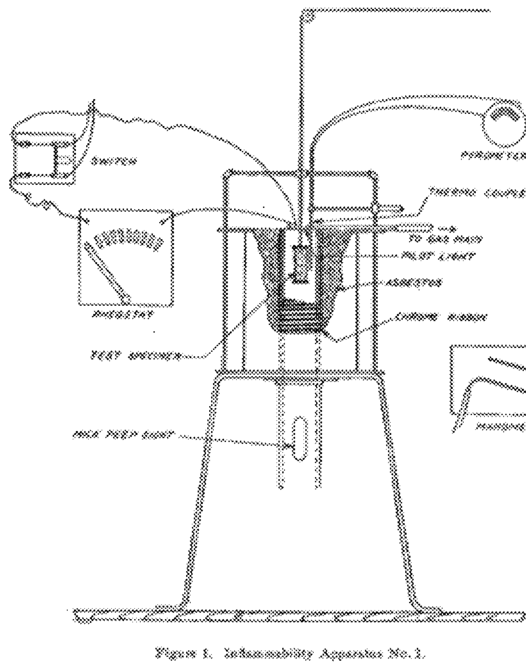
251. This is noteworthy because the *observed behaviours* were a function of both the material under test and the particular configuration in which the material was tested.

[121] BSI 1953.
[122] BSI 1970.
[123] BSI 1953, 5.
[124] This term was, at that time, considered to be synonymous with the term "non-ignitable" (see BSI (1932)).
[125] Babrauskas 2017.
[126] Prince 1915.

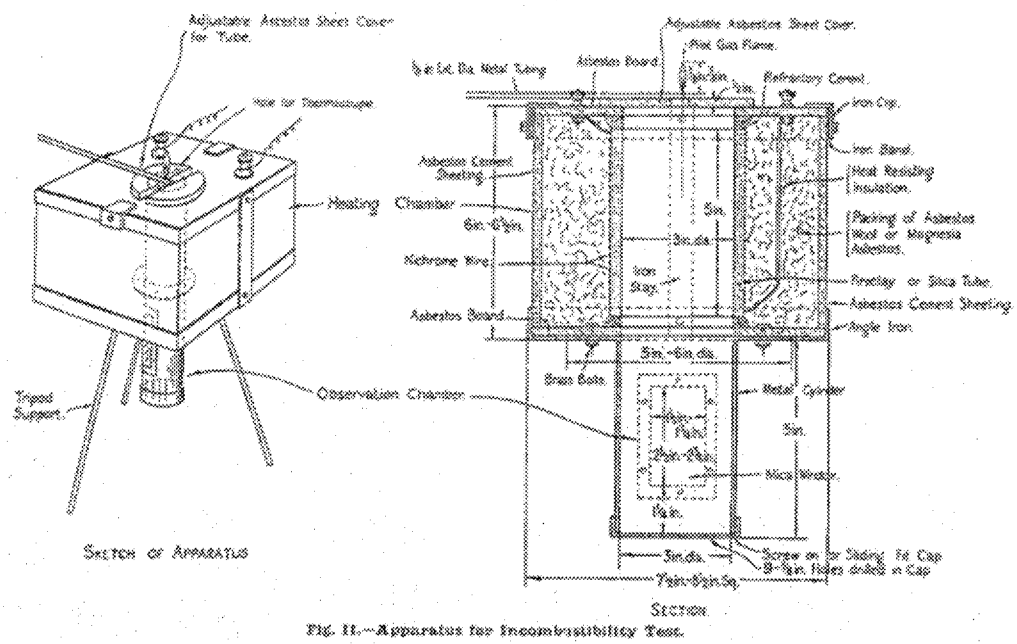
If the test configuration or procedures had been different, then the *observed behaviours* would also have been different. Whether a material or product was defined as incombustible (i.e. combustible) or non-combustible was therefore inextricably (and semi-arbitrarily) linked to the peculiarities of the test method. If a slightly different test method had been selected, then the same material might have received a *different classification*. By a "not unusual inversion of the scientific method"[127], the concept of *what* was to be measured was determined by the *manner* in which it was measured.

[127] Project Report FCRC PR 00-01, "Fire Resistance and Non-Combustibility – Evaluation of Non-Combustibility Requirements", Fire Code Research Reform Program, Fire Code Reform Centre Limited, Sydney, Australia, February 2002.

LBYP20000001_0055



(a)



(b)

Figure 5 Testing apparatus for "incombustibility" a) Forest Product Laboratory inflammability apparatus as described by Prince;[128] b) BS 476 (1932) incombustibility apparatus.[129]

---

[128] Prince 1915.
[129] BSI 1932.

252. Although it was published in 1932, it took several years for BS 476 to make a mark on regulations and guidance. Moreover, a new research facility was required in order to execute the larger "fire resistance" tests then set out within BS 476; this new facility was constructed at Borehamwood, Watford by the Fire Offices Committee.[130]

253. In the mid 1930s, London County Council undertook a wide-ranging review of the rules that covered fire safety.[131] This led to various updates to the London Building Act between 1930 and 1938. The 1938 update to the London County Council Constructional Bylaws finally made explicit reference to the "newly created" BS 476.[132]

254. This was an important step for those who were seeking to build structures from new (and incombustible) materials, products, or structural systems. Previously, a manufacturer would have had to lobby for their product to be added to the pre-approved list of "fire resisting" materials and then wait for the next update to the legislation. The introduction of BS 476 meant that if a product was tested and achieved the test criteria defined in the legislation, then it could be used immediately.

255. In the case of "combustible" materials this development was not quite so revolutionary; there was no pre-approved list of combustible materials.

256. Throughout the mid-1930s there was a growing recognition that a more coherent organisation of both fire prevention and firefighting was required. Until this time, there had been no centrally organised fire brigades, nor was there any obligation of local authorities to either maintain (or co-operate in the maintenance of) a fire brigade.[133] Thus, while some fire brigades received funding from local authorities, the only state aid directly provided to a fire brigade was a £10,000 per annum grant provided to the London Fire Brigade for the protection of government buildings.

257. In 1935, the Riverdale report called for a more co-ordinated approach and for fire brigades (including those jurisdictions outwith London) to be provided with state aid; this eventually led to the Fire Brigades Act 1938.[134] Riverdale had also recommended that, as "a matter of national importance", research into technical questions of fire protection and fire extinction should be initiated and supervised by the Department of Scientific and Industrial Research.[135]

258. When the original version of BS 476 was published in 1932, the committee had noted that "many problems may arise during the early days of the application of these definitions", and that they would "be glad to hear from local authorities and other users of any difficulties experienced in connection therewith".[136] One such problem was the binary (pass/fail) nature of the tests – the fire hazards presented

[130] "Testing Station at Elstree for the Fire Offices Committee." 1936. *The Architects' Journal* 84 (2187): 854.
[131] Anon. "Higher Buildings in London." *The Manchester Guardian*, May 13, 1935.
[132] Hamilton 1958, 43.
[133] Balfour 1936, 11.
[134] Balfour 1936.
[135] Balfour 1936, 65.
[136] BSI 1932, 6.

by materials that did not meet the incombustibility criteria could vary widely, and the existing system failed to allow for any granularity in reaction-to-fire classifications.

8.2. Testing for "Surface Spread of Flame"[137]

259. World War II slowed progress in fire safety regulation during the early 1940s. However, during World War II the chief hazard of interest for building materials was that of incendiary bombing.[138] A test method was therefore devised by which to test the effectiveness of "incombustible" products at resisting incendiary bombs. However, it was recognised that materials which did not pass the incombustibility test could, in some cases, still afford a "useful degree of protection against incendiary bombs".[139]

260. To allow such a distinction to be made, new test methods were developed to allow for some flaming of the test product due to the radiant heat of a thermite bomb placed in the centre of the sample.[140] This approach was still a pass/fail test – but it demonstrated a clear utility in being able to distinguish between fire hazards presented by different products, above and beyond the incombustibility test (i.e. some products that were combustible could, nevertheless, pass).

261. This led to a series of full-scale tests in corridors lined with different types of wallboard, and based on this configuration a "laboratory test was devised to measure the rate of spread of flame".[141] This test was incorporated into BS 476 as an addendum in 1945,[142] and would later evolve to become the standalone BS 476 Part 7 "Surface Spread of Flame Tests for Materials" (1971, 1987, 1997).

262. The new surface spread of flame test did not use an incendiary bomb as its source of radiation, but rather a gas-fuelled radiant panel. The specimen and radiant panel were arranged in an L-shaped configuration (see Figure 6) and the rate of *lateral* (i.e. horizontal) flame spread across the surface of the specimen was measured. This "lateral flame spread" test supported a more nuanced and complex classification system than was possible with only the incombustibility test. Where fire spread was rapid and/or extensive, the material or product was deemed to be of higher hazard and was "Class 4"; where fire spread was slow and/or confined, the material or product was deemed of lower hazard and was "Class 1".

263. However, in the same manner as was the case for the incombustibility test, the definitions of Class 1, 2, 3 and 4 were directly linked to observed behaviours in this testing configuration. The classifications did not – and do not – represent any fundamental, inherent physical properties of a material or product – rather, they represent the combined effects of a material/product and a particular testing setup and procedure.

[137] The test method introduced here would eventually become BS 476 Part 7.
[138] "Arial Bombardment." 1938. *The Architects' Journal*, 19.
[139] "Standard of Protection against Incendiary Bombs." 1940. *Nature* 146 (October 5).
[140] "BS/ARP 47 Testing Incombustible Material to Provide a Minimum Standard of Protection Against Incendiary Bombs." 1940. London.
[141] Hamilton 1958, 47.
[142] Amendment No. 2: July 1945 to B.S. 476: 1932 Surface Spread of Flame. n.d.

264. Again, if a different test method had been selected, then the criteria for classification – or indeed a material or product's acceptance for certain building situations/applications – may also have been chosen differently, and the same material/product may have received a different classification.

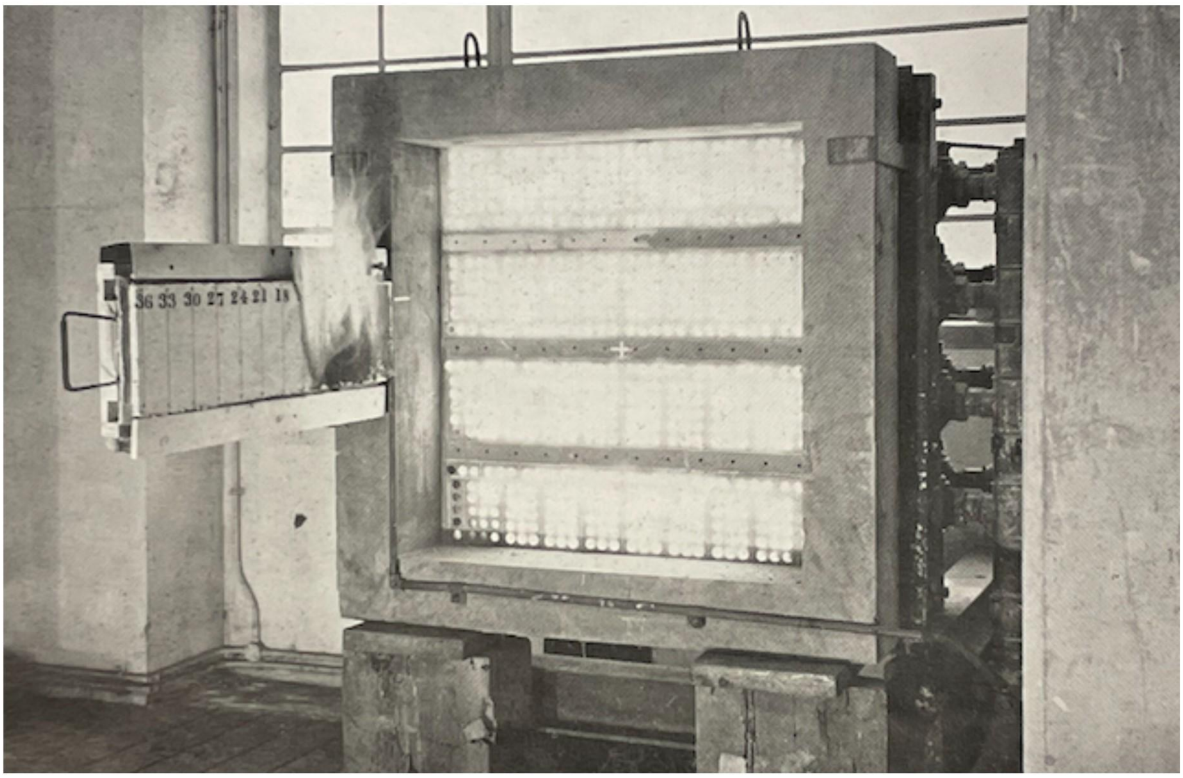


Figure 6 The surface spread of flame test apparatus described in the 1946 update to BS 476.[143]

265. In introducing the new "surface spread of flame" test method in 1945, PD 374[144] openly noted that the original BS 476 (1932) demands for incombustibility were "on occasion… unreasonably severe and definitions and a test were therefore provided to distinguish degrees of inflammability"; hence its initial inclusion of the "test for non-inflammability of materials".

266. However, by 1945, experience in using the BS 476 (1932) non-inflammability test method had shown that it failed to "give completely the degree of discrimination which [was] required". The need for a more precise "degree of discrimination" appears to have arisen from the fact that "many building materials in common use, *and having valuable properties in other directions*, are too inflammable to be classified in the [non-inflammability] test" (emphasis added).[145]

267. The new surface spread of flame test method set new limits on material and product performance for materials that were inflammable, but which nonetheless showed "obvious differences in the nature of the fire hazards that they may

143 JFRO 1947, Plate 6.
144 BSI 1945.
145 BSI 1945.

present". The 1945 introduction of the surface spread of flame test represented an explicit compromise between permitting the use of combustible products and the control of the hazard these might present in floor and ceiling lining applications.[146]

268. By 1946 the British Standards Institution had, therefore, selected three fire test methods that could be used to quantify the reaction-to-fire hazards of construction materials and products; a test for incombustibility, a test for non-inflammability, and a test for surface spread of flame. The first was binary, whereas the second and third allowed for more complex *gradings* of classifications.

269. World War II also saw the development of a more comprehensive assembly of information relevant to the construction and performance of buildings. The Post War Building Studies (PWBS) were commissioned in 1941 by the Ministry of Works to inform the direction of the (anticipated) boom in construction following the end of the war. The resulting reports were wide ranging, covering topics as varied as plumbing, the construction of schools, and painting. Two reports from the PWBS suite were dedicated to fire safety;[147, 148] these are discussed in greater detail in the following sections.

270. The final push of organisation during this period resulted from a decision, in 1944, to create a state-sponsored fire research organisation.[149] Riverdale's 1935 calls for organisation were heeded, and, on 1st January 1947, the Joint Fire Research Organisation (JFRO) was created.[150] The JFRO brought together various disparate branches of ongoing fire safety research into a single organisation. The work at Borehamwood was continued – and the JFRO brought together staff from the (already existing) Building Research Station, and chemists and physicists from Imperial College London and Leeds University.

271. The creation of the Joint Fire Research Organisation was the culmination of a period of organisation. The interwar period had seen repeated calls for better organisation of firefighting and fire precautions. The initial organisation was "bottom up" – the creation of the new fire testing standard was something that could be requested and enabled by practitioners. Similarly, changes to local acts and byelaws could be demanded by interest groups and invoked by regional administrations. However, the most fundamental acts of organisation were driven by central state intervention – i.e. "top down"; new legislation and substantial public funding was required to allow fire brigades to operate as a public service; the JFRO needed state funding in order to give strategic direction to a range of existing, but disparate, fire safety research activities.

---

146 This highlights an early example of an explicit regulatory compromise being made – and articulated – between fire hazards presented by materials and products and their "valuable properties in other directions." An obvious, and relevant, more contemporary example would be the challenge of achieving a balance between building energy performance and the use of combustible insulation materials.
147 Fire Grading of Buildings, Part I. 1946. Post-War Building Studies No. 20. H M Stationary Office.
148 Fire Grading of Buildings. Part II Fire Fighting Equipment. 1952. Post-War Building Studies No. 29. H M Stationary Office.
149 Read 1994, 14.
150 Read 1994, 16.

9. Control and Innovation (1947 to 1965)

272. The consolidation of knowledge embodied within the Post War Building Studies created an opportunity to make substantial revisions to the existing local byelaws throughout the UK. Moreover, there was a view during this period that byelaws that were comprised of lists that "described the methods" of building were not fit for purpose.[151]

273. A Scottish Working Party for the revision of model byelaws concluded (in 1954) that the existing byelaws "were restrictive, sometimes inappropriate, and even insufficient when applied to modern building methods and materials".[152] Similarly, the DSIR reported (in 1955) that "the rapid development in building materials and techniques over the [previous 30 years had] rendered obsolete the traditional form of byelaw".[153]

274. Such innovations in building materials and techniques included an increasingly widespread use of reinforced concrete, the widespread use of structural steel, prefabricated, or industrialised construction, and the emergence of plastics as potential construction materials and products. The kinds of buildings that were being proposed were also changing; high rise flats were becoming increasingly popular amongst architects and housing developers during this period.[154]

275. Writing earlier in 1936, the Building Research Board had set out their vision for the replacement of the existing byelaws. They had stated that "the ideal is undoubtedly that the byelaws should state the performance required, leaving open the methods by which the requisite standard is to be attained".[155]

276. By the early 1950s, the Department of Housing and Local Government in England (and the Department of Health for Scotland, in Scotland) were ready to act on this vision. In doing so, they created an "entirely new" form of building regulation. A new set of "model byelaws" were created; these were to be used as the basis upon which the various local authorities could draft their own local byelaws.[156]

277. However, rather than describing the precise method by which a building should be constructed, the new legislation set out "functional" statements about the required building performance. The format of this approach was to make general statements about the function that would be required from a building. This was then followed by a "performance standard" – a statement about the performance which, if achieved, would be deemed to achieve the functional statement. Finally, this was then followed by a series of "deemed-to-satisfy" clauses which, if adhered to, were assumed to provide an acceptable standard of performance. The intent of this approach was that basic standards would be safeguarded, but that the legislation

151 "Department of Scientific and Industrial Research, Report for the Year 1953-1954." 1955. pp. 32.
152 "Reports of the Department of Health for Scotland and the Scottish Health Services Council 1953, Cmd. 9107." 1954. pp 94.
153 "Department of Scientific and Industrial Research, Report for the Year 1953-1954." 1955. pp. 32.
154 e.g. Dunleavy 1981, 57.
155 Guest 1957, 57.
156 "Modal Byelaws; Series IV; Buildings." 1952. London.

would also be sufficiently flexible to take account of rapidly developing building materials, products, and techniques.[157]

278. This approach is exemplified in the functional statement that "all materials used in the construction of buildings… shall be of a suitable nature and quality for the purposes for which they are used".[158] This functional statement was followed by a performance statement indicating that materials which conformed with the relevant British Standard would be deemed to be compliant with the requirements of the byelaw. Finally, a list of materials was provided that would be deemed to be *inadequate* for certain applications.

279. The model byelaws therefore followed a pattern: (1) functional statement, (2) performance standard against which the function must be judged, and (3) prescriptive list of deemed-to-satisfy provisions. The prescriptive list was similar to the old byelaws, however the functional statement, linked to a method of demonstrating adequacy, was radical. Just as London's byelaws had cited BS 476 as a method to demonstrate the fire performance (i.e. "fire resistance") of structures, the new byelaws now cited a suite of standards for a wide range of aspects of a building's design and construction.

280. As a relevant example, the new byelaws did not specify exactly how an external wall of a building should be constructed, but instead defined that those external walls should be "incombustible throughout".[159] The definition of "incombustible throughout" was a wall "composed entirely, apart from any combustible *internal* lining, of incombustible material or materials" (emphasis added).[160] "Incombustible" was defined with reference to BS 476 (1932 with 1945 updates) as already described.

281. The 1952 model byelaws thus marked a significant shift in the way that the fire safety of buildings was regulated. The move away from "lists" and toward functional statements represented a major departure from the pre-existing approaches. However, the introduction of the functional standards resulted in another, more subtle, change. Once a functional standard was established, it became necessary to have some means (other than a "list") of judging whether or not the functional standard would be achieved. As such, testing standards and codes of practice were immediately elevated in their importance.

282. BS 476 was updated in 1953 to formally incorporate the surface spread of flame test that had been added as an appendix in 1945.[161] Other notable updates in the 1953 version of BS 476 included a change in terminology from "incombustibility" to "combustibility", and a number of significant changes in both the methods and criteria used for the "combustibility test of materials". For instance, whereas the combustibility test had previously slowly heated the sample up to 750°C over a period of 90 minutes, the sample was now to be "plunged" into a furnace which had

[157] "Reports of the Department of Health for Scotland and the Scottish Health Services Council 1953, Cmd. 9107." 1954. pp. 94
[158] "Modal Byelaws; Series IV; Buildings." 1952. London. Section 13
[159] "Modal Byelaws; Series IV; Buildings." 1952. London. Section 39
[160] "Modal Byelaws; Series IV; Buildings." 1952. London. Section 32
[161] BSI 1953.

already been heated to a stabilised temperature of 750°C (and then left for 20 minutes); this change being made to prevent slow off-gassing of combustible pyrolysis products from samples during the pre-existing slow heating process, which could result in an otherwise "combustible" material passing the test.

283. The combustibility test "pass" criteria were also modified in 1953 to remove failure criteria based on (the presumably rather subjective) visible evidence of "glowing combustion", and to place numerical limits on the permissible temperature rise within the tube furnace. A thermocouple was placed within the testing apparatus to monitor the temperature adjacent to the sample. The rationale for this new measurement and criterion was that a significant rise in temperature above 750°C within the furnace (in this case 50°C or more above 750°C) could be taken as an indication of "exothermicity" from the sample.[162]

9.1. Compromise and Evolution in Defining "Combustibility"

284. I believe that it is important to understand that these apparently subtle changes in the testing standards all represent manifestations of technical compromise amongst a range of stakeholders.

285. In discussing the early development of the *concept* of "non-combustibility", as well as tests to demonstrate it, Herpol[163] – writing in 1973 – provided an informative discussion of the technical rationales behind many of the seemingly arbitrary numerical values/limits quoted within the BS 476 (1953) testing standard – and indeed in various subsequent combustibility testing standards, including BS 476 parts 4[164] and 11,[165] and ISO 1182[166] (see discussion below beginning Paragraph 377).

286. Herpol's paper elucidates the conceptualisation of the term "combustible" and highlights a range of relevant considerations that ought to be borne in mind when assessing (or critiquing) any testing standards for reaction-to-fire properties.

287. For example, Herpol[167] notes, albeit with respect to the later development of the similar ISO 1182[168] non-combustibility test, that the definition that underlies essentially all non-combustibility tests could be worded as:

288. "a noncombustible material is the one that, when submitted to heat at a high temperature level, does not contribute whatsoever to the severity of the fire."

289. He goes on to note that this definition incorporates three important ideas, these being:

290. that the sample is exposed to heat at "a high temperature level";

---

[162] i.e. the liberation of energy by combustion – hence "combustible".
[163] Herpol 1972.
[164] BSI 1970.
[165] BSI 1982.
[166] ISO 1975.
[167] Herpol 1972.
[168] ISO 1975.

291. that the sample "does not contribute whatsoever"; and

292. that the sample's contribution in the test should be considered as regards its contribution to the resulting "fire severity".

293. Regarding (1), the "high temperature level" of 750°C that was chosen was essentially arbitrary, although tests at temperatures up to 900°C had apparently "not shown greater selectivity" as regards combustibility classification outcomes.

294. Regarding (2), it was noted that non-combustibility tests should be "go or no-go" tests, and that they should "not yield anything else, particularly not the degree of contribution, which should, for combustible materials, be given by other tests". This second assertion is interesting in light of the later development and regulatory application of BS 476 Part 11 and ISO 1182 to distinguish between "combustible" materials/products and those of "limited combustibility" (see Paragraph 424 below).

295. Regarding (3), it was noted that potential contributions to the "fire severity" were assessed based on "go, no-go" assessments of:

296. (1) the liberation of heat outside the specimen in its immediate surroundings – assessed via a limiting 50°C temperature increase within the chamber but outside the test specimen; and

297. (2) the production of visible flames, either at the surface of the specimen or from combustible gases exiting the furnace – given that any visible evidence of flaming, however subjective, can obviously be taken as indicating *some* contribution to fire severity.

298. Instructively, Herpol[169] also notes two key "problems" in applying such test methods in practice, namely: (1) deciding the permissible limits of temperature increase, and (2) defining the permissible time limits of flaming.

299. Regarding the 50°C temperature increase, Herpol notes that the members of the ISO TC92 WG2[170] committee were (at least as early as 1973) "aware of the arbitrary character of such a limit, but whatever the limit taken it will always be arbitrary". And that "the only way of establishing such a limit is to take a certain number of materials *considered completely safe*, although having *some combustibility*, and then measure the temperature rise for these materials" (emphasis added).

300. Herpol rightly points out that "there is no doubt that certain materials declared not combustible by the ISO test may [in reality] contain a low calorific potential… the calorimetric criterion, although it is a measure of the reaction-to-fire, is not sufficient

[169] Herpol 1972.
[170] ISO TC92 is an ISO code committee responsible for ISO standards relevant to fire safety. WG2, which appears to no longer exist in the context which is relevant here, will have referred to a specific "working group" charged – presumably – with developing test standards for non-combustibility (see: https://www.iso.org/committee/50492/x/catalogue/).

by itself since *in a fire all the heat contained in a material is not always released*" (emphasis added).

301. The above statement is similar to one which I have previously made within this Inquiry, and which I continue to consider to be of central importance: "just because a material *can* burn under some circumstances doesn't necessarily mean that it *will* burn under a particular set of circumstances".[171]

302. Concerning the time limits of flaming, the BS 476 (1953) requirement was for "no flaming". However, Herpol[172] points out that "as a *matter of fact*, all materials producing flaming should be declared combustible, but to be sure that there is *real flaming* inside the furnace the flame has to last for a certain time". The "certain time" limit – later adopted in BS 476 Part 4 and ISO 1182 – "is also arbitrary" and based entirely on a collective decision amongst members of the code committee.

303. In any case, BS 476 (1953) thereafter became the measure by which it was determined whether products or materials met the requirements of the byelaws. Where previously a committee would have discussed and agreed which products could (or could not) be used in specific situations, the byelaws now allowed manufacturers (and/or designers) to demonstrate by test, on a case-by-case basis, that any particular product or material could be considered appropriate for a given use in or on a building. Standards and codes of practice were also cited in the deemed-to-satisfy provisions.

304. The key societal value of this approach to functionally-based building regulations had been articulated many years earlier in the Building Research Station's 1936 report, wherein it had been envisaged that, by such an approach, "the resource and ingenuity of the industry would then be set more free to devise new and improved methods and materials of construction".[173]

9.2. The Building Regulations 1965

305. The liberation enabled by the creation of the new model byelaws in the early 1950s was not, however, sufficient to fully remedy problems with the UK's patchwork of sometimes archaic laws that controlled the construction of buildings. Problems were particularly acute in Scotland, where the underlying legislation was older than that in England. Scotland therefore took the lead in examining a more comprehensive legislative solution to the problem of building regulation.

306. On examining the existing regulatory systems in 1958, the Guest Committee wrote that "it soon became apparent to us … that the old patchwork quilt of building law was not only full of holes and frayed at the edges: it only covered part of the bed. We needed little convincing that the time had come for it to be discarded in favour of a full-sized bedcover in contemporary style".[174] The Guest Committee

[171] Bisby, Oral evidence to the Inquiry, 20th June 2018, {Day7/25:}.
[172] Herpol 1972.
[173] Guest 1958, 57.
[174] Guest 1958, 11.

recommended that the existing system of local byelaws should be replaced by a new, national Building Act.

307. The Guest Committee also endorsed the idea that building regulation should be accomplished via a series of functional standards similar to those that had been pioneered by the byelaws. Guest recommended that "the regulations should continue and extend as far as possible the practice of laying down requirements by way of technically expressed performance standards in respect of each function, rather than by a rigid specification of what is to be done".[175] Thus, Guest reinforced the need for the functional statement to be accompanied by a standard test or code-of-practice that could be used to *demonstrate adequacy*. Guest also recognised the value of "deemed-to-satisfy clauses" to provide examples of the most frequent methods by which the technical performance standards could be met.[176]

308. Not everyone, however, was supportive of Guest's views. The Building Research Station and the Royal Institute of British Architects envisioned an *even more flexible* approach which more fully severed the link between the functional requirements and the technical standards. They were keen that "in the interests of flexibility" *only* the functional requirement should be mandatory.[177] One of the key arguments behind this proposal was that the performance standards (e.g. that an external wall should be incombustible throughout) could become "out-moded by new ideas and technology" and that there was therefore a risk that the performance standard could become as restrictive as the old byelaws' lists.

309. However, whilst RIBA also strongly advocated flexibility, their enthusiasm was tempered by the somewhat contradictory acknowledgement that complete flexibility could also lead to non-uniformity in the application of the legislation. Responding to Guest's report, RIBA's Committee on Building Regulations presciently noted that "the nearer a requirement is related to pure function (and that is the ideal for perfect flexibility), the harder it is to give it a legal precision and *the greater becomes the risk of differences in interpretation*" (emphasis added).[178]

310. The discussion presented in Guest's report, along with the associated commentary, clearly lays out the inherent conflict between the "ideal" of "perfect flexibility" versus the use of standards and deemed-to-satisfy clauses to provide more readily agreeable methods and solutions.

311. The idea of a three-tiered system was a powerful one, however, and Scotland was first to adopt Guest's national approach to regulation in 1963[179] followed quickly by England in 1965.[180]

312. Writing a "building regulations plan for [the] minister" in 1964, the RIBA had outlined their vision for the new national building regulations. They envisaged a single

[175] Guest 1958, 58.
[176] Guest 1958, 58.
[177] Guest 1958, 58.
[178] "RIBA: Building Law Revision." 1958. *The Architects' Journal* 128 (3327): 807.
[179] Building Standards (Scotland) Regulations 1963.
[180] The Building Regulations 1965.

enabling act covering the whole of the UK, which would be supplemented by regulations that would be under the control of a single government department. Amongst RIBA's sometimes contradictory requests included that: "the regulations should be drafted in plain English"; they "should be comprehensive"; "they should be framed so as not to inhibit invention"; they should be "a precise guide to the designer and constructor, stating the performance standard required" with reference to tables or British Standards; "they should not be interrupted by 'deemed-to-satisfy' clauses". Finally, they suggested that a central authoritative testing and certifying agency should be set up to approve new materials, components and methods for building" so as to encourage innovation within the performance standards proposed for the regulations.[181]

313. The 1965 English regulations followed the overall model of the Scottish approach; however, RIBA were not given a single UK wide enabling act. The new regulations were enabled by pre-existing legislation, but in other respects England's regulations essentially followed the template set-out by Guest.

314. Discussing the concept of "functional requirements", the Government's new Building Regulations Advisory Committee (BRAC) wrote – in their first report, in 1964 – that this approach would give "a great deal of flexibility and is therefore in principle very satisfactory".[182] They noted, however, that there were shortcomings in that "it imposes the burden of proving compliance upon the designer, but it gives no guidance to the authority on how to satisfy itself that compliance is achieved", and that the method therefore "works best where agreement on what is needed in practice to fulfil the functional requirements is widespread".[183] This "agreement on what is needed in practice" would continue to be provided in the form of "deemed-to-satisfy" clauses.

315. The English Building Regulations thus retained the three-tiered system: (1) functional requirement, (2) performance standard, and (3) prescribed clauses. Whilst the use of performance standards was cited as the "ultimate objective",[184] the committee did not feel able to replace all deemed-to-satisfy clauses. This was partly due to lack of knowledge – they felt there was insufficient research on some topics to allow an agreed performance standard to be defined. They were concerned that local authorities "may be neither qualified nor equipped to handle such a problem" in terms of assessing compliance with the emerging performance standards. The retention of the deemed-to-satisfy clauses was also pragmatic – they recognised the utility of having a simple list of deemed-to-satisfy solutions for the more straightforward situations.[185]

316. The resulting Building Regulations 1965 were therefore a mix of functional statements, performance standards, and deemed-to-satisfy provisions. The intended functional nature of the regulations was stated as follows:

---

181 "Building Regulation Plan for Minister." 1964. The Architects' Journal 140 (3): 137.
182 "Building Regulations Advisory Committee First Report." 1964. London. pp. 12.
183 "Building Regulations Advisory Committee First Report." 1964. London. pp. 12.
184 "Building Regulations Advisory Committee First Report." 1964. London. pp. 12.
185 "Building Regulations Advisory Committee First Report." 1964. London. pp. 12.

317. "A3. No provision in these regulations stating that the use of a particular material, method of construction or specification shall be deemed to satisfy the requirement of any regulation or part thereof shall be construed so as to require any person necessarily to use such material, method of construction or specification."

318. Despite the move towards this three tier system, the text of the 1965 regulations placed more importance on performance standards in some areas than others. For example, while the provisions concerning the use of materials/products were clearly based around functional requirements, the fire provisions were mostly statements of performance standards – with few statements of function.

319. The above paragraphs have shown how, over the course of several decades, the idea of functional requirements came to dominate the discussion around UK building regulations. The idea that functional requirements promoted flexibility and innovation was clearly powerful in the minds of industry (e.g. RIBA), the Building Research Station, and government.

320. It was recognised that mandating *only* the functional statements was the best way to enable total flexibility. However, the zeal with which this ideal could be pursued appears to have been tempered by realism. Fears about inconsistent interpretation led to the functional requirements being coupled to performance standards in most cases. Performance standards (or codes) were defined methods whereby consensus had been reached about whether a requirement had been met. Deemed-to-satisfy clauses were also retained (until 1985) in cases where there were no "agreed" performance standards, and to expedite simple, common solutions.

321. The coupling between functional requirements and performance standards created a new market for standards and codes of practice. The standards and codes of practice produced by, for example, the British Standards Institution (BSI) became the arbiters of adequate building performance. These were based on testing methods that were underpinned by assessments of adequacy that represented the collective opinion of a group of selected stakeholders, most of whom will have had particular motivations and interests as regards standardisation processes.

322. Indeed, it was recognised that if a deemed-to-satisfy provision were to reference a code or a standard, then this standard could be readily updated to allow the incorporation of new materials, products, or methods. Codes and standards *themselves* thus, under the auspices of, for example, the BSI rather than central government, became a key means by which innovation and flexibility were embedded within the new functionally-based system of building regulations.[186]

323. In the case of regulations to guard against fire, this resulted in a perhaps surprising lack of fundamental change in the relevant testing standards. The 1965 building regulations cited the 1953 version of BS 476 – which was largely unchanged since

[186] "Building Regulations Advisory Committee First Report." 1964. London. pp. 18.

the addition of the flame spread test in 1946 (albeit with the deletion of the "anomalous" non-inflammability test[187]).

324. However, since the establishment of the JFRO in 1947 a significant amount of research into fire behaviour and fire precautions had been undertaken. The new building regulations provided a potential home for the findings of this (and other) research. Investigations on the burning behaviours of buildings and their structural response in fire led to various changes to the "fire resistance" requirements;[188] testing on novel cladding systems led to changes to the rules on the construction of external walls;[189] studies on radiation from building fires led to new methods for calculating safe distances between neighbouring buildings.[190] The JFRO and the Fire Research Station at Borehamwood therefore had significant impacts on the generation of the 1965 building regulations. The proposed regulations were the subject of a particularly vigorous consultation exercise in the mid 1960s; the draft regulations received 2,797 comments, 888 of which were in respect of the fire provisions.[191]

9.3. The Introduction of "Class 0"

325. A notable development during the 1960s (given the current context) was the way that the BS 476 (1953) tests were invoked within the new 1965 building regulations. The Building Regulations Advisory Committee (BRAC)[192] had expressed dissatisfaction with the pass/fail nature of the existing BS 476 (1953) combustibility test. They felt that relaxing the non-combustibility requirement for "external walls" and "cladding" could, in some cases, be appropriate. They noted that this concession would "be of particular benefit in the case of non-traditional industrialised housing[193] systems",[194] but suggested that certain elements of construction shall be non-combustible – in accordance with BS 476 Part I (1953) – including:

326. "External walls beyond 3 feet [0.91 metres] from boundaries, *excluding cladding*, in buildings over 50 feet [15.2 metres] in height. The cladding of walls in buildings over 50 feet in height beyond 3 feet from boundaries may be timber or class Alpha up to a height of 50 feet, but *must be class Alpha*[195] above 50 feet" (emphasis added).

[187] See Paragraph 246.
[188] Law and Bisby 2020.
[189] Law and Kanellopoulos 2020.
[190] Law 1963.
[191] "Building Regulations Advisory Committee First Report." 1964. London. pp. 21.
[192] "Building Regulations Advisory Committee First Report." 1964. London. pp. 41.
[193] "Industrialized Housing" is terminology widely used to describe a multiple unit residential structure constructed in one or more modules or constructed using one or more modular components manufactured at off-site and then assembled on-site. Many highrise social housing blocks were constructed using this general approach in the UK, in particular during the 1960s and 1970s (e.g. concrete large panel system (LPS) buildings, such as Ronan Point).
[194] "Building Regulations Advisory Committee First Report." 1964. London. pp. 26.
[195] As outlined in what follows, the terminology "Class Alpha" was replaced with "Class 0" in the eventual 1965 Building Regulations.

327. The above concession was modelled on an approach that had previously been pioneered in Scotland.

328. Rather than using a single test to grade the fire hazard of a particular material or product, the Scottish approach (specifically to "linings") had been to use multiple test standards and criteria to create a grading scale (initially denoted as Grades A-E).[196] In the original 1961 draft of the Scottish legislation, Grade A corresponded to "non-combustible" (i.e. a pass in the BS 476 (1953) combustibility test), while Grades B-E were linked to Classes 1-4 when tested in the BS 476 (1953) surface spread of flame test,[197] as follows:

329. "Grade A – The lining is non-combustible.
Grade B – The lining is Class 1 obtained without impregnation of surface treatment of a combustible material.
Grade C – The lining is Class 1.
Grade D – The lining is Class 2 or Class 3.
Grade E – The lining does not fall into any of the foregoing Grades."

330. I note that in the final Scottish legislation Grade A also included products that were non-combustible but covered with an up to 1/32 inch (0.8 mm) thick combustible surface, provided that "the aggregate of the combined lining is Grade B" as defined in the above list. Combustible products that were covered in a not less than 1/8 inch (3 mm) Grade A (i.e. non-combustible) lining were also able to be classified as Grade A.

331. England followed BRAC's advice and employed a similar approach to Scotland, however, adopting a slightly different nomenclature. Classes 1-4 from the BS 476 (1953) surface spread of flame test were retained, but to this was *added* Class 0 (zero) for materials/products that were *non-combustible in addition to being Class 1* when tested in accordance with BS 476 (1953). Thus, Class 0 was essentially the same as "Grade A" in Scotland,[198] and contained the same two caveats for layered products as described in the preceding paragraph. Indeed, in the first drafts of the English regulations Class 0 was referred to as "Class Alpha", as had been proposed by BRAC the previous year (see above at Paragraph 326).[199]

332. With respect to external wall construction for taller buildings, the 1965 Building Regulations,[200] again in accordance with BRAC's 1964 advice, required that for buildings taller than 50 ft (15.24 m) and situations where the wall was more than 3 feet (0.91 m) from "the boundary":

333. (1) the *external wall* should "not include any combustible material" except for *internal linings* complying with applicable surface spread of flame requirements (omitted here); and

[196] "Building Standards (Scotland) Regulations, 1963, Explanatory Memorandum, Part 5: Means of Escape from Fire and Assistance to Fire Service." 1963.
[197] Building and Buildings, Scotland, Draft Building Standards (Scotland) Regulations 1961. pp. 61.
[198] The Building Regulations 1965. pp. 49.
[199] "Building Regulations Advisory Committee First Report." 1964. London. pp. 42.
[200] The Building Regulations 1965.

334. (2) any *cladding* on any external wall should have a surface complying with the requirements for Class 0 (as defined above), except that up to 50 feet (15.24 m) it was permitted to use timber of not less than 3/8 inch (9.5 mm).

335. Thus, from 1965 there was an explicit distinction in the regulations (and later guidance) between the "external wall" and "cladding".

336. The publication of the 1965 Building Regulations was the culmination of a decades long process of change. The "patchwork quilt" of local byelaws that had been criticised by Guest had been replaced[201] by national legislation in "contemporary style". The underlying drivers for the change were part practical, part ideological. Locally, the practice of building was clearly difficult and frustrating when requirements changed from jurisdiction to jurisdiction; this was a clear motivator for overhauling the machinery of building control and introducing uniformity of approach. However, the manner of achieving that uniformity was also ideologically driven. The prescribed lists of the local byelaws made the introduction of new products and building systems a difficult and drawn out process. The potential to innovate in construction was enabled by a shift to "functional" requirements linked to performance standards. The idea of flexibility was championed in the name of "innovation" and "setting the ingenuity of industry free".

337. The ideal of flexibility appears to have been enthusiastically embraced by government researchers at the JFRO, and by leading industry bodies such as RIBA. The committees charged with overseeing the new legislation did not, however, champion the ideology of flexibility at the expense of all else. They held back from creating a system that allowed total flexibility. Instead, they imbued *standards* and *codes of practice* with the power to arbitrate over the adequacy of particular design proposals – in the case of fire safety, they largely shied away from defining the regulations in purely functional terms.

[201] Although the national Building Regulations were not applied to Inner London until July 1987.

10. Frustration (1965-1979)

338. The new system of national building regulations that emerged in 1965 had the potential to allow significantly more flexibility than the old byelaws. However, the refusal of the relevant committees to fully commit to *total* flexibility meant that the "performance standards" that underpinned the functional requirements were at risk of becoming a new barrier to innovation. This issue was particularly acutely felt in relation to the fire provisions which were mostly not supported by functional statements.

339. Regular updates to standards and codes of practice would be required to keep pace with new innovations. It was recognised there was a "flood" of new materials and products flowing into the building industry – and that it was impossible for architects, or even the product manufacturers themselves, to have sufficient knowledge to assess their performance in use.[202] It was suggested that "in order to counteract restrictiveness", arrangements could be made for new materials, products, and methods to be provided with "approval" by a third party organisation.[203]

10.1. The British Board of Agrément (BBA)

340. In 1966, such an organisation was created. The "Agrément Board" – as it was called at that time – was modelled on the French Agrément system; the development of which had in turn been informed by French visits to DSIR's Building Research Station.[204]

341. The initial motivator for the creation of the French Agrément system had been to enable the necessarily rapid and extensive rebuilding that was needed after World War II. A barrier to this rebuilding had been the concern of architects and builders regarding their potential legal liabilities for innovating and constructing at pace. Under French law, architects and builders of the time remained liable for defects for up to 10 years; this created nervousness about the use of new and sometimes unfamiliar building materials, products, and techniques.

342. Indemnity insurance was difficult to obtain unless insurers were satisfied that new materials and products were appropriate and were being properly used. The French Agrément system solved this problem by issuing Agrément certificates. The Board of Agrément would issue certificates about the suitability of products and materials for various usages – and such certificates would provide the insurers (and thus architects and builders) with the "comfort" they needed to build.[205]

343. In Britain, there was concern about the cost of such an Agrément Board. Setting up a new organisation with the requisite expertise and facilities would be costly. It was therefore decided to make use of the existing facilities within the UK. The existing Building Research Station and Fire Research Station became the laboratories of

[202] "Dr Parker Explains the Agrément Board." 1966. The Architects' Journal 144 (2): 74.
[203] "Building Regulations Advisory Committee First Report." 1964. London. pp. 19.
[204] "Dr Parker Explains the Agrément Board." 1966. The Architects' Journal 144 (2): 74.
[205] "Dr Parker Explains the Agrément Board." 1966. The Architects' Journal 144 (2): 74.

the Agrément Board. Dr Parker, former Deputy Director of the Fire Research Station, was appointed director of the new Board.

344. The idea behind the Agrément Board was apparently that if a manufacturer had a new construction product, they could approach the board and request that – for a fee – they issue a certificate. The certificate would "state the material inspected, the use specified, and the board's belief that the work done leads them to believe it satisfactory".[206]

345. It was intended to limit the validity of certificates to three years – with a renewal possible after a period of "assessment in use". It was envisaged that the certificates could then be used as the basis for new British Standards – thereby "cutting out the eight-year-long business of formulating British Standards or Codes of Practice".[207]

346. One early question raised regarding Britain's Agrément Board was "what would happen if the board issued a certificate for something which subsequently turned out to be a failure".[208] Dr Parker expressed his view that such occurrence "would not happen", but that if it did the "usual defence would be that the certificate was 'based upon the best advice obtainable at the time'". Ultimately, however, Dr Parker conceded that "if the board made a real mistake it could perhaps be held liable".[209]

347. England's new functionally based legislation, coupled with a mechanism to rapidly approve new building materials and technologies, was ready at the beginning of 1967; the Agrément Board issued their first certificate in January of that year.[210]

348. However, problems soon began to emerge. The checks that needed to be performed by local authorities were taking longer under the new regulations than under the old byelaws.[211] The Ministry of Housing and Local Government's own Building Legislation committee recommended, in 1967, the need for a central administration of regulations (i.e. the business of checking compliance) through an organisation large enough to have enough good staff with the required range of skills – and to be supported by a network of local enforcing officers.[212]

349. RIBA complained that the 1965 regulations were "so complex, and some of the language so obscure, that they are in danger of defeating the objective of uniformity through the possibility of varying interpretations". There were demands for "regulations written in plain English", with the use of diagrams to convey the intention of a regulation more quickly or clearly.[213] Similarly, the first Agrément Certificate was criticised as being "in style and content… indistinguishable from and

[206] "Dr Parker Explains the Agrément Board." 1966. The Architects' Journal 144 (2): 74.
[207] "Dr Parker Explains the Agrément Board." 1966. The Architects' Journal 144 (2): 74.
[208] Handisyde, Cecil. 1966. "Doubts about Building Regulations." The Architects' Journal 144 (15): 895.
[209] Handisyde, Cecil. 1966. "Doubts about Building Regulations." The Architects' Journal 144 (15): 895.
[210] "Agrément Board First Certificate." 1967. The Architects' Journal 145 (4): 234.
[211] Hutton 1966.
[212] "JCBL Authoritative Criticism of Building Regs." 1967. The Architects' Journal 147 (16): 947.
[213] Minogue 1967.

less use than, a manufacturer's leaflet".[214] There were also concerns from ministers that it was taking too long for the Agrément Board to issue certificates.[215]

350. Updates to the Building Regulations brought more dissatisfaction due to the number of documents to which reference had to be made. By 1971 there had been seven amendments to the regulations,[216] and full re-issues of the regulations were made in 1972[217] and again in 1976.[218]

351. By the late 1970s there were a multitude of proposals for reform of the regulation of building. RIBA supported a nationwide system of "district surveyors", the Institution of Structural Engineers (IStructE) advocated the creation of a National Construction Control Board, which would establish and manage district offices. The Royal Institution of Chartered Surveyors (RICS) suggested formally grouping district councils into regions – with each region having its own Chief Building Regulation Officer.[219]

352. There was also dissatisfaction with the Agrément Board. The original intent had been that the Board would be established with government support but that, once established, its costs would be recovered from the fees that manufacturers would pay for Agrément certificates. However, even after 10 years of operation the board continued to receive a substantial government grant, and there was concern that if the Board was not self-sustaining, then this implied that industry did not accord value to its certifications.[220]

353. The Agrément Board was not the only organisation that was not meeting expectations. In May 1970, Sir Ronald Holroyd delivered a report that had been commissioned by the Home Office.[221] The primary focus of the report was the organisation of the UK's Fire Services, and Holroyd made numerous recommendations. One key recommendation of the report was that there should remain a separation between legislation for (and the administrative machinery of) the construction of new buildings, and the legislation for (and the administrative machinery of) occupied buildings.

354. Holroyd also addressed fire research. He concluded that the JFRO gave "insufficient priority and effort" to "practical problems",[222] that there "was too much research of a basic scientific nature", and that the reporting was "too slow" and not in a form suitable for those "whose job it was to put the findings to practical use".[223]

355. Although many of Holroyd's recommendations for restructuring were not implemented, changes *were* made at the Fire Research Station. The Building Research Station, Fire Research Station, and the Forest Products Research

[214] "Agrément Board First Certificate." 1967. The Architects' Journal 145 (4): 234.
[215] HC Deb (Monday 5 February 1968) Vol. 758 Col. 19.
[216] Elder 1972.
[217] The Building Regulations 1972.
[218] The Building Regulations 1976.
[219] Mitchell 1977.
[220] HC Deb (Wednesday 14 December 1977) Vol. 961 Col. 805.
[221] Holroyd 1970.
[222] Holroyd 1970, 22.
[223] Holroyd 1970, 190.

Laboratory were combined to create the Building Research Establishment (BRE).[224] A further reorganisation was undertaken in 1976 when the JFRO was dissolved. Under this new arrangement, routine testing continued at Borehamwood, however, now by the insurance industry (as had been the case prior to 1947). The Fire Research Station continued as a purely government financed research station.[225]

10.2. Testing for "Fire Propagation"[226]

356. With the introduction of the 1965 Building Regulations, one of the topics of particular concern at the JFRO had been the suitability and applicability of the tests described in BS 476 (1953). During the 1950s the JFRO had undertaken a series of 1/5th scale compartment fire tests where different products had been used to *internally* line the compartments. It was found that materials and products that achieved the *same* classification in the surface spread of flame test sometimes resulted in significantly *different* behaviour in the scaled compartments.[227] It was therefore decided to develop a new test method which could better distinguish between the hazard presented by materials and products when used to line a real compartment.

357. The idea behind the new test was that it should be possible to correlate its results with the observations from the scaled compartment fires. Moreover, it was intended that the new test method would investigate a range of phenomena that were relevant for the growth of a compartment fire; subjecting the test sample to impingement of a small flame along with the heating of the sample by an external radiant source.[228]

358. The resulting test was comprised of a small gas burner and two electric heaters situated inside a box with an exhaust flue (Figure 8). The test would start with the ignition of the gas burners – with the reasoning that this would be representative of a local ignition source. Then, over the course of several minutes, the electrical elements were heated so as to subject the entire sample to radiation – with the reasoning that this would be more representative of a larger source of heat coming from burning of compartment contents in a real fire.[229] The rate of temperature increase in the exhaust flue, and the duration of this increase, were then compared against the results from the 1/5th scale compartment tests. Initially, a classification system was proposed where Class A (plasterboard in this case) was the best, and Class D (compressed straw slabs) was the worst.[230]

359. Although the new test was originally developed during the mid 1950s, it was not until 1968 that it was formalised as a new, standalone British Standard.[231] When

[224] HC Deb (Wednesday 22nd December 1971) Vol. 828 Col. 354.
[225] Read 1994, 25.
[226] The test method introduced here was BS 476 Part 6.
[227] Hird and Fischl 1954, 8.
[228] Hird and Fischl 1954.
[229] Hird and Fischl 1954, 2-3.
[230] This classification system was discussed previously in Part I of this report.
[231] BSI 1968.

the new test was published in 1968 as BS 476 Part 6, the "Fire Propagation[232] Test for Materials", the classification system of Class A-D had been replaced with a calculation procedure that yielded an "index".

10.3. Permissive Evolution of "Class 0"

360. The new "fire propagation" test also provided an opportunity to provide a more refined definition for Class 0. Previously Class 0 materials and products had been defined largely on the basis of being either non-combustible materials or being specific types of layered products meeting Class 1 when tested in accordance with the BS 476 (1953) surface spread of flame test criteria (as already discussed).

361. The 1972 Building Regulations instead defined Class 0 in terms of the value of the index that resulted from the new BS 476 Part 6 (1968) test;[233] notably without any reference to the surface spread of flame test. Any reference to "a surface being of Class 0" was now to be construed as:

362. (1) the material being "non-combustible throughout"; *or*

363. (2) the "surface material (or, if it is bonded throughout to a substrate, the surface material in conjunction with the substrate)" having a BS 476 Part 6 (1968) index (I) not exceeding 12 and a sub-index (i_1) not exceeding 6.

364. The second criterion above was further caveated to deal with a number of specific hazards that might arise from use of products incorporating plastics "having a softening point less than 120°C".[234] Any products *other* than those that were Class 0 were to be classified *only* according to the surface spread of flame test given in BS 476 (1953).

365. The adequacy (or otherwise) of a material or product for a given situation was therefore dependent on the *observed behaviours* in the new BS 476 Part 6 (1968) test. If the test configuration had been different, or the resulting indices specified differently, then the *observed behaviours* would have also differed. Whether a material or product was defined as Class 0 was inextricably linked to the peculiarities of the new test method and the research which underpinned it. If a different standard test method been developed or selected, or indeed if the compartment geometries and lining materials used in the underlying research had differed, then the same material or product might have received a different classification.

366. Nevertheless, the new BS 476 Part 6 test and the criteria for classification were based on a link to underpinning research; this was a *model test* whose outcome was intended to allow the users to make a claim about how a particular product might perform in a real world scenario.

[232] As noted in Part I of this report, I disagree with the use of the word "propagation" in this context, as I believe it implies travelling of the flame front (as in a surface spread of flame test), rather than the growth of a fire to flashover within a compartment. I would therefore prefer the word "escalation" in this context.
[233] The Building Regulations 1972, 1111.
[234] It appears that these caveats were related to the recognition that mobilisation of low melting point polymers could invalidate the results of BS 476 Part 6 testing.

367. With respect to external wall construction, the 1972 Building Regulations[235] required that, for buildings taller than 15 metres (note the metrification as compared with 1965) and situations where the wall was more than 1 metre from "the boundary":

368. (1) the *external wall* should "be constructed wholly of *non-combustible materials*", again except for internal linings complying with applicable surface spread of flame requirements (omitted here); and

369. (2) any *cladding* on any external wall should have a surface complying with the newly-modified definition of Class 0; except that up to 15 metres in height it was permitted to use timber of not less 9 mm thickness *or* a material/product "having a surface" that resulted in an index (I) of less than 20 when tested to the new BS 476 Part 6 (1968) testing method.

370. The explicit distinction between the "external wall" and "cladding" persists in the above. It is also noteworthy that, in 1972, the BS 476 Part 6 (1968) testing method was also used, albeit with less stringent limits than those required to achieve Class 0, as a means of controlling the fire hazards for cladding *below* 15 metres.

371. The above observation raises some interesting questions that I consider illuminating in terms of thinking about how fire scientists and engineers collectively decide where to set the numerical limits that exist in most reaction-to-fire tests and classification systems: What does the index "I" actually represent? How is it calculated? And why were these particular "lines in the sand" drawn at index values of 12 or 20 for regulatory purposes?

372. As in the case of tests for non-combustibility, the specific values that were chosen are semi-arbitrary, but that does not mean that they have no meaning or that they are devoid of intent.

373. I have discussed the development of the fire propagation test both above and in Part I (see Section 10.2 of this report). The idea of the fire propagation test was to correlate the index "I" with the time to flashover in a compartment. Figure 7 shows an annotated reproduction of a plot by Rogowski (from the original 1950s research).[236] On the vertical axis is plotted the index "I" for products tested using the fire propagation tests; on the horizontal axis is plotted the time to flashover (in minutes) that was recorded when *the same product* was tested in a small-scale compartment fire test. Each circle in this plot represents a different product. There is a trendline to show the general trend in the data points.

374. Observing the data in this form makes obvious the reasons for the index values being chosen at 12 and 20. Below an index of 12, the only data points are at the far right hand side of the plot – with the longest times to flashover, and hence the lowest "fire propagation hazard". Above an index of 20 one finds the shortest times to flashover, and the trendline increases rapidly – and hence giving the products

[235] The Building Regulations 1972, 1101.
[236] Rogowski 1970.

with the highest fire propagation hazards. Between indices of 12 and 20, the products produce an intermediate fire propagation hazard.

375. The developers of the fire propagation test thus appear to have felt able to say, albeit based only on the experimental data they had to hand at that time, that a fire propagation index below 12 would produce a lower hazard, whilst values above 20 could produce the highest possible hazards. All other products were thus semi-arbitrarily classed as "intermediate".

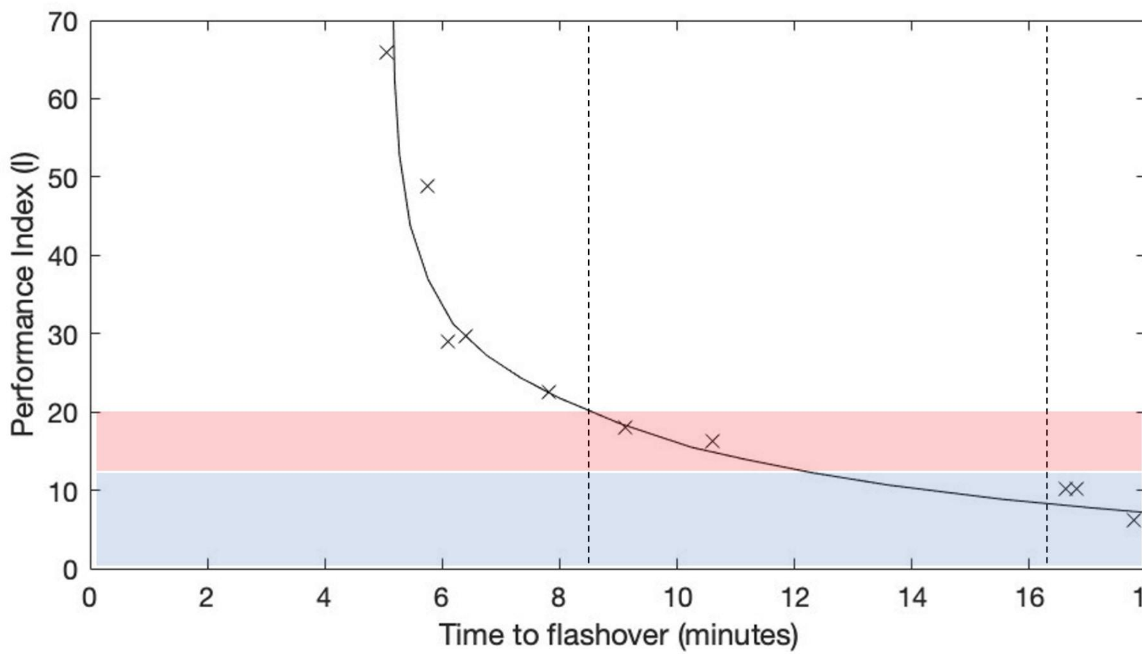


Figure 7 Plot reproduced from Rogowski[237] showing the index "I" plotted as a function of time to flashover (in minutes) in a compartment for wall lining products assessed in the original research leading to the fire propagation test.

376. At around this time, the pre-existing version of BS 476 (1953) was also split into a suite of separate parts, each dealing with one of the various existing BS 476 testing methods, as well as introducing some new testing methods (e.g. the new "fire propagation" test discussed above).

377. One notable change that occurred when BS 476 (1953) was split into multiple parts was the publication of the standalone BS 476 Part 4 (1970) "non-combustibility test for materials". This new test was, in fact, an updated and slightly modified version of the BS 476 (1953) "combustibility test of materials". The title of the test was changed. Rather than being a "combustibility" test, it was now a "non-combustibility" test – this change apparently resulted from a recognition that the purpose of the test was to ensure that a material or product made "no contribution whatsoever" to a fire.[238] Various updates were also made to the physical apparatus as described in Part I of this report.

[237] Rogowski 1970.
[238] Herpol 1972.

378. A change was also made to the permissible time of flaming that could occur during BS 476 Part 4 tests. Whereas previously this had been "zero seconds" of flaming, the 1970 version of this test standard permitted flaming of "10 seconds or more inside the furnace". This change appears to have been influenced by parallel developments within the code committee of the International Standards Organisation (ISO TC 92 WG2), wherein the similarly motivated ISO R1182 test method[239] was being developed. As described in Part I of this report, Herpol[240] has noted that this increase in permissible flaming time was semi-arbitrary, and represented a compromise between *absolute* and *acceptable* levels of "non-combustibility".

379. The next major reissue of the Building Regulations was in 1976. These were mostly unchanged from the 1972 version as regards combustibility, external wall and cladding requirements, and Class 0.

380. One subtle change was made, however, to the definition of Class 0; any reference to "a surface being of Class 0" was now to be construed as:

381. (1) the material being "non-combustible throughout"; or

382. (2) the surface material (or, if it is bonded throughout to a substrate, the surface material in conjunction with the substrate) "*shall have a surface of Class 1* and, if tested in accordance with BS 476: Part 6: 1968, shall have an index of performance not exceeding 12 and a sub-index not exceeding 6" (emphasis added), again with caveats relating to specific hazards that might arise from the use of plastics having a softening point less than 120°C.

383. Thus, in 1976 Class 0 was *re-defined* based on testing to BS 476 parts 6 (1968) and 7 (1971). This definition and approach remained in place – largely unchanged – up until the tragic events of 14th June 2017.

384. In summary, the period from 1965 to 1979 appears to have been characterised by frustration. There was frustration with the machinery of building control – the act of checking performed by local authorities. There was also frustration with the regulations themselves. The new format of the regulations had been created under a guiding principle of "functional requirements" supported by performance standards and deemed-to-satisfy measures. However, the reality does not appear to have delivered the flexibility that had been sought. Moreover, the Agrément Board – the organisation that was supposed to allow innovations to be rapidly brought to market – does not appear to have been performing this role in the way that had been intended.

---

[239] ISO 1970.
[240] Herpol 1972.

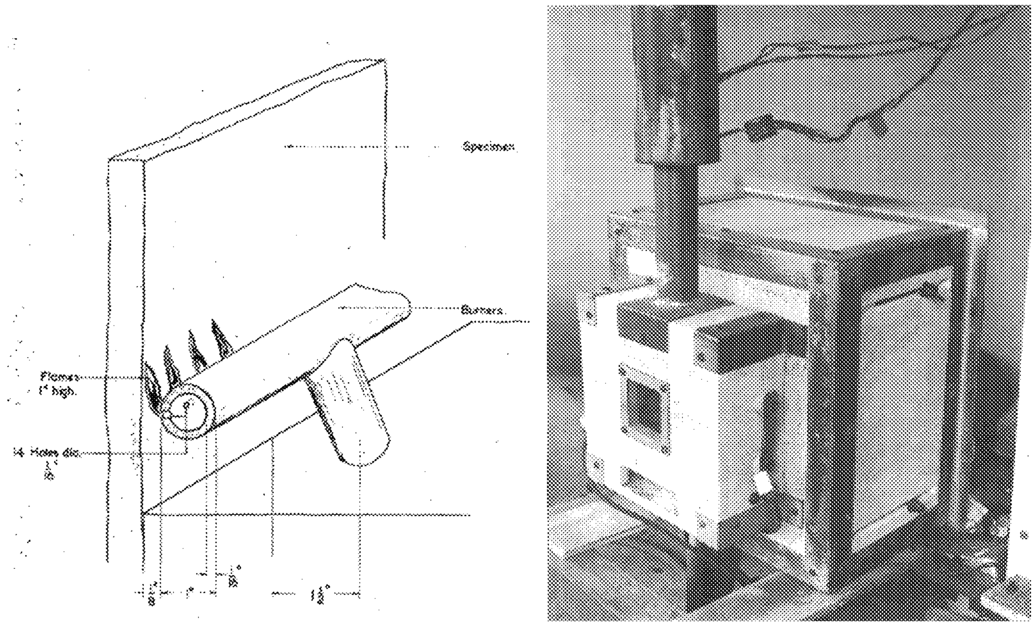


Figure 8 Test configuration that became BS 476-6 (1968),[241] images from Hird[242] and Read.[243]

241 BSI 1968.
242 Hird 1955.
243 Read 1994.

11. A New Hope (1979 to 1985)

11.1. The Shift to Functionally-Based Building Regulations

385. In December 1979, the new Secretary of State at the Department of the Environment, Michael Heseltine, gave a speech to National House Building Corporation (NHBC).[244] In his speech, Heseltine set out a vision for revising the building regulation system. Whereas previously there appears to have been agreement about the need for reform, Heseltine's speech provided it with direction. In this vision, the new system would have to satisfy four criteria: (1) encourage maximum self-regulation; (2) involve minimum government interference; (3) be totally self-financing; and (4) have simplicity in operation. He called for a consultation, and in February 1981 published a paper on "The future of building control in England and Wales".[245]

386. There appears to have been relative unanimity at that time that the Building Regulations themselves should be revised.[246] In fact, the ideas presented in the Department of the Environment's Summary of Recommendations were strikingly aligned with Guest's recommendations from 20 years earlier.[247]

387. As with Guest's report it was suggested that the new building regulations should be underpinned by functional requirements. Curiously, specific questions on the role of "performance standards", which had been so central to Guest's three tier system, were absent from the 1981 white paper. Instead, the emphasis was that the functional requirements should be "supported by a wide range of *approved guidance*, including BSI standards and codes, and Agrément Certificates".[248] There was a recognition that deemed-to-satisfy measures had some value – particularly for smaller buildings – and that there "*might* therefore be a case for retaining them" (emphasis added) in some form for domestic buildings.[249] There was a particular emphasis on brevity – i.e. that there should be "a minimum number" of functional requirements.

11.2. Privatisation of Building Control

388. The relative unanimity on the need for revision of the Building Regulations was, however, in contrast to the more controversial proposals then also made in relation to private certification and self-certification.

389. Part of Heseltine's motivation for changing the system was his stated conviction that Local Authority (public sector) Building Control was attracting too much of the liability for defective buildings – and, for the private sector, Building Control was a service that "relieves them of worry". He noted that "with the lapse of years, architects retire and builders may disappear. But the local authority is always there to be sued". He wanted to shift the balance, "to see a system of control which

[244] "Heseltine Demands Debate on Building Regs." 1979. The Architects' Journal 170 (51).
[245] "The Future of Building Control in England and Wales Cmnd 8179." 1981. London.
[246] "The Future of Building Control in England and Wales Cmnd 8179." 1981. London. pp. 4.
[247] Guest 1957.
[248] "The Future of Building Control in England and Wales Cmnd 8179." 1981. London. pp. 15.
[249] "The Future of Building Control in England and Wales Cmnd 8179." 1981. London. pp. 6.

embodies the principle that anyone who carries out work, or causes it to be carried out or authorises it, should be responsible for the outcome".[250]

390. During his speech, Heseltine had suggested the idea of private certification of plans (i.e. an architect could *self-certify* that their plans met the functional requirements) and also floated the idea that the NHBC could become a *private* building control authority.[251] It was proposed that Local Authorities should no longer be the only organisations able to approve building designs. Instead, it was suggested that developers could appoint a private company to act as a building control body. Similarly, it was proposed that some large organisations (e.g. British Aerospace) could simply self-certify their own buildings.

391. The reaction to Heseltine's proposals on private building control appears to have been mixed. NHBC were apparently enthusiastic about becoming a private building control authority for housing.[252] The idea of self-certification had initially been met with some enthusiasm;[253] it was proposed that professional institutions – such as the Institution of Structural Engineers, the Royal Institution of Chartered Surveyors, and the RIBA for example – would be able to approve their members to self-certify.[254]

392. However, this initial enthusiasm appears to have subsided once it became clear that the Government required self-certifiers to carry professional *indemnity insurance* to cover potential future claims. Some professional institutions believed that "the law on defects liability must be reformed before the insurance industry will provide the requisite cover at an acceptable cost".[255]

393. During the early 1980s, there appears to have been much wrangling about the exact nature of the required legislation. Eventually it was decided that there would be a single unifying act (essentially bringing England and Wales into line with Scotland), a short regulation that stated the mandatory (functional) requirements, and a series of supporting statutory guidance documents. Unlike the previous system proposed by Guest – the legislative link to mandatory performance standards would disappear. Thus, the standards and codes of practice which had been so empowered by the previous legislation would now, in principle, become optional. The supporting guidance would be "approved" by the Secretary of State to indicate that following the guidance would, most likely, result in compliance with the mandatory functional requirements. Standards and codes of practice would now be either directly "approved" by the secretary of state – or referenced in other "approved" documents.

[250] "The Future of Building Control, Speech by the Secretary of State for the Environment, 10 December 1979, to the National House-Building Council." 1979.
[251] "Heseltine Demands Debate on Building Regs." 1979. The Architects' Journal 170 (51).
[252] "Building Control: An Open Letter." 1980. The Architects' Journal 171 (5): 223.
[253] "Profession Hails Heseltine's Regs Proposal." 1979. The Architects' Journal 170 (27): 12.
[254] "RIBA to Boycott Private Certification." 1985. The Architects' Journal 182 (30): 28.
[255] "RIBA to Boycott Private Certification." 1985. The Architects' Journal 182 (30): 28

11.3. The "Approved" Documents

394. The above activities culminated in the primary enabling legislation of *the Building Act 1984*, under which secondary legislation, *the Building Regulations 1985*, was made. The Building Act 1984 set the legal status of the "Approved Documents" (e.g. Approved Document B), and also created the role of "Approved Inspector" (i.e. private, for profit, building control authorities).

395. The Department for the Environment appointed architectural firm BDP to interpret the measures defined in the then existing legislation – and to translate these into the new "approved" guidance.[256] The result was a suite of approved documents first published in 1985.[257]

396. The measures outlined in the new approved documents were remarkably similar to the previous regulations – indeed, in their first editions, it was intended that the requirements would change mostly in form rather than in content.[258] However, because these were no longer "legal documents" diagrams could now be used for illustrative purposes. There was also a belief that, by moving them out of legislation, the approved documents could be updated more frequently to take account of innovation.

397. Separation of the legal from the technical appears to have been met with satisfaction by many practitioners.[259] Whilst most of the measures described in the approved documents were "guidance", there were some measures that remained mandatory. For example, it remained mandatory to follow the rules in CP3 Chapter IV for means of escape (see Todd[260]).

398. Regarding requirements related to external walls, cladding, and external fire spread, the functional requirements of the 1985 Building Regulations stated that:

399. "the external walls of the building shall offer adequate resistance to the spread of fire over the walls and from one building to another, having regard to the height, use and position of the building".[261]

400. The new *guidance* given in Approved Document B (1985) provided designers with additional detail on the means by which, in the opinion of the Secretary of State, the above functional requirements of the Building Regulations could be met. The new guidance explicitly stated that "The requirements of Paragraph B4 *will* be met if the provisions set out in [the relevant sections] are incorporated" (emphasis added).[262]

401. The new guidance also, however, explicitly noted that "there is no obligation to adopt any particular solution… if you prefer to meet the requirement in some other way".

[256] "Disapproved Documents." 1983. The Architects' Journal 178 (47): 58.
[257] "'85 Regulations Reviewed." 1985. The Architects' Journal 182 (37): 79.
[258] "New Improved Documents." 1984. The Architects' Journal 179 (22): 63.
[259] Davies 1983.
[260] Colin Todd, Expert Report for Grenfell Tower Inquiry, 2.26 {CTAR00000001/11}
[261] The Building Regulations 1985, 3408.
[262] Approved Document B 1985, 3.

402. The potential legal implications of meeting the requirements in "some other way" were also explicitly highlighted:

403. "If a contravention of a requirement [of the Building Regulations] is alleged then, if you have followed the guidance in the [approved] document, that will be evidence tending to show that you have complied with the Regulations. If you have not followed the guidance then that will be evidence tending to show that you have not complied. It will then be up to you to demonstrate by other means that you have satisfied the requirement."[263]

404. The above statement in the Approved Document B (1985) echoed Section 7 of the Building Act 1984, which stated that:

405. "A failure on the part of a person to comply with an approved document does not of itself render him liable to any civil or criminal proceedings; but if, in any proceedings whether civil or criminal, it is alleged that a person has at any time contravened a provision of building regulations… a failure to comply with a document that at that time was approved for the purposes of that provision may be relied upon as tending to establish liability, and proof of compliance with such a document may be relied on as tending to negative liability."[264]

406. With respect to civil liabilities associated with breaches of the Building Regulations, the Building Act 1984 also included specific provisions outlining the extent to which such breaches might be actionable (in Section 38 of the Act), stating that:

407. "breach of a duty imposed by building regulations, so far as it causes damage, is actionable, except in so far as the regulations provide otherwise."

408. Section 134 of the Building Act 1984 goes on to note that "except so far as [it] enables regulations to be made", Section 38 does not come into force until "such a day as the Secretary of State may by order appoint". As at 2021, no such regulations have yet been made, and Section 134 has not been brought into force to enable claims to be made.

409. In the wake of the Grenfell Tower Fire, and as part of their 2019 "Building a Safer Future" consultation,[265] the Government sought views on "on whether it should commence section 38 and, if so, whether section 38 requires any amendment before being brought into force." The 2020 government response to this consultation[266] – as well as the accompanying "Economic assessment of the

[263] I do not hold myself out as an expert in the legal status of the approved documents. I make these comments simply because I believe that potential civil liability is centrally important when considering the ways in which construction industry professionals interact both with testing and with building regulations and associated guidance.
[264] The Building Act 1984, Chapter 55, pg. 6.
[265] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/806892/BSP_consultation.pdf.
[266] https://www.gov.uk/government/consultations/building-a-safer-future-proposals-for-reform-of-the-building-safety-regulatory-system.

benefits and costs to the government response to the 'Building a Safer Future' consultation"[267] – are silent on this point.

11.4. "Limited" Combustibility

410. In relation to the construction of external walls and cladding, Approved Document B (1985) gave broadly similar advice to the pre-existing building regulations (1976). However, a number of additions and subtle differences are noteworthy.

411. More descriptive advisory text was present within the guidance as compared with the pre-existing Building Regulations. For instance, new and instructive *commentary*[268] was included regarding "External fire spread":

> **External fire spread**
>
> **0.29 Walls –** The construction of external walls and the separation between buildings to prevent external fire spread is closely related, and many of the provisions specified are related to the distance of the wall from the boundary.
>
> **0.30** Whether a fire will spread across an open space between buildings, and the consequences if it does, depends on:
>
> - the size of the fire in the building involved
> - the risk it presents to people in the other building
> - the distance between the buildings, and
> - the fire protection given by their facing sides.
>
> **0.31** There are provisions to limit the extent of openings in external walls in order to reduce the risk of fire spread by radiation. Various methods are set out in Appendix J. The basis of the methods described is set out in Fire Research Technical paper No. 5. *Heat Radiation from fires and building separation* (HMSO 1963). It should be noted that as for fire resistance of elements of structure *(see paragraph 0.24)*, less onerous provisions for the separation of buildings apply where compartmentation exists. Therefore it may sometimes be advantageous to provide compartments of smaller size than specified (or to provide compartments where none may be necessary).

412. Review of the above text gives a strong impression that, in 1985, the stated provisions for the external wall were focused primarily on external fire spread *to other buildings*, rather than necessarily on external fire spread on the exterior of the building of fire origin; nothing in the descriptive text on "external fire spread" specifically draws the reader's attention to storey-to-storey external fire spread. Cladding, as distinct from the external wall, is not explicitly mentioned.

---

267 https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/877521/A_reformed_building_safety_regulatory_system_-_economic_assessment_of__benefits_and_costs_to_the_gvt_response_to_the_Building_a_Safer_Future_consultation.pdf.

268 The inclusion of descriptive commentary had been enabled by the new legal status of the approved documents.

413. In addition to updating passages of text, additional standards were also cited within the new Approved Documents. One such standard was the BS 476 Part 11 test[269] which was first published in 1982.

414. This new test used a testing device similar to that originally proposed by Prince in 1915, and therefore also similar to the pre-existing BS 476 Part 4 (1970) and ISO R1182 (1970) test methods. However, various features of the sample size, test procedures, and performance criteria were modified (see below). The reasons for the change of primary test method from the pre-existing BS 476 Part 4 test to the new Part 11 test are not entirely clear, however it seems likely that technical work that was underway within ISO Committee TC92, on the development of ISO 1182 (1979), which at the time was chaired by Philip Thomas of the Fire Research Station, resulted in a view that this new test represented best practice at that time, given increasing scientific knowledge and the ongoing development of new construction products and materials.

415. For the new Part 11 test, the sample was changed from prismatic to cylindrical, the number of specimens to be tested was increased from three to five, and an additional thermocouple was added; in addition to the “furnace” and “specimen” thermocouples, a new “contact” thermocouple was placed in direct contact with the specimen’s outer surface.

416. Furthermore, all performance criteria were removed from the testing standard; the Part 11 test method yielded only a testing report. No assessment of “combustibility” was offered within the new testing standard. Thus, the new test allowed explicit separation of testing method from its regulatory application. Users would now need to consult the Approved Document B (1985) for acceptability criteria.

417. The new Part 11 test standard was incorporated into the definition for “non-combustible materials”. These were defined as follows (within Table A6 of ADB 1985):

> (a) Any material which when tested to BS 476: Part II does not flame and there is no rise in temperature on either the centre (specimen) or furnace thermocouples.
> (b) Totally inorganic materials such as concrete, fired clay, ceramics, metals, plaster and masonry containing not more than 1 per cent by weight or volume of organic material. (Use in buildings of combustible metals such as magnesium/aluminium alloys should be assessed in each individual case).
> (c) Concrete bricks or blocks meeting BS 6073: Part I: 1981.
> (d) Products classified as non-combustible under BS 476: Part 4: 1970.

418. There were therefore now four ways in which a material/product could be deemed “non-combustible”.

419. Criterion (a) applies BS 476 Part 11 (1983) in the strictest possible manner (i.e. no flaming, no temperature increases).

[269] BSI 1982.

420. Criterion (b) is based on knowledge of the mass or volumetric proportions of constituent materials, rather than on the basis of testing, and would most likely result in construction materials and products with heats of combustion somewhat less than 1 MJ/kg; and is thus reasonably conservative as regards "combustibility".

421. Criterion (c) is obvious given the absence of organic materials in conventional brick or blockwork.

422. Criterion (d) permits readers to "fall back" on the pre-existing definition of "non-combustible" based on testing to BS 476 Part 4 (1970). This was presumably so as to avoid suddenly prohibiting the use of materials/products that may already have been in widespread use based on being acceptable under existing guidance, but which might fall foul of the new BS 476 Part 11 (1983) testing method.

423. The retention of BS 476 Part 4 (1970) in the above definitions illustrates a common and recurring problem when introducing new testing methods or classification systems into existing regulations and guidance. That is, the introduction of new methods may require existing products or systems to be retested – and it is possible that the new test (either by accident or by design) may be harder to "pass" than the previous test. The narrative in this report shows that UK regulators have tended to avoid introducing new regulatory tests or requirements without retaining the existing ones. This issue arose again during, for example, the UK's 2002 introduction of the harmonised European reaction-to-fire classification system.

424. The flexibility provided by omitting the criteria from the test standard also meant that the Part 11 test could be used to define other classes of materials and products. Approved Document B introduced the term "limited combustibility" as a newly coined classification for materials or products. With respect to external walls of "flats", Approved Document B (1985) suggested that "the external walls" of buildings above 15 metres "should be constructed of materials of limited combustibility".[270] "Materials of limited combustibility" were defined in ADB (1985) as follows:

(a) Any non-combustible material listed in Table A6.
(b) Any material of density 300kg/m³ or more, which when tested to BS 476: Part II, does not flame and the rise in temperature on the furnace themocouple is not more than 20°C.
(c) Any material with a non-combustible core of 8mm thick or more, having combustible facings (on one or both sides) not more than 0.5mm thick. (Where a flame spread rating is specified, these materials must also meet the appropriate test requirements.)
(d) Any material of density less than 300kg/m³, which when tested to BS 476: Part II, does not flame for more than 10 seconds and the rise in temperature on the centre (specimen) thermocouple is not more than 35°C and the furnace thermocouple is not more than 25°C.

[270] Approved Document B, B2/3/4, 1985, 13.

425. There were therefore four ways in which a material/product could be deemed to be of "limited combustibility":

426. The logic of Criterion (a) is obvious (i.e. the criteria for non-combustibility were stricter than the criteria for limited combustibility).

427. Criterion (b) applies to higher density, combustible materials and prohibits *any flaming* of the sample, along with a limiting temperature rise of the *furnace* by 20°C. This definition is similar – but not identical – to that applied in BS 476 Part 4 (1970) for non-combustible materials; in fact, both the permissible duration of flaming and the allowable temperature increase of the furnace thermocouple are less stringent than those imposed via the BS 476 Part 4 (1970) test standard – all other factors being considered equal.

428. Criterion (c) appears to be intended to permit the use of non-combustible materials which might have a thin combustible coating (e.g. a polymer based skin, paint, or powder coating); and noting the requirement that applicable surface spread of flame requirements would then also need to be considered.

429. Criterion (d) is for lower density, combustible materials (e.g. some insulation products) and prohibits *more than 10 seconds of flaming* of the sample along with limiting temperature rises of the specimen thermocouple by 35°C or the furnace by 25°C. Thus, the requirements for lower density materials were slightly less stringent than for higher density materials, possibly because lower density materials would necessarily contain less combustible content per unit mass as a consequence of their lower overall densities. It seems likely that this definition was included because certain low density construction materials may have existed at that time that were unable to meet criteria (a), (b), or (c), but that were desirable for one or more applications and that were not considered to present unacceptable hazards based on the manner in which they were being used.

430. The introduction and application of BS 476 Part 11 (1985) is striking on various grounds:

431. The earlier view expressed by Herpol[271], that non-combustibility tests should be "go or no-go" tests and that they should "not yield anything else, particularly not the degree of contribution" appears to have been set aside. This is evident from the fact that the test standard's title avoided using any permutation of the word "combustibility", and instead referred to a "method for assessing the *heat emission* from building materials" (emphasis added).

432. The BS 476 Part 11 (1983) test standard did not comment on the acceptability of application of testing outcomes as regards combustibility (or otherwise); such matters were left to the (strictly optional) guidance of Approved Document B (1985).

[271] Herpol 1972, 5.

433. Despite the introduction of the new BS 476 Part 11 (1983) testing standard, BS 476 Part 4 (1970) remained a permissible option to demonstrate "non-combustibility", and hence also "limited combustibility".

434. Approved Document B (1985) also introduced new and specific guidance related to the fire hazards associated with "external cladding to a wall", which stated that cladding "to a wall that should be of limited combustibility *may also be combustible* if it is not being relied on to contribute to the fire resistance of the wall" (emphasis added), and if it met the provisions given in the following table:

Table 2.2 Limitations on external cladding *(flats)*

Maximum height of building [m]	Distance of cladding from any point on the relevant boundary*		
	Less than 1m	1m or more	
15	Class 0	no provision	
over 15	Class 0	any cladding less than 15m above the ground	timber at least 9mm thick; or any material with an index of performance (I) not more than 20
		any cladding 15m or more above the ground	Class 0

Notes
For meaning of Class 0 and index of performance (I) *(see Appendix A)*
* The relevant boundary might be a notional boundary. *(see Appendix J)*

435. Thus, external cladding was permitted to be combustible, provided it was Class 0 (in accordance with Approved Document B) when applied above 15 metres.

436. As in 1976, Class 0 was defined as "a material or the surface of a composite product" that is either:

437. "(a) composed throughout of materials of limited combustibility, or

438. (b) a Class 1 material [based on testing to BS 476 Part 7 (1971)] which has a fire propagation index (I) of not more than 12, and (i_1) of not more than 6 [based on testing to BS 476 Part 6 (1981)]".

439. Thus, any material or product that was of limited combustibility could automatically be assumed to also be Class 0. Critically however, the converse was (and is) not true; *A material that was Class 0 could not automatically be assumed to be of limited combustibility.*[272]

440. The commentary that accompanied the definition of Class 0 stated that this classification "restricts both the spread of flame across a surface and also the rate at which heat is released from it" and that it "imposes a more strict control than

[272] Confounding of "Class 0" with "non-combustible" appears to have been a widespread problem prior to the Grenfell Tower Fire. For example, even leading fire science and engineering researchers Nathan White and Michael Delicatsios (2015, 119) appear to have got this wrong, stating that: "National Class 0 materials are either non-combustible when tested to BS 476-4 or Limited combustibility when tested to BS 476-11".

Class 1" and "is not a classification identified in a British standard test, and is considered a higher class than Class 1".[273]

11.5. Summary – A Fundamental Shift

441. What is most remarkable about the early 1980s is the upheaval of the administration of building regulations and the fundamental shift away from linking functional requirements to mandatory performance standards. However, despite all of this upheaval the standards remained largely the same (notwithstanding the subtle evolution noted in the preceding sections), and the performance standards defined in the new "approved" documents also remained (for many provisions) largely unchanged from the pre-existing regulations.

442. There had, therefore, been a fundamental shift in the way designers could practice. In principle, there were no prescribed constraints on how the adequacy of proposed design could be demonstrated against the requirements of the Building Regulations (1985). There had not, however, been any fundamental changes in the testing standards which underpinned the approved documents. Indeed, to maintain continuity with the past it was logical to retain the majority of the existing testing methods and performance standards; even if these were no longer mandatory, or if new test methods or classifications were available to supersede pre-existing ones.

443. The idea of linking a performance standard and a test method had been enshrined in law since the 1950s. It was necessary to continually review the tests and the performance standards to ensure that they were fit for purpose; to check that they had not been invalidated by a new material, product, or system. This had been the fundamental objection of RIBA and the FRS to mandatory performance standards in 1958; that such mandatory standards constrained innovation. Breaking this link was expected to allow unconstrained "flexibility".

444. Since the performance standards and tests were no longer seen as constraints, the need to continually review and update became less urgent. If a new and innovative product failed to meet the stated performance standard, then the product manufacturer could simply find "alternative means" by which to "demonstrate safety". In this new, functionally-based model of building regulations, devising ways to circumvent the prescribed guidance of the approved documents was not "finding loopholes", it was the *intent* of the regulatory system.

445. Writing in 1986, Malhotra, then a long-time veteran of the Fire Research Station, summed up the significance of these fundamental changes as follows:

446. > "Historically over the last three centuries we have moved from strict constructional specifications to functional or semi-functional requirements with performance oriented objectives as and when feasible. Rigid controls are being replaced progressively by a more flexible system which permits alternative solutions to be considered. The burden of responsibility is being

[273] Approved Document B, B2/3/4, 1985, 46.

shifted from the central or the local authorities to the individual or corporate designer/contractor for the adequacy of his [sic] system".[274]

447. Malhotra concludes:

448. "It will be perhaps another 2 or 3 decades before the consequence of this approach can be seen".[275]

[274] Malhotra 1986, para 1.20
[275] Malhotra 1986, para 1.20

12. Function (1986 to 1996)

449. Once the aim of making the building regulatory system self-financing was established, the Agrément Board again came under review. At about the same time that Heseltine had launched the review of the building regulations, a government review had begun with the scope of "increasing the marketability" of the Agrément Board; with a view to possibly merging it with the British Standards Institution.[276] In 1982, the Agrément Board was renamed the British Board of Agrément (BBA).[277] By the mid 1980s, the BBA remained a source of dissatisfaction given the amount of funding it still received from government, and a new plan was put in place to transition it to receiving zero government financial support.[278] There also appears to have been a hope that the new functionally-based building regulations would increase demand for BBA certifications.[279]

450. The format of the BBA certificates was updated such that it stated, "precisely how the product satisfied various aspects of the Building Regulations".[280] However, these changes did not yield the financial results that the Government appear to have hoped for. Indeed, on 31st March 1987 the BBA was considered by government to be "technically insolvent".[281] In response to this, the manner in which the Government supported the BBA was changed. From 1989, rather than receiving a cash grant from the Department of the Environment, monies were paid by the Department to the BBA "on a contractual basis" for agreed programmes for work.[282]

451. In addition, new legislation in Europe (the European Construction Products Directive) was intended to allow products produced and tested in one member state to be sold without hindrance in other member states. To facilitate this, governments were allowed to nominate designated bodies which had the power to issue certification with respect to a product's "conformity" with various harmonized European standards. The Government chose to nominate the BBA as its designated body – and it was expected that this would radically change (and increase) the amount of work undertaken by the BBA.[283]

452. Similarly, at BRE there were significant changes from the mid 1970s through to 1990. In the mid 1980s, there was a move to run BRE "more as a business"

[276] "Week at a Glance: Government Agrément Board Handed over to BSI." 1979. *The Architects' Journal* 170 (49): 1178.
[277] "Second Report from the Environment Committee, Session 1984-85 British Board of Agrément." 1985. pp. 5.
[278] "Third Special Report from the Environment Committee, Session 1984-85, Department's Response to the Committee's Second Report, 1984-1985 (HC156) British Board of Agrément." 1985. pp 5.
[279] "Second Report from the Environment Committee, Session 1984-85 British Board of Agrément." 1985. pp. 8.
[280] Duell 1986.
[281] Environment Committee, Second Report Department of the Environments Main Estimates 1988-89, Report together with the Proceedings of the Committee, the Minutes of Evidence and Appendices, pp. 17.
[282] Environment Committee, Second Report Department of the Environments Main Estimates 1988-89, Report together with the Proceedings of the Committee, the Minutes of Evidence and Appendices, pp. 16.
[283] Third Report, Department of the environment's main estimates, 1990-9, Report Together with the Proceedings of the Committee the Minutes of Evidence and an Appendix, Minutes of Evidence taken before the environment committee Wednesday 25th April 1990. pp. 22.

whereby more income was obtained from non-government sources to encourage application of expertise and research findings. BRE launched a technical consultancy in 1988 with the aim of serving non-government clients. Nevertheless, the core function of BRE remained to support government policy.[284]

12.1. The Emergence of "Overcladding"

453. A key interest that emerged during the 1980s was improving the environmental performance of existing buildings. The "industrialised housing" buildings of the previous decades were notorious for being cold and damp.[285] The solution offered by the construction industry in the 1980s was "overcladding"; adding thermal insulation and additional external cladding systems to the exterior of existing highrise (typically residential) buildings.

454. This topic was of particular interest to the Department of the Environment and therefore became the subject of research by BRE. In 1986, BRE published a report on overcladding of Large Panel System (LPS) dwellings.[286] The report was drafted at a time when only a relatively small number of overcladding schemes had been completed; however, a large number of overcladding schemes were then under consideration. The intent was that government funded research by BRE would assist the technical departments of local authorities to assess the various factors that needed to be considered in any potential overcladding scheme.[287]

455. BRE's overcladding report primarily focused on considerations associated with "rainscreen" cladding. It discussed the loading, drainage paths, thermal performance, and durability of such systems. As part of their investigations around potential fire hazards presented by the use of combustible materials within rainscreen systems, BRE also performed a large-scale fire testing programme.[288] Through this work it was identified that the fire hazards depended on the presence of combustible materials within the cladding and the associated spread of fire both on and within the overcladding systems.

456. The materials available for overcladding presented the full gamut of innovative materials that had been developed over the preceding decades. For insulation, products included polystyrene, polyurethane, polyisocyanurate, foamed glass, phenolic foam, and mineral fibres.[289] For the outer skins, these included: cement render, thin plastics (with cement or glass fibres), wood, metal, uPVC, tiles, brickwork, metal sheets, fibre cement, glass reinforced polymer (GRP), and composite "sandwich" panel products.[290]

457. BRE's investigation on the fire performance noted that "at least four 12-storey blocks of flats have had rendered expanded polystyrene insulation systems applied

---

[284] Courtney 1997.
[285] Ardill 1987.
[286] Harrison et al. 1986.
[287] Harrison et al. 1986, 1.
[288] Rogowski et al. 1988.
[289] Harrison et al. 1986, 33.
[290] Harrison et al. 1986, 33-37.

to the wall and blocks of flats up to 22 storeys high have been treated with polystyrene incorporated behind a ventilated cladding".

458. It was noted that "possible advantages in terms of economy and ease of installation might favour increased use of polymeric insulation were there not fears about the effects of these on fire spread and doubts as to their acceptability under the provisions of the Building Regulations".[291]

459. During their investigation, BRE undertook tests on various candidate systems in which the systems were mounted onto a 9.2 m high wall, and a large timber crib fire was ignited at the base. Some key conclusions of this work (published in 1988) were that:

460. "mineral insulants may be safely used… in cladding systems incorporating metal or non-combustible sheeting supported by steel or timber framework and ventilated by a continuous cavity; fire barriers are not essential"; and

461. "proposed systems incorporating combustible insulants with sheeted overcladding should be designed to incorporate fire barriers in the ventilated cavity every two storeys".[292]

462. The potential of overcladding was also examined by RIBA's Energy Policy Group, who suggested that the approach represented a viable alternative to demolition of existing building stock.[293] At the time, this approach to remediating highrise housing appears to have generated some controversy, with some commentators asking whether overcladding was a "panacea or just another generation of under-researched and over-sold building systems".[294]

463. Nevertheless, the Department of the Environment (DoE) made part of the budget for its "Estates Action Programme (EAP)" available for Local Authorities to implement overcladding schemes on their stock of residential tower blocks.

464. A pilot building for this EAP scheme was an eleven-storey building in Merseyside called Knowsley Heights.[295] The overcladding scheme's architect, Sydney Bolland[296], proposed a design whereby mineral wool insulation was fixed to the outside of the building, outside which a ventilated air gap was enclosed by a "rainscreen" cladding system mounted onto aluminium rails.[297]

465. The rainscreen used at Knowsley Heights was a glass fibre reinforced polymer (GRP) sheeting product with an aggregate finish on its outside face (Figure 9). The product's marketing literature suggested that the polymer used was a polyester

[291] Rogowski et al. 1988, 1.
[292] Rogowski et al. 1988, 6.
[293] Cowan 1987.
[294] Brookes and Stacey 1988.
[295] Ardill 1987.
[296] An 11th April 1991 issue of *New Civil Engineer* magazine noted that: "Architect Sydney Bolland specified the system. He works closely with several electricity supply companies and is an energy consultant to the United Nations" and that "regional electricity company Manweb designed the building's energy efficient heating system".
[297] Assessment of Overcladding to Knowsley Heights, Liverpool, National Archives, AT 66/389.

polymer resin.[298] The GRP rainscreen was a product called “Cape Stenni” sheeting, and was presented as being a “Class 0” product.[299, 300]

466. To achieve Class 0 in compliance with Approved Document B (1985), the GRP rainscreen would have needed to be “a material or the surface of a composite product” that was either “(a) composed throughout of materials of limited combustibility, or (b) a Class 1 material which has a fire propagation index (I) of not more than 12, and (i_1) of not more than 6”.

467. I consider it unlikely that a polyester-based GRP product could have been “composed throughout of materials of limited combustibility”, and I therefore believe that the GRP rainscreen used at Knowsley Heights must have been able to achieve Class 1 based on testing to BS 476 Part 7 (1971)[301] and had a fire propagation index (I) of not more than 12, and (i_1) of not more than 6 based on testing to BS 476 Part 6 (1981).[302]

12.2. The Fire at Knowsley Heights (1991)

468. The overcladding of Knowsley Heights, completed in 1989, appears initially to have been considered a success. Indeed, since the scheme was a Department of the Environment pilot, BRE were asked to review the success of this overcladding scheme; concluding, overall, that the “Knowlsley [sic] heights project demonstrates a successful package of energy saving measures”.[303]

469. The success was short lived.

470. In the early hours of 5th April 1991, a fire occurred at Knowsley Heights. On arrival, the fire brigade reported that “it was the most frightening thing any of us had ever seen as fire-fighters”, and that “flames were coming from every landing window between the ground floor and the roof”.[304] There were no fatalities and the fire brigade were eventually able to bring the fire under control.

471. BRE, along with local fire service and the lead architect, were dispatched to investigate the fire. The investigative team found that the fire had initiated outside the tower in refuse at its base, adjacent to the exterior wall, and that the fire had spread rapidly within the rainscreen cavity (i.e. void) between the insulation and the GRP rainscreen panels.

472. The investigations concluded that the primary reason for the rapid and widespread progression of the fire had been the complete absence of cavity barriers between

298 Product News, Cladding, Stenni. 1985. *The Architects' Journal* 182 (28): 61.
299 BRE report, Summary of fires investigated: April 1991 to March 1992, pp 18 {CTAR00000018/2}
300 Sydney Bolland later stated that the scheme was designed to “all the accepted principles” – “Void fire promotes cladding review”, New Civil Engineer, 11th April 1991.
301 I consider it noteworthy that, around this time, BS 476 Part 7 (1987) was published; this is significant because it is in 1987 that the water-cooled frame is added to this test method “to improve the ability to classify certain thermoplastics materials” [from the foreword, BS 476 Part 7:1987].
302 An updated version of BS 476 Part 6 was published in 1989, however aside from some subtle changes to calibration procedures and fuel supply gases, it does not appear to have been substantively different from the pre-existing versions.
303 Assessment of Overcladding to Knowsley Heights, Liverpool, National Archives, AT 66/389.
304 Shennan 1991.

the rainscreen cladding and the (mineral fibre) insulation.[305] As a result, the first major revision of Approved Document B (which was already underway at the time of the fire) increased the degree to which cavity barriers were recommended within rainscreen cladding systems.[306]

473. At the time that the Knowsley Heights refurbishment was undertaken, the Appendix G, Approved Document B (1985) guidance on cavity barriers was (amongst other things):

474. that "the edges of cavities… should be closed by cavity barriers… around any openings through a wall, floor or any other part of the construction which contains a cavity"; and

475. that "cavities… should be interrupted by cavity barriers where… a wall, floor, ceiling, or roof [abut the cavity]".

476. The above recommendations would, in my opinion, have the effect of requiring "full fill" horizontal cavity barriers at each storey height and "full fill" vertical barriers in line with the fire separating walls between individual compartmented residential units. However, it should be noted that ADB (1985) does not explicitly mention ventilated rainscreen cavities as candidate cladding (or overcladding) systems for buildings. I note that requiring such full fill cavity barriers would have likely been impractical for a novel (at that time) ventilated rainscreen overcladding system such as that used at Knowsley Heights.

477. Indeed, writing later in September 1991, BRE's Penny Morgan, who had been one of two BRE staff who had performed the on-site fire investigation following the Knowsley Heights fire, explained the compromise that had needed to be reached with respect to ventilation in rainscreen cavities:

478. "while the provision of cavity barriers might be indicated to inhibit fire spread, it may be necessary to have ventilation to prevent condensation-induced corrosion… a balance must be sought".[307]

479. It appears that the absence of cavity barriers within the rainscreen overcladding system at Knowsley Heights had been justified by its designers using an "alternative solution" by reversion to functional requirement B4 of the Building Regulations (1985). This was apparently done because "DOE/BRE guidance at the time" suggested that cavity barriers "could be omitted where the cladding system was non-combustible",[308] albeit which it was not in this case.[309]

480. Whilst I do not know what specific "DOE/BRE guidance" is being referred to in the above quote, I consider it likely that this is an erroneous reference to the external

[305] {CTAR00000018}
[306] Approved Document B 1992, 62. {BLA00005482/64}
[307] Morgan 1991, 5.
[308] {CTAR00000018}
[309] The external rainscreen cladding panels installed at Knowsley Heights were Class 0 (at least on their outside face) but were *not* "non-combustible".

fire spread guidance developed by BRE during the 1980s. This is presented in the 1st edition of BR 135 (1988), where it is stated that:

481. "mineral insulants may be safely used… in cladding systems incorporating metal or non-combustible sheeting supported by steel or timber framework and ventilated by a continuous cavity; *fire barriers are not essential*" (emphasis added).

482. As already noted, at that time ADB (1985) recommended that the external wall should be comprised of materials of limited combustibility. The 1986 BRE report on "overcladding the external walls of large panel system dwellings"[310] – which was "one of a series being prepared as part of BRE's programme of investigation to assist local authorities and their consultants in appraisal, maintenance and repair of large panel system dwellings" – noted that "there is generally no risk [from fire] when non-combustible materials are used for insulation *or overcladding*" (emphasis added).

483. The 1986 report went on to explain, however, that "there is an obvious risk of spread on the outer surface, which is already limited in highrise dwellings under the Building Regulations, but a small risk also exists for fire propagation within any cavity containing combustible insulation, for example with polyisocyanurate foam or polystyrene."

484. For the case of "combustible insulation and ventilated cavity", BRE's 1988 report highlighted that "recent tests have indicated that a risk of vertical flame spread may be associated with certain metal overcladding systems which incorporate combustible insulation, fixed adjacent to a ventilated cavity behind the metal cladding", that further research on this issue was ongoing, and that "designers of such systems for highrise blocks are urged to seek advice from BRE (Mr J Southern)."

485. The report therefore explicitly addressed the case of combustible insulation, but it did not address the use of combustible rainscreen products (as used within the Knowsley Heights refurbishment); whether achieving Class 0 or otherwise.

[310] Harrison et al. 1986, 26.

Figure 9 Architect Sydney Bolland showing a demonstration of the cladding system, and the cladding during installation. Stills from the BBC Two Documentary "The Fires that Foretold Grenfell".[311]

486. From my perspective, what is most notable about the report of the BRE investigation into the Knowsley Heights fire is the striking absence of any explicit discussion regarding the degree to which the GRP rainscreen product may have contributed fuel to the fire[312]. I find this particularly notable since Knowsley represented a highly significant project in the development of rainscreen cladding systems. I have found no documentary evidence to suggest that anyone openly asked the question: "*what was burning within the cladding at the top of the building?*". It appears that the sole focus regarding the fuel for the fire was on the refuse judged to have initiated the fire at the building's base.

487. I find it surprising (and alarming) that nobody appears to have taken an explicit and active interest in the *combustibility* of the "Class 0" GRP rainscreen product; at the time of writing I have seen no such interest evident in the documents made available to me.

488. Indeed, the fact that the rainscreen cladding at Knowsley Heights was combustible (and possibly also not Class 0 on its inside face), appears never to have been openly stated or discussed in any documentation that I have reviewed in my role as expert witness to the Inquiry.

489. The first (and to my knowledge only) explicit acknowledgement that the GRP rainscreen contributed to the fire at Knowsley Heights was in 2014 by Martin Shipp and colleagues.[313] This is contained within a BRE research report entitled "Investigation of real fires - External fire spread in multi-storey buildings", which had been undertaken for the (then) Department for Communities and Local

[311] https://www.bbc.co.uk/programmes/b0bqjp75.
[312] Whilst the reports of BRE investigations into the Knowsley Heights fire fail to comment in any detail on the contributions that might have been made by combustion of the Stenni GRP rainscreen cladding product, an 11 April 1991 article in *New Civil Engineer* magazine commented that "investigations [into the fire] will also examine whether the cladding panels helped *fuel* the fire" (emphasis added) ["Void fire promotes cladding review", New Civil Engineer, 11th April 1991.].
[313] {BRE00043751/5}

Government. In providing background into the issue of external fire spread in buildings, this report makes the following statement (emphasis added):

490. "The most significant of the historic [external] fires is that of the 1991 fire in Knowsley Heights; a residential block of flats which had been refurbished with the addition of thermal insulation to the external walls of the block. The fire started external to the block and *ignited the combustible cladding system*, resulting in extensive fire spread across the face of the building (mostly upwards)."[314]

491. I agree that the Knowsley Heights fire was the "most significant of the historic [external] fires", which is why the apparent failure to properly interrogate the key issues or make the necessary changes to the relevant guidance is so tragic with hindsight. The above quote also suggests an unarticulated knowledge of this issue within BRE going back for decades.

492. In addition, a key BRE summary of the investigation following the Knowsley Heights fire[315] appears to conflate "Class 0" products with "non-combustible" products. In the BRE report "Summary of fires investigated: April 1991 to March 1992" – which was produced as part of an ongoing contract for the Construction Directorate of the Department of the Environment, and in which it was noted it "should not be referred to in published work" – it is stated that "cavity barriers were not fitted [at Knowsley Heights] to allow unrestricted air movement and under DOE/BRE guidance at the time could be omitted where the cladding system was non-combustible".[316] This statement implies that the GRP cladding at Knowsley Heights was considered, at least by BRE, to be non-combustible.

493. However, as outlined in Paragraph 439, simply because a product achieves Class 0 does not mean that it is non-combustible, and I am surprised that BRE's fire investigators appear to have made this basic error.

494. Although there is no direct discussion of the contribution of Knowsley Heights' GRP rainscreen to the fire, the following statement in the BRE fire investigation summary report appears to allude to this possibility, and perhaps to an implied recognition that the guidance given in their 1986 overcladding guide[317] required amendment:

495. "Where Class 0 is called for, BRE suggests that it should be Class 0 on both sides of the cladding exposed to air".[318]

496. On the basis of the above summary it is apparent to me that the BRE investigation into Knowsley Heights failed to fully address the degree to which the presence of a combustible rainscreen may have contributed to the spread and magnitude of the fire. Even with the considerable benefit of hindsight, I struggle to understand how this factor could have been overlooked during these investigations. This is particularly the case given that the rainscreen product used at Knowsley Heights

[314] BRE Research Report {BRE00043751/6}
[315] {CTAR00000018/2}
[316] {CTAR00000018/3}
[317] Harrison et al. 1986.
[318] {CTAR00000018/3}

was a glass reinforced polyester composite, which will almost certainly have had some (and perhaps significant) potential to contribute fuel to an escalating external fire.

497. Similarly, in the reporting of the Knowsley Heights refurbishment and subsequent fire, there appears to have been some confusion, even within the BRE investigation team, regarding the distinction between "non-combustible" and "Class 0". While the GRP rainscreen products used are claimed to have achieved Class 0, it is unclear whether the product was tested on its aggregate-coated (i.e. external) face or on its uncoated (i.e. internal) GRP face, or independently on both. The subsequent BRE allusion to introducing a requirement for BS 476 parts 6 and 7 testing on "both sides" is suggestive, however, of a later recognition that the Knowsley Heights' rainscreen cladding had only achieved Class 0 on its outer (i.e. aggregate-coated) face.

498. To date I have not seen any evidence that provides clarity on this point.

12.3. Reputational Investment at Knowsley Heights

499. In reviewing the events surrounding Knowsley Heights, it appears that the Department of the Environment and BRE were significantly invested in the success of the Knowsley Heights overcladding scheme. Indeed, the overcladding of Knowsley Heights represented not one flagship policy, but many.

500. Knowsley Heights was a pilot scheme for the Estates Action programme, wherein government investment was intended to support local improvements; it was a pilot scheme for the new overcladding technologies that had been the subject of BRE review; it was a pilot scheme for the fire safety of such systems as informed by BRE's earlier large scale fire testing programme; it was also (to some extent) a pilot scheme for the new building regulatory system whereby new technologies could be deployed without meeting specific performance standards and via "alternative routes", rather than by strict compliance with Approved Document B.

501. I am aware that there is a relevant question with regard to overcladding schemes as to whether such work constitutes a "material alteration" such that it is "controllable" under the Building Regulations. At the time of the Knowsley Heights overcladding project, a material alteration was defined in the Building Regulations (1985)[319] as in the excerpt below:

> (2) An alteration is material for the purposes of these regulations if—
> (*a*) the work, or any part of it, carried out by itself would at any stage adversely affect the existing building in relation to compliance with the requirements contained in Part A (structure), paragraph B1 (means of escape in case of fire), paragraph B3 (internal fire spread — structure) or paragraph B4 (external fire spread) of Schedule 1, or
> (*b*) it involves the insertion of insulating material into the cavity wall of a building, or

[319] The Building Regulations 1985, 3399.

502. Whilst the extent to which an overcladding project might be considered to have the potential to "adversely affect the existing building" in relation to fire safety is certainly open to discussion and subjectivity, I consider that it is hard to argue that overcladding of an existing building (particularly using one or more combustible materials or products) does not constitute a "material alteration". I do not, however, hold myself out as an expert in this area, and I will therefore make no further comments on this issue.

503. The degree to which the above context of – and reputational investment in – the Knowsley Heights fire might affect the outcome of the subsequent fire investigation was not lost on commentators at the time. For instance, contributors to the satirical magazine, *Private Eye*, noted at the time that "The Building Research Establishment is not expected to make a great fuss of its report into the fire at Knowsley Heights, a showpiece council towerblock in Merseyside". They noted that "the new cladding experiment was acclaimed by the Department of the Environment and the British [sic] Research Establishment".[320]

504. As part of my work for the Inquiry, I have also reviewed the contents of File 'AT 66/389' at the National Archives at Kew, entitled "Investigation of the fire at Knowsley Heights, Huyton, Liverpool, 5 April 1991: results... ". This file contains an unstructured assortment of documents associated with the Knowsley Heights fire and its investigation, the full context of which is difficult to unpick with hindsight. However, the file does contain documents which highlight the particular context of, and potential interests involved in, this fire.

505. In a handwritten note dated 5th April 1991 (i.e. the same day as the fire), Alison Curtis of the Government's Housing Management Estates Action (HMEA) Division wrote to the Fire Research Station's (i.e. BRE's) Penny Morgan[321] as follows:

506. "Fire at Knowsley Heights, Knowsley. 5.4.91.

507. 1. I attach a news cutting about this fire, which is of particular interest to the Department in that Knowsley Heights is an Estate Action scheme, and was overclad using techniques relatively new to public sector housing in this country, but which are being replicated on other blocks now.

508. 2. The performance of the scheme in energy efficiency is being monitored by BRECSU[322] (Mr Don Ward[323]) and the buildability aspects of the overcladding were observed by BRE Scotlab. So we should have a lot of information on it in different parts of the department (or agencies).

509. 3. Can you advise me as to whether FRS is likely to be involved as a matter of course, or, if not, what steps I might need to take to involve FRS if it was agreed that it was desirable to do so.

---

[320] *Private Eye*. 1991. "Fire News," June 21, 1991.
[321] {INQ00014752}
[322] BRE Conservation Support Unit (BRECSU).
[323] Head of Housing at BRECSU.

510. 4. You will appreciate that it is the innovative and high profile nature of the improvements to the block which concern me, together with the suggestion that the fire spread up in behind the over-cladding."

511. No response to this note is recorded in the file.

512. File AT 66/389 also contains a note from Curtis on 8th April 1991[324] which states (amongst other things), that:

513. "the news from MTF and the consultant architect this morning is that the fire is being treated by Knowsley as 'insignificant'";

514. "the block performed well";

515. "the fire brigade are reported to be pleased with the performance of the block. It did not have vertical fire stopping which is in line with BRE recent advice in cases where all materials used in the over cladding and insulation are non combustible";

516. "the fire brigade is reported as supporting the absence of vertical cavity barriers in that, had these been present, the fire might have spread horizontally round the block, or the gases caused by combustion might have leap-frogged the barriers in any case";

517. "as far as implications for future projects of this type are concerned, the Fire Research Station will be involved in the investigation of this fire";

518. "apparently the London borough of Lambeth, where a similar but considerably different project is now in progress are content to proceed"; and

519. "the particular situation which occurred at Knowsley Heights, could not therefore be reproduced at Rundell."

520. The above comments are striking on various grounds. I do not understand the relevance of the fact that the fire is "being treated by Knowsley as 'insignificant'", unless there was some hope that this might be the case and that relevant parties would assist in playing down the significance of this fire.

521. I am surprised by the statements that "the block performed well" and that "the fire brigade are pleased with the performance of the block", and I struggle to understand how any such statements could have been made on the basis of the rapid and extensive vertical fire spread that had been experienced.

522. I note that Curtis also – and again wrongly – suggests that the Knowsley Heights overcladding was "non combustible."

523. I note the comment that "the fire brigade is reported as supporting" the narrative that the reason for the external fire spread was the absence of cavity barriers;

324 {INQ00014995}

rather than, for instance, the combustibility of the Class 0 "Cape Stenni" rainscreen panels.

524. Perhaps most strikingly, Curtis notes that "a similar but considerably different" overcladding project was then underway in Lambeth, apparently at a Building called "Rundell", but that the "situation which occurred at Knowsley Heights… could not … be reproduced at Rundell".

525. I have undertaken a planning application search on "Rundell Tower, Lambeth", and have found a 5th February 1992 issuance of "deemed planning permission" for Rundell Tower, Mursell Estate, Hampton Way, SW9.[325] The planned development, the original application for which had been submitted 17th August 1990, is described as follows:

526. "The recladding of the building and the provision of double glazed windows, together with the erection of an entry porch, refuse store, and railings."

527. The "condition(s)" of the planning permission approval include:

528. "The building shall be clad in Cape Senni [sic] cladding; colours snow white, oatmeal, sienna, salmon pink and sea green."

529. The consultant architect on the planning application authorisation is listed – as at Knowsley Heights – as Sydney Bolland (see Figure 9).

530. Based on the available evidence, I have not been able to determine what Curtis is referring to when she states that the Rundell Tower cladding system is "similar but considerably different", nor on what basis she asserts that an external fire spread event similar to Knowsley Heights "could not… be reproduced at Rundell".

531. I have also found a 19th October 2020 application for planning permission to Lambeth Council for "full replacement of flat roof, EWI replacement of cladding, replacement of existing windows/spandrel panels."[326] This was granted planning permission on 13th January 2021.[327] Appended to this planning application, I have found a "design access statement" prepared by Pellings on behalf of the London Borough of Lambeth,[328] which states that:

532. "A planning application for a major refurbishment to the building was made on 13th December 1991 (Ref. No: 90/00988/PLANAP - RUNDELL TOWER, MURSELL ESTATE, HAMPSON WAY, SW9). These works included: '...recladding of the building and the provision of double-glazed windows, together with the erection of an entry porch, refuse store and railings.' 'The building shall be clad in Cape Senni cladding; colours snow white, oatmeal, sienna, salmon pink and sea green. The entrance porch shall be roofed with steel cladding; colour sienna'.

[325] Deemed permission for development, Rundell Tower {LBY00000373}
[326] Application for Planning Permission, Rundell Tower {LBY00000374}
[327] Lambeth Planning Decision Notice, Proposed Development at Rundell Tower {LBY00000372}
[328] Design and Access Statement for 1-82 Rundell Tower {LBY00000375}

533. As the planning application was granted on 5th February 1992, I assume the cladding was installed later the same year or thereabouts, making these works circa 28 years old.

534. Rundell Tower is of the same architype as Kelvedon House a planning application [sic] to replace windows with PVCu, as well as install external cladding at Kelvedon House was made on 2nd September 1992 and granted on 8th September 1992. It is assumed works were completed post this date, circa 1993 making the cladding to both Kelvedon House and Rundell Towers of similar age and construction.

535. The existing external wall insulation on the block has been found not to comply with modern regulations relating to fire, particularly in relation to the horizontal fire breaks. The existing windows are also estimated to be the same age of the existing EWI system which is circa 28 years and are considered to reach the end of their design life."

536. If the above information is correct,[329] this could mean that Rundell Tower has, for almost three decades, been clad with the same (or similar) combustible Cape Stenni rainscreen cladding product that was used at Knowsley Heights, and – as at Knowsley Heights – installed with inadequate cavity barriers.

537. Regardless of the veracity of the above information, it is hard to consider as unimportant (for the Department for Environment, its HMEA programme, or indeed BRE) the fact that a Cape Stenni rainscreen cladding system was about to be installed on Rundell Tower at the time of the Knowsley Heights fire and its investigation – particularly in light of the note discussed beginning at Paragraph 539 below.

538. I have not been able to ascertain how many other similar buildings may have been reclad using "Cape Stenni" (or similar) GRP cladding materials after Knowsley Heights, but I believe that it would be prudent for government to examine the records of the HMEA scheme and to follow up on all funded projects that involved overcladding.

539. File AT 66/389 also contains a handwritten note from "Lyn" on 11th April 1991 which is addressed to "Mr Sage",[330] which reads as follows:

540. "Knowsley Heights.

541. You will wish to be aware of Alison Curtis' comments on the recent fire.

---

[329] I have some uncertainty about this due to some inconsistencies both within and between the 2020 planning application design and access statements prepared by Pellings for both Rundell Towers and the neighbouring Kelvedon House – which was also overclad in about 1992. Kelvedon House appears to have been overclad using a "STOtherm Classic 'Rainscreen' system", which is essentially an EPS-insulted render system, rather than a classical ventilated rainscreen as used at Knowsley Heights. It appears that the only way to determine the reality here would be to personally undertake an inspection of Rundell Towers.

[330] 'Knowsley Heights', handwritten note from National Archive File AT 66/389 {INQ00014755}

542. We have received, via HMEA, a request from M. St Press Office to play down the issue of the fire. Our briefing for S of S is purely factual and as far as I am aware Knowsley will not be making an issue of the fire."

543. I assume that "M. St Press Office" is referring to the Press Office of the Department of the Environment, in Marsham Street, London, and that "S of S" refers to the Secretary of State. No response to this note is recorded in the file.

544. With hindsight, if the fundamental fire hazards that appear to have been generated by the combustibility of the Cape Stenni GRP rainscreen used at Knowsley Heights had been explicitly addressed at that time – for instance by implementing a recommendation for rainscreen cladding products to be materials/products of limited combustibility rather than simply Class 0 – I consider it likely that the Grenfell Tower fire, a number of other external cladding fires discussed throughout the remainder of this report (some of which were fatal), and much of the current post-Grenfell cladding crisis, could perhaps have been avoided.

545. As it transpired, *Private Eye* were correct to predict no "great fuss" about the Knowsley Heights fire. However, there was an upcoming opportunity to make changes to Approved Document B.

12.4. Approved Document B (1992)

546. The first editions of the Approved Documents in 1985 had – notwithstanding my specific comments in the preceding sections – largely been a transcription of the previous legislation into a new format, with additional diagrams and instructive commentary. However, during the late 1980s a "Stage Two Review of the Building Regulations" was undertaken.[331] With a focus on life safety (as opposed to property protection) and egress,[332] this led to the reissue of the Approved Documents in 1992.

547. The main change related to fire safety was that the measures described in the Approved Document for egress were no longer mandatory (Approved Document B 1992, pp. 1).[333] The 1992 edition also made reference to the new European Construction Products Directive[334] that would (in subsequent decades) lead to significant changes in the fire test methods and standards referenced within Approved Document B.[335]

548. The 1992 version of Approved Document B, which also referenced an updated version of the Building Regulations (1991), contained a number of notable changes and updates. The section "Main changes in the 1992 edition" highlighted that provisions for cavity barriers had been "simplified" but that "cavity barriers are needed in rainscreen cladding to tall buildings"; it seems reasonable to assume that this was a direct result of the investigation into the Knowsley Heights fire. This section also noted that combustible insulation was hence "precluded from external

[331] Fire and Building Regulations, A review by Bickerdike Allen Partners, 1990, pp 5 {FBU00000153/12}
[332] {FBU00000153/13}
[333] Approved Document B 1992, 1.
[334] Construction Products Directive (Council Directive 89/106/EEC)
[335] Approved Document B 1992, 6.

wall construction in buildings with a storey at over 15m[336] above ground" and that for external wall surfaces "controls relate to performance rather than to specific materials".

549. Similar to the 1985 version, Approved Document B (1992) continued to include instructive introductory commentary on the use of the Approved Documents and the extent to which they could be used as "Evidence supporting compliance"[337] (see Para 403). It also now included a caveat that: "the detailed provisions in the approved documents are intended to provide guidance for some of the more common building situations".

550. The Building Regulations requirement B4 was also changed, in that the word "adequate" no longer appeared within Requirement B4, and that the requirement consequently read as absolute. The updated B4 stated that:

551. "the external walls of the building shall resist the spread of fire over the walls and from one building to another, having regard to the height, use and position of the building."

552. Approved Document B 1992, however, recasts the objective of Requirement B4 as follows:

553. "that external walls and roofs have *adequate* resistance to the spread of fire in the external envelope…" (emphasis added).

554. In the 1992 version of Approved Document B, it is noted that:

555. "in the Secretary of State's view the requirements of B4 will be met… if the external walls are constructed so that the risk of ignition from an external source, and the spread of fire over their surfaces, is restricted by making provision for them to have low rates of heat release."

556. Comparing this text with that set out in ADB 1985, and with the Knowsley Heights fire of 1991 in mind, this new and explicit reference to the spread of fire over external surfaces appears to signal a renewed recognition of the dual intent of Regulation B4. Explicit reference to "ignition from an external source" is also conspicuous, in light of the initiating fire source that had been apparent at Knowsley Heights.

557. As regards specific provisions for "External walls", the 1992 version of ADB stated that its provisions were made:

558. "in order to reduce the [external wall] surface's susceptibility to ignition from an external source, and to reduce the danger from fire spread up the external face of the building."

[336] Note the "trigger height" of 15 metres which is quoted for the preclusion of combustible insulation in external walls.
[337] This text on "evidence supporting compliance" is absent from subsequent versions of Approved Document B, for reasons unknown to me.

559. To accomplish this, a new diagram (Diagram 36, see Figure 10 below) was introduced to describe and illustrate the recommended classifications for "external surfaces" – this diagram essentially required external wall *surfaces* to be Class 0 above 20 m[338].

560. It was also stated that both the inner *and* outer surfaces of "rainscreen" cladding construction should achieve the recommended classifications in Diagram 36 – i.e. Class 0 above 20 m.[339] It was again stated that these controls related to "performance rather than to specific materials".

561. Class 0 in 1992 was defined on the same basis as in 1985 (see Paragraph 436). Indeed, the 1985 definition of Class 0 remained the same until its effective withdrawal in 2019. Limited combustibility (and indeed non-combustibility) in 1992 was defined on the same basis as in 1985 (see Paragraph 425).

562. In relation to the use of combustible insulation in the external walls of highrise buildings, a reference was introduced to BRE's 1988 fire testing programme[340], noting that "advice on the use of thermal insulation material is given in the Building Research Establishment Report 'Fire performance of external thermal insulation for walls of multi-storey buildings' (BR 135, 1988)". However, a separate clause (Clause 12.7, sitting below a heading of "External wall construction") recommended that above 20 m "insulation material used in the external wall construction" should be of "limited combustibility". [341, 342]

563. The apparent "illogicality" of discussing the risk presented by combustible insulation and then "almost banning" such materials was noted in a contemporaneous reviews of the new documents.[343] Nevertheless, the reference to BRE's 1988 fire testing report at least suggested that methods other than those outlined in Approved Document B could be used as an alternative approach to meet the functional requirements of the Building Regulations (1991).

564. As with the 1985 version of Approved Document B, the updated 1992 document indicated that *any product that was found to be of limited combustibility could automatically be assumed to be Class 0*. This was further emphasised in a report by the Bickerdike Allen Partnership, who were commissioned by the Department of the Environment to produce an illustrated text on the fire safety principles underlying then current English legislation.

565. The Bickerdike Allen Partnership report[344] was co-authored by Philip Thomas, a veteran of the Fire Research Station and one of the creators of the BS 476 Part 6 test in the mid 1950s. The report noted that "non-combustible materials are

338 Note the increase in "trigger height" from 15 m in 1985 to 20 m in 1992, without any explanation being given within the Approved Document, and without this change being highlighted in the "main changes in the 1992 edition" section (or at least, being erroneously highlighted – see Para 548).
339 Approved Document B 1992, 72.
340 Rogowski et al. 1988.
341 Approved Document B 1992, 72.
342 This restriction did not apply to masonry cavity walls meeting certain other recommendations which are not rehearsed here.
343 Dickinson et al. 1992.
344 Design Principles for Fire Safety, Bickerdike Allen, Department of the Environment, 1996.

inherently Class O".[345] It did not, however, explicitly state that the converse was not also true; i.e., that Class 0 materials could *not* automatically be assumed to be non-combustible.

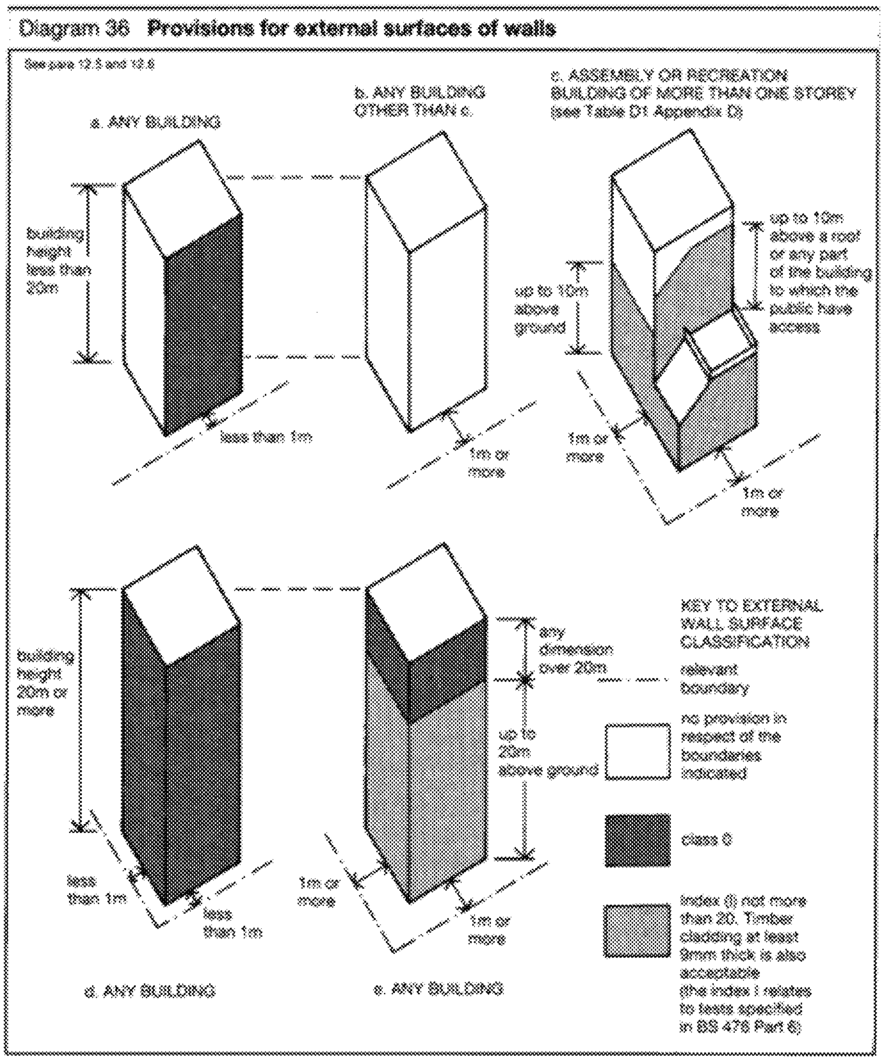


Figure 10 "Diagram 36" from the 1992 Edition of Approved Document B.

566. Thus, whilst the possible contribution of Knowsley Heights' Class 0 rainscreen panels appears not to have been explicitly addressed (or at least, highlighted) during the investigations into the Knowsley Heights fire, the 1992 updated guidance sought to ensure that Class 0 was achieved on both surfaces of rainscreen cladding. With hindsight, it is hard for me to imagine this as being a coincidence.

567. In my opinion, this occurrence is likely to represent an example of a significant change being made to Approved Document B, apparently without any public acknowledgement of either the motivation for the change, or the fact that the previous guidance had not been sufficient to mitigate against fire hazards presented by materials and products in the external wall.

[345] Design Principles for Fire Safety, Bickerdike Allen, Department of the Environment, 1996, 124.

12.5. Further Cladding Fire Testing

568. The Knowsley Heights fire and its investigation are also notable in that they led to a new, government funded research programme at BRE. Just three years later, in 1994, BRE's Raymond Connolly[346] reported a series of 10 large scale external fire spread tests on various cladding systems. Unlike the previous BRE work, which had focused on the hazards presented by combustible insulation products, this new project was – unsurprisingly with the Knowsley Heights fire and the conclusions of its investigation as a contextual backdrop – more focused on the properties of the rainscreen products used, and on the type and placement of *cavity barriers*.

569. The tested cladding systems were similar in build-up to the cladding arrangement used at Knowsley Heights. In fact, Test 2 of this programme appears to have been almost a reconstruction of the Knowsley Heights cladding system and fire – being built up from GRP (polyester) rainscreen panels with an outer aggregate finish, mineral fibre insulation, and initiated by an *external* crib fire.[347] The test programme used similar systems with various combinations of cavity barriers and rainscreen cavity widths.

570. The rainscreen panels used in this programme had previously been tested and found to achieve Class 0 "on both the front and rear faces".[348] The test on the reconstructed Knowsley Heights arrangement (Test 2) showed that "under direct thermal attack from the crib fire, the cladding sheeting quickly softened, distorted and ignited", and that "on burning, the sheeting material disintegrated and allowed fire access to the open cavity". The entire façade "quickly became involved in the fire, with burning on both the front and rear faces of the cladding sheet", there was "unlimited vertical spread of fire over the full height of the test facility", and "flames would probably have spread to upper storeys had they been present".

571. This led Connolly[349] to two key conclusions, namely:

572. that "the reaction to fire properties of the sheeting materials [i.e. that the rainscreen sheeting was Class 0 on both faces] *do not* give a true indication of the potential fire hazard" (emphasis added);[350] and

573. that there was a "need for some form of fire barrier protection with the polyester bound sheeting [i.e. the GRP rainscreen panels]".

---

[346] {RCO00000001}
[347] pp 12-14 {RCO00000001/16}
[348] pp 8 {RCO00000001/12}
[349] pp 14 {RCO00000001/18}
[350] Thus, by at least as early as 1994 BRE and the Construction Sponsorship Directorate of the (then) Department of the Environment (DOE) should have been aware that Class 0 did not give a true indication of the potential fire hazard of a rainscreen product, and that this fact could contribute to a cladding system experiencing "unlimited vertical spread of fire over the full height" of a cladding system.

Figure 11 Tests reported by Connolly (1994)

574. The other tests in the research presented by Connolly were on similar systems with various different cavity barrier arrangements. Taken together, they demonstrated that the presence of a cavity barrier could have *some* impact on the spread of fire, but that ultimately *the "effectiveness of the barriers [was] dependent on the nature of the cladding sheeting materials"*.[351]

575. In summarising his work, Connolly wrote that *"it is clear that the BS 476 Parts 6 and 7 tests do not accurately reflect the fire hazards that may be associated with cladding systems"*.[352]

576. He also suggested that to determine the appropriate cavity protection, it would be necessary to consider the cladding system *as a whole*.

[351] pp 43 {RCO00000001/47}
[352] pp 42 {RCO00000001/46}

577. Finally, he suggested that there was a need for full-scale testing of systems to assess the combination of fire barrier systems when used in conjunction with different sheeting products.[353]

578. It is notable that the clear focus of Connolly's report is on the hazards presented by the cavity, and on the need for cavity barriers. The focus of the discussion is very much on the type and location of the cavity barrier and how its presence mitigated (or not) the hazard presented by the cladding system. The combustible nature of the rainscreen is not directly addressed, and the degree to which fire might spread in the absence of a combustible rainscreen is not interrogated or discussed.

579. In the context of the investigation into the Knowsley Heights fire; the lack of "great fuss" that it generated; the potential interests of the various agencies involved; the fact that – at the time of this fire – the HMEA programme was funding the refurbishment of other highrise social housing blocks with similar cladding systems, materials, and products (see discussion beginning Paragraph 524); and the 1992 updates to Approved Document B; I consider this to be striking.

580. Connolly's approach appears to have been as follows: Given that ADB allows Class 0 rainscreens, and given that Class 0 does not fully address the fire hazards associated with Class 0 (yet combustible) rainscreens, what mitigations could/should be introduced in order to reduce the hazards to acceptable levels? The question of *whether a Class 0 rainscreen was/is appropriate* does not appear to have been asked; or, if it was asked, this was not articulated or investigated.

581. I consider the Knowsley Heights fire, its investigation, and Connolly's subsequent research to represent significant missed opportunities to explicitly address the potential hazards associated with combustible Class 0 rainscreen products.

582. I understand that the Inquiry obtained Connolly's 1994 report directly from the author, and that BRE was – for whatever reason – unable to provide the Inquiry with a copy.

12.6. The Group of Eight

583. I discuss other notable missed opportunities in the subsequent sections. However, in the period 1986 to 1996, there is one other development to which I would like to draw the Chairman and the Panel's attention.

584. When Michael Heseltine became Secretary of State for the Environment in 1979, the construction industry's representations to government were made largely via an organisation known as the "Group of Eight". The group consisted of representatives of three professional institutions (The Royal Institute of British Architects (RIBA), The Royal Institution of Chartered Surveyors (RICS), The Institution of Civil Engineers (ICE)), three employer trade associations (The National Federation of Building Trades Employers (NFBTE), The Federation of Civil Engineering Contractors (FCEC), The National Council of Building Material Producers (NCBMP)), and two trade unions (The Union of Construction, Allied Trades and

[353] pp 45 {RCO00000001/49}

LBYP20000001_0111

Technicians (UCATT) and The Transport and General Workers' Union (TGWU)).[354] Their role was to influence government policies that might directly or indirectly affect the level of construction demand.

585. The group was typically chaired by the sitting RIBA president, and when Heseltine took office the Group of Eight pressed him to "spare the construction industry" from government cuts.[355] However, the success of the group at increasing (or maintaining) spending was limited. By the mid-1980s, the influence of the Group of Eight had diminished, and various other groups were beginning to claim that *they* represented the construction industry. One such organisation was the Building Industry Council,[356] forerunner to the Construction Industry Council (CIC). As an organisation it was initially "pooh-poohed" by the establishment,[357] but it quickly proved to be an "important step" providing the industry with a "single voice in one umbrella body".[358]

586. As previously noted, the Building Act 1984 opened a route to "flexibility", and the Building Regulations and Approved Documents issued in 1985 enabled this flexibility in practice. However, other aspects of Heseltine's intended reforms did not result in such rapid change. Concerns about the *liability* that might fall upon a private building control officer meant that the NHBC were the only organisation who were licenced to perform the role of a private building control (i.e. approved inspector).[359] This remained the situation for the subsequent decade.[360]

587. However, in the mid 1990s there was a concerted effort to "deal with the insurance problem".[361] The Construction Industry Council were, by this time, comfortably established as the leading voice "for professionals" within the construction industry. With fortnightly meetings with ministers and as a key supporter of the Latham Review, the CIC became a key part of the mechanism for realising the vision of creating a private building control industry.[362]

588. In 1996 the Secretary of State nominated the CIC as a designated body for approved inspectors. This meant that as well as representing construction professionals, the CIC (via the Construction Industry Council Approved Inspectors Register (CICAIR)) was also the body charged with licencing privatised building control.[363] The Minister for Construction, Nick Raynsford, speaking in 1998, noted that "wider competition between approved inspectors and local authority building

354 Connaughton et al. 1983.
355 "Group of Eight Urges Heseltine to Spare Construction Industry." 1979. *The Architects' Journal* 170 (42): 814.
356 New Civil Engineer. 1998. "Speaking with One Voice," October 22, 1998.
357 Forty heads on one peacock: *Ten years of the Construction Industry Council. 1998,* Andrew Ramsey.
358 Forty heads on one peacock: *Ten years of the Construction Industry Council. 1998,* Tony Blair.
359 Billington 1986.
360 DEREGULATION COMMITTEE. FOURTEENTH REPORT. THE PROPOSAL FOR THE DEREGULATION (BUILDING). 1996.
361 Cecil 1994
362 Matheou 1996.
363 Stephenson 2005.

control should be a stimulus to greater efficiency and higher standards of service to the customer".[364]

589. Thus, in the period from 1986 until 1996, the vision that Heseltine had initially set out in 1979 was largely realised. The construction industry had been granted the flexibility that it had been seeking, essentially since the 1930s, and the creation of private building control meant that designers and contractors were no longer (necessarily) limited by constraints applied by Local Authority Building Control. The "race to the bottom"[365] had begun.

13. Harmonisation (1997 to 2002)

13.1. The Privatisation of BRE

590. Although Heseltine's vision had been largely realised in the previous decade, initially in the period around 1996 BRE remained a government funded organisation. In November 1995 however, John Gummer (the then Secretary of State for the Environment) had decided to investigate the possible privatisation of BRE. He wished "to see BRE's expertise more directed towards stimulating innovation in construction and to helping industry improve its performance and competitiveness". He also stated that he believed "that closer links between BRE and industry will be achieved more effectively if BRE were in the private sector".[366]

591. Following a review, the Government decided to proceed with BRE's privatisation. However, there were concerns that transitioning to a profit-making organisation might compromise the independence of the advice that BRE was able to give.[367] During the initial discussions on privatisation, the CIC formulated a working group led by Arup's Turlogh O'Brien, who proposed a plan for a National Centre for Construction. This plan initially found favour with ministers, with the CIC pitching the idea to the then Deputy Prime Minister, Michael Heseltine. However, as noted subsequently by the CIC's Graham Watts, "politics is ever a fickle business" and Gummer ultimately decided to put the sale of BRE to competitive tender.[368]

592. The winning tender was from a not-for-profit "Foundation for the Built Environment" that had been established by BRE's own management team. The sale was finalised on 19th March 1997.[369]

13.2. European Reaction-to-Fire Classification

593. Coincident with this period of organisational upheaval at BRE, the influence of Europe on UK building regulations was growing. The Construction Products Directive that had been introduced into the Approved Document B in 1992 had led to the initiation of a pan-European project to create a "harmonised" set of reaction-

[364] HC Deb: Vol. 308 Col. 192 (1998).
[365] Hackitt 2018, 5.
[366] HC Deb 07 November 1995 Vol 265 Col. 747.
[367] Courtney 1997.
[368] Watts 1997.
[369] Courtney 1997.

to-fire tests.[370, 371] As already noted, British testing standards had been updated during the 1970s and 1980s with various new BS 476 fire tests and explanatory documents. However, the core British reaction-to-fire test methods remained those that had been initially developed in 1932 (combustibility), 1946 (surface spread of flame), and 1968 (fire propagation). The European Construction Products Directive required that UK authorities should accept certification from elsewhere in Europe[372]; however, at the time there was no agreed set of harmonised fire tests that could be universally applied.

594. In 1988, a new approach to creating a harmonised reaction-to-fire classification system for materials and products was proposed.[373] This was based on a test where a small gas burner was placed in the corner of a realistic scale room; hence the "Room Corner Test". The room was lined with the construction products of interest, and the growth of the fire (and time to flashover[374]) were noted. It was proposed to rank construction products based on the heat released during the fire, and on whether the fire grew to flashover. Classifications included Class A (i.e. very limited burning, no flashover), Class B (the room approaching, but not achieving flashover), through to Class E where flashover occurred after just two minutes.

595. The logic of the classification system was based on the relevant hazard being a small (and growing) fire within a room. However, the test was large (3.6 × 2.4 × 2.4 m), and therefore expensive in both money and time. Thus, during the 1990s a series of linked research projects were undertaken at the behest of the European Commission to develop a reaction-to-fire classification test that was smaller, but that could give essentially the same information as at the real scale compartment test as regards the relevant fire hazards.[375]

596. The eventual result, after more than five years of development, regulatory wrangling, round robin testing, and debate across Europe, was the Single Burning Item (SBI) test – EN 13823.[376] The SBI (previously described in Part I of this report, and by Dr Lane[377]) did not test an entire room, but rather only the corner of a room next to a small, triangular gas burner. The growth rate of, and the total heat

---

370 Wickstrom 1993.
371 Matheou 1996.
372 The introduction of the Construction Products Directive, and its implications for UK regulations – are discussed in some detail within the introductory sections of the amended (2002) edition of Approved Document B (2000), where it is noted that, "the implementation of the Construction Products Directive (CPD) will necessitate a time period during which national (British) Standards and European technical specifications will co-exist. This is the so-called period of co-existence. The objective of this period of co-existence is to provide for a gradual adaptation to the requirements of the CPD. It will enable producers, importers and distributors of construction products to sell stocks of products manufactured in line with the national rules previously in force and have new tests carried out. The duration of the period of co-existence in relation to the European fire tests has not yet been clearly defined."
373 Sundstrom and Goransson 1988, 17.
374 "Flashover" is a term which is used within the fire science and engineering community to describe a set of conditions within a fire compartment wherein, according to Drysdale (2011), "there is an onset of a very rapid change in the character of the fire, from localized burning to full room involvement, when all combustible items are burning". Drysdale also notes that "Anyone who has not escaped from a compartment before flashover is unlikely to survive."
375 Mierlo and Sette 2005.
376 BSI, 2002c.
377 Lane, Oral evidence to the Inquiry, 10th November 2020, {Day68/61:} – {Day68/75:}.

released from, the fire when testing in this smaller configuration was measured – and the results compared to the Room Corner Test. Researchers observed what they collectively considered to be a reasonable correlation between the fire growth rates in the SBI versus those in the Room Corner Test. Thus, they concluded that it was possible to use the results of SBI tests to *infer* conclusions about the results that could be expected from an equivalent Room Corner Test.[378]

597. A new classification system was subsequently proposed that was fundamentally based on the SBI test. However, rather than using the Room Corner Test and its original classifications, the original Classes of A to E were coupled directly to behaviours from the SBI test. The intent was that Class A or B products would not induce a flashover, whereas Classes C to E would allow for "grading" of products that *could* induce a flashover.

598. The threshold for Class A was set to align with products that were *collectively perceived* as not presenting significant fire hazards (i.e. totally non-combustible products, mineral wool, and plasterboard). However, it was quickly recognised that some countries had a regulatory need to distinguish products made a *little* contribution to a fire from those that were "truly" non-combustible, Class A was split into Classes A1 and A2 – whereby A2 represented products such as plasterboard – which has paper facing that can be expected to burn in a fire – and A1 included products with even less combustible content.

599. To allow distinction between A1 and A2 materials and products, an even more sensitive test method was required.[379] Two pre-existing reaction-to-fire test methods were considered sufficiently sensitive to allow this distinction to be made: (1) the bomb calorimeter (EN ISO 1716[380]) – using a scientific piece of equipment for measuring the heat of combustion of a material – and (2) a "non-combustibility test" (EN ISO 1182[381]) which was essentially the same as the BS 476 Part 4 test that was, in turn, based on the 1932 edition of BS 476 and the NFPA's original test method from 1915.

600. The culmination of this research activity was a European Commission Decision in 2000,[382] wherein it was decided that the new reaction-to-fire classification system, the "Euroclass system" (EN 13501-1[383]), would be adopted across the European Community. Member states would be allowed to determine and dictate which classifications would be required for particular building applications; the classification method, however, would be *harmonised* throughout Europe.

601. Of particular note from the European Commission Decision is its statement of applicability to construction products, that "may contribute to the generation and spread of fire and smoke within the room (or area) of origin or beyond". The

[378] Messerschmidt 2008.
[379] Ryber and Hedskog 1998.
[380] ISO 1973.
[381] ISO 1990.
[382] 2000/147/EC Commission decision of February 2000, European Commission.
[383] BSI 2002a.

implementation of the decision was delayed until 2002, since the SBI standard had not yet been published.

602. The new European classification system is notable for several reasons.

603. As with England's pre-existing reaction-to-fire classification system (i.e. classes 1 through 4 and Approved Document B's additional Class 0), EN 13501-1 was a *composite* classification system that relied on various test methods to construct the full range of classifications.

604. EN 13501-1 was constructed on the basis of a similar logic to the National class system; it purported to relate the behaviour of a product in particular test methods and apparatus to the behaviours of the product in larger, more realistic fire scenarios. As with the BS 476 Part 6 test that had been developed during the 1950s and 1960s, an attempt was made to link the product classification method to the rates of growth of a fire *in a room*.

605. However, there were two key differences between the National classification system and the new EN 13501-1 system. First, the room on which the classification system was based (and calibrated) was a realistic scale room, as opposed to the British work which had been based on a smaller scale model of a room. Second, both the full-scale Room Corner Test[384] room and the SBI testing apparatus[385], were equipped with *oxygen consumption calorimetry* – a novel measurement technology that had been unavailable to the British researchers of the 1950s (because it had not yet been invented).

606. The new test method thus included more direct and useful measurements (i.e. heat release rate) of the fire hazards that might be presented by different materials or products *when used within a room*. In many respects, the EN 13501-1 approach can therefore be seen as following the same logic as the pre-existing National classification system, however with a more advanced quantification of the fire hazards based on state-of-the-art measurement techniques.

607. As already noted in Part I, despite the SBI's implementation via the European Directive of 2000, there was disquiet in some quarters because it could not easily classify some products. EN 13501-1 classification of "exotic" composite panels – with combustible cores and external metal skins[386] – was felt by some to be dangerously misleading.

608. Nevertheless, despite the perceived inadequacies of the SBI test to accurately reflect the fire hazards presented by metal faced polymer-filled/cored panels, the European decision allowed some such panels to achieve advantageous European classifications and associated CE marks. Some of the relevant concerns were noted, for example, by Birgitte Messerschmidt in 2008 when she characterised such situations as "a very sad example of unsafe classification", and an example of "what happens when [people] forget the basic principles behind the test". She

[384] ISO 1993.
[385] BSI 2002c.
[386] Messerschmidt 2008.

rhetorically asked, "if you make a product that is going to go on a facade, who wants a reference scenario that's a fire in a room?".[387]

13.3. RADAR 2 and the "Transposition" of European Classifications

609. Despite these shortcomings, UK governments were obliged by the Construction Products Directive to update the relevant guidance and to include reference to the new European classification method. However, an immediate and wholesale change to the new classification system, without a suitably long transition period, could have led to market disruption within the construction sector.

610. Needing to understand how the new European classification system should be implemented within the existing British regulatory context, and rather than seeking advice from the recently privatised BRE, the Department of the Environment, Transport and the Regions (DETR) commissioned Warrington Fire Research Centre to undertake a study, called the "RADAR 2 Project", to compare the classifications of various products when tested in accordance with the existing National classification approach versus those obtained using the new European approach.[388]

611. The stated objective of the study "was to ensure that no significant change to the regulatory status quo would occur due to the introduction of the new reaction to fire tests".[389]

612. The project involved "back-to-back" testing "to compare and correlate product performance on both current UK and future European systems", and was overseen by an Industry Advisory Group (IAG) with representation from the wood, mineral wool, paints, cellular plastics, wallcoverings, board and sheet products, and plastics industries.

613. Table 2 provides a summary of the various testing standards considered during the RADAR 2 project[390].

[387] Messerschmidt 2008, https://youtu.be/bYuj7KNXi_A.
[388] {CLG00000949}, {CLG00000950}, {CLG00000951}
[389] Briggs 2002.
[390] {CLG00000949}, {CLG00000950}, {CLG00000951}

Table 2 Summary of the National and European testing standards considered during the RADAR 2 project[391]

Jurisdiction	Test Standard	Descriptor
National Methods	BS 476 Part 4	Non-combustibility test for building materials
	BS 476 Part 6	Method of test for fire propagation of products
	BS 476 Part 7	Method of classification of the surface spread of flame of products
	BS 476 Part 11	Method for assessing the heat emission from building materials
European Methods	prEN ISO 11925-2	Ignitability when subjected to direct impingement of flame
	prEN 13823	Single Burning Item (SBI) test
	prEN ISO 1182	Non-combustibility test
	prEN ISO 1716	Determination of the calorific value (bomb calorimeter)

614. Back-to-back testing using the above methods was performed on a total of 65 different[392], representative construction products including those used for internal wall and ceiling linings, within concealed spaces (cavities), in the construction of external walls, and various plastics (glazing, lighting diffusers, insulated panels). These included fourteen products incorporating cellular plastics, and fourteen other plastics that were "supplied in a variety of polymer types and physical forms". I will not provide a full summary of the results here.

615. Warrington Fire Research Centre used the data obtained to develop and propose a "transposition" of the National classifications into the Euroclass system (but not *vice versa*). The overall results of this transposition are shown in Figure 12 below.

[391] {CLG00000949}, {CLG00000950}, {CLG00000951}
[392] The RADAR 2 Project Report 1 {CLG00000950} states that 65 products were evaluated, however the RADAR 2 Project Report 2 {CLG00000951} states that 64 products were evaluated.

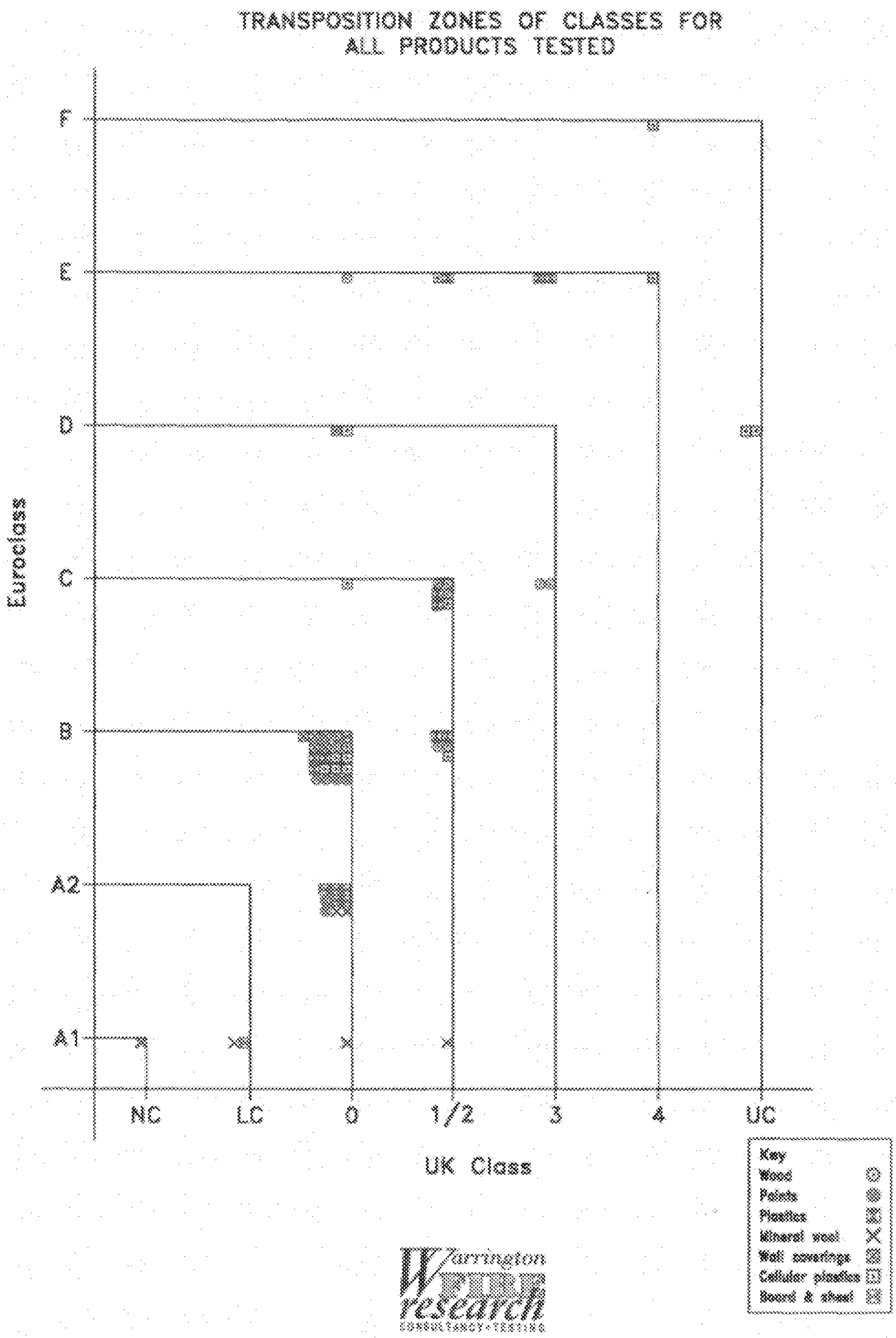


Figure 12 Extract from RADAR 2 report, showing the comparative classifications of various construction products when assessed in accordance with National and European classification systems.[393]

616. In general, it was found, as is visually apparent from Figure 12, that there was "no overall correlation between the Euroclass system and the UK system".[394]

[393] {CLG00000951/15}
[394] Briggs 2002.

LBYP20000001_0119

617. Whilst it was determined that *several* of the products which achieved Class 0 in the National classification system achieved class B in the European system, there were some significant discrepancies. For example, where foil-faced polyisocyanurate (PIR) and phenolic foam (PF) insulation products achieved Class 0 in the National classification system, they were only able to achieve classes D and C, respectively, in the European classification system. The authors of the RADAR 2 Project Report 2 commented specifically on possible reasons for this discrepancy:

618. "With these products it was observed that in the SBI test, the aluminium foil facing was penetrated such that the underlying foam was then available to contribute to the rate of heat release calculation whereas in the UK BS 476:Part 6, the heat release found in that test was not sufficient to displace the classification away from the UK class 0. Clearly, the introduction of a simple replacement of the UK Class 0 by a Euroclass B requirement in any regulatory procedure would discriminate against [these products] against the practical experience of their acceptability in the UK market for Class 0 applications."[395]

619. The above is a clear and explicit statement recognising that retention of the National classification system, and retention of "Class 0" in particular, in parallel with – rather than being replaced by – the introduction of the new European classifications, was important so as to avoid "discriminating" against foil-faced PIR and PF polymer foam insulation products (e.g. products such as Celotex RS 5000 or Kingspan K15). And this was regardless of their comparatively poor reaction-to-fire performance when assessed against the Euroclass system.

13.4. Approved Document B (2000/2002)

620. Despite the (unsurprising) observation that it was not possible to make a universal statement of equivalence, or transposition, between the National classification system and the Euroclass system, in May 2000 Warrington Fire proposed a "possible option for transposition of classes for reaction-to-fire performance" as shown in Figure 13. This transposition was then implemented in the 2002 (and subsequent) editions of Approved Document B.[396]

621. Whereas previously it had been recommended that the external surfaces of walls on tall buildings should be Class 0[397] – this was now supplemented by "Class B-s3, d2 or better"[398] via the European Method as an *alternative*. The external surface could now be *either* Class 0 *or* Class B-s3, d2.[399]

---

[395] {CLG00000951}
[396] Approved Document B, 2002.
[397] With Class 0 defined in the same manner as in the 1992 edition of Approved Document B.
[398] The use of "s3" and "d2" in the European classification essentially indicated that the guidance in Approved Document B controlled neither smoke production nor the production of burning droplets/debris. This lack of control was logical in the context of a comparison with the National classes – as the national classes did not specifically control smoke or droplet production.
[399] It is noteworthy that both the 2000 and 2002 amended versions of Approved document B contain the following text on the replacement of National class standards by European harmonised standards: "The Department intends to issue periodic amendments to its Approved Documents to reflect emerging

British class	Euroclass
Non-combustible	A1
Limited combustibility	A2
0	B
1	C
3	D
Unclassifiable or no performance determined	F

Figure 13 DTLR proposed transposition for reaction-to-fire performance.[400]

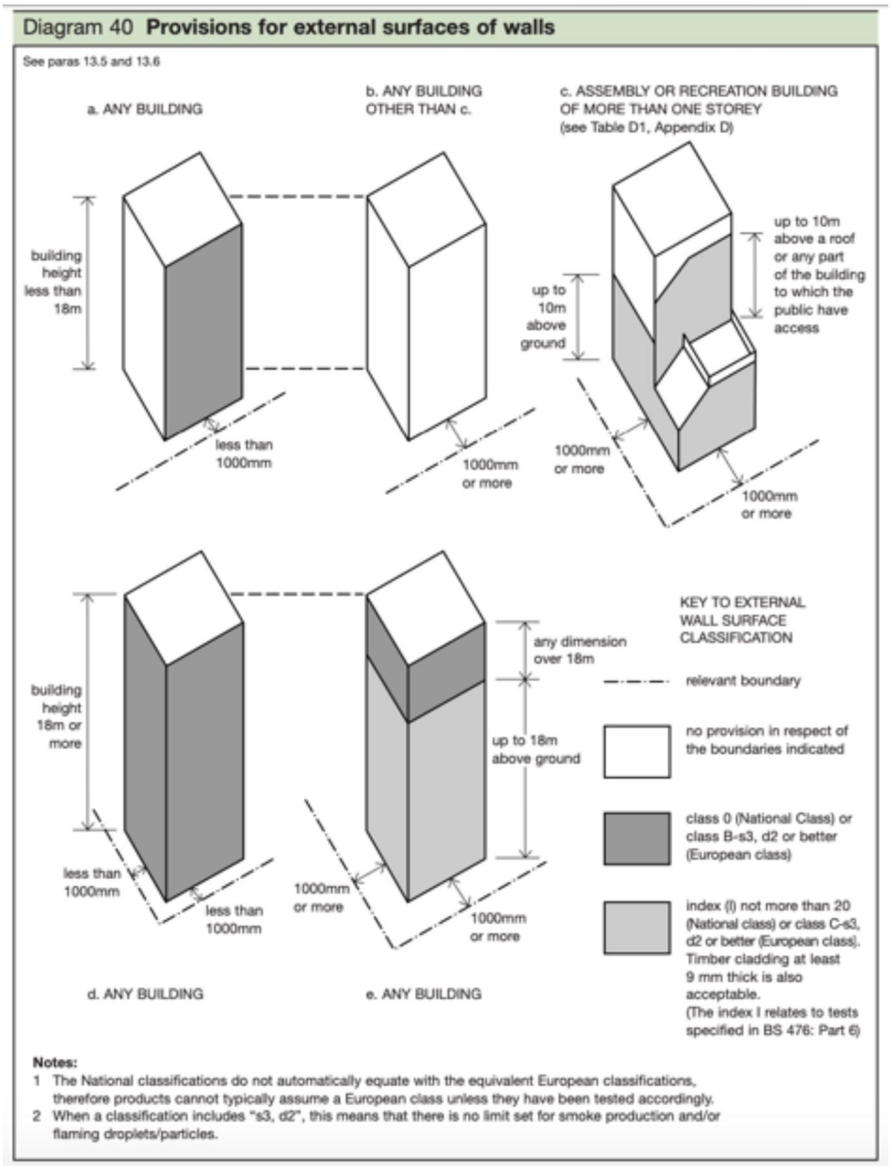
622. However, to highlight the *lack of true equivalence* between the European method and the National Class method, the guidance noted that National classification did not automatically equate with equivalent European classifications (as shown in Figure 14):

623. "The National classifications do not automatically equate with the equivalent European classifications, therefore products cannot typically assume a European class unless they have been tested accordingly."[401]

harmonised European Standards. Where a national standard is to be replaced by a European harmonised standard, there will be a co-existence period during which either standard may be referred to. At the end of the co-existence period the national standard will be withdrawn."

400 "The impact of changes to approved Document B to accommodate the new Euroclass reaction to fire classification systems." Briggs, Peter The Architects' Journal (Archive: 1929-2005); May 23, 2002; 215, 20.

401 The statement that "products cannot typically assume a European class unless they have been tested accordingly" is odd; would most readers assume that the converse was also true? I.e. is it also the case that products cannot typically assume a National class unless they have been tested accordingly?



624. Figure 14 Diagram 40 of Approved Document B (2002).

625. In addition, a new note was added within the section of Approved Document B (2000/2002) dealing with "external surfaces", which served to remind the reader that alternative approaches to demonstrating compliance with the functional objectives of the building regulations were also available to them:

626. "Note: One alternative to meeting the provisions in Diagram 40 could be BRE Fire Note 9 Assessing the fire performance of external cladding systems: a test method (BRE, 1999)[402]."

627. A transposition for "limited combustibility" had also been proposed by Warrington Fire via their 2000 RADAR project[403] (see Figure 13). Limited combustibility was now defined as had been the case previously (i.e. as in the 1992 version of

[402] BRE Fire Note 9 would later be updated and become the BS 8414 testing standard.
[403] {CLG00000949}, {CLG00000950}, {CLG00000951}

Approved Document B) or, alternatively, on the basis of being classified as A2-s3, d2 (or better) in accordance with the Euroclass system.

628. In the 2000/2002 version of ADB, it was recommended that "insulation material used in ventilated cavities in the external wall construction should be of limited combustibility" when used above 18 metres (rather than 20 metres as had previously been the case).[404, 405]

629. The simultaneous use of both the National classifications and the European classifications is notable because it was the only mechanism whereby the "status quo" could remain effectively unchanged (i.e. British industry could continue as previously, if it wished) while the UK could also meet its new obligations to not create barriers to trade within the European community under the Construction Products Directive.

630. If the National class system had been abruptly and completely replaced by the new European system, however, this would have adversely impacted on the kinds of products that could be used in buildings; if the European system had not been implemented, then the UK would have breached the expectations of the Construction Products Directive.

631. Thus, the 2002 updates to ADB represented a *decision* to provide a technical solution to a political problem.

632. The status quo was retained, and products that had been tested in Europe could now be sold into the UK market without the need for re-testing.

13.5. The Fire at Garnock Court (1999)

633. The new European classifications had been developed based on the hazards presented by materials and products when used *within* rooms. However, a fire that spread on the outside an overclad 14-storey block of flats in Irvine, Scotland, on 11th June 1999 had again refocussed UK interest in vertical fire spread on the external walls of buildings.

634. The Garnock Court fire started in the living room of a 5th floor flat and then rapidly spread, within 15 minutes, to the roof level of the building via its refurbishment external cladding, igniting fires in the living rooms of a vertical line of flats above the flat of fire origin.[406, 407] One fatality occurred in the flat of origin.

635. As had been the case at Knowsley Heights, Garnock Court had been reclad using a GRP cladding product, however in this case the GRP was installed over a more localised portion of the building, essentially as pre-formed "spandrel" panels installed below the living room windows along isolated vertical lines up the sides of the building (see Figure 15). At Garnock Court, however, the refurbishment GRP

---

404 In fact, the reduction in 'trigger height' from 20 m to 18 m had actually been implemented within the 2000 edition of Approved Document B (without any comment or explanation for this in the "main changes" section).
405 Approved Document B 2002, 88.
406 The Herald. 1999. "Man Dies in Tower Block Inferno," June 12.
407 {BRE00000967}

cladding was not a ventilated rainscreen and the cladding system therefore also did not (and did not need to) incorporate cavity barriers.

636. As was also the case after the Knowsley Heights fire, the fire at Garnock Court was immediately investigated by BRE, however in this case with reporting on the fire issued not only to the Department for Environment, Transport, and Regions (DETR) via BRE's DETR framework project on investigation of real fires,[408] but also (in confidence) to Irvine Council and the Procurator Fiscal's office (who were leading a sudden death inquiry). And, as at Knowsley Heights, it was BRE's Penny Morgan who undertook the investigation and authored the resulting reports (discussed below).

637. The fire investigation report issued by BRE to DETR (in August 2000) described Knowsley Heights' refurbishment GRP cladding in considerable detail, as follows:

638. "The buildings suffered damp penetration and in 1989 invitations to tender were sent out for a partial refurbishment, concentrating on improving the roof and upgrading all the windows to double-glazed PVC-U. In addition, aluminium cladding between the windows on the living-room face was planned to reduce water penetration in those parts of the blocks. However, due to the unavailability of suitable aluminium, its cost and the need to complete the works in 1991 the specification was altered after discussion between the architect, engineers and contractor. This resulted in Sunline, the supplier of the windows also supplying Abacus panels, a glass reinforced plastic (GRP) material, in a custom-designed system for all five blocks on the living-room faces. The new system also changed the configuration so that the windows were now enclosed in a GRP pod; there was no insulation behind the GRP."

639. The only substantive technical commentary on the role of the cladding in the fire spread at Garnock Court is contained in the following passage:

640. "The video from Tesco's security camera shows full involvement 15 minutes after the call to the brigade and for the next seven minutes. The video shows even burning up the external surface of the GRP with the production of flames and dense black smoke. This indicates the involvement of the GRP alone rather than the contents of the flats as the burning pattern would vary according to the materials burning."

641. It is clear from the above descriptions that the presence of the combustible GRP spandrel panels was the primary contributor to the rate and extent of external vertical fire spread at Garnock Court. The video has unfortunately not been made available to me.

642. However, no further testing on the spandrel panels appears to have been undertaken in preparing this report to DETR. No effort was noted as having been expended to understand the heat of combustion, surface spread of flame, fire

[408] BRE client report, Investigation of Real Fires. {BRE00000967}

propagation potential, or other relevant reaction-to-fire properties of the GRP cladding used at Garnock Court.

643. No explicit comment was made as to whether these GRP panels would have met the recommendations for Class 0 (as had been the case for the GRP rainscreen used at Knowsley Heights). Similarly, no statement was made regarding whether this fire (in Scotland) might have implications for England's Building Regulations or Approved Documents. I consider these to represent surprising oversights, particularly given the similarities with the Knowsley Heights fire, the fact that GRP cladding was also implicated in that case, and the fact that BRE's Penny Morgan appears to have led both of these fire investigations.

644. With respect to the "implications for building regulations" of the Garnock Court fire, the BRE fire investigation report to DETR made reference to a contemporaneous Select Committee Inquiry[409] – which I will discuss below. The BRE fire investigation report stated only that:

645. "The implications with respect to the cladding have been thoroughly explored by the Select Committee for the Environment since this fire."

646. I also consider it noteworthy that Garnock Court's cladding refurbishment was completed in 1991;[410] the same year that the Knowsley Heights fire had occurred. Had BRE's Knowsley Heights fire investigation explicitly highlighted the potential role of the GRP cladding in that case, rather than focusing on the role of cavities and cavity barriers, or had a "great fuss" been made about the Knowsley Heights fire, the potential hazards of Garnock Court's cladding (which was present also on at least four other similar buildings) may have been more immediately obvious before the 1999 fire occurred.

[409] The 1999 Select Committee Report of The Environment, Transport and Regional Affairs Committee inquiry into the "potential risk of fire spread in buildings via external cladding systems" {CLG10003009}.
[410] {BRE00000967}

Figure 15 Garnock Court in the immediate aftermath of the 1999 fire.[411]

Figure 16 Garnock Court window treatments (undamaged).[412]

[411] https://www.bbc.co.uk/news/uk-scotland-40406057.
[412] {BRE00000967}

13.6. The Select Committee on Environment, Transport and Regional Affairs

647. The Garnock Court fire occurred within the constituency of Brian Donohoe MP, who was also a member of the Environment, Transport and Regional Affairs Committee of the House of Commons. The fire immediately resulted in calls for a "full inquiry"[413]. A "brief" Select Committee inquiry[414] was called, with Donohoe playing a central role.[415] The inquiry was prompted by "the necessity of ensuring that steps be taken to minimise [the potential risk which could be posed by fire spread involving external cladding systems] should it prove a serious danger to life and/or property". The Select Committee inquiry took evidence on 20th July 1999,[416] although its first report was not published until January 2000.[417]

648. Evidence submitted (or given orally) to the Committee's inquiry[418] contains several ideas and insights that I consider to be of central importance in the context of subsequent changes (or the absence thereof) to fire safety classifications and guidance related to external fire spread. I have highlighted some of that evidence below.

649. However, I should make clear at this point that I have been advised by the Inquiry that the Committee's proceedings are, in its view, proceedings in Parliament within the meaning of Article IX of the Bill of Rights 1689 and thus may not be the subject of investigation or comment by the Inquiry. In those circumstances, *I have been asked not to pass comment on the evidence which was given to the Select Committee*.

650. Thus, whilst I have highlighted evidence from the Select Committee inquiry that I consider to be noteworthy, I do not pass comment on it within this report.

13.6.1. Fire Brigades Union Evidence

651. During the Committee's inquiry the Fire Brigades Union (FBU) provided a discussion on their particular concerns associated with "external cladding", stating that "we believe that all cladding used on multi-storey buildings over 25 metres in height and the fixing systems should be completely non-combustible, or achieve a fire resisting standard equivalent to the external walls."

652. Regarding recommendations for "fire testing of external cladding systems", The FBU focused their comments on the existing BS 476 Part 11 test, this being the method by which "limited combustibility" was defined within the 1985 and 1992 versions of ADB[419]. They criticised the Part 11 test for being "small scale" and "not particularly suitable for composite or bonded products".

653. The FBU go on to state that they had "been particularly concerned for some time with the principle of small scale fire testing of large building components such as

[413] https://www.heraldscotland.com/news/12268601.man-dies-in-tower-block-inferno/.
[414] This was accomplished via a special hearing of the Select Committee on the Environment.
[415] DETR File on Garnock Court, Part 1. {BRE00035379}
[416] Minutes of Evidence and Appendices. {CLG10000349}
[417] {CLG10003009}
[418] {CLG10000349}
[419] I note that the refurbishment cladding of Garnock Court was completed in 1991.

composite cladding, or insulated sandwich panel systems" and that they "believe strongly that such testing and its findings should be validated by large scale testing of the complete system under realistic fire conditions".

654. To address their concerns regarding the BS 476 Part 11 test, the FBU pointed to the post-Knowsley Heights research at BRE, culminating in the FBU's proposal for "A Test Method to Assess the Fire Performance of External Cladding Systems" (this would eventually become BS 8414).

655. The FBU concluded that "What ever [sic] happens in the future, we believe that the existing small scale test method is unsatisfactory and that a new test for both internal and external cladding systems and sandwich panels should be developed which should be based on the ISO 9705 Room Corner Test."

13.6.2. Fire Safety Development Group Evidence

656. The Fire Safety Development Group (FSDG) was "created in 1992 as a consortium of companies in the passive fire protection field"[420], and was represented in the 1999 Select Committee inquiry by David Harper and Dr Bob Moore.

657. The FSDG identified the ADB recommendations[421] for external cladding at the time, noting that "exterior cladding should [only] be Class 0 fire performance" without any explicit requirement for cladding to be of "limited combustibility".

658. With respect to use of Class 0 as an appropriate classification to address external fire spread hazards, the FSDG made various relevant points (italics added for emphasis):

659. > "We believe that there is *confusion about the Class 0 standard* for two reasons. Class 0 materials refers to the performance of the surface of the material, but applies to the total product, ie the facing plus any coating, adhesive, paint, etc plus the substrate to which the facing is bonded. Clearly these other elements will affect the performance of the cladding in a fire, and will vary with the nature of the coating, the thickness of the adhesive, the type of substrate etc."

660. FSDG went on to state that:

661. > "A material of limited combustibility can achieve a Class 0 rating as defined by the regulations but a Class 0 material is not equivalent to a material of limited combustibility. A material of limited combustibility is generally a material which is totally non-combustible or which contains a small amount of combustible material. Combustible materials, like plastic, wood, etc are not materials of limited combustibility but can achieve Class 0 performance by adding fire retardant chemicals or facing the combustible material with a metal foil or sheet. Thus there is a fundamental difference between products that are inherently Class 0 and products modified to enhance their performance. This

420 https://publications.parliament.uk/pa/cm200102/cmselect/cmtlgr/482/48240.htm.
421 I note that in various places in their evidence, the FSDG incorrectly identify items as requirements of the "Regulations", rather than more correctly as being recommendations of the Approved Document B.

serves to undermine the integrity of the regulations and therefore reduces fire safety."

662. The FSDG noted that:

663. "We are particularly unhappy with what we call this Class '0' rating. Particularly with plastic products, you can obtain this rating by putting chemicals in; you can cover up plastic foam or a combustible material with a metal sheet or a foil which, in effect, still allows the fire to burn and destroy the plastic material underneath; and in effect *you may even meet the requirements for a Class '0' material, but the actual product can still contribute to the fire, can still cause problems and can still give off fumes, toxic chemicals when they burn and, if they are the right sort of plastic, can drip plastics on people who are trying to fight the fire*. Overall there are a number of reasons why our Group is unhappy with the Regulations particularly in relation to this Class '0' rating…" (emphasis added).

664. It appears (as discussed below) that little was subsequently done by government to address these concerns. FSDG also noted that:

665. "Confusion often occurs because some *manufacturers refer to Class 0 products without due consideration* for the way the product will be used or treated" (emphasis added).

666. It appears (as discussed below) that little was subsequently done by government to address this concern.

667. The FSDG also made the following statements (emphases added):

668. "We also wish to make a distinction in the regulations between integral Class 0 materials and modified products. This should reflect the different fire performance between a non combustible composite cladding and one consisting of a *metal-face foam plastic*."

669. "There is also widespread concern amongst many fire fighters about the safety of external cladding systems consisting of *metal-faced foam plastics*. These systems will generally have Class 0 fire performance, but in real fires the foam plastic lining can ignite and burn. This helps to spread the fire via the building fabric and there will be an increase in the generation of smoke and toxic fumes. Collapse is also possible. We believe this subject is still being reviewed by the DETR and consider more stringent controls a priority."

670. In these comments, the FSDG are highlighting particular concerns associated with metal-faced polymer foam insulation products. These concerns, whilst not immediately relevant to the Garnock Court fire, were indeed prescient – as would later be demonstrated in 2005 by a fire in Salford (see Section 13.11). However, it appears (as discussed below) that little was subsequently done by government to address this concern.

671. The FSDG also made a number of comments specifically related to concerns around the use of thermoplastic[422] polymers (emphases added):

672. "We do not consider there should be a wholesale review of all external cladding systems, as we are sure that the majority will have met regulatory requirements. *A* more detailed study is, however, needed to examine the fire behaviour of *thermoplastic products* when used in exterior applications"

673. "*Thermoplastic products should not be used* in areas where they could melt or be destroyed by fire and thus add to the spread of fire. It may therefore be necessary to replace some of these plastic products with materials of limited combustibility."

674. "We have highlighted some problems with burning plastics which this fire has raised. There is at present *nothing in Building Regulations* to require control of smoke, fumes or *burning droplets* from building materials. This should be rectified as the increasing use of plastic materials means *there will be further instances of burning or molten plastic helping to spread the fire or cause injuries* to fire fighters or building occupants. The DETR should act to rectify this, especially as Home Office Statistics consistently demonstrate how more people die in fires after being overcome by smoke than any other cause."

675. In the above three comments, the FSDG focused specifically on "thermoplastic products". They highlighted the particular hazards associated with burning droplets of melted thermoplastic material (this being a much reduced concern with thermosetting polymers). It appears (as discussed below) that little was subsequently done by government to properly address this concern. Finally, the FSDG stated (emphasis added):

676. "We consider *the use of Class 0 materials should be more stringently controlled for external wall cladding*. Products which can only achieve this rating by means of surface treatments, coatings, foil coverings or impregnation treatments should not be allowed."

13.6.3. BRE Evidence

677. The "Building Research Establishment Fire Research Station" were represented by Peter Field (Deputy Director), Tony Morris, and Sarah Colwell (who would go on to play a central role in the evolution of BS 8414-1, BS 8414-2, and BRE 135). There is no record, however, of Colwell having said anything during these hearings.

678. During oral evidence, BRE were asked to comment on the outcomes of the research that they conducted after the 1991 Knowsley Heights fire, and the conclusions that they reached with respect to the "risk of spread". BRE presented the progress that had been made on large scale testing since Connolly's 1994 test report on these issues.[423] In the intervening years, BRE had (at the request of

[422] I have explained the key differences between thermoplastics and thermosets in my previous reports {LBYS0000001/99}. Polyethylene, as used within the Reynobond ACM cladding at Grenfell Tower, is a thermoplastic polymer.
[423] Evidence, pp 15-18 {CLG10000349/19} – {CLG10000349/22}

government) developed a large-scale fire test method for external walls; this was published in 1999 via a report called "Fire Note 9".[424]

679. Presenting his evidence to the Select Committee inquiry, Field echoed the misgivings articulated by Connolly about the ability of the National Classification system to "adequately identify the fire performance of the complete system".[425]

680. Field commented that:

681. "There have also been issues referred to already relating to the Class '0' system of fire spread, which is basically a material based system of classification. I think there are some circumstances whereby utilising that of itself would not adequately identify the fire performance of a complete system."

682. "What our [large-scale] test method does is adds to this body of guidance. I do not think the guidance that is currently there should be ignored completely. It is far from being totally adequate. We think the tests add to the current guidance which is likely to be available."

683. The BRE witnesses also repeatedly made reference to the (then) recent privatisation of BRE. When asked what result would have been achieved if the cladding system at Garnock Court had been subjected to the new BRE large scale cladding test, Field notes that BRE "have not looked at systems which allegedly have been used [at Garnock Court]", because they had "not been asked to do so by anybody at this moment in time". When then asked, "have you got to be asked to do any testing?", Field responded:

684. "We are a private sector organisation; we are not part of government. Clearly, in days gone by, when we were part of DoE then this work was done and would have been done in the public interest without the need for formal contract. One regrets there are now commercial pressures that require clients to place formal contracts with us before we can undertake work."

13.6.4. Evidence of the Department of the Environment, Transport and the Regions

685. The Department of the Environment, Transport and the Regions (DETR) were represented at the 1999 Select Committee inquiry by Nick Raynsford (Parliamentary Under Secretary in the Department for the Environment, Transport and the Regions), Paul Everall (who had overall responsibility for the building regulations within DETR at that time), and Anthony Burd and Tony Edwards (both of whom were involved in the DETR section looking at building regulations and associated fire issues).

686. In discussing issues around Class 0 the following was stated:

[424] Fire Note 9 {CTAR00000019}
[425] {CLG10000349/19}

687. "Whilst non-combustible materials are inherently of the Class "O" referred to above, many materials that are by definition combustible will also achieve this classification. The intent of this methodology is to identify materials that will have *a low risk of fire spread*" (emphasis added).

688. The DETR written evidence went on to state that:

689. "Where a building is 20 metres or more in height, the external surfaces of walls more than 20 metres from ground level should achieve a class "O" surface spread of flame rating. Below this height timber cladding at least 9mm thick, or some other materials that are less restrictive than class "O" materials, could be used. This is to reduce the risk of fire spread over the walls of tall buildings *whilst allowing certain commonly used materials to be retained in positions where fire fighting operations from the ground could be effective*" (emphasis added).

690. Later within their written evidence, DETR noted that amendments to the Building Regulations, and possibly also the Building Act (1984), might be needed to ensure that all "material alterations" that could have an impact on external fire spread hazards are controlled by the Building Regulations (see Paragraph 501). The Building Regulations would "need amendment to ensure that all such work was covered". It is further noted that:

691. "Any such amendment would need careful drafting to ensure that an undue burden was not inadvertently imposed on replacement and repair work. However *a balance needs to be struck between construction costs and safety* (emphasis added)."

692. In oral evidence, when questioned about the appropriateness of Class 0, Raynsford stated that:

693. "in high buildings and also where buildings are close to boundaries with other buildings, there must be the highest standard of *flammability* and that is why Class O applies (emphasis added)."[426]

694. He later stated that:

695. "It is very important indeed that infill materials should meet the standards of non-combustibility particularly in the circumstances I described where the greatest risk is where you have buildings very close to adjacent buildings and where you have high buildings where it is more difficult for fire fighters to gain access. That is why the requirement for Class O surface spread of flame rating must apply in those cases."[427]

[426] Evidence pp 30 {CLG10000349/34}
[427] Evidence pp 31 {CLG10000349/35}

LBYP20000001_0132

13.6.5. First Report of The Environment, Transport and Regional Affairs Committee

696. In January 2000, the Select Committee published their report.[428] They found that the evidence submitted to the Select Committee inquiry did "not suggest that the majority of the external cladding systems currently in use in the UK poses a serious threat to life or property in the event of fire".[429]

697. They stated that the evidence "strongly suggests that the small-scale tests which are currently used to determine the fire safety of external cladding systems are not fully effective in evaluating their performance in a 'live' fire situation". Thus, they suggested that the new BRE test (i.e. the test described in Fire Note 9, which would later become BS 8414) should be re-issued as a British Standard and be *substituted* in Approved Document B to *replace* previous recommendations relating to the fire safety of external cladding systems (i.e. that Class 0 should no longer be used in this context).[430]

698. The online version of this report also contained a footnote (Footnote 24), that provided a clear statement about the status quo as understood by the Select Committee:

699. > "It should be noted that both 'Class O' and 'limited combustibility' are different from the classification 'non-combustible', which is the highest level of material performance on exposure to fire, and is measured by reference to test BS476: Part 4: 1970 or Part 11: 1982. *In no circumstances are external cladding systems required to be non-combustible*" (emphasis added).

700. Finally, it is perhaps noteworthy that, in publishing their first report, The Environment, Transport and Regional Affairs Committee included a statement "to thank Dr Raymond Connolly and his colleagues at International Fire Consultants Ltd, whose advice on the technical aspects of this inquiry was invaluable".[431] As already noted, Connolly had previously worked at BRE and authored their report on the post-Knowsley research that eventually led to Fire Note 9.

13.7. Garnock Court Fire Investigations for North Ayrshire Council

701. Possibly in response to the Select Committee inquiry questioning noted in Section 13.6.3, BRE were asked to more fully investigate the circumstances surrounding the Garnock Court fire. Between August 1999 and May 2000, BRE completed a significant programme of fire investigation, experimental research, and standard testing on the GRP cladding product used at Garnock Court. This work was performed under confidential[432] contract to North Ayrshire Council.[433]

---

428 {CLG10003009}
429 {CLG10003009/9}
430 {CLG10003009}
431 {CLG10003009/6}
432 A 26th July 1999 informal fee proposal letter from J N Smithies of BRE to G D Wallace of North Ayrshire Council explicitly notes that, "BRE is now fully privatised and is owned by the Foundation for the Built Environment. Any work we do for non-government customers is confidential." {BRE00035380/8}
433 BRE Client Report, prepared for North Ayrshire Council, August 1999. {BRE00035377}

702. Despite the public-safety-critical nature of this work, I can find no evidence to suggest that the results of this work were ever communicated to the 1999 Select Committee inquiry, at any point up to them issuing their second report in March 2000[434]). Nor can I find any evidence to suggest that the results were ever communicated to DETR under BRE's ongoing contract to investigate and report on fires of special interest, at any point up to them issuing their final report to DETR for the relevant period in August 2000[435].

703. As part of my work for The Grenfell Tower Inquiry, I have performed a side-by-side comparison of the reports prepared by BRE for North Ayrshire Council, and the report prepared by BRE for Department for Energy, Transport and Regions. The reports for North Ayrshire Council (dated August 1999 and April 2000) were prepared by Penny Morgan, Brian Martin, and Tony Morris.[436] The report for DETR was submitted to Anthony Burd as part of the August 2000 Investigation of Real Fires Report and was prepared by Penny Morgan[437]). I have noted what I consider to be some potentially significant differences.

704. BRE's August 2000 DETR Investigation of Real Fires report contains various sections of text which are essentially identical to BRE's August 1999 first report to Ayrshire Council[438], with one notable exception.

705. The report to North Ayrshire Council makes numerous references to the fact that the Cladding at Garnock Court ought to have had a Class 0 classification, whereas BRE's subsequent report to DETR makes no mention of Class 0. The removal of mentions of Class 0 from the reports to DETR appears to have been performed intentionally.

706. For instance, in describing the remedial measures undertaken by North Ayrshire Council to address ongoing problems within Garnock Court, the August 1999 text presented to the Council[439] was as shown in the following excerpt:

> *3.1.1. Remedial measures*
>
> The Council have made the decision to remove all the material associated with the 1991 window replacement and start again. Technical Services described their approach which has still to be finalised. They have opted for composite aluminium and timber windows which are fully openable to allow cleaning. The spandrel panel to be an external insulated render of panels between the windows of either a non-combustible or Class 0 material. The render to be taken round the corner as the outer edge of the building is No Fines/nib/column/No Fines in construction. A Building Warrant has been applied for.

---

[434] Government Response to the First Report of the Environment, Transport and Regional Affairs Committee {CLG00019479}
[435] BRE Client Report for DETR {BRE00035375}
[436] {BRE00035377}
[437] {BRE00035375}
[438] {BRE00035377}
[439] {BRE00035377}

707. However, the text presented to DETR in August 2000[440] was modified as shown in the following excerpt:

> *Remedial measures*
>
> The Council have made the decision to remove all the material associated with the 1991 window replacement and start again. Technical Services opted for composite aluminium and timber windows which are fully openable to allow cleaning. The spandrel panel to be an external insulated render of panels between the windows of a non-combustible material. The render to be taken round the corner as the outer edge of the building is No Fines/nib/column/No Fines in construction. A Building Warrant has been applied for.

708. I note a double space where specific text dealing with Class 0 has been removed; this could be explained by the fact that a year had passed between the issuing of these two reports, and the decision to use "non-combustible" material for the replacement spandrel panels appears to have been made at that point.

709. Similarly, however, the text in the discussion/comments section of the August 1999 text presented to the Council was as shown in the following excerpt:

> moving out of the building. Initially the plume would have been small due to the close proximity of the fire to the open window and therefore would have tended to have adhered to the surface of the building and the GRP. The plume will have ignited the GRP and remained in contact with it and generated a self-propagating fire. This was assisted by the cavities behind the spandrel panels which allowed fire to attack both sides of the GRP. The heavy black smoke and flames seen on the Tesco's video support this view that the GRP was the main material involved.
>
> Although the material used in 1991 should have been Class 0 we have reservations about its current performance.
>
> The remedial measures planned for the high rise blocks in Irvine should address the problems identified ie damp penetration and the avoidance of an external route for fire spread. We suggest that non-combustible materials are chosen wherever possible.

710. Whereas the substantively identical text presented to DETR in August 2000 was again modified to remove mention of Class 0, as shown in the following excerpt:

[440] {BRE00035375}

> In the case of the fire in Garnock Court the severity of the initial fire and its position close to the window has resulted in the plume of smoke and hot gases from the fire moving out of the building. Initially the plume would have been small due to the close proximity of the fire to the open window and therefore would have tended to have adhered to the surface of the building and the GRP. The plume will have ignited the GRP and remained in contact with it and generated a self-propagating fire. This was assisted by the cavities behind the spandrel panels which allowed fire to attack both sides of the GRP. The heavy black smoke and flames seen on the Tesco's video support this view that the GRP was the main material involved.
>
> The remedial measures planned for the high rise blocks in Irvine should address the problems identified ie damp penetration and the avoidance of an external route for fire spread.

711. Given the further findings that BRE presented to North Ayrshire Council in their April 2000 report[441], following extensive testing of the GRP cladding panels implicated as the key factor in the Garnock Court Fire – and despite the fact that this work was undertaken in a "confidential" capacity – I am surprised that mention of Class 0 was simply removed from this text, rather than being updated to explicitly notify government that the product used in 1991 was *not* Class 0 (see discussion below).

712. In April 2000, BRE reported to North Ayrshire Council the results of a range of fire tests performed on samples of the GRP cladding panels that had been installed on Garnock Court. Amongst other things, these test data clearly showed that "the cladding panels that [BRE] collected from [Garnock Court] *are not Class 0 and it is doubtful if they ever were*" (emphasis added).[442]

713. The above data, reported to North Ayrshire Council in April 2000, had been made available to Penny Morgan (BRE) prior to mid-March 2000 (i.e. *before* final recommendations were made by the Select Committee inquiry in April 2000).

714. These data clearly showed that the central issue at Garnock Court was that the cladding panels were unable to meet the *existing recommendations* of ADB (either 1985 *or* 1992) for cladding used at height. The Garnock Court GRP cladding panels were unable to achieve Class 0, and BRE considered it "doubtful" that they ever could have.

715. Aside from client confidentiality, it is not clear to me why BRE failed to clearly articulate this information in all reports issued to DETR beyond April 2000, or why BRE do not appear to have notified either DETR or the Select Committee of these findings. To date, I have not seen any evidence to suggest that these findings were ever formally communicated by BRE to government, or that BRE requested permission for such communication from their client (i.e. North Ayrshire Council).

[441] BRE Client Report, prepared for North Ayrshire Council, April 2000 {BRE00035831}
[442] {BRE00035381}

13.8. The Government Response

716. In April 2000 the Government responded to the recommendations of the Select Committee inquiry[443]. In their response they noted that the 2000 edition of Approved Document B had recently been consulted upon and updated, that it already made reference to "Fire Note 9", and that this had been passed to the British Standards Institute with a view to drawing up a standard.

717. However, the Government also suggested that "it is unlikely that any such changes will be made immediately the status of the test method is changed as such minor amendments to the Approved Documents are difficult to promulgate to ensure that all users of the document are made aware of the change [sic]". Nevertheless, the Government suggested that the new large scale British Standard test would be included when Approved Document B was updated to include "the new harmonised European methods of test".[444]

718. The Government noted the following in their response:

719. "During the review [of ADB] there was no suggestion that the guidance given in the Approved Document was insufficient or if followed would tend to create an unsafe scenario in a fire situation with respect to the external cladding. However, as I indicated in my evidence to the Committee, the Department has asked the Fire Research Station to review the guidance given in BR135:1988 (Fire performance of external thermal insulation for walls of multi-storey buildings) that we refer to in Approved Document B. A contract with regard to this work was let in January this year. The study is underway with a survey of the existing multi-storey building stock in Great Britain to establish the composition and design of systems in use. This will be followed by a series of large scale fire tests to assess the fire performance of a range of existing and new cladding systems. The results of this work will be used to determine the most appropriate method for specifying the fire performance requirements of cladding systems. The revised guidance should be available by September 2001."

720. "Class 0" was not mentioned within the government's response to the first report of the 1999 Select Committee inquiry.

721. The Government thus appear to have effectively ignored the numerous criticisms that had been raised with respect to Class 0 as the main basis of recommendations for cladding materials and products used at height. This was despite a substantial body of well-articulated evidence that Class 0, rather than the development of a standardised large scale cladding compliance test, was the critical issue that urgently needed to be addressed. With hindsight, I consider this *a significant failing by government and its advisors*, for (at least) the following reasons:

[443] {CLG00019479}
[444] {CLG00019479}

722. It should have been obvious (or been made obvious) after the 1991 Knowsley Heights fire that Class 0 was potentially inadequate, particularly for composite rainscreen cladding products incorporating thermoplastic polymers.

723. Connolly's research at BRE during the early 1990s had shown that "it is clear that the BS.476 [sic] Parts 6 and 7 tests do not accurately reflect the fire hazards that may be associated with cladding systems".

724. The evidence available after the 1999 Select Committee Inquiry, was clear, credible, and compelling as regards an urgent need to reconsider use of Class 0 for external cladding on buildings at height.

725. The testing by BRE under contract to North Ayrshire Council should have led to a realisation that the fire at Garnock Court actually provided little or no support to the idea that a standardised large scale cladding test was required – at least, not based on the available evidence from real fires.

726. Given that Garnock Court's GRP overcladding fell significantly short of meeting the recommendation for Class 0, and hence did not even comply with the recommendations of Approved Document B at the time of Garnock Court's overcladding refurbishment, the key issue at Garnock Court was actually one of *inadequate adherence to the existing guidance,* rather than the existing guidance necessarily being inadequate. It is not clear what steps were subsequently taken by government – if any – to enhance oversight of adherence to building regulations guidance or to verify that similar oversight had not occurred on other buildings across Britain.

727. Rather than eliminating the use of Class 0 for external cladding products, or alternatively more tightly restricting its application to products where the testing methods underpinning a Class 0 classification were more technically credible, the Government chose to simply add a new – and potentially lucrative to the recently privatised BRE – alternative route to demonstrating compliance with the recommendations of the Approved Document B; i.e. large scale fire testing to BS 8414.

728. Thus, rather than addressing the concerns raised by Knowsley Heights and Garnock Court, the Government appears to have taken a decision to preserve the status quo whilst also further loosening restrictions on the use of combustible materials and products in external cladding applications. It is, therefore, my opinion that the Government's response to Garnock Court and the Select Committee inquiry represents a missed opportunity for government to address key issues relating to industry practice on the design and construction of external wall systems; (1) that Class 0 was inadequate to mitigate external fire spread hazards, and (2) that some products being used in the industry were failing even to achieve a Class 0 level of performance. Both of these points would manifest again in the future.

13.9. BRE Research on External Fire Spread via Windows

729. In or around 2001, the Department for Transport, Local Government and the Regions (DTLR) commissioned BRE's "Fire Safety Engineering Centre" to

"investigate the problem of external fire spread via windows".[445] The reporting on this research project does not give a clear indication as to what motivated DTLR to commission this work. Nevertheless, given what had occurred at Garnock Court, I believe that it was almost certainly a result of the rapid and extensive vertical fire spread (via spandrels, windows, and window surrounds) that occurred during that fire.

730. The closing report for the project[446] stated the project objectives as follows:

731. "The object of the project was to examine the issues surrounding the phenomenon of external fire spread via windows, in order to provide comprehensive and up-to-date advice on the scale of the problem and cost-effective ways of minimising the risks.

The objectives set out were:

to collate and evaluate existing knowledge and research from the UK and around the world on methods of preventing vertical flame spread through windows; and

to produce design guidance on preventing external fire spread through windows."[447]

732. The project consisted of (1) a historical survey of fire incidents, both domestic and international, where external fire spread "via windows" had been observed, and (2) a review of (then) current codes and guidance dealing with this issue, both domestic and international.

733. The historical survey of fire incidents,[448] yielded few useful insights, concluding that it "proved very difficult to obtain information on the rate of occurrence of fire spread via windows in cases which have not been widely reported".

734. BRE's review of British and international code guidance[449] did, however, yield some interesting insights and commentary. For instance, it was noted that:

735. "many countries [sic] codes address general problems in external spread but few, it would seem, deal directly with floor-to-floor spread via the windows."

736. In my opinion, the above statement begs a fundamental (but neither asked nor answered) question: *Why not*?

737. It was also noted that:

---

[445] BRE Project Report dated 15 August 2001{LBY00000368}, BRE Project Report dated 18 August 2001 {LBY00000370}, BRE Project Report dated 30 November 2001 {LBY00000369}, BRE Project Report Closing Report {LBY00000371}.
[446] BRE Project Report Closing Report {LBY00000371}
[447] This second objective was never achieved, as noted in the BRE Project Closing Report.
[448] {LBY00000368}
[449] {LBY00000369}

738. "There are indications that many regulatory and guidance codes tend to focus more on internal spread of fire (or smoke) through the building, rather than the potential for external spread (other than that which is confined to the outer surfaces). It may be that this reflects a genuine difference between the risks from internal and external spread. However, if it is to be assumed that the levels of internal compartmentation in modern UK buildings is now of a generally high standard, due to improved design and construction, *it may be that the relative balance has shifted somewhat, and the potential risk of external floor-to-floor spread should not be neglected*" (emphasis added).

739. The final sentence in the above is curious; it implies that – as things stood in 2001 – the English guidance in Approved Document B "neglected" external floor-to-floor fire spread. Any such implication is clearly incorrect, given that by 2000 there was ample commentary and guidance in Approved Document B dealing with external fire spread hazards.

740. It may have been correct that no Approved Document B guidance *directly* addressed the issue of window-to-window fire spread. However, I note that all of the then existing provisions related to external fire spread were in fact relevant to the problem of window-to-window fire spread. I am therefore surprised that more in-depth analysis of the existing provisions in Approved Document B appears not to have been included.

741. One aspect of this report that I find very surprising is that (yet again) no comments were made concerning Class 0, or the fact that the UK was something of an international outlier in terms of explicitly accepting the use of combustible (albeit Class 0) cladding products on the exterior of highrise residential buildings.

742. Requirements/recommendations for the use of "non-combustible" materials in cladding and external wall situations was explicitly noted when outlining the existing provisions in a number of international codes and guidance documents – with Hong Kong, Australia, Sweden, and Malaysia all having provisions requiring non-combustibility for cladding products.

743. One of the BRE project reports, issued in November 2001 stated that:

744. "Certain combustible claddings can support unlimited vertical flame spread. However, some do not, if the combustibility of the cladding is not significant. Factors such as the amount of combustibles per unit area, their heat of combustion, the ignition temperature of the combustible components, composition of the cladding and preservation of integrity when exposed to fire determine the propensity for vertical flame spread and hence its contribution to the window flame plume".[450]

745. Of the five factors that "determine the propensity for vertical flame spread" listed in the above comment, none of these was (or is) explicitly addressed by BS 476 Part 6 or 7 testing, and hence none were addressed by the National classification system or Class 0. However BRE made no comments on this issue. Indeed, when

[450] {LBY00000369}, {LBY00000371}

commenting specifically on the role(s) of external cladding within a list of "mitigatory or protective measures", only the following was stated:

746. "*Limited combustibility of claddings* – submit all cladding materials to appropriate test methods available. BRE cladding test – Fire Note 9 outlines such a test. Additional full size testing should be carried out for applications of glazed façades."

747. The above comment again failed to highlight that Class 0 *explicitly* permitted the use of combustible cladding products. The end of project report states:

748. "It was clear from the Task 1 [historical survey] and 3 [review of codes and guidance] reports and from that found within Task 2 [milestone report], that there is insufficient guidance provided by national regulation within England and Wales, or codes of practice to effectively address the particular problems of fire spread via windows."

749. However, the report concludes that:

750. "The evidence acquired for this project therefore leads to the conclusion that the measures currently called upon in England and Wales through AD B are still commensurate with the risk."

751. The above remark, when considered alongside the other remarks that I have highlighted from the reports for this BRE project, appears to be a statement that storey-to-storey fire spread via windows will not definitively be prevented by application of the guidance given in Approved Document B. Hence, this is an implicit statement that external fire spread was considered to be acceptable[451] in the opinion of the Secretary of State.

13.10. BRE's "Review of Fire Performance of External Cladding Systems and Revision of BRE Report BR135"

752. On 23rd December 1999, less than six months after the 1999 Select Committee hearings referred to in Section 13.6 of this report and one month *before* the first report of the select committee inquiry was published, BRE submitted a bid to DETR "under the CD / BRE Framework Agreements" to undertake a "review of fire performance of external cladding systems and revision of BRE report BR135". This project was assigned the contract number CC1924. The stated objectives of this project were (emphasis added):[452]

753. "To review the guidance contained within the Approved Documents that serve the Building Regulations with regard to external cladding systems on multi-

[451] I note that this implicit (but unstated) tolerance of external vertical fire spread has implications particularly for buildings with "stay put" evacuation strategies, most notably with respect to the criticality of maintaining tenable evacuation routes.

[452] Bid by BRE, Review of the fire performance of external cladding systems and revision of BR135 {BRE00041836/3}

storey buildings, in particular *fire stopping*[453] between floors and *surface spread of flame*.

754. To update and maintain the Building Regulations and associated guidance based on a series of experimental studies on new and *existing cladding systems*.[454]

755. To support the process of regulation and harmonisation with Europe."

756. The bid document also stated that, "based on the findings of the work in this proposal, a holistic approach to the reaction to fire issues related to both existing and new build multi-storey blocks will be developed that will also encompass the latest European developments."

757. The proposed programme of work included:

758. "a comprehensive survey of the U.K. building stock which will form the basis for DETR to specify generic external cladding systems for experimental investigation;

759. large-scale experimental studies [that] will be used to produce a replacement for BR 135 containing information more relevant to current practise; and

760. work [that] will be carried out to form the basis of a proposal to Europe for a test method to determine the fire performance of external cladding systems."

761. The proposed "large-scale experimental studies" were stated as needing to consider "a minimum of 5 different cladding systems" and as each requiring "large-scale fire performance tests."

762. It was also noted that:

763. "For each type of cladding system, at least 2 tests will be required to understand the contribution of fire stopping. These would cover any frequently used but ad-hoc installation practices (such as used at Irvine) or the 'industry standard' and an appropriate utilisation of fire barriers."[455]

764. The bid document thus concludes that "the minimum number of tests required would be 12. Ten to complete the programme outlined above and two additional tests to investigate any anomalies observed during the test programme."

765. It was also proposed that any cladding products included in the large-scale test programme should also be evaluated via the European and National classification

---

[453] This would include issues around provision and performance of cavity barriers within rainscreen cladding systems.

[454] I consider it noteworthy that the proposed research was intended to be based on a survey of cladding products and systems that were *already* in widespread use across England and Wales.

[455] This comment would appear to indicate that there was an explicit desire to evidence, understand, and possibly quantify the role(s) of cavity barriers in mitigating external fire spread. The comment is also striking, because it appears to imply a knowledge that the "industry standard utilisation of fire barriers" was not considered by BRE to be "appropriate".

systems, as well as being tested via ISO 9705[456] full-scale room fire testing. This additional testing was apparently included in the overall project so as to "establish the validity of the Euroclasses and ISO 9705 tests for classifying cladding systems".

Fire Performance of External Cladding Systems – A Literature Review

766. On 30th March 2000, BRE (Colwell, Foster, and Martin) issued a report on "Fire Performance of External Cladding Systems – A Literature Review".[457] The purpose of this report was to identify and summarise:

767. "the types of external cladding systems currently in use;

768. the current requirements and guidance as given in Approved Document (B) [sic], 2000 revision; and

769. the research previously undertaken on external fire spread in buildings."

770. I will not comment extensively on the contents of the 30th March 2000 report, other than to highlight a few key points that I consider relevant in the current context.

771. In reviewing the requirements of the "Building Regulations" with respect to fire performance of external cladding systems, the report makes the following statement:

772. "Irrespective of the boundary distance, Diagram 40 (provisions for external surfaces of walls), Figure 1 of this report, in AD B, restricts the combustibility of external walls of high buildings… to reduce the danger from fire spread up the external face of the building."

773. The above comment is false. Diagram 40 of Approved Document B (2000) said (and says) nothing about the "combustibility" of the external surfaces of walls. This again highlights the apparently widespread confounding of "Class 0" and "limited combustibility" within the fire safety community prior to the Grenfell Tower fire (see e.g., Paragraph 439 of this report and its accompanying footnote). The above comment also suggests that this confounding extended to key employees of BRE who had a role in advising government on these issues.

774. The 30th March 2000 report also notes that Approved Document B, at that time, recommended that "for external wall constructions that include cavities (such as rainscreen cladding) cavity barriers are recommended at the junctions between the wall and every compartment floor or wall or other wall or door assembly that forms a fire-resisting barrier"; thus, explicitly highlighting the perceived importance of cavity barriers as regards external fire spread hazards.

775. The report presents a table of "typical costs associated with different cladding systems based on figures given in the Architects Journal (AJ) in February 1998". Interestingly, particularly in the context of the Grenfell Tower fire, the cost data given in this March 2000 report include – albeit with respect to "infill panel systems"

456 ISO 1993.
457 BRE client report, Fire Spread in External Cladding – A Literature Review {BRE00041853}

rather than "overcladding" systems – products consisting of "composite panel of 0.5mm stove lacquered aluminium, 3mm polyethylene core, 0.5mm mill-finish aluminium". Thus, both BRE and government appear to have been aware that ACM PE products were being used in "typical" cladding systems in the UK at least as early as 2000.[458]

BRE Cladding Survey

776. On 28th March 2000, BRE (Colwell) wrote to 44 individuals representing various stakeholders within the cladding sector, including seven "specifiers", 26 "councils", and 11 "suppliers", with the following request: [459]

777. "Following the publication of the Environment Sub-committee inquiry, into the 'potential risk of fire spread in buildings via external cladding systems', published in December 1999, the Construction Division of the Department of the Environment, Transport and the Regions, has asked BRE to review the guidance given in BRE Report, BR135 'Fire performance of external thermal insulation for walls of multi-storey buildings.' 1988.

778. As part of the revision of BR135 we are endeavouring to establish, in general terms, the types of systems in use and the number of units involved.

779. As a body with experience in this type of structure, we are asking for your assistance in completing the short questionnaire attached. Any information you are able to provide will be most gratefully received and all response will be kept confidential to this project."

780. I do not believe that there is any great value in rehearsing all of the questions included in the survey. The obtained response data, however, and BRE's analysis thereof, warrant a brief discussion.

781. I have reviewed a BRE spreadsheet which contains the (17) responses that were obtained to their survey.[460] One of the "specifier" respondents was R Wolstenholme of WS Atkins, a British multinational engineering, design, planning, architectural design, project management and consulting services company (now part of the SNC-Lavalin Group).[461] In response to the survey question, "Have you had any incidents involving fire spread due to external cladding systems, any details would be appreciated", Wolstenholme responded "yes".

782. Appended to Wolstenholme's "yes" in BRE's spreadsheet is a Microsoft Excel note which states:

[458] It is perhaps noteworthy that ACM cladding with a PE filler/core had initially been invented and patented in 1968, and so had been in use for up to three decades at this point in time.
[459] BRE letters, 28 March 2000 {BRE00041869}
[460] BRE cladding survey database {BRE00041886}
[461] I note that WS Atkins were designers of the Address Downtown Dubai hotel, which suffered a severe cladding fire, with associated rapid and extensive external fire spread linked to the use of ACM PE cladding panels, on New Year's Eve 2015/16.

783. "BRE: Spread of flames generally rapid due to loss of integrity of composite aluminium panels using combustible cores."

784. It is not clear to me at the time of writing whether this comment came from Wolstenholme, or instead from whoever within BRE compiled the spreadsheet of survey responses; nor is it possible to confirm, on the basis of the documentary evidence available to me at the time of writing, that the above comment is referring specifically to ACM with a PE filler/core (it is conceivable that this comment was referring to sandwich panel products with combustible cores). However, this comment again appears to imply knowledge of the poor fire performance of "composite aluminium panels using combustible cores" in or around 2001, as well as the fact that such products were being used on buildings.

Survey Summary and Options Report

785. On 24th July 2000, BRE (Colwell) issued a "Survey Summary and Options Report"[462] to Anthony Burd (DETR), outlining the results of the BRE Cladding Survey and providing various options for the "large-scale experimental studies" that had been proposed in the original bid documentation (see Paragraph 759).

786. The key results of the "survey" (in the context of the current discussion) indicated that "the level of knowledge within the local authorities with regard to both the number and types of cladding systems installed is extremely limited". It was suggested that "if this lack of information within the local authorities is coupled with the frequently reported uncertainty as to whom has overall responsibility within each authority for these units, this may help to explain the relatively high number of the non-returns".

787. It was also noted that "a significant number of [predominantly local authority cladding] contracts are let using materials from a range of manufactures [sic] for which no installation approval can be applied", and that "the survey has also highlighted a missing link in the supply chain, contractors appear to play a significant role at all stages of the process from those who provide a design and build service through to those who are purely site-based installers"; thus suggesting that regulatory oversight of residential overcladding projects appeared, *at that time*, to have been weak across the industry.

788. I consider it notable that this July 2000 survey report identified that "the use of fire barriers appears to be very sporadic and typical responses included 'only fitted when asked' or 'unknown'", thus suggesting credible concerns with the extent to which cavity barriers (which had been recommended in the building regulations guidance for more than a decade, and with heightened importance after the 1991 Knowsley Heights fire) were being properly utilised across the industry.

789. BRE (Colwell) then go on to present two "options" for DETR as to possible large-scale testing programmes to be performed "in accordance with BRE fire Note 9 using the existing test facility at BRE Cardington":

[462] BRE Cladding Survey Summary and Options Report {BRE00041887}

790. **Option 1** would involve five tests on three different "rendered systems" using one of mineral fibre, expanded polystyrene, or phenolic foam insulation. Tests with combustible insulation would also be tested both without *and with* "fire barriers".

791. This option would also involve six tests on four different "ventilated rainscreen systems", these being proposed as:

792. Test 1 - Metal faced panel on metal rail (mineral fibre insulation) – without "fire barriers".

793. Test 2 – Non-combustible panel on wooden battens (mineral fibre insulation) – without "fire barriers".

794. Test 3 - Class 0 panel on metal rails (mineral fibre insulation) – without *and with* "fire barriers".

795. Test 4 - Class 0 panel on wooden batten (mineral fibre insulation) – without *and with* "fire barriers".

796. The rationale for the proposed test programme is not explained in any detail in any reports that I have reviewed to date, and remains unknown to me.

797. **Option 2** would involve testing to address "several issues" relating to the use of "built-up, preformed insulation (where no masonry wall is present) and curtain wall systems" to assess "the influence of an internal masonry wall". This option would apparently be used support the modification of the then existing Fire Note 9 (which would later become BS 8414-2) to allow built-up systems and preformed insulation panels to be tested.

798. On the basis of the documents that have been made available to me at the time of writing, I have not been able to establish how the testing programme that was eventually undertaken and reported as part of this project – which was substantially different from that outlined above – was eventually decided. Nor have I been able to establish the technical or practical rationale for choosing the products and cladding configurations tested.

Large-Scale Cladding Test Programme

799. By the time that results from the large-scale testing programme were available, as outlined (for example) in a 13th December 2001 BRE spreadsheet,[463] the full testing programme consisted only of the tests shown in Table 3.

[463] {BRE00041913}

Table 3 Excerpt from BRE spreadsheet providing summaries of the testing programme actually performed by BRE under DETR contract No. cc1924.[464]

Row	System	Ext Cladding	Insulation	Fixing	Fire Break
1	Render	Thin scrim	Rockwool	Dab	None
2		Thin scrim	Phenolic	Dab	None
3		Thin scrim	PUR	Dab	None
4		Thin scrim	EPS	Dab	None
5		Thin scrim	EPS	Dab	Rockwool
6	Rainscreen	Resoplan	Rockwool	Wood	None
7		Resoplan	Isowool	Metal	Rockwool
8		Rockclad	Rockwool	Wood	None
9		Rockclad	Isowool	Metal	None
10		Aluminium	Isowool	Metal	None
11	Composite	Steel Profile	Rockwool	NA	None
12		Steel	PUR	NA	None
13		Steel	PIR	NA	None
14		Steel	EPS	NA	None

800. Thus, the eventual CC1924 large-scale test programme included a total of 14 tests, only two of which included "fire barriers" (one render system and one rainscreen system). Additionally, a range of insulation products were used across the testing programme, thus making like-for-like comparisons across any given parameter, or generating a generalised understanding of the various factors influencing cladding systems' responses to fire, essentially impossible.

801. The poor correlation between the options proposed to DETR in July 2000 versus those reported as having been performed in December 2001 is surprising from my perspective. Provision of cavity barriers within rainscreen cladding systems had been a key focus of BRE's external fire spread research since the 1991 Knowsley Heights fire, and one of the stated objectives of the CC1924 DETR contract was to understand the contribution of any "fire stopping" present within cladding systems. Why there appears to have been a preference in this testing programme to perform tests on systems *without* "fire barriers", and why the initial focus on understanding the role(s) of "fire barriers" appears to have been mostly set aside, is not clear to me.

802. In any case, I do not consider that the test programme presented in Table 3 was/is capable of significantly informing questions as regards the influence of cavity barriers. This is particularly true for the rainscreen cladding systems tested, given that at least two key variables were varied across the tests.

803. Notwithstanding my criticism of the overall experimental design for the test programme undertaken as part of DETR Contract No. CC1924, I believe that the testing outcomes from this work represent ***perhaps the most important of the***

[464] Excerpt from {BRE00041913}.

numerous missed opportunities highlighted within my expert reporting for the Inquiry, as I set out in what follows.

Data Generated via the CC1924 Contract

804. Table 4 provides a summary of test data derived from the CC1924 large-scale testing programme.[465] These data are from tests that used what would later become the BS 8414 testing method, which has been described elsewhere in this report (see e.g. Paragraph 199).

Table 4 Excerpt from BRE spreadsheet providing data from the large-scale testing programme performed by BRE under DETR contract No. cc1924.[466]

Rainscreen System		Ti °C	Time to 200 °C (min)	Time to 600 °C from Ts (min)				Test Time (min)	Fire Note 9 Pass/Fail
				Ext	1st TC	Insulation	1st TC		
1	Rockpanel mounted on wood battens no fire barriers	14.8	5.83	NR	NR	9.67	L2-E	30.00	Fail internally
2	Rockpanel mounted on aluminium rails no fire barriers	18.3	6.50	13.00	L2-C	12.33	L2-B	30.00	Fail external + internal temp
3	Resoplan mounted on wood battens no fire barriers	15.1	6.00	10.33	L2-C	12.33	L2-C	30.00	Fail external + internal temp
4	Resoplan mounted on aluminium rails intumescent grill fire barriers fitted	16.3	6.67	9.50	L2-B	8.50	L2-B	30.00	Fail external + internal temp
5	Aluminium sheets mounted on aluminium rails no fire barriers	18.2	6.33	3.00	L2-D	4.34	L2-H	5.75	Fail external + internal temp
Render Systems									
1	Phenolic insulation with acrylic render coat no fire barriers	19.5	6.50	8.33	L2-E	NR	NR	30.00	Fail external temp
2	Polyurethane insulation with acrylic render coat no fire barriers	18.2	6.67	4.16	L2-C	18.83	L2-D	30.00	Fail external temp
3	Expanded polystyrene core with acrylic render coat no fire barriers	19.9	6.67	12.83	L2-C	12.83	L2-A	13.50	Fail external + internal temp
4	Expanded polystyrene core with acrylic render coat.100mm lamella fire barriers at each floor	18.3	6.50	NR	NR	NR	NR	30.00	Pass
5	Rockwool core with acrylic render coat	18.6	6.67	NR	NR	NR	NR	30.00	Pass
Composite Panel Systems									
1	Polyisocyanurate cored panel no fire barriers	13.9	6.16	NR	NR	NR	NR	28.83	Fail flame penetration
2	Polyurethane cored panel no fire barriers	15.4	6.50	NR	NR	NR	NR	13.50	Fail flame penetration
3	Expanded polystyrene cored panel no fire barriers	8.0	6.33	12.58	L2-D	12.58	L2-D	30.00	Fail flame penetration + external + internal temp
4	Rockwool cored built up system no fire barriers	11.8	6.50	NR	NR	NR	NR	30.00	Pass

Notes:

1. L2 – (A-H) – Location of Thermocouples refer to BRE report 209169 revision 1 for full details.
2. NR – This parameter was not reached.

805. I make a number of observations on Table 4:

806. None of the rainscreen systems tested, regardless of the combustibility or National/European classification of the rainscreen products used, and regardless of the provision of cavity barriers or otherwise, passed these tests in terms of meeting the requirements of BRE Fire Note 9.

807. The test listed as Rainscreen System 5 in Table 4, which is described by BRE as having an "Aluminium sheets" external cladding (i.e. rainscreen) and "Isowool" (i.e. mineral fibre) cavity insulation,[467] and which did not have any "fire breaks" (i.e. cavity barriers) installed, reached the Fire Note 9 failure criteria *extremely* rapidly. The time to "external" failure was only 3.0 minutes, and the time to "internal" failure was only 4.34 minutes. Indeed the test was manually terminated only 5.75 minutes after the test start time. But *why*?

---

[465] BRE Client Report, Analysis of Fire Test Data for BRE 135 Project {BRE00041882}
[466] {BRE00041882}
[467] {BRE00041913}

808. In terms of the other "rainscreen" tests listed in Table 4, and based only on these summary data, the performance of the test listed as Rainscreen System 5 is clearly (and alarmingly in my opinion) more concerning as regards external fire spread than any of the other systems tested. All other tests ran the full 30 minute duration; albeit also failing according to the Fire Note 9 criteria.

809. Specific observations regarding the unusual severity the Rainscreen System 5 test are provided in what appears to be an internal (i.e. unformatted) BRE document that has been made available to me[468]. This is reproduced in Table 5.

Table 5 Excerpt from internal BRE document providing visual observations of the test listed as Rainscreen System 5 in Table 4.[469]

Rainscreen 3 – Aluminium + Isowool on metal no FB 18-07-01

0:00	Ignition of crib
0:41	Flame out of hearth
1:24	Flame reaches front level 1 TCs
2:02	Distortion of front face, row 1 panels
2:30	Flashing detail around heath falls away
2:30	Distortion of front face, row 2 panels
3:05	Molten aluminium drops off front face
4:08	Flame reaches front level 2 TCs
4:20	Flame reaches top of rig
5:00	Flame approximately twice height of rig (20m)
5:45	Crib doused
7:00	Front and wing faces extinguished

810. I note that I cannot reconcile the times given in Table 5 with those given in Table 4, particularly for the "time to 200°C (min)" column in Table 4, given "Ignition of crib" at 0:00. I suspect that "Ignition of crib" should actually read "Test start time".

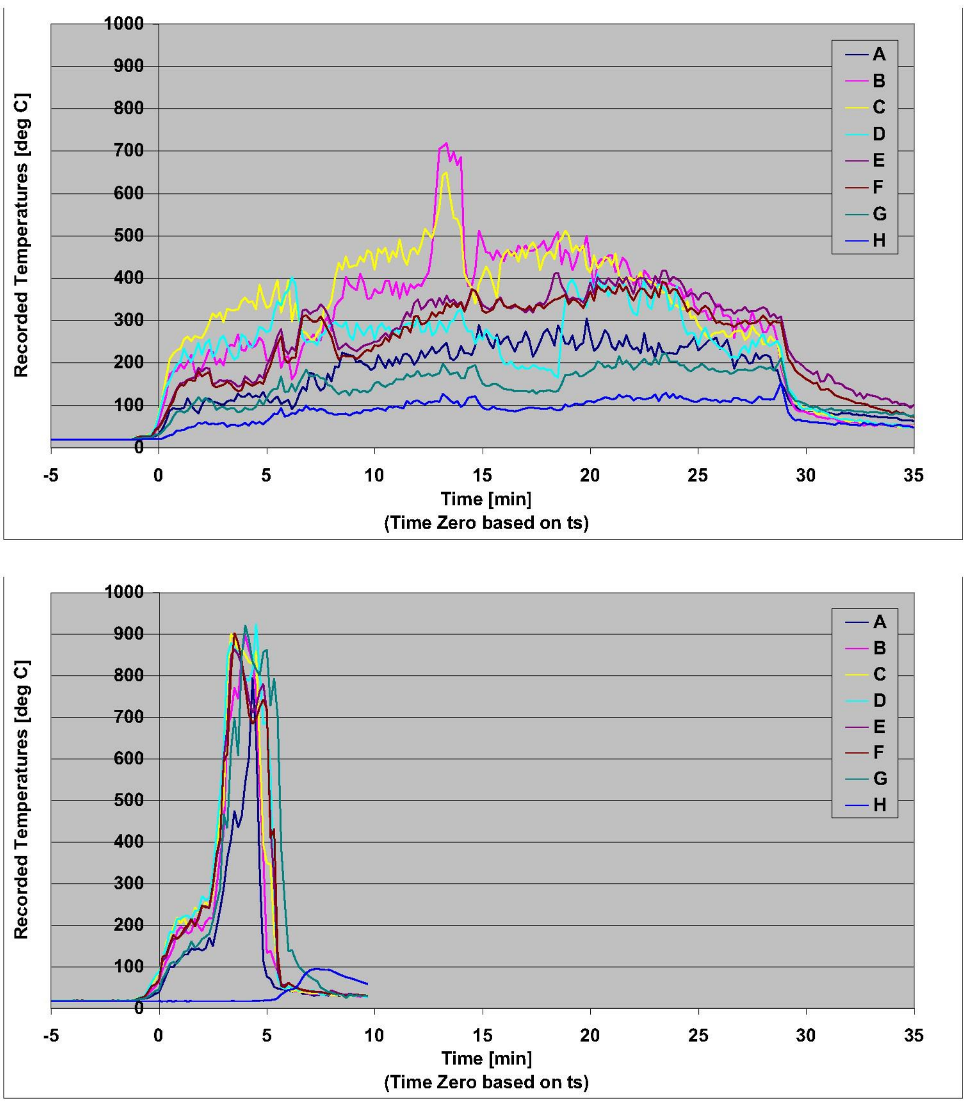
811. Notwithstanding the above comment, the observations in the Table 5 are striking in that they note that the "flame reaches top of rig" in just 4:20 minutes, and that just 40 seconds later the flaming was "approximately twice height of rig (20m)". I consider this to be very clear evidence that the "Aluminium" rainscreen product used in this test was obviously unsuitable for external cladding applications on the vast majority of multistorey buildings, and – critically – that this ought to have raised an alarm, given that it appears this product was being used specifically because it was *already* being used on local council buildings in the UK; possibly widely.

812. A final further indication of the severe fire hazards associated with the system listed as Rainscreen System 5 in Table 4 is illustrated by comparison of the test data recorded for this system versus, for example, the system listed as Rainscreen System 2 in Table 4; this was identical to the Rainscreen System 5 system, however substituting a "Rockpanel"[470] rainscreen product for the "Aluminium" rainscreen. These respective test data are shown in Figure 17.

[468] Excerpt from what appears to be an unformatted internal BRE document {BRE00041911/3}.
[469] Excerpt from {BRE00041911/3}.
[470] I note that this rainscreen product is variously referred to as Rockpanel and Rockclad in the BRE documentation for DETR Contract No. CC1924.

813. It is evident in Figure 17 that that Rainscreen System 5 test escalates extremely rapidly, with temperatures in excess of 800°C being recorded at Level 2 within just a few minutes from the start of the test (and with the test needing to be manually extinguished shortly thereafter).

814. Conversely, Rainscreen System 3 – which *also failed* to meet the requirements of Fire Note 9 – demonstrated much lower temperatures, over much longer durations, and apparently did not escalate so catastrophically that it needed to be manually extinguished.



(a)

(b)

Figure 17 Temperature data recorded by the Level 2 external thermocouples[471] in Rainscreen System (a) Test 2[472] and (b) Test 5[473] in Table 4[474] (screen captures from the original BRE reports).

[471] See BS 8414 and BR 135 for a description of the "Level 2 external thermocouples".
[472] Excerpt from {BRE00041914/8}.
[473] Excerpt from {BRE00041914/7}.
[474] I note that this rainscreen product is variously referred to as Rockpanel and Rockclad in the BRE documentation for DETR Contract No. CC1924.

815. Given that the only difference between Rainscreen System 2 and Rainscreen System 5 appears to have been the type of rainscreen cladding product used, the data in Figure 17 thus clearly demonstrate the extreme external fire spread hazards associated specifically with the "Aluminium" rainscreen product used in this test. Whilst both systems failed to meet the acceptance criteria of Fire Note 9, Rainscreen System 5 is, in my opinion, and order of magnitude more concerning in this regard than Rainscreen System 2.

816. In reviewing the evidence associated with Contract No. CC1924 that has been made available to me, I have noted that the rainscreen cladding product used in Rainscreen System 5 is variously described (almost everywhere that it is mentioned in all of the test descriptions, summaries, reports to DETR, etc) as "Aluminium", or "Aluminium sheets", or "Aluminium sheet product". The response to fire suggested by the data provided in Table 4, Table 5, and Figure 17 is – in my opinion – highly inconsistent with these descriptions; I would not generally expect a fully non-combustible ventilated rainscreen cladding system, either with or without the presence of cavity barriers, to escalate so rapidly with respect to external fire spread.

817. However, in (only) two locations within the 70+ documents that I have reviewed with respect to DETR Contract No. CC1924, I have noted descriptions of this particular "aluminium sheets" rainscreen product that align much more convincingly with the test data presented above.

818. In a 19th September 2002 client report submitted to Anthony Burd (Office of the Deputy Prime Minister),[475] the "aluminium" system is described more specifically as (emphasis added):

819. "Aluminium / *polyethylene core* sheets on aluminium railing"

820. The same description is given in a separate (blank) BRE tabulated summary of test results to BS 476 Part 6 and 476 Part 7, ISO 9705, and the Euroclasses.[476]

821. I consider it very likely that this particular product was *actually* an ACM PE rainscreen cladding product. At the time of writing I am unable to confirm the specific product used or its thickness/dimensions. Nevertheless, it is my understanding that most products available on the market at this time comprised 3 mm polyethylene filler/core between two 0.5 mm thick sheets of aluminium. I consider it likely, therefore, that the product used in this project was of the same type (though not necessarily produced by the same manufacturer) as that which was later used for the rainscreen cladding at Grenfell Tower.

822. The 19th September 2002 client report[477] also provides summaries of the additional data generated from tests performed on the various cladding products used in the systems tested at large-scale via Contract No. CC1924.

---

[475] {BRE00041882}
[476] {BRE00041909}
[477] {BRE00041882}

823. **National Reaction-to-Fire Classifications**

824. Table 6 provides a summary of the outcomes of National reaction-to-fire classification tests for products used in the CC1924 testing programme. Test results are given for testing to BS 476 Part 6 and BS 476 Part 7, apparently with a view to establishing which of these products was able to achieve Class 0 in accordance with Approved Document B (2000).

825. In presenting these test data, BRE make the following remarks:

826. "The results from these tests were not as expected, with only four of the eleven products achieving Class 0. All the materials tested were believed to be Class 0 products when purchased for this project.

827. The aluminium cladding panels achieved a Class 0 performance when tested to BS 476 parts 6 and 7, both their performance in the fire propagation test and the surface spread of flame test showed they fully met the requirement of this classification."

828. I note the (not uncommon, but imprecise) use of the word "materials" to describe the *products* that were tested. Also, I am not aware of the basis for BRE's "belief" that all of these products were Class 0 when purchased, and no evidence to support this claim is available to me at the time of writing.

829. The data in Table 6 confirm that, of the three rainscreen cladding products used in this testing programme, only the "Aluminium sheet" (which, as already noted, I believe to have actually been an ACM PE cladding product, rather than solid aluminium) was able to achieve Class 0, despite the fact that all three of these products was apparently "believed to be" Class 0.

830. In my opinion, this realisation *alone* ought to have been sufficient for the relevant government departments to consider potentially serious questions about the effectiveness of fire safety compliance testing and the regulatory oversight of product testing/marketing in England and Wales.

LBYP20000001_0152

Table 6 Tabulated National reaction-to-fire classification test results from DETR Contract No. CC1924 research.[478]

Product Description		BS 476 part 7		BS 476 part 6				Class 0
Rainscreen systems		**Class**	**Comment**	**I**	**i1**	**i2**	**i3**	
1	Rockpanel sheet	2	1 spec 280mm 5 spec 0mm	1.4	0.3	0.4	0.7	N
2	Resopian sheet	2	1 spec 210mm 5 spec<60mm	9.3	1.4	2.7	5.2	N
3	Aluminium sheet	1	Zero flame	2.4	2.1	0.1	0.2	Y
Render Systems								
1	Phenolic insulation with acrylic render coat	2	1 spec at 10min all flame start 2+min	4.2	0.1	3.7	0.4	N
2	Polyurethane insulation with acrylic render coat	2	3 spec at 10min all flame start 2+min	4.9	0.1	4.2	0.6	N
3	Expanded polystyrene core with acrylic render coat	1		3.9	2.3	1.4	0.2	Y
4	Rockwool core with acrylic render coat	1		2.0	0.0	1.7	0.3	Y
Composite Panel systems								
1	Polyisocyanurate cored panel	4	At 1.5 min 2 specs 1spec cl3, 3 sp cl2	3.9	1.6	1.3	1.0	N
2	Polyurethane cored panel	3	At 1.5min 3 spec 2 specs class 2	3.1	0.4	2.4	0.3	N
3	Expanded polystyrene cored panel	1		3.4	1.9	1.4	0.1	Y
4	Rockwool cored built up system facing only tested	2	At 1.5min –3 horizontal specs	0.7	0.2	0.5	0.0	N

European Reaction-to-Fire Classifications

831. Table 7 provides a summary of the outcomes of BS EN ISO 11925 Part 2 small flame impingement tests performed on the cladding products used in the CC1924 testing programme; such testing is relevant to the European reaction-to-fire classification system outlined in BS EN 13501-1. If a product were to pass this test, then it would achieve a Class E under the European system. I have included these test results simply to highlight that no face or edge ignition was observed for the "Aluminium sheets" under these testing conditions.

[478] {BRE00041882}

Table 7 Tabulated BS EN ISO 11925 Part 2 test results from DETR Contract No. CC1924 research.[479]

Product Description		Small Flame Test EN ISO 11925 -2:2002 30 sec flame application	
		Face	Edge (if applicable)
Rainscreen Panels			
1	Rockpanel mounted on wood battens	no ignition	no ignition
2	Rockpanel mounted on aluminium rails		
3	Resoplan mounted on wood battens	no ignition	no ignition
4	Resoplan mounted on aluminium rails		
5	Aluminium sheets mounted on aluminium rails	no ignition	no ignition
Render Systems			
1	Phenolic insulation with acrylic render coat	no ignition	not applicable
2	Polyurethane insulation with acrylic render coat	no ignition	not applicable
3	Expanded polystyrene core with acrylic render coat	no ignition	not applicable
4	Rockwool core with acrylic render coat	no ignition	not applicable
Composite Panel Systems			
1	Polyisocyanurate cored panel	no ignition	not applicable
2	Polyurethane cored panel	no ignition	not applicable
3	Expanded polystyrene cored panel	no ignition	not applicable
4	Rockwool cored built up system	no ignition	not applicable

832. Table 8 provides a summary of the "indicative" outcomes of EN 13823 single burning item SBI testing for products used in the CC1924 testing programme, with all tests performed in duplicate. SBI testing is of central relevance to the European reaction-to-fire classification system outlined in BS EN 13501-1.

833. BRE note the following regarding the SBI testing outcomes:

834. "The aluminium system generated high rates of fire growth and in both cases was extinguished early due to excessive temperatures and fire growth. This is reflected in the indicative classification of D - s2,d0."

835. It is noteworthy that such a cladding product would not have been considered suitable for use on any building above 18 metres in height, either installed above or below 18 metres, if evaluated only based on the Euroclasses in accordance with Diagram 40 of Approved Document B (2002). If evaluated based on the National Classification system, however, the "Aluminium sheets" product, which had achieved Class 0 as noted above, would have been considered suitable either above or below 18 metres and on buildings of any height, despite its self-evidently and alarmingly poor response when tested in the SBI or at large-scale.

836. In my opinion, the data given in Table 8 provide additional clear evidence of the severe external fire spread hazards associated with the "Aluminium sheets" system tested. The observed fire growth rates and smoke generation values for the

479 {BRE00041882}

systems incorporating "aluminium sheets" as their rainscreens were *far greater* than those observed for any of the other rainscreen systems tested. Indeed, the tests incorporating the "aluminium sheets" rainscreen product again had to be terminated early "due to excessive temperatures and fire growth".

837. I consider that this evidence, generated by BRE and commissioned by government, clearly highlights the inability of the National reaction-to-fire classification system to detect the hazards presented by ACM with a polyethylene core. Taken together with the evidence that the ACM PE also caused rapid fire spread in a full scale test, I am shocked that this did not precipitate a decision to withdraw the National reaction-to-fire classifications from use in relation to the external wall (or, at the very least, in relation to a particular class of metal-faced composite cladding products).

Table 8 Tabulated EN 13823 (2002) (Single Burning Item) test results from DETR Contract No. CC1924 research.[480]

Product Description		**Single Burning Item Test EN 13823 : 2002**					
Rainscreen System		**Rank**	**Indicative Classification**	**$FIGRA_{0.2}$ ($W.s^{-1}$)**	**$FIGRA_{0.4}$ ($W.s^{-1}$)**	**SMOGRA ($m^2.s^{-2}$)**	**THR_{600s} (MJ)**
1	Rockpanel mounted on wood battens	2	B - s1,d0	49.3	19.3	4.9	2.6
				60.9	60.9	4.6	3.0
				55.1	**40.1**	**4.8**	**2.8**
2	Rockpanel mounted on aluminium rails	1	B - s1,d0	18.4	18.4	0.0	3.1
				17.0	17.0	0.8	2.9
				20.1	20.1	0.9	3.3
				18.5	**18.5**	**0.6**	**3.1**
3	Resoplan mounted on wood battens	3	B - s2,d0	76.4	51.9	19.3	3.4
				46.4	33.8	11.6	3.7
				61.4	**42.9**	**15.5**	**3.6**
4	Resoplan mounted on aluminium rails	4	B - s2,d0	91.7	45.6	3.5	3.0
				107.8	63.8	16.1	3.0
				99.8	**54.7**	**9.8**	**3.0**
5	Aluminium sheets mounted on aluminium rails	5	D - s2,d0	414.2	414.2	20.8	36.1
				328.6	328.6	17.0	0.6
				371.4	**371.4**	**18.9**	**18.4**
Render Systems							
1	Phenolic insulation with acrylic render coat	2	B - s2,d0	37.7	37.6	3.5	2.7
				44.4	42.5	4.0	3.5
				41.1	**40.1**	**3.8**	**3.1**
2	Polyurethane insulation with acrylic render coat	4	C - s2,d0	84.1	84.1	9.0	7.7
				90.3	90.3	8.5	7.8
				92.6	92.6	7.6	7.2
				89.0	**89.0**	**8.4**	**7.6**
3	Expanded polystyrene core with acrylic render coat	3	B - s2,d0	59.3	56.8	5.5	2.0
				56.3	49.3	3.9	2.0
				57.8	**53.1**	**4.7**	**2.0**
4	Rockwool core with acrylic render coat	1	B - s2,d0	39.7	33.5	3.9	1.6
				29.3	24.9	2.3	1.5
				34.5	**29.2**	**3.1**	**1.6**
Composite Panel Systems							
1	Polyisocyanurate cored panel	2	C - s3,d0	226.2	184.0	69.0	1.9
				217.7	145.6	68.5	4.7
				222.0	**164.8**	**68.8**	**3.3**
2	Polyurethane cored panel	1	C - s3,d0	162.7	108.1	60.7	6.8
				195.9	133.1	87.9	9.6
				179.3	**120.6**	**74.3**	**8.2**
3	Expanded polystyrene cored panel	4	D - s3,d0	428.4	428.4	182.2	45.7
				717.7	717.7	163.3	58.4
				573.1	**573.1**	**172.8**	**52.1**
4	Rockwool cored built up system	3	C - s3,d0	274.1	215.6	99.6	1.4
				250.4	185.4	84.3	1.2
				262.3	**200.5**	**92.0**	**1.3**

Notes:
1. Average values are given in bold.
2. No lateral flame spread to the edge of the samples was observed.
3. Ranking based on FIGRA values

480 {BRE00041882}

ISO 9705 Room Corner Tests

839. Table 9 provides a summary of the "indicative" outcomes of ISO 9705 room corner testing for products used in the CC1924 testing programme. Whilst such testing has no direct bearing on European reaction-to-fire classification, as noted in Paragraph 605 the ISO 9705 test represents the reference scenario upon which the Single Burning Item (SBI) test method was developed and calibrated.

Table 9 Tabulated ISO 9705 – Room Corner test results from DETR Contract No. CC1924 research.[481]

Product Description		Room Corner Test - ISO 9705					
Rainscreen System		Rank	Indicative Class	HRR_{peak} (kW)	FIGRA ($kW.s^{-1}$)	THR (MJ)	Comment
1	Rockpanel mounted on wood battens	2	B	282	0.25	77.7	Full Test
2	Rockpanel mounted on aluminium rails	1	A2	85	0.12	23.2	Full Test
3	Resoplan mounted on wood battens	4	C	828	1.26	35.0	F/O – 671s
4	Resoplan mounted on aluminium rails	3	C	879	0.64	99.8	F/O – 879s
5	Aluminium sheets mounted on aluminium rails	5	D	807	3.32	27.2	F/O – 305s
Render Systems							
1	Phenolic insulation with acrylic render coat	2	C	1031	1.15	314.7	F/O – 900s
2	Polyurethane insulation with acrylic render coat	4	D	804	2.38	147.8	F/O – 340s
3	Expanded polystyrene core with acrylic render coat	3	C	243	1.40	38.7	Roof collapsed-288s
4	Rockwool core with acrylic render coat	1	C	526	0.69	99.9	F/O – 770s
Composite Panel Systems							
1	Polyisocyanurate cored panel	2	C	973	1.22	48.6	F/O – 900s
2	Polyurethane cored panel	4	D/C	1548	2.09	72.5	F/O – 340s
3	Expanded polystyrene cored panel	3	D/C	1115	1.74	53.3	F/O – 640s
4	Rockwool cored built up system	1	A2	82	0.13	15.0	Full Test

Note:
1. F/O – Flash over test terminated
2. Composite panel systems - PUR/PIR Euroclass D by FIGRA, Class C by time to Flashover

840. Again, the "aluminium sheets" cladding system performed very poorly when compared against the other rainscreen cladding systems tested, with BRE commenting that:

841. "the aluminium panel system was the poorest performer in this group and flashed over 305s after ignition… "

842. Table 9 also shows that the "aluminium sheets" cladding system displayed the shortest time to flashover and the highest fire growth rate, in both cases by considerable margins.

843. Again, this provides additional clear evidence of the fire spread hazards associated with products of this type.

[481] {BRE00041882}

Summary and Discussion – A Critical Missed Opportunity

844. In concluding their report to Anthony Burd, BRE (Colwell) make the following comments and recommendations, stating amongst other things that (emphasis added):

845. "The results from the British Standard [National reaction-to-fire classification] tests showed that ***although purchased as Class 0 products, only four of the eleven products tested satisfied Class 0 requirements***.

846. ***The aluminium sheet product satisfied Class 0 requirements, but in the full-scale, intermediate scale and Single Burning Item test, proved to be one of the worst performing products***.

847. The ISO 9705 classifications, based on FIGRA, for the rainscreen systems appeared to provide more differentiation between products than the Euroclass tests.

848. The full-scale test was the only method which satisfactorily assessed the system performance, including detailing such as fire barriers."

849. I consider the final statement (paragraph) to be somewhat misleading. While I agree that the full scale facade test was the only test to assess the system performance including detailing such as fire barriers – this fails to acknowledge that the full scale facade test was the only test that was both a system test *and* included cavity barriers. The results from the SBI and Room Corner were not a full scale system test – nevertheless, they *unambiguously* highlighted the hazards presented by the ACM PE – which was also confirmed by the full-scale test.

850. In my opinion, the testing reported via BRE's DETR Contract No. CC1924 demonstrated, beyond any reasonable doubt, in 2001/2002:

851. (1) that the National reaction-to-fire classification system in general, and Class 0 in particular, was not able to detect the fire hazards associated with the use of some (apparently common) combustible rainscreen cladding products;

852. (2) that the poor correlation between the National reaction-to-fire classification system and the European reaction-to-fire classification system meant that application of the "equivalencies" developed during the RADAR 2 project (see Paragraph 609 and Figure 13) created potentially significant public safety hazards;

853. (3) that cavity barriers were (are) not a panacea for addressing the relevant external fire spread hazards associated with combustible rainscreen cladding systems; as had already been clearly demonstrated by Connolly's 1994 research, which was also performed by BRE (at that time as a government agency);

854. (4) that despite being able to achieve a Class 0 reaction-to-fire classification according to the National classification system, the "aluminium sheet" cladding (which I believe to have been ACM cladding panels with a polyethylene core,

similar to those later used at Grenfell Tower) presented a clear and alarming external fire spread hazard; and

855. (5) that an "aluminium sheet" (i.e. ACM PE) rainscreen cladding product – which appears to have been chosen for this research project, based on a survey of predominantly social housing providers, *specifically because it was already being used* to overclad social housing stock – was likely to perform unacceptably with respect to external fire spread hazards.

856. And yet, I have seen no evidence that any of the above realisations were acted upon. The 2002 revision of ADB did not omit Class 0 as a means of classifying cladding materials and products, and instead introduced the European classification system *in parallel*.

857. The consequence of the choice to retain Class 0 in 2002 would manifest in many subsequent fires over the following 15 years. However, none of these events were apparently sufficient to motivate government to withdraw Class 0. It would take the deaths of 72 people at Grenfell Tower to motivate government into withdrawing Class 0, and into disrupting industry's status quo.

858. Only then did government see fit to act on Class 0, and to discontinue its use.

859. As a final remark on the overall project under DETR Contract No. CC1924, I note that I have reviewed feedback that was provided to BRE by the project's "Industry Advisory Board". I am surprised that nobody on that board appears to have raised any concerns with respect to the performance of the "aluminium sheets" rainscreen cladding product tested. Nobody appears to have been concerned by the test data provided, by the significant discrepancies between the National and European reaction-to-fire classification systems, the ISO 9705 testing, and the large-scale testing. Nobody appears to have demanded (or even suggested) that Class 0 should be discontinued. Even with hindsight, I struggle to understand how this can be.

Aside: DCLG's Post-Grenfell Cladding Tests

860. As I have previously noted in Section 6.1.4 my *Phase 1 – Final Expert Report* for the Inquiry,[482] following the Grenfell Tower fire the (then) Department of Communities and Local Government (DCLG) commissioned a series of seven BS 8414-1 large scale cladding fire tests. These tests are described in a series of seven individual BRE reports.[483]

861. DCLG Test 2[484] was on a cladding system build up that consisted of a 4 mm thick ACM PE rainscreen product over 240 mm deep stone wool insulation, and a 55 mm deep ventilated cavity. Stone wool/intumescent strip cavity barriers were also used. This cladding build-up is reasonably similar to that which I assume was included in the CC1924 contract testing described in the preceding sections, albeit many subtle

[482] {LBYS00000001}
[483] All seven are available here: https://www.gov.uk/guidance/aluminium-composite-material-cladding.
[484] {CLG00016732}

differences between the two systems tested may exist, in addition to the presence of cavity barriers in the DCLG test whereas none were used in the CC1924 test.

862. The September 2017 BRE report for DCLG Test 2[485] introduced the post-Grenfell testing as follows:

863. "This report is one of a series, commissioned by the Department for Communities and Local Government (DCLG) intended to establish how different types of Aluminium Composite Material (ACM) panels in combination with different types of insulation behave in a fire."

864. In my opinion, the likely performance of DCLG Test 2 had already been sufficiently established, some 15 years earlier, as part of the CC1924 contract. Despite having been personally involved in witnessing several of the post-Grenfell large-scale cladding tests performed by government, at no point have BRE or government ever made me aware of the CC1924 research or its outcomes.

13.11. Fire at The Edge, Salford (2005)

865. As described previously, the harmonised European test methods were introduced into Approved Document B in 2002. This was followed by a subsequent update to Approved Document B in 2006.[486] In this new edition, the new large-scale test that had been created by BRE in the 1990s was cited as BS 8414.[487] The Select Committee inquiry had recommended that the new, large scale cladding test should be "substituted" for the existing small scale tests. However, the 2006 edition did not introduce BS 8414 as a replacement; it was added as an "alternative" route whereby compliance with the Building Regulations could be demonstrated.[488] The addition of BS 8414 was not highlighted within the "Main Changes" section of ADB 2006.

866. The existing recommendation that external surfaces above 18 metres in height should be Class 0 (or Class B-s3, d2) was retained in the 2006 edition, and the recommendation that insulation should be of limited combustibility (which had previously been limited to insulation within a ventilated cavity) was broadened to include "any insulation product, filler material (not including gaskets, sealants and similar) etc. used in the external wall construction".[489] Critically in the context of the subsequent Grenfell Tower fire, this new text introduced the word "filler" within Clause 12.7 of ADB 2006. Also critically, the new text was introduced beneath a new heading of "Insulation Materials/Products".

867. The new heading and text appear to have been introduced in 2006 as a response to an external cladding fire which occurred in a highrise residential building called "The Edge", in Salford, on 6th January 2005. As at Knowsley Heights and Garnock

[485] {CLG00016732}
[486] Approved Document B, 2006.
[487] BSI 2002b.
[488] Approved Document B, 2006, 93.
[489] Approved Document B, 2006, 94.

Court, The Edge fire was also investigated as part of BRE's ongoing[490] "Investigation of real fires" project (for April 2004 - March 2005 in this case).[491] On this occasion the investigation was conducted by Sam Greenwood and Sarah Colwell.

868. The Edge is a 19-storey residential building in Salford. The 2005 fire occurred whilst the building was under construction but had been partially occupied. The building was originally clad (in some locations) with panels comprising an expanded polystyrene (EPS) filler/core with aluminium skins on its inside and outside faces.[492] This product was frequently used "for decorative purposes" such as external cladding.[493] These products are more commonly referred to in the construction industry as "sandwich panels", and are shown in Figure 18.

Figure 18 Intact sandwich panel assembly forming the exterior cladding at The Edge, Salford in 2005.[494]

[490] It is my understanding that BRE have been contracted to investigate and report on "fires of special interest" for government, essentially continuously since 1974 (see https://www.lambeth.gov.uk/sites/default/files/LakanalTranscriptDay34.pdf, 56).
[491] BRE Investigation of Real Fires April 2004 – March 2005,{BRE00000937}, BRE Final Research Report, Investigation of Real Fires, 27 March 2007 {BRE00000936}
[492] {BRE00000937}
[493] BRE report into the fire at The Edge {BRE00035368}
[494] {BRE00000937}

Figure 19 Scaffolding over the full height of The Edge, Salford in 2005.[495]

869. BRE's investigation reports that fire started on a balcony at second floor level and, subsequently involved a scaffold that had been erected to the full height of the building (see Figure 19). BRE suggest that "the burning timber caused the sandwich panels to delaminate and once the expanded polystyrene core became involved, the spread of fire up the building was extremely fast", with some reports "that the fire then spread up the remaining 17 floors in less than 10 minutes".[496]

870. The BRE report also states that "once the fire had spread to the top of the building it then was wind driven across the top of the roof and in places had began [sic] to burn down the pitch of the roof on the adjacent side of the building", going on to note that "this downward fire spread is unusual and probably as a result of being driven by the prevailing wind".[497]

871. It is not clear what evidence is being used to support the above fire spread hypothesis. I believe that it is worth considering that downward fire spread over the pitched roof could have been (at least partly) due to flow of melting, burning thermoplastic expanded polystyrene foam filler/core material originating from the ACM cladding (sandwich panels). I also note that dripping and flowing of burning thermoplastics was an important factor during the Grenfell Tower fire[498].

872. Surprisingly from my perspective, BRE comment in their report that "it was not possible to establish if the cladding system had been installed complete with cavity barriers at floor level in accordance with the Approved Document B", but that "Fire

[495] {BRE00000937}
[496] {BRE00000937}
[497] {BRE00000937}
[498] {LBYS0000001}

and Rescue Service sources believe that this was the case". I am surprised that greater effort was not made to definitively establish whether cavity barriers had been present and properly installed within the cavity behind the cladding panels. Since the 1991 Knowsley Heights fire, considerable importance had been ascribed to cavity barriers within rainscreen cladding systems by BRE; cavity barriers had been a key focus of much of the subsequent BRE research dealing with external cladding fires that had occurred during the intervening 14 years.

873. I am also surprised that BRE did not explicitly comment on the presence (or otherwise) of any thermal insulation placed within the cavity at The Edge. It is simply stated that, "the sandwich panels were fixed to the building leaving a cavity between the panels and the structural walls".[499]

874. In summarising what they considered to be the key issue during The Edge fire, BRE point out that:

875. "the fact that the fire burned so readily through the core of this type of sandwich panel means that even if the construction complied with current guidance, the rapid fire spread through the panels themselves would not be restricted".

876. They go on to state that:

877. "the Fire and Rescue Services have grave concerns that when the building becomes fully occupied a fire of this nature could quickly become out of control and put the lives of occupants at risk".

878. In their fire scene investigation report for the Department for Communities and Local Government,[500] BRE add additional detail to the above remarks. For example, they note the following (original emphases):

879. "it is clear that there was no attempt to provide barriers within the core of the panels and as such fire spread through the panels themselves was not restricted.

880. Paragraph 13.7 of Approved Document B[501] states that;

881. "*the external envelope of a building should not provide a medium for fire spread if it is likely to be a risk to health or safety. The use of combustible materials for cladding framework, or of combustible thermal insulation as an overcladding or in ventilated cavities, may present such a risk in tall buildings"*

882. **and**

[499] {BRE00035368}
[500] {BRE00035368}
[501] I assume it is Approved Document B (2000, amended 2002) which is being referenced here.

883. *"In a building with a storey 18m or more above ground level, insulation material used in ventilated cavities in the external wall construction should be of limited combustibility (see Appendix A)."*

884. Whilst the first general statement warns against the use of combustible materials the subsequent more specific guidance refers only to insulation material used in ventilated cavities. In the case of this building, however, the polystyrene core was not, primarily, used for its insulating properties but rather as a low cost filler to provide stiffness to the decorative aluminium cladding. The polystyrene core was also not exposed to the cavity. It is conceivable therefore, that the designers of this building may have taken the view that this restriction was not applicable.

885. It may be advisable to revisit this guidance and consider if more explicit guidance could be given to avoid any confusion in the future."

886. Based on the available evidence, I think it is reasonable to assume that the above comments substantively explain the 2006 changes made to the relevant sections of Approved Document B.

887. I have reviewed all available evidence relating to BRE's reporting of their investigation of the fire at The Edge. This was undertaken as part of their "Investigation of Real Fires" project for Anthony Burd of Communities and Local Government.[502]

888. BRE's final report for this project for the period April 2004 to March 2007 notes the overall objectives of this programme as being (partial list)[503]:

889. "(1) to provide timely feedback to Communities and Local Government on the effectiveness or otherwise of the guidance in Building Regulations Approved Document B (Fire safety) in achieving fire safety in real buildings in England and Wales;

890. (2) to improve understanding of how unusual fires develop and grow, particularly in domestic and other residential property;

891. (3) to monitor the impact of European Standards on building materials and systems;

892. (4) to identify the effect of the Building Regulations in providing/failing to provide protection for fire-fighters;

893. (5) to maintain close contacts with other investigators in the brigades and elsewhere to encourage the exchange of information on unusual fires that will be of benefit to Communities and Local Government; and

[502] {BRE00000936}
[503] With respect to BRE's approach to investigating fires within this overall project, [BRE00000936] also points out that "If the fire receives a high level of press and media coverage it is investigated as a way of keeping Ministers informed in a timely and appropriate manner."

894. (6) to disseminate findings from fire investigations to the fire service, building designers and owners and others, as relevant."

895. I believe it is worthwhile to interrogate (as an illustrative example) the extent to which the above objectives were met via BRE's investigation and reporting of the 2005 fire at The Edge, given the important concerns that I believe this fire raised[504].

896. With respect to Objective (1), BRE state that "the findings from this period have reaffirmed the overall effectiveness of the building regulations and AD B in providing for the safety of life in the event of fire. Most of the significant issues that have been identified during this study fall outside the scope of these regulations".[505]

897. It is my opinion that the above statement is difficult to support based on the BRE reporting of the fire at The Edge, and that instead this fire raised obvious questions regarding the effectiveness or otherwise of the guidance in Approved Document B (2002).

898. I believe it ought to have been of interest whether the EPS-filled sandwich panels were National Class 0, or alternatively European Class B-s3, d2 or better, as they would have been recommended to be (above 18 metres) according to Diagram 40 in Approved Document B (2002). I am surprised that no comments were made on this point in any of the BRE evidence available to me at the time of writing. Indeed, I have found no mention of Class 0 (or of any European classifications) anywhere in BRE's reporting of this fire to government. It is therefore my opinion that objective (1) had not been met with respect to this fire.

899. With respect to Objective (2), it is my opinion that the descriptions of how this fire grew and spread are incomplete, and that some of the explanations given represent conjecture which is not supported by any clear evidence. For instance, the BRE reports on this fire state that "a fire in a block of flats (Birmingham) highlighted the need for fire stopping or cavity barriers in the core of sandwich panel cladding systems".[506] Notwithstanding the fact that this fire occurred in Salford, rather than Birmingham as stated, I am not aware of any evidence – then or now – that the presence of cavity barriers within the core of an EPS-filled sandwich panel is able to prevent rapid and extensive external vertical fire spread when such panels are used as cladding as at The Edge.

900. No evidence of the specific mechanisms of fire spread (either upward in the cladding or across and downward on the pitched roof) are provided in the reporting on this fire.

901. The performance of any cavity barriers that could have been placed within the cores of the sandwich panels would presumably have relied on the aluminium skins

[504] Here I use the 2005 fire at The Edge, Salford, as an example (admittedly with the benefit of hindsight) of the extent to which the objectives of this long-running programme for government can be viewed as having met its stated objectives. Similar questions can be considered as regards other fires of major interest investigated by BRE under their fires of special interest projects going back to Knowsley Heights. However, in this report I will not provide a detailed critique of all such relevant investigations.
[505] {BRE00000937}
[506] {BRE00000936}

remaining intact and in place with minimal mechanical deformation; I consider such a scenario to be unlikely given the thermally-induced deformations that I would expect to occur due to severe thermal exposures in a fire.

902. In any case, I am not aware of any commercially available sandwich panel products which incorporate cavity barriers within their cores. I am therefore unaware of any evidence to support BRE's statement; it is my opinion that Objective (2) had not been met with respect to this fire.

903. With respect to Objective (3), the evidence available to me suggests that BRE did not comment on the possibility that the EPS-filled cladding panels used at The Edge might have been approved based on the (still relatively new) European classification system, first introduced in ADB 2002, rather than based on the pre-existing National classification system. I believe that this ought to have been an obvious question to consider in any reporting for the benefit of government. It is therefore my opinion that Objective (3) had not been met with respect to this fire.

904. With respect to Objective (4), given that fighting a rapidly escalating external cladding fire is likely to put fire and rescue services significantly at risk, and given my comments above, it is my opinion that Objective (4) had not been met with respect to this fire.

905. With respect to Objectives (5) and (6), I note a 12th May 2005 letter from BRE's Martin Shipp to Simon Hunt of the Greater Manchester Fire and Rescue Service (GMFRS).[507] In this letter, Shipp states that Hunt had asked if BRE could provide GMFRS with their report regarding the fire at The Edge. Shipp responds that BRE's "reports to ODPM are typically confidential" but that "Anthony Burd at ODPM has agreed that we can provide you with a copy of our report since we understand that this may be of assistance to your investigations". Shipp goes on to point out that, "whilst it has not generally been ODPM policy to circulate such specific briefings, we have received permission on this occasion to forward a copy of our report to the Fire and Rescue Service and to the relevant Building Control Body, as it is felt it could be useful to all concerned on this particular occasion".

906. In my opinion the above statements are fundamentally inconsistent with an objective to "encourage the exchange of information on unusual fires that will be of benefit to Communities and Local Government", and also inconsistent with an objective to "disseminate findings from fire investigations to the fire service, building designers, and owners and others".

907. It is my opinion that the specific results of BRE's fire investigations at The Edge could have been of very significant interest (and importance) to fire and rescue services, building designers, building owners, and others across the UK. Other buildings may have used similar cladding products and systems in their construction. This had the potential to generate a risk that – in BRE's own words –

[507] Letter from Martin Shipp (BRE) to Simon Hunt (Greater Manchester County Fire and Rescue) {BRE00035367}

another “fire of this nature could quickly become out of control and put the lives of occupants at risk”.

908. I consider it troubling that I have seen no evidence that either BRE or government took any specific steps to notify fire and rescue services, building designers, owners, or others of the significant concerns raised by The Edge fire. It is therefore my opinion that objectives (5) and (6) had not been met with respect to this fire.

909. I therefore disagree with the overarching claim that “all of the objectives of the programme have been achieved”.[508]

910. The report eventually concludes, however, that:

911. “The findings from this programme have reaffirmed the overall effectiveness of the building regulations and AD B in providing for the safety of life in the event of fire and most of the significant issues that have been identified during this study fall outside the scope of these regulations.”

912. This statement is self-evidently and factually inaccurate, given that BRE had advised government that specific revisions to Approved Document B were needed to mitigate the external fire spread hazards observed at The Edge.

13.12. Approved Document B (2006)

913. In the previous section, I briefly summarised the changes that were made to Approved Document B in 2006. However, these updates bear closer examination given that the key guidance formulated in this edition of the document was largely still in place during the Grenfell Tower refurbishment.

13.12.1. Overall Changes

914. Table 10 provides a side-by-side comparison of some of the relevant sections of text from the 2002 and 2006 versions of Approved Document B. Noteworthy changes include:

915. changes to the headings used within these clauses, with overall comments on issues relevant to all “External Wall Construction” considerations having been brought to the front of this section of the guidance;

916. the clause dealing specifically with provisions for “External Surfaces” having been moved *below* the overarching guidance on “External Wall Construction”; presumably[509] so as to highlight to the reader that Clause 12.6 (and indeed clauses 12.7-12.9 also) is subservient to Clause 12.5;

917. references to Fire Note 9 having been updated to reflect the publication of BRE 135 (2003) and BS 8414 parts 1 (2002) and 2 (2005);

[508] {BRE00000936}
[509] This is an assumption on my part. Whilst this is certainly how I have always read these clauses, I have no evidence to suggest that the those who drafted ADB 2006 were thinking along these lines at the time that this text was drafted, nor that this view was widely held within the industry prior to the Grenfell Tower fire.

918. the movement of the references to BR 135 and BS 8414 within the clauses, so as to change the situation from where "insulation used in ventilated cavities in the external wall construction should be of limited combustibility [regardless of testing to BS 8414]" to one where "external walls should either meet the guidance given in paragraphs 12.6 to 12.9 or meet the performance criteria given in [BR 135] for cladding systems using full scale testing data from [BS 8414-1 or BS 8414-2]", thus opening the door that had previously been closed to use of combustible insulation products in ventilated cavities above 18 metres in height; and

919. the new heading of "Insulation Materials/Products" having been added above Clause 12.7 along with the addition of the word "filler" within Clause 12.7 (as noted previously), as well as changing the recommendation from one applicable only to "insulation used in ventilated cavities", to one applicable to "insulation materials/products" used in the "external wall" regardless of being in a ventilated cavity.

920. I am surprised that none of the above changes were highlighted within the "Main Changes" section of ADB 2006, given that they will have been significant to those involved with external cladding. I can think of no reason for not highlighting these changes, particularly given that – as already discussed – they appear to have been motivated by the 2005 external cladding fire at The Edge, Salford which had significant implications for public safety.

921. It is also possible that similar cladding materials and products may have been widely used elsewhere in England and Wales prior to the 2006 changes to Approved Document B being implemented. I am not aware of any evidence that building owners were notified or cautioned based on these significant updates to Approved Document B.

Table 10 Side-by-side comparison of the relevant sections of text from the 2002 and 2006 versions of Approved Document B

ADB 2002	ADB 2006
External surfaces **13.5** The external surfaces of walls should meet the provisions in Diagram 40. However, the total amount of combustible material may be limited in practice by the provisions for space separation in Section 14 (see paragraph 14.7 et seq). Where a mixed use building includes Assembly and Recreation Purpose Group accommodation, the external surfaces of walls should meet the provisions in Diagram 40c. **Note:** One alternative to meeting the provisions in Diagram 40 could be BRE Fire Note 9 *Assessing the fire performance of external cladding systems: a test method* (BRE, 1999). **13.6** In the case of the outer cladding of a wall of 'rainscreen' construction (with a drained and ventilated cavity), the surface of the outer cladding which faces the cavity should also meet the provisions of Diagram 40. **External wall construction** **13.7** The external envelope of a building should not provide a medium for fire spread if it is likely to be a risk to health or safety. The use of combustible materials for cladding framework, or of combustible thermal insulation as an overcladding or in ventilated cavities, may present such a risk in tall buildings, even though the provisions for external surfaces in Diagram 40 may have been satisfied. In a building with a storey 18m or more above ground level, insulation material used in ventilated cavities in the external wall construction should be of limited combustibility (see Appendix A). This restriction does not apply to masonry cavity wall construction which complies with Diagram 32 in Section 10. Advice on the use of thermal insulation material is given in the BRE Report *Fire performance of external thermal insulation for walls of multi-storey buildings* (BR 135, 1988).	**External wall construction** **12.5** The external envelope of a building should not provide a medium for fire spread if it is likely to be a risk to health or safety. The use of combustible materials in the cladding system and extensive cavities may present such a risk in tall buildings. Externall walls should either meet the guidance given in paragraphs 12.6 to 12.9 or meet the performance criteria given in the BRE Report *Fire performance of external thermal insulation for walls of multi storey buildings* (BR 135) for cladding systems using full scale test data from BS 8414-1:2002 or BS 8414-2:2005. The total amount of combustible material may also be limited in practice by the provisions for space separation in Section 13 (see paragraph 13.7 onwards). **External surfaces** **12.6** The external surfaces of walls should meet the provisions in Diagram 40. Where a mixed use building includes Assembly and Recreation Purpose Group(s) accommodation, the external surfaces of walls should meet the provisions in Diagram 40c. **Insulation Materials/Products** **12.7** In a building with a storey 18m or more above ground level any insulation product, filler material (not including gaskets, sealants and similar) etc. used in the external wall construction should be of limited combustibility (see Appendix A). This restriction does not apply to masonry cavity wall construction which complies with Diagram 34 in Section 9. **Cavity barriers** **12.8** Cavity barriers should be provided in accordance with Section 9. **12.9** In the case of a an external wall construction, of a building which, by virtue of paragraph 9.10d (external cladding system with a masonry or concrete inner leaf), is not subject to the provisions of Table 13 *Maximum dimensions of cavities in non-domestic buildings*, the surfaces which face into cavities should also meet the provisions of Diagram 40.

LBYP20000001_0168

13.12.2. "Filler Material"

922. The heading and text used in Clause 12.7 in ADB 2006 (and subsequent versions of Approved Document B up until 2019) have taken on particular significance in the wake of the Grenfell Tower fire. Both I and other experts have commented on this issue.

923. I have previously commented on this issue in my *Interim & Phase 1 Recommendations*,[510] although at that time I was unaware of the significance of the 2005 fire at The Edge in generating the relevant text (and its heading title).

924. I have previously noted that I disagree with the Ministry of Housing, Communities and Local Government (MHCLG)'s apparent stance[511] that the relevant provisions of Approved Document B (Volume 2) (2006 edition incorporating the 2010 and 2013 amendments) were unambiguous prior to the Grenfell Tower fire.

925. I have previously referred specifically to ambiguity around the applicability of Paragraph 12.7 to materials and products other than "insulation", and the resulting applicability of the linked provisions given in ADB Diagram 40[512].

926. I have previously noted that, as far as I could ascertain, the closest that MHCLG had (or have since) come to acknowledging the potential ambiguities within Section 12 of ADB was in a footnote to a 22nd June 2017 letter authored by Melanie Dawes[513], which stated (emphasis added):

927. *"For the avoidance of doubt;* the core (filler) within an Aluminium Composite Material (ACM) is an "insulation material/product", "insulation product", and/or "filler material" as referred to in Paragraph 12.7 ("Insulation Materials/Products") in Section 12 "Construction of external walls" of Approved Document B (Fire safety) Volume 2 Buildings other than dwelling houses. (The important point to note is that Paragraph 12.7 does not just apply to thermal insulation within the wall construction, but applies to any element of the cladding system, including, therefore, the core of the ACM)."

928. I have previously noted that this ambiguity was well known and specifically discussed within some parts of the cladding/construction industry at least as early as 2014[514].

929. It was (and remains) my opinion that any perceived ambiguity in the specific wording of Paragraph 12.7 cannot credibly be used to absolve design or construction professionals of their responsibility for failings as regards installation of unacceptably dangerous external cladding on buildings.

---

[510] {LBYI00000001}

[511] Letter from Minister of State for Housing to Clive Betts MP, 1st May 2018 {INQ00015023}

[512] I note that much of this ambiguity has already been addressed by a series of *Amendments to the Approved Documents* issued in November 2018: {INQ00015022}

[513] Letter from Melanie Dawes to Local Authority and Housing Association Chief Executives 22 June 2017 {CLG00003750}

[514] See e.g. letter from CWCT to Clive Betts MP 10 May 2018 {LABC0013248} or minutes from the 2nd July 2014 CWCT meeting held at Arup's Fitzroy Street offices {CLG00019336}

930. Part of my rationale for the above opinion was (and is) that I believe it is reasonable to expect that any suitably competent design or construction professional, when faced with ambiguity in specific clauses of ADB (or any other statutory guidance), will consider this ambiguity in light of all other relevant clauses within the guidance, and will then make design and construction decisions that err on the side of caution and conservatism, rather than ignorance, cost, speed, convenience, or convention.

931. In the case of Paragraph 12.7, when considered in conjunction with Paragraph 12.5 – as is explicitly recommended in accordance with ADB Paragraph 0.4 – it is my opinion that *all* cladding designers are required to consider material and product characteristics that present external fire spread risks (and that may not be addressed by the potentially less stringent restrictions given in Diagram 40 of Approved Document B (2006), see Figure 20).

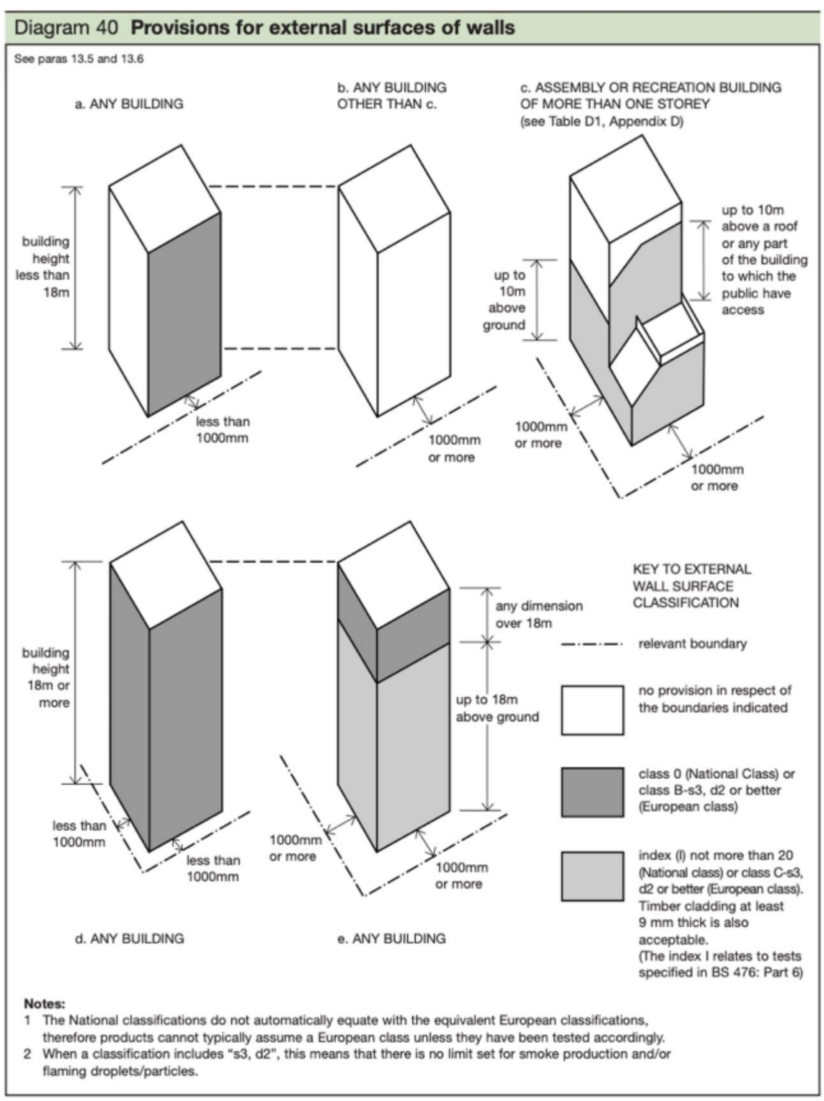


Figure 20 Diagram 40 of Approved Document B (2006).

932. I do not believe that individuals who have no understanding of the fundamental bases upon which construction materials and products are tested and certified for use in the design and construction of complex, safety critical engineering artefacts

– like buildings – should be legally permitted to operate as professionals within this space.

933. Other Inquiry expert witnesses have also highlighted the ambiguity in Clause 12.7 of Approved Document B. For Example, Dr Lane, in Appendix F or her Phase 1 Report to the Inquiry,[515] states that: "ADB 2013 Section 12.7 is directly under the title Insulation Materials/Products. I have therefore no understanding why it applies to anything else" and that "until the DCLG post-Grenfell Fire clarification, I had no prior professional experience of the core of an [ACM] system, being termed *Filler material* within the category of Insulation Product/Materials in ADB 2013."

934. Dr Lane also provides a detailed analysis of the specific words used in Approved Document B (2006-2013), and their strict definitions and perceived meanings in relation to guidance given in a range of available British, European, and ISO standards, eventually concluding that (original emphasis):

935. > "I cannot agree with the clarification provided after the Grenfell Fire, that the *Filler material* referred to in Section 12.7 of the ADB 2013, was intended to incorporate the external surface (dealt with by means of Diagram 40) when it is formed of an aluminium composite panel."

936. Based on the above discussions of The Edge fire, it would appear that those who implemented these changes to Approved Document B (2006) had in mind metal composite cladding products that consisted of two metal skins sandwiching a filler/core of thermoplastic insulation which acted as "low cost *filler* to provide stiffness to the decorative aluminium cladding" (emphasis added);[516] the word "filler" thus appears to have been taken verbatim from the text that BRE had used to flag this problem at The Edge to government.

937. It therefore appears that the "filler" material that Approved Document B (2006) "had in mind" was, as a matter of fact, polystyrene foam insulation acting as the filler/core of an aluminium faced sandwich panel – as informed by the investigation into The Edge fire.

938. In the cladding system design at The Edge, this appears to have been a sandwich panel which had an insulating core that was not primarily intended to provide insulation to the building; i.e., the fact that the core was insulating was not the reason why it had been used at The Edge. This may partly explain why the heading for Clause 12.7 ambiguously refers to "Insulation Materials/Products", and why the guidance relating to "filler materials" is found within the clause immediately beneath this heading.

939. This interpretation appears to be confirmed by a 25 November 2013 email from Brian Martin (DCLG) to BRE's Tony Baker and Sarah Colwell (cc'd).[517] In response to questions about the "interpretation of Diagram 40 and AD-B B4 clauses 12.6 & 7 [sic]", Martin made the following comments (emphases added):

---

[515] {BLAS0000027}
[516] {BRE00035368}
[517] Email from Brian Martin to Tony Baker, Sarah Colwell, Stephen Howard {BRE00047585}

940. "The problem we have with Class B is that you can have a thin surface that gives you the performance and back it with something less desirable. So *there's no such thing as a class B 'material'*.

941. The word *filler was introduced because of a particular incident where a polymeric foam was used to keep an aluminium panel stiff*. The foam was not used for thermal reasons so it wasn't 'insulation'! (it still burned of course!!!) Sarah will remember the details I'm sure.

942. I'm thinking out loud here but I think a homogenous Class B board would be fine (effectively a class B material?). But *a lamination of board with something else should revert to the limited combustibility criteria*.[518]

943. Does this make sense.

944. Don't quote me on this yet, what do you think?"

945. I believe that this email is referring specifically to the fire at The Edge, at which Colwell had participated in the BRE fire investigation.

946. In the external cladding system used at The Edge, the purpose of the polystyrene foam filler/core material appears to have been broadly the same as that served by the polyethylene filler/core used within the ACM PE cladding installed within the over-cladding system at Grenfell Tower; i.e. to provide a low cost filler that could provide a mechanical connection (called "composite action" in engineering terminology) between the cladding panels' outer aluminium skins.

947. My opinion remains that the ambiguity of the language used in Clause 12.7 and its heading could not (and cannot) credibly be relied upon as "tending to negative liability" by cladding designers seeking to defend a design decision to install ACM PE on highrise buildings within England and Wales *after* 2006, for reasons I have already stated.

948. However, it is also my opinion that, prior to 2006, the Approved Document B contained no recommendation that "cladding" products be comprised entirely of materials of limited combustibility; only that they be National Class 0 (or, from 2002, European Class B-s3, d2) in accordance with Diagram 40.

949. It would therefore appear that only from 2006 could Approved Document B be claimed (however ambiguously) to even attempt to explicitly address filler/core materials used within composite cladding products[519].

950. As an important aside, the above email also demonstrates that actors within government had been made explicitly aware, and indeed had articulated, at least as

[518] I note that the ideas being articulated in this paragraph, on 25th November 2013, closely echo many of the very same issues that had arisen during Martin's questioning during the Lakanal House Coroner's Inquest earlier that year, on 13th March 2013 – but about which it appears nothing was subsequently done to address.

[519] Of course, designers are still ultimately required to meet the functional requirements of the Building Regulations, rather than simply to comply with the guidance given in Approved Document B (this has been the case since the first appearance of the Approved Documents in 1985).

early as November 2013, that the guidance given in Approved Document B was potentially inadequate to address external fire spread hazards associated with the use of composite cladding products, and that in such cases a revision of the guidance to explicitly recommend limited combustibility was probably needed.

13.12.3. BS 8414 and BR 135

951. In addition to citing BS 8414[520], the 2006 revision of the Approved Document B also cited an updated version of BR 135[521]. This document, prepared by Sarah Colwell and Brian Martin (then) of BRE, included the acceptance criteria that were cited by the Approved Document as the pass/fail criteria for the BS 8414 test results.[522]

13.13. Multiple Routes to Compliance

952. The 2006 version of Approved Document B thus represents the confluence of three different approaches to testing (and regulating) materials and products used in the external walls of highrise buildings. The “old” British Standards testing and classification approach (which originated during the 1930s, 40s, and 50s as already described) was retained so that the “status quo” would not be adversely affected; the new European testing and classification system was introduced in order to meet the Government’s emerging obligations in Europe, after being imprecisely benchmarked against the existing National classification system via the RADAR 2 Project[523]; and the large scale BS 8414 cladding test(s) were introduced in response (in principle) to concerns regarding the behaviour of combustible cladding and insulation products in real fires such as Knowsley Heights and Garnock Court; and to permit (in practice) the use of products that did not meet the recommended classifications derived from National or European small-scale tests.

953. These three testing and classification methodologies represented three fundamentally different approaches.

954. The National method was relatively “low tech” compared to the methods embodied by European Classes and the SBI test – nevertheless, both of these two approaches were rooted in an attempt to evaluate the potential for a small fire to grow to flashover.

955. By contrast, 8414 testing was intended to explicitly evaluate the fire hazard posed by a cladding system when exposed to a fire that had *already* achieved flashover and broken out of a building. These issues have already been discussed in Part I of this report.

956. From this review of the background to the tests and guidance it emerges that Connolly, Field, and the members of the 1999 Select Committee inquiry panel were fundamentally correct to be concerned about the capacity of the existing National classification’s small scale fire tests to adequately evaluate the hazards posed by any material or product on the external wall of a building.

[520] BS 8414-1:2002 {CEL00001205} and BS 8414-2:2005 {BSI00000097}
[521] Rogowski et al. 1988.
[522] Colwell and Martin 2003.
[523] {CLG00000951/6}

957. However, the modernisation brought by the new European classification system, having been developed based on a reference scenario that was only loosely applicable to external fire spread hazards, was inadequate to address these more fundamental concerns. The reason for this emerges from Messerschmidt's 2008 analysis of the European system – that the European methods for classifying products were almost entirely based on an assessment of the likelihood of a fire's growth to flashover *inside* a compartment.

958. The reference scenario for the European (and, notably, also the National) material/product classifications is a room, with the materials/products in question used as *internal* linings. By contrast, the relevant scenario for vertical fire spread on the external wall (as notionally represented by BS 8414 or similar testing) is the impingement of the plume from an already large fire on the external cladding. *These two scenarios present fundamentally different thermal and mechanical conditions to the exposed materials/products.*

14. Confusion and Manipulation (2007 to 2013)

959. When the Approved Documents were introduced in 1985, they were launched into a regulatory environment that was dominated by prescription. However, over the course of the subsequent two decades, the notion of demonstrating adequacy by means of any number of alternative means had gained considerable momentum. Similarly, the introduction of competition between local authority and private building control authorities that had been given fresh impetus under the auspices of the CIC's Approved Inspectors Register (CICAIR) meant that building control bodies (both public and private sector) were *competing* to win the work over which they were then required to adjudicate. A key ideal of flexibility which had been sought by architects and researchers since before World War II had firmly taken hold within the industry.

14.1. Fundamental Changes in Building Control

960. Earlier in this report (Section 9.2) I discussed the Guest report of 1957[524] which laid much of the groundwork for the Building Regulations 1965. In that report, Guest provided a view on the fundamental purpose of building control which I consider to be relevant to the Grenfell Tower fire.

961. "It seems to us that the object of building control is—and should be—to ensure that the public (and this must be taken to include the occupants of buildings) do not suffer as a result of the way a building is designed and constructed: that is to say *the basic purpose of building control should be the protection of the public interest as regards health and safety*" (emphasis added).

962. In Appendix A of this report, a key change introduced by the Building Act 1984 is highlighted; that the move towards "private certification" by "approved inspectors" meant that local authority building control no longer retained a monopoly over design approval, thus introducing an element of competition within the building approvals process in England and Wales. Others have since noted that this led to a "race to the bottom"[525].

963. Fundamental changes in the culture and provision of building approvals have been articulated (in passing) by individuals with direct links to the Grenfell Tower fire. For example, in oral testimony heard within Module 2 the Inquiry, David Jones – the former Herefordshire Council building control officer who signed off LABC's deficient LABC Type Approval certificate for Kingspan K15 phenolic foam insulation boards in 2009[526] – provides relevant comments in both his written witness statement and his oral testimony[527].

964. In his witness statement, Jones points out that local authority building control agencies were/are increasingly under "a great deal of pressure to consider and accept innovative solutions for clients which did not necessarily follow rigidly the

524 Guest 1957, 15.
525 Hackitt 2018, 5.
526 System Approval Certificate for Kingspan K15 Rainscreen Board {HBC00000030}
527 David Jones, Oral Evidence, 4 March 2021 {Day 101:}

approved documents", and that "private building control bodies were frequently known to exploit local authority stereotypes in their marketing – 'go to the local authority and get tied up in red tape and rigid application of outdated approved document solutions; come to us and we'll give you innovative and free-thinking approaches to compliance'."

965. During his oral testimony, Jones points out that this led to "pressure on local authority surveyors to be open to new products and innovative solutions which the approved documents had yet to assimilate", and that "it was not uncommon for prospective clients to test our willingness to 'think outside the box' before placing their business with us".

966. Jones expands on this and explains that "this is a principle that applied in our building control business, as and when we were dealing with building control clients, which was our bread and butter, if you like, that's what we did... I felt, when I was writing the statement, that perhaps it was important to point this out as the backdrop against which we worked, and it might perhaps explain why, when dealing with the Kingspan exercise, my -- the way I went about it might have been influenced by the way I went about our normal building control activity."

967. Similarly, John Hoban – formerly the building control officer for the Royal Borough of Kensington and Chelsea, and who was assigned to the Grenfell Tower refurbishment and overcladding project – on at least four occasions in his oral evidence explained his own inadequate interrogation of various issues that arose during the refurbishment by stating that he was trying to "work with" one or more of Studio E, Rydon, or Harley.[528]

968. It is my opinion that fundamental changes in the role of (and approach taken by) building control authorities need to be considered in any root cause analysis of the factors conspiring to eventually yield the Grenfell Tower fire. This can be summarised as a change from a stance that was viewed by many as obstructive, to a stance that was proactively client-driven – working *with* clients so as to compete with private approvers. I also believe it is worth reiterating that the move to allow private certification was a political choice that was facilitated by the Construction Industry Council, and that the resulting changes in building control culture and practice were, in my opinion, entirely predictable.

14.2. Ideology and the "Third Way"

969. The actions that had led functional statements to being the sole legal requirement for building performance appear to have been driven by an ideology. As outlined by Guest in 1958, removal of regulatory constraints would enable "the resource and ingenuity of the industry" with the notion that industry would "be set more free to devise new and improved methods and materials of construction".[529] As noted in previous sections of this report, it was presumed that breaking the link between technical "rules" and legal requirements would allow greater "flexibility". If the guidance documents that had been approved by government were found to be too restrictive, then it was *the intent* of the system that manufacturers, designers, and

[528] John Hoban, Oral Evidence, 30 September 2020 and 1 October 2020 {Day45:} – {Day46:}
[529] Guest 1957, 57.

approvers should be able to circumvent the guidance given in the approved documents. Such a system obviously relies very heavily on the competence and professionalism of those operating within it. This is why some deemed-to-satisfy guidance was initially retained, rather than simply moving to a solely performance-based regulatory approach.

970. However, underpinning this system appears to have been a fundamental assumption; that those operating within the system would have sufficient *competence* to understand the more prescriptive contents and intent of the Approved Documents and, if they were seeking to demonstrate compliance with the functional requirements of the Building Regulations, would (1) be *competent* to do so and also would (2) willingly *accept the liability for this deviation from the Approved Documents*.

971. The mid 2000s saw a boom in "performance-based design" for fire safety which (at best) sought to realise this ideology – in the form of alternative or "fire engineered" solutions based on first principles analysis and industry-led research. However, while parts of the industry were indeed being "set more free", other parts of the industry had found and followed "third ways" of "demonstrating compliance" with the functional requirements of the Building Regulations.

972. The "first way" was for designers to treat the Approved Documents as a "deemed-to-satisfy" list of design solutions that could be assumed to meet the functional requirements of the Building Regulations. This was despite the fact that the provisions in Approved Document B were not (and have never been) deemed-to-satisfy provisions[530].

973. The "second way" was to demonstrate, via performance-based engineering design and first principles analysis, compliance with the functional requirements of the Building Regulations. This "way" was (and is) fraught with challenges because the system for checking and approving such design approaches is not well-developed and typically relies on 3rd party review. This brings additional complexities, costs, approvals risks, and – to be credible – requirements for a high level of competence within both the design *and* approvals teams.

974. The "third way", however, used a *hybrid* approach wherein the functional requirements of the Building Regulations and the guidance of Approved Document B were mixed together. This allowed designers to create the *appearance* of complying with Approved Documents, and hence the *appearance* of automatically satisfying the Building Regulations. Designers following the "third way" were able to avoid both the complications of the "second way" *and* the rigidities of the "first".

975. The logic of this approach is that the Approved Document is "just guidance" and can therefore be flexibly "interpreted" in line with the functional basis of the Building Regulations. However, demonstrating compliance with the Approved Document is both technically and administratively easier than undertaking (or approving) a full,

[530] Hackitt (2018, 26) has observed that, "the cumulative impact of the Approved Documents changes an outcome based system of regulation to one that is often *inferred* by users to be prescriptive" (emphasis added).

functionally-based design. Fewer difficult questions would be asked during the design and approval processes for ADB-compliant materials and products. And the liability for all parties was also *perceived* as being reduced, since compliance with the Approved Document was widely *perceived* as being "deemed-to-comply" with the Building Regulations.

976. Thus, if a manufacturer had (or an approver was faced with) a material or product that they wished to use in a given situation, but which did not *strictly* meet the recommendations of the Approved Document B, there was a powerful incentive to attempt to create the *appearance* of compliance with the Approved Document. This incentive would exist whether or not they *believed* that the particular product would meet the requirements of the building regulations in practice.

977. If such a manufacturer followed this route, then they would be able to sell their (otherwise unsaleable) product, whilst perceiving that they would attract little or no liability, and avoid additional costs, approvals risks, or any indeed need for competence within the design or approvals teams.

978. The potency of this "third way" has been demonstrated within the evidence and testimony during the Grenfell Tower Inquiry.

979. For example, the evidence has shown that Kingspan (successfully) attempted to claim a National Class 0 classification for their K15 foil-faced phenolic insulation boards. They then used this classification to support the case for use of their product in rainscreen cladding systems above 18 metres. It is my opinion that this demonstrates the "third way" approach to generating the *appearance* of complying with the Building regulations by generating the *appearance* of complying with the provisions of Approved Document B.

980. Similarly, Arconic successfully attempted to claim a blanket classification of European Class B-s3, d2 for Reynobond 55 PE. Again, by claiming this classification, they were able to create the *appearance* of complying with the Building Regulations by generating the *appearance* of complying with the provisions of Approved Document B.

14.2.1. Exploring the Third Way

981. The provisions of Approved Document B (taking the 2006 version incorporating 2007 amendments as an example) recommend that "any insulation product, filler material (…) etc." used in the external wall construction of a building with a storey 18 metres or more above ground level should be of limited combustibility.

982. Notwithstanding the debate as to whether "filler" in the above recommendation ought to apply to the filler/core of an ACM cladding product (see previous discussion in Section 13.12.2), it is nonetheless the case that neither Kingspan K15 nor Arconic's Reynobond 55 PE are – or could ever be credibly considered – materials, or, more accurately, products, of limited combustibility.

983. Diagram 40 of Approved Document B (e.g. 2006 incorporating 2007 amendments) also recommends that the *external* surfaces of cladding above 18 metres (or less than 1000 mmm from the boundary) should be Class 0 or Class B-s3, d2, or better.

984. Notably, Diagram 40 also includes a footnote that indicates that: "The national classifications do not automatically equate with the equivalent European classifications, therefore, products cannot typically assume a European class unless they have been tested accordingly". This is to say that European Class B-s3, d2 cannot be assumed to be the same as Class 0, and (presumably[531]) vice versa.

985. I am not aware that there has ever been any explicit recommendation in Approved Document B for *insulation* materials to achieve Class 0 when used in appropriately subdivided rainscreen cladding systems on highrise residential buildings[532].

14.2.1.1. An Example of "Third Way" Thinking – Kingspan K15 Insulation

986. Table 10 shows that, to be used within a rainscreen cladding system above 18 metres in accordance with the "linear route" recommendations of Clause 12.7 of Approved Document B (taking the 2006, amended 2007 version as an example), Kingspan's K15 insulation would need to be a material (product) of limited combustibility. Given that this was/is not the case, the "first way" was not open to the use of K15 insulation. The "second way" *was* open to the use K15, but this would require a bespoke, first-principles fire safety engineering design for each and every project in which K15 was proposed for use.

987. I am aware that the Inquiry has obtained examples – of varying rigour – of first-principles fire engineering designs[533] for a number of UK highrise residential building projects applying Kingspan K15 insulation within rainscreen cladding systems. However as already noted the "second way" is costly in time and money – and creates "approvals risks" that may be considered unacceptable in an industry where designers "live and die by their approvals".

988. And so to the "third way".

989. Between 2004 and 2016, Kingspan commissioned a large number of BS 476 Part 6 tests[534] relevant to obtaining a National classification for K15 foil-faced insulation boards. As already noted, BS 476 Part 6 – the Fire Propagation Test – is the test which is used to distinguish Class 0 products from Class 1 products (for which only the BS 476 Part 7 – the surface spread of flame test – is required). This suggests that Kingspan were interested in obtaining a National Class 0 classification for K15 insulation boards. But why?

531 I believe that competent construction professionals would assume that it is equally true that products with European classifications cannot necessarily assume a corresponding National class, unless they have been tested accordingly.

532 From 1992 (as a direct consequence of the fire at Knowsley Heights), Approved Document B included a recommendation that "the surface of the outer cladding which faces the cavity" should also be Class 0 when using "rainscreen" construction at height. This recommendation persisted in the 2000 and 2002 versions, but appears to have been removed in 2006, coincident with the reorganisation of the external fire spread clauses (see Section 13.12). There are, however, recommendations within Approved Document B for insulation products to achieve Class 0 in some other applications and types of buildings (however these are not relevant here).

533 Such design approaches are sometimes referred to as "Route 4" or "Option 4" designs, in accordance with the four routes to compliance outlined – for example – in BCA Guidance Note 18 {CEL00002066}.

534 Schedule of Kingspan BS 476 testing relevant to K15 {KIN00022306}.

990. Evidence heard by the Inquiry during Module 2 highlighted the apparent conflation of Class 0 with limited combustibility by many individuals working with the construction professions; it appears that many in the industry failed to comprehend that while limited combustibility (and non-combustible) products are by definition Class 0, the converse is not necessarily true.

991. I believe that that the extensive body of evidence and testimony collected during Module 2 of Phase 2 of the Inquiry has demonstrated that, at least during the years 2004 to 2016, Kingspan sought to capitalise on this confusion so as to support a "third way" path to generating the *appearance* of building regulations "compliance" for K15.

992. If K15 could obtain a Class 0 classification, then people would (wrongly) assume either that it was a material/product of limited combustibility, or at least that it had achieved the "best possible" National reaction-to-fire classification, such that no higher standard of product fire safety was possible.

993. This strategy appears to have been successful, in 2009, when David Jones of LABC was convinced, after meeting with Kingspan representatives, to assert in an LABC type approval[535] that Kingspan K15 could be "considered a material of limited combustibility" – thus generating the *appearance* of compliance with Approved Document B, and hence the *appearance* of compliance with Paragraph B4 of the Building Regulations. Kingspan's satisfaction with Jones' choice of words is readily apparent in their evidence – no longer would time and effort need to be expended to answer challenging questions regarding the use of Kingspan K15 within cladding systems on highrise residential buildings.

994. Evidence obtained by the Inquiry also shows that at least six of the BS 476 Part 6 tests commissioned by Kingspan during the period 2004 to 2016 were performed on the foil facer materials *alone*,[536] stapled to a non-combustible calcium silicate board rather than backed by Kingspan's combustible phenolic foam insulation.

995. Bearing in mind the logic of the "third way" it is my understanding that tests might be undertaken in this way in order that a claim could be made that the surface of the K15 was Class 0 – despite the fact that the product as a whole was not. Such an approach would allow Kingspan to generate the *appearance* of a product being Class 0, and thereby generate the *appearance* of compliance with Approved Document B, and hence the *appearance* of compliance with Paragraph B4 of the Building Regulations.

996. I note that I would consider this practice to be utterly indefensible, both by any manufacturer and/or by any compliance testing laboratory who knowingly undertook and reported such testing.[537]

---

[535] {HBC00000030}
[536] {KIN00022306}
[537] In my opinion, the BS 476 Part 6 (BS 476-6:1989+A1:2009) testing standard is *absolutely clear* that the Part 6 test method is to be used to assess the "fire propagation" performance of *products*. I am not aware that Kingspan sell aluminium foil facers (on their own) as distinct products for the construction industry,

LBYP20000001_0180

997. Kingspan's misleading deployment of BS 8414 testing results and BR 135 classification reports within their marketing and product data sheets, as evidenced during Module 2 of the Inquiry, could also be used to illustrate a "third way" path to generating the *appearance* of compliance with Approved Document B, and hence the *appearance* of compliance with Paragraph B4 of the Building Regulations.

14.2.1.2. Arconic's "Third Way"

998. Table 10 shows that, to be used within a rainscreen cladding system above 18 metres in accordance with the "linear route" recommendations of Clause 12.6 and Diagram 40 of Approved Document B (taking the 2006, amended 2007 version as an example), Arconic's Reynobond 55 PE rainscreen cladding would need to be (at least) National Class 0 or European Class B-s3, d2.

999. The Inquiry has seen evidence that, from 2008, Alcoa Architectural Products (AAP) had a BBA Agrément Certificate for "Reynobond Architectural Wall Cladding Panels", which included Reynobond 55 PE, which claimed that "the panels may be regarded as having a Class 0 surface".[538] However, The Inquiry has also heard that this Class 0 claim does not appear to have been backed up by any National class testing of the Reynobond 55 PE product. Nor could/can any claim be credibly made that the BS 476 Part 6 or BS 476 Part 7 testing, performed on "a fire retardant sample of the product"[539] and noted within the BBA Agrément Certificate, offered any useful evidence of Class 0 performance for Reynobond 55 PE.

1000. The BBA Agrément Certificate for "Reynobond Architectural Wall Cladding Panels", which included Reynobond 55 PE, also claimed a European classification of B-s2, d0[540] for "a standard sample of the product" (which I take to mean a sample of Reynobond 55 PE), despite the fact the EN 13501-1 testing which led to this claim had been performed on a cladding build-up that was unrepresentative of typical end-use applications for this product, and despite the fact that this classification had only ever been achieved for a "riveted" cladding mounting configuration[541], and despite the fact that an alternative "cassette" mounting configuration had subsequently only managed to achieve a (much inferior) Class E classification[542].

1001. The Inquiry has also heard evidence that the update 2017 issue of this BBA Agrément Certificate was materially incorrect, and that the BBA struggled to obtain

---

and so I do not understand how either Kingspan or any competent testing laboratory could undertake BS 476 Part 6 testing on this basis. I am aware of the view Approved Document B could be interpreted so as to indicate that "the surface of a composite product" can be assessed independently of the rest of the composite product. I consider any such claim to be patently absurd. In discussing the "test specimens" to be used in BS 476 Part 6 (BS 476-6:1989+A1:2009), the testing standard explicitly states that: "4.2.2 *Products* of normal thickness 50 mm or less shall be used to full thickness", and "4.2.3 For *products* of normal thickness greater than 50 mm, the specimens shall be obtained by cutting away the unexposed face of the product to reduce the thickness to 50 [+0-3] mm." The *product* in this case is Kingspan K15 foil-faced phenolic foam insulation, and so I consider it self-evident that the foil facer *must* be tested alongside a phenolic foam backing (about 50mm thick for a 100 mm thick product being sold to the construction industry) – regardless of the specific definition of Class 0 given in Approved Document B.

[538] BBA Certificate 08/4510 {ARC00000678/1}

[539] {ARC00000678/5}

[540] {ARC00000678/5}

[541] e.g. CSTB Reaction to Fire Classification Report No. RA05-0005A {ARC00000358/4}

[542] e.g. CSTB Reaction to Fire Classification Report No. RA13-0333 {ARC00000393/3}

LBYP20000001_0181

up to date information on the reaction-to-fire performance of AAP's Reynobond products between 2014 and 2017.

1002. The above commentary reveals a "third way" path to "compliance", because Arconic appear to have used sometimes non-representative BS 476 and SBI tests on sometimes non-representative products and systems to generate the *appearance* of achieving Class 0, the *appearance* of achieving Class B-s2, d0, and hence the *appearance* of compliance with Approved Document B (Diagram 40) for Reynobond PE. And hence the *appearance* of compliance with Paragraph B4 of the Building Regulations.

14.2.2. Summary

1003. When considering the above examples of "third way" paths to "compliance", it is noteworthy that such paths could be taken in "good" or "bad" faith. It may be that a given product manufacturer or designer genuinely believes that their product is "safe". In such situations the "third way" may simply be viewed as a justifiable means to an end that is less costly in time, effort, and money, and that is not perceived as generating unacceptable hazards. In other cases, however, it may be that a given product manufacturer or designer knows very well that a product is potentially "unsafe", but decides to follow the "third way" regardless.

1004. The legal and regulatory structures and guidance that were put in place by the Building Act 1984 therefore created a set of conditions that enabled "high end" designers to do as they pleased, but also powerfully incentivised manipulation of the "approved" guidance. The capacity of the system to be manipulated was indifferent to the motivation of those undertaking such a manipulation.

1005. By the mid-2000s, the vision of "flexibility" had been largely realised and was now embedded within industry practice.

1006. With the publication of the 2006 edition of Approved Document B, each of the key elements of the compliance testing and building regulatory systems in which Grenfell Tower was refurbished were in place. From 2006, the substance of the regulatory system governing external cladding of buildings changed very little, but was relatively complex compared to the previous systems.

1007. In the 1990s, there had been a single suite of small scale BS 476 tests and a National system for product classification. After 2006, there were also European tests and classifications which were viewed as (but were explicitly not) identical to the National system. There was also the alternative of the BS 8414 large scale tests with the accompanying BR 135 classification guidance. As such, multiple formally "approved" routes were available whereby a product manufacturer (or a building designer) could seek to "demonstrate" that the functional requirements of the Building Regulations had been met. In addition to these formal routes, there were a number of "informal", "approved" routes by which attempts could be made to "demonstrate" that the functional requirements of the Building Regulations had been met[543].

1008. Whilst this system encouraged flexibility, there were some elements of the system that were substantially less flexible. The European system for classification *required* that products which had been certified by a designated body – should be accepted for sale across Europe. If a manufacturer was selling a product that had a British Board of Agrément (BBA) certificate indicating that it had achieved Class B, access to the British market was assured. It was not for the seller to demonstrate why their classification was appropriate for their particular product, but for others to demonstrate that it was not.

1009. The confluence of multiple factors created a system that was both *susceptible* to manipulation, and that *incentivised* manipulation. In summary, these factors were:

1010. the (subjective) functional building regulations' requirements,

1011. the widely misunderstood legal status of the Approved Documents,

1012. the updated guidance in Approved Document B that mixed legacy test standards with more recent test standards and which therefore effectively included three approved routes[544] to compliance,

1013. the expectation of flexibility by practitioners and approvers,

1014. a gradual cultural shift in which the role of building control (both public *and* private) evolved from one of oversight and "policing" of building designers, developers, and contractors to one of being flexible and "working with" their "customers", and

1015. (apparently) a requirement to accept European classifications.

1016. These factors manifested within a built environment industry where there was no legal mandate for those undertaking safety critical activities to hold any particular competencies or to adhere to any professional codes of conduct.

14.3. The Fire at Lakanal House (2009)

1017. Between 2006 and the Grenfell Tower fire, little of substance changed in the Building Regulations or Approved Document B related to the fire safety of external cladding materials, products, and systems. However, a major fire at Lakanal House, Camberwell, London on 3rd July 2009 highlighted a range of issues that I consider significant.

[543] For example, a number of alternative "routes to compliance" had been set out in guidance documents produced both by the Building Control Alliance (BCA) and the NHBC prior to the Grenfell Tower Fire, see e.g. {CEL00001301}.
[544] These being: (1) testing to National classifications, (2) testing to European classifications, and (3) large scale testing to BS 8414 and classification to BR 135.

1018. At the request of the Inquiry, I have undertaken a detailed review of evidence related to the Lakanal House fire and subsequent Coroner's Inquest.

1019. Lakanal House is a 16-storey block of two-storey "maisonette" apartments that was originally constructed between 1955 and 1960.[545] Between the date of its original construction and the fire in 2009 a number of changes, upgrades, and refurbishments to the building had been made[546].

1020. For the purposes of the current discussion, the most important of these refurbishments was the 2006/2007 replacement of the majority of the exterior walls of Lakanal House with a system of aluminium-framed window units that incorporated double-glazed windows, partially glazed doors (opening onto a shallow balcony, on alternating floors, which also served as an evacuation route), and combustible composite "infill" panels. Also replaced in the cladding refurbishment were opaque panels that formed the solid balustrades for the shallow evacuation balconies. A detailed description of Lakanal House is given in David Crowder's 2012 (BRE) Lakanal Fire Investigation – Expert Witness Report.[547]

1021. On 3rd July 2009, a fire broke out in Maisonette 65 (on floors 9 and 10) of Lakanal House. The fire eventually spread, both up *and* down, to a number of other maisonettes, thus compromising other fire compartments and evacuation routes within the building.

1022. The resulting fire investigations and Coroner's Inquest resulted in a considerable volume of information on this fire, and on the various factors that contributed to the six fatalities that occurred. This included about fifty days of oral evidence during the Coroner's Inquest. I will not rehearse all of this information here. However, I note my resulting opinion that the central fire safety issues at Lakanal House were related to the installation of combustible cladding materials and products on the exterior of Lakanal House during its 2006/2007 refurbishment. This issue was largely, and surprisingly from my perspective, overlooked in the various investigation reports on this fire, and in the eventual outcomes of the Coroner's Inquest (in 2013).

1023. Figure 21 shows a photo of one façade of Lakanal House taken after the 2009 fire.

1024. Immediately beneath the windows on levels that do not have balconies, one can observe a darker coloured horizontal line of opaque panels which are being held within an aluminium frame so as to form the lower portion of the external wall (see Figure 22). These panels, whilst not visible within Figure 21, were (I believe) also present within partially glazed doors that allowed access from the apartments onto the evacuation balconies (see Figure 23). I will refer to this product as a "window panel" throughout the subsequent discussions.

545 BRE Global Lakanal House Fire Investigation – Computer Modelling and Reconstruction Fire {BRE00005878}

546 I will not rehearse all of these changes here but will instead focus on changes to the building's external wall; the various other historical changes are described in some detail elsewhere (BRE Global Lakanal House Fire Investigation Expert Witness Report) {BRE00005881}.

547 {BRE00005881}

1025. The window panels were composite “sandwich panel” products consisting of front and rear faces of high pressure laminate[548] (HPL) sheets, between which were sandwiched an insulating polymer foam material.

1026. On levels with balconies, one can observe a lighter coloured opaque panel which essentially forms the balustrade for the shallow evacuation balconies that were present on these levels. I will refer to this product as a “balcony panel” throughout the subsequent discussions.

1027. The balcony panels were solid high pressure laminate (HPL) sheets (i.e. solid sheets of HPL without foam cores).

Figure 21 External Overview of the fire spread sequence at Lakanal House (according to BRE reports).[549]

---

548 The UK designingbuildings.co.uk wiki states that: “High Pressure Laminate (HPL) panels are a form of cladding typically manufactured by layering sheets of wood or paper fibre with a resin and bonding them under heat and pressure. They sometimes include additional chemicals to provide fire retardant properties and are available in a wide range of colours and finishes.” (https://www.designingbuildings.co.uk/wiki/HPL_cladding)

549 {BRE00005878/214}

Figure 22 External wall on even numbered floor at Lakanal House, providing access to balconies.[550]

Figure 23 Typical bedroom at Lakanal House (without furniture etc) showing window assembly.[551]

[550] {BRE00005878/207}
[551] {BRE00005878/207}

1028. A timeline of key events in the spread of the fire is provided within BRE's December 2010 "Lakanal House Fire Investigation – Computer modelling and reconstruction fire" report.[552] This was authored by BRE's David Crowder, Richard Chitty, Martin Shipp, and Roisin Cullinan.

1029. The following is a summary of the critical timeline points, focusing on the performance of Lakanal House's external wall and the observed external fire spread (refer also to Figure 21):

1030. "From ignition (estimated around 16:15), the fire in Flat 65[553] developed rapidly on both floors as a result of doors within the flat being left open and windows failing rapidly, ventilating the fire and allowing it to grow until a flashover or backdraught event occurred at approximately 16:25."

1031. "The combined fire plumes emitting from the upper and lower floors of Flat 65 (following the flashover/backdraught event) impinged upon the window panels of bedroom 1 of Flat 79. By approximately 16:30, after the window panels had been exposed to flaming from Flat 65 for approximately 4 minutes 30 seconds, a fire had established itself inside bedroom 1 of Flat 79."

1032. "At approximately 16:48, the fire involved the staircase in Flat 79. Less than a minute later, falling burning debris ignited Flat 37 below… At approximately 16:49, burning debris also ignited Flat 53."

1033. Notwithstanding some apparent confusion in the above descriptions as regards the specific fire science phenomena of "flashover" and "backdraught"[554], what is most striking about this timeline of the Lakanal House fire – from my perspective – is that the fire *was able to spread externally* to the fire compartment *above* the compartment of fire origin, possibly in as little as *four minutes and 30 seconds*[555] after breaking out of the compartment of fire origin.

---

[552] {BRE00005878}

[553] {BRE00005878} states that the fire was caused by a faulty portable television standby switch located in a bedroom of Flat 65 on the 9th Floor.

[554] I have previously explained the meaning of the term "flashover" in the footnote to Paragraph 594. Conversely, a "backdraught" (backdraft) event involves rapid burning when ventilation is provided to a compartment in which fuel-rich smoke has accumulated during conditions of poorly ventilated flaming combustion (Drysdale 1988, 376). Fleishman et al. (1994) have described the conditions leading to backdraft as follows, assuming a fire in a closed room: "The fire heats up the room, and leakage in the bounding surfaces minimizes the pressure differential [with the atmosphere outside the room]. The hot layer [of smoke and hot gases] descends over the fire as the oxygen concentration is reduced and the combustion efficiency decreases [due to lack of oxygen]. Excess pyrolyzates accumulate in the upper layer forming a fuel rich mixture of low oxygen content [that cannot burn under those conditions]. A small flame or glowing ember exists as a source of ignition. Suddenly, a new ventilation opening is provided [e.g. a door is opened or a window breaks] and cold, oxygen rich, air enters the compartment and propagates across the floor as a gravity current. Large scale mixing in the gravity current provides mixed zones within the flammable range that ignite when they contact an ignition source. Once ignited, a flame propagates through the compartment and drives the remaining unburned fuel out through the opening to burn outside the compartment in a spectacular fireball." Flashover and Backdraught are thus significantly different phenomena, and warrant differentiating in a fire investigation report.

[555] I note that this timeline is based on analysis presented within the "Lakanal House Fire Investigation – Computer modelling and reconstruction fire" report {BRE00005878}, rather than being based on observations of the actual fire at Lakanal house.

1034. The fire was then also *able to spread externally* to two further fire compartments *below* the compartment of fire origin in less than 30 minutes.

1035. At the time of the refurbishment, the Building Regulations (2000) stated that "the external walls of the building shall adequately resist the spread of fire over the walls and from one building to another, having regard to the height, use and position of the building".

1036. Given the rate and extent (and directions other than "up") with which the fire was able to spread externally at Lakanal House, any investigation of this fire would – in my opinion – be expected to be immediately interested in understanding the mechanisms by which this external fire spread had occurred, the underlying causes of these mechanisms (both physical and regulatory), and the extent to which these mechanisms and causes might present hazards in other buildings across the United Kingdom[556].

1037. In the following sections I have chosen to discuss the investigation of the Lakanal House fire by taking a chronological approach. Whilst this results in some repetition of ideas, I feel that this is the most effective way to cover the necessary ground.

14.3.1. The BRE Fire of Special Interest Report

1038. On 16th July 2009, less than two weeks after the fire, Crowder, Shipp, Cullinan, and Chitty issued a "Fires of Special Interest" (FOSI) report on the Lakanal House Fire "under contract to Sustainable Buildings Division of the Department for Communities and Local Government"[557]. The report notes the presence of "layered polymeric panels forming the lower halves" of the "full height painted aluminium window frame assemblies" making up the external wall "on odd floors". These are the "window panels" described previously. The FOSI report also notes the presence, "on even floors", of balconies that have steel guardrails and "polymeric panels fitted to them".[558] These are the "balcony panels" described previously.

1039. However, despite identifying these polymeric (and therefore combustible) products within (and on) the external walls at Lakanal House, the FOSI report contains very little insight into the roles of either of these products in the fire's development. For instance, it is stated only that (emphasis added):

1040. "The fire broke out of the windows [of Flat 65], with flames extending up the building façade on both east and west faces, and back in through the window assembly of the flat above on the west face… The fire is believed to have only spread via this route from one level to the next as all other routes (ducting, cavities) have been eliminated… The window frame is not currently believed

[556] This is not to say that a wide range of other issues were relevant for consideration in the aftermath of the Lakanal House fire; many of which were also interrogated within the fire investigation reports and Coroner's Inquest.
[557] This was another of the BRE reports forming part of their ongoing contract for government, (apparently) since 1974, under the banners of "Investigation of Real Fires" or "Fires of Special Interest". This is reproduced in Appendix A of BRE's report {BRE00005878}.
[558] {BRE00005878}

LBYP20000001_0188

to have failed prematurely, simply to have eventually burnt through *as would be expected*."

1041. It is not immediately clear what is meant by "as would be expected" in the above statement. This may, therefore, be an allusion to BRE's previous work on floor-to-floor fire spread, as discussed in Paragraph 1406.

1042. Seminal research on external fire spread performed in the 1960s by Langdon-Thomas and Law of the (then) Fire Research Station[559] demonstrated that post flashover compartment fires must be *expected* to spread externally vertically from floor to floor via a building's windows (if not by other means). They specifically noted (in 1966) that: "to provide adequate protection [against external fire spread] it would be necessary virtually to omit all windows from the storey immediately above the one with openings in it [i.e. above the compartment of fire origin]", concluding that "the enclosure of a building has little to contribute to the reduction of fire spread within a building" and that "a substantial relaxation could be made in the structural design requirements for external walls". However, they also noted that ignition of furniture in the room above the fire compartment would not occur "for as long as 15 min"[560].

1043. Whilst the expected (or indeed acceptable) time delay for this *inevitable* storey-to-storey fire spread has not, so far as I'm aware, ever been explicitly articulated within the Building Regulations or Approved Document B, it is noteworthy that the performance criteria for both internal and external fire spread given in BR 135, for classification of tests to BS 8414-1 or BS 8414-2, are met only if the failure criteria are not reached "within 15 min of the start time".[561]

1044. I believe it is likely – albeit as yet without any documentary evidence – that the 15 minute criterion given in BR 135 is linked to the 1966 Langdon-Thomas and Law research, and that it suggests an unstated acceptance of external vertical fire spread, provided that this takes longer than about 15 minutes per floor.

1045. I also note that the "start time" used in BS 8414 tests is intended to represent "a fully developed fire in a room abutting the external face of a building and venting through an aperture"[562], which is essentially the same scenario that actually occurred at Lakanal House.

1046. I therefore do not understand how the rapid external upward fire spread observed at Lakanal House could be described as "expected". I am surprised that this observation appears not to have immediately raised questions as regards the compliance of Lakanal House with the Building Regulations and/or Approved Document B, or indeed why the appropriateness of the external fire spread

[559] Langdon-Thomas and Law 1966.
[560] Law and Kanellopoulos 2020.
[561] Colwell and Baker 2103, 19.
[562] BSI 2002b.

provisions given in Approved Document B (2002) were not highlighted as warranting reconsideration[563].

1047. The BRE FOSI report continues:

1048. "Falling burning debris from Flats 79 and 65 (most probably from both the window façade assemblies and the contents of Flat 79), ignited materials in Flats 37 and 53, located on the 5th and 7th floors respectively. It has not been possible to determine which source of falling debris was responsible for each Flat that was ignited. Footage from Channel 4 confirmed reports that these two flats happened to have windows open. These windows appeared to be open in such a way that would enable them to collect falling debris into the flat."

1049. I am surprised that the observation that *downward* external fire spread occurred at Lakanal House, potentially because of ignition due to downward transport of flaming debris from the combustible window and balcony panels, did not also cause concern and result in comment regarding the appropriateness of the external fire spread provisions given in Approved Document B (2002) and/or the testing methods underpinning the guidance.

1050. Also, as discussed previously in Section 13.4, the early 2000s saw the incorporation into the Approved Document B of the European classification methods alongside the pre-existing National classification methods. This incorporation had been enabled by a transposition of the European classifications onto the National classifications (see Figure 13), such that National Class 0 was transposed into European Class B-s3, d2.

1051. The use of "s3" and "d2 indicated that the guidance in Approved Document B controlled neither smoke production nor the production of burning droplets/debris. This lack of control was logical in the context of a comparison with the National classes – since the National classes did not specifically control smoke or droplet production.

1052. However, given that BRE's initial investigations at Lakanal House offered compelling evidence that "burning debris", at least in part from the window façade assemblies, was responsible for *downward* external fire spread to two additional apartments, I am somewhat surprised that no suggestion appears to have been made that government should consider reviewing the decision not to control smoke or droplet production and/or the decision to continue to allow application of the National classifications alongside the new European classification system.

1053. When commenting specifically on the "potential implications for building regulations" (and Approved Document B) resulting from the Lakanal House fire, the BRE FOSI report states:

---

[563] A central purpose of the FOSI contract was, "to provide timely feedback to Communities and Local Government on the effectiveness or otherwise of the guidance in Building Regulations Approved Document B (Fire safety) in achieving fire safety in real buildings in England and Wales".

1054. "Yes. Fire initially spread up externally from flat of origin. Fire spread down due to burning material falling."

1055. No further commentary on the possible reasons for the observed external fire spread, either up or down, is provided. No information on the specific make-up of the external wall products is given, nor is their compliance (or otherwise) with the recommendations then set out in Approved Document B discussed.

1056. BRE's *Communities and Local Government Final Research Report: BD 2651 Investigation of real fires* report[564] eventually concludes, however, that:

1057. "The findings from this programme have reaffirmed the overall effectiveness of the building regulations and AD B in providing for the safety of life in the event of fire and most of the significant issues that have been identified during this study fall outside the scope of these regulations."

1058. Given the information that appears to have been available to BRE at this early stage of the investigation of the Lakanal House fire, I am surprised to see this statement so definitively made. Lakanal House *is* highlighted in this report, but only with respect to the "responsibilities of the owners of the properties to satisfy the requirements of the Fire Safety Order"; no comments on the upward or downward fire spread experienced at Lakanal House are included.

14.3.2. Report to the Secretary of State by the Chief Fire and Rescue Adviser

1059. On 30th July 2009, Sir Ken Knight, then the "Chief Fire and Rescue Advisor" to the Department for Communities and Local Government, submitted a "Report to the Secretary of State by the Chief Fire and Rescue Adviser on the emerging issues arising from the fatal fire at Lakanal House, Camberwell on 3rd July 2009."[565]

1060. This report makes a number of comments with regard to external fire spread considerations:

1061. "it is believed that the fire… spread externally to the 11th floor where the maisonette directly above caught light. This is *not unusual fire spread* by heat and flame coming from the 10th floor balcony and rising up via the external face of the building."

1062. As noted above, whilst it is indeed "not unusual" for a fire to spread from floor to floor via windows, in my opinion it is noteworthy that this occurred comparatively rapidly, i.e. within just a few minutes.

1063. "… it seems that the fire also spread downwards setting light to maisonettes on the 5th and 7th floors. It appears that this was spread by burning products from the fire above, which dropped down and entered the maisonettes via open windows on what was a very hot day. These products could have come from anything that had burnt within the maisonettes. From initial observations

[564] {CLG00019142}
[565] {HOM00045791}

the windows and infill panels did not appear to have burnt unduly, however, this is subject to further conformation arising from the full investigation."

1064. The evidential basis for the above statement is not clear, particularly given that all subsequent reports commented on the fact that the window panels did, in fact, exhibit burning from the early stages of the fire.

1065. Later investigations would also confirm that the window panels experienced spalling disintegration when exposed to fire, and that they were capable of generating flaming debris (see Paragraph 1082). It therefore seems clear that the window panels *did* "burn" – although the degree to which they burnt "unduly" is of course a matter of perspective. Knight concluded that:

1066. "From the early findings, the issue of external fire spread is not seen as significant. The initial inquiries do not point to any particularly new methods of fire spread externally."

1067. Again, the basis for this view is not clear, particularly given my comments in Paragraph 1082. Knight finally concludes that:

1068. "There is clearly evidence of internal fire spread which, [sic] breached the fire protection compartmentation that would have been expected in this property and on which the safety of occupants and firefighting relies."

1069. A curious aspect of the reporting to government on the Lakanal House fire, in my opinion, is the extent to which the potential importance of the idea that the window and balcony panels might have contributed to the rate and/or extent of external fire spread appears to have been overlooked, whereas the perceived importance of internal compartmentation appears to have been elevated (as in the above statement).

14.3.3. BRE Lakanal House Fire Investigation – Computer modelling and reconstruction fire report

1070. On 17th December 2010, BRE's Crowder, Chitty, Shipp, and Cullinan, issued a voluminous report on a range of computer modelling activities and a "partial full-scale reconstruction" fire test that had been commissioned by the Metropolitan Police Service (MPS) and the London Fire Brigade (LFB). Amongst other objectives, the work presented in this report was apparently aimed at:

1071. "5. Determining the likely fire performance of the window façade panels of Lakanal House during the incident. Whether, and how quickly, fire might penetrate these from the extended flames emitting from a fully developed fire burning on a floor below."

1072. I will not present a detailed critique of the contents of this report here, or the various activities it described. I note, however, that in my opinion a large number of factors relevant to the real fire event, all of which could have significantly affected the outcomes of the reconstruction, were not convincingly reproduced or controlled during the reconstruction.

1073. As an illustration of one such factor, the following summary of the outcomes of the reconstruction as regards Objective 5 (see Paragraph 1071 above) is given:

1074. "The window façade panels visibly contributed towards the initial growth and development of the reconstruction fire; providing a fuel source in themselves and then deforming to allow fire spread into the bedroom of the reconstruction rig. They did, however, require a significant quantity of energy to be ignited, evidenced by the blistering and scorching, but not ignition, of the panels on the first floor of the reconstruction rig. The computer modelling indicated that the combined fire plumes from the upper and lower floors of Flat 65 were forced against the face of the building by the prevailing wind. The amount of heat energy to which the panels on Flat 79 of Lakanal House were exposed during the incident was therefore much greater than that to which the panels in the reconstruction fire were exposed."

1075. This indicates that the heating to which the window panels were exposed in the reconstruction fire was significantly less than presumed to have occurred during the Lakanal House fire. I believe that these (and other) inconsistencies make it difficult to draw meaningful conclusions regarding mechanisms of external fire spread (either up *or* down) from the BRE reconstruction of the Lakanal House fire.

1076. The BRE reconstruction did not provide any useful information on the potential *downward* fire spread mechanisms relevant to the observed (and unusual) downward fire spread during the Lakanal House fire.

14.3.4. National Classifications for Products used at Lakanal House

1077. With regard to the classification of the products used within the external wall at Lakanal house, I consider the most useful and relevant information provided by BRE to be the results of BS 476 Part 7 (1997) tests that were reported on window panels and balcony panels taken (undamaged) from Lakanal House after the fire. These are presented in the appendices of the BRE "computer modelling and reconstruction fire report".[566]

1078. Unfortunately, the various products tested are not well-described in the report, making it difficult to draw definitive conclusions regarding the specific locations where each of the various tested products were taken from the external wall at Lakanal House. Test data are provided on the following composite window/door panel products:

1079. "BS 476: Part 7: 1997 on a plastic faced foam filled panel (pale yellow foam) [Figure 24];

BS 476: Part 7: 1997 on a plastic faced foam filled panel (pink foam core)[Figure 25]; and

BS 476: Part 7: 1997 on a plastic faced foam filled panel (orange foam core)[Figure 26]."

[566] {BRE00005878}

LBYP20000001_0193

1080. I note that the specific types of "plastic" faces and "foam" fillers are not described in any detail. The types of polymers used, whether these were thermosetting or thermoplastic, the specific product names, and so on, are not provided. Indeed, despite the extensive scope of investigation into the Lakanal House fire, at time of writing I have not as yet been able to determine the characteristics of the polymer foam cores used in any of these products, or to understand their respective locations on or in the building.

1081. The window panel products are described in the BRE testing reports[567] as having one plastic face which is white and one face which is dark green in colour. The panels were all tested to BS 476 Part 7 with fire exposure on their dark green faces. *All three of them achieved Class 3.*

1082. In the context of the downward fire spread at Lakanal House, I consider it noteworthy that *the BRE test reports all note that "incandescent spalling was visible throughout all test runs,"* that *"specimens were flaming strongly at the end of all test runs"* (see e.g. Figure 27), and that *"flaming debris was observed burning on the floor".* The reports also include various statements regarding pieces of "flaming debris" being "ejected" and continuing "to burn on the floor" for between 20 and 48 seconds.

[567] {BRE00005878}

LBYP20000001_0194

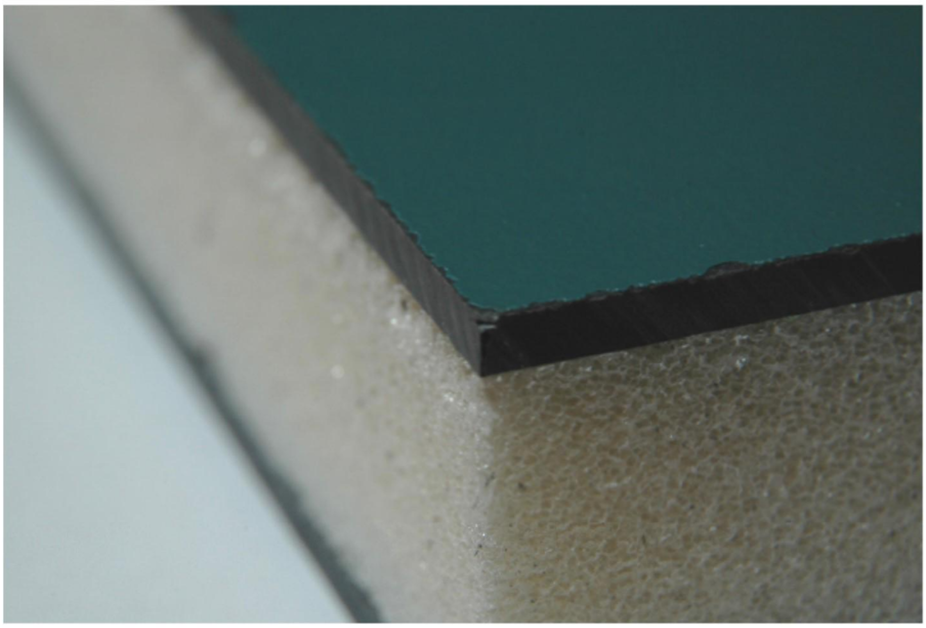


Figure 24 The plastic faced foam filled panel (pale yellow foam) sampled by BRE at Lakanal House.[568]

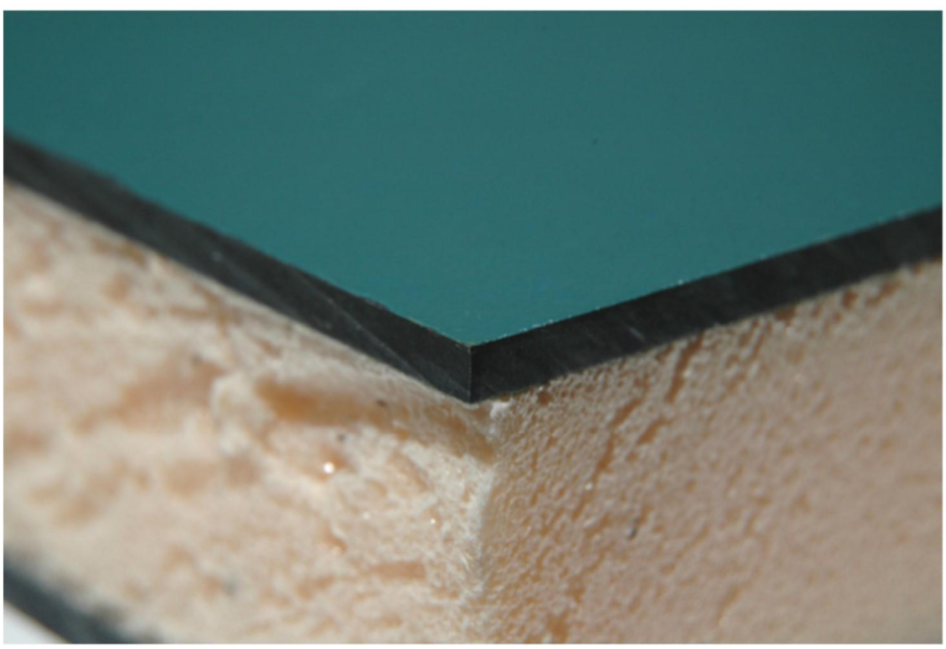


Figure 25 The plastic faced foam filled panel (orange foam core) sampled by BRE at Lakanal House.[569]

568 {BRE00005878/245}
569 {BRE00005878/270}

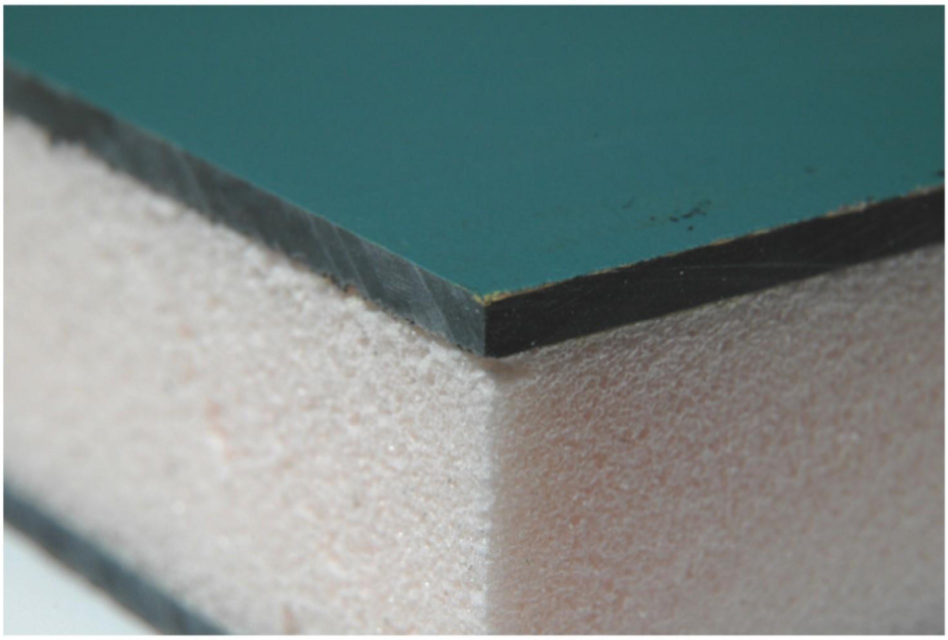


Figure 26 The plastic faced foam filled panel (pink foam core) sampled by BRE at Lakanal House.[570]

Figure 27 "Typical flaming visible during test run" for the "plastic faced foam filled panel (orange foam core)" tested by BRE under BS 476 Part 7.[571]

[570] {BRE00005878/261}
[571] {BRE00005878/271}

1083. Tests were also performed on balcony panels; these are described as "BS 476: Part 7: 1997 on a rigid plastic panel with green faces on both sides", although no photos of the tested product or the testing outcomes are included. In this case, the product achieved Class 2, and it is stated that "non-flaming spalling was visible throughout all test runs" and that "specimens were flaming at the end of all test runs".

1084. I note that Approved Document B (2002), in force at the time of the refurbishment of Lakanal House, would have recommended the window panels achieve Class 0 when used above 18 metres. Below 18 metres, the window panels would have been recommended to have "an index (I) not more than 20 (National Class) or Class C-s3, d2[572] or better (European class)".

1085. I am surprised that I have seen no evidence that BRE undertook any testing to determine whether the window panels at Lakanal House met the above recommendations, either under National or European classification systems.

1086. Thus, a central technical issue (perhaps *the* central technical issue) in the fire at Lakanal House is that the composite window panels, and arguably the balcony panels, failed to meet the guidance of Approved Document B (2002) for Class 0 above 18 metres, and possibly also Approved Document B's recommendations for surfaces of external walls below 18 metres.

1087. I am therefore surprised at how little attention these issues received from BRE, The Chief Fire and Rescue Advisor, The Department for Communities and Local Government, or indeed during the subsequent Coroner's Inquest.

1088. I am also surprised that a greater effort to properly characterise the window panels (the foam filler/cores in particular) is not evident from the documentary evidence available to me at the time of writing.

14.3.5. Questions from the Crown Prosecution Service

1089. On 30th April 2012, after almost three years of being involved in investigating the Lakanal House fire, Crowder submitted a report to the Metropolitan Police Service giving responses to a number of questions that had been posed to him by the Crown Prosecution Service. The most interesting question posed, in the context of the current discussion, was as follows (original emphasis):

1090. "[Q1] In the BRE report dated 27 July 2011[573] it is indicated that "the severity of the fires in flat 65 and flat 79 <u>as well as the spread from the former to the latter</u> was partly attributable to the performance of the window panels installed during the 2006/7 refurbishment. The window framed sets and composite panels <u>installed increased the susceptibility of the building to allow vertical fire</u>

[572] I note that the stated recommendation for external surfaces of walls below 18 metres in height based on the European classification system essentially ignores the production of smoke or burning droplets. I consider this relevant because BRE testing showed that the window panels generated "incandescent spalling" {BRE00005878/242, 258, 267} which is likely to have played a role in the downward spread of fire at Lakanal House.

[573] This is a reference to the first draft of {BRE00005881}, which is {LFB00028456}.

spread from floor to floor. This is partly evidenced by the difference between this incident and the 1997 fire."[574]

1091. [a] What other factors contributed to the spread from flat 65 to flat 79"

1092. [b] if window panels of the correct fire resistance (under Approved Document [B] 2000) had been installed in 2006/7, how would this have affected the fire spread from flat 65 to flat 79 which occurred?"

1093. In answering the above question, Crowder comments on a range of factors that *may* have affected the initial fire spread from Flat 65 to Flat 79, eventually stating his opinion that the window panels within the window sets "had a significant impact upon the way in which the fire spread" and that "the panels affected this both in terms of their spread of flame properties (i.e. whether the surface will burn and/or provide a medium for fire spread) and their fire resistance properties (i.e. the time required for fire to pass from one side of the panel to the other)".

1094. I note that, as far as I can ascertain, there was (and is) no recommendation that the window panels in Lakanal House should have any fire resistance.[575]

1095. Given that Approved Document B did not make any recommendations concerning the fire resistance of the panels, Question [b]'s reference to the "correct fire resistance" appears somewhat incongruous.[576] Nonetheless, the 11 subsequent pages of this report are devoted to "modelling" various fire scenarios that might have materialised had the window panels remained in place for longer during the fire.

1096. This response eventually concludes that "the determining factor regarding whether the fire spreads from Flat 65 to Flat 79 becomes the susceptibility of the Flat 79 panels to ignite or burn through as a result of the direct flame impingement [from the fire plume generated by Flat 65, below]".

14.3.6. Expert Witness Report for the Metropolitan Police Service

1097. On 11th May 2012, Crowder submitted a "Lakanal Fire Investigation – Expert Witness Report"[577] to the Metropolitan Police Service. This report provided some limited information regarding the physical makeup of the Lakanal House refurbishment window panels; this may have been based on witness statements

---

574 In {BRE00005892}, Crowder highlights the outcome of a 1997 fire at Lakanal House, stating: "Following the fire at Lakanal in 1997, the window frames and panels were still in situ despite severe damage having been sustained by the flat. Whilst information regarding the 1997 incident is scant, damage on photographs in my opinion indicate that it is highly likely that these panels were able to survive a fully flashed over fire for some time; possibly 30 minutes or more." The relevance of this comment is not clear, given that Approved Document B did not recommend that these panels had any fire resistance (as previously noted).

575 Aside, from a possible recommendation that the window panels mounted within the doors to the evacuation balconies (only) had fire resistance ratings of 30 minutes (in ADB 2000). This recommendation, however, appears to be open to "interpretation" (https://www.lambeth.gov.uk/sites/default/files/LakanalTranscriptDay40.pdf).

576 Nor can I find any mention in this report of what would have been "the correct fire resistance" for the window panels.

577 {BRE00005881}

provided to the Coroner's Inquest from TRESPA Manager David Laing[578], noting that these were composite panels that "incorporated compressed cellulose and resin outer layers and a foam core".

1098. A review of statements from David Laing's original witness statement[579] suggests that the window panels at Lakanal house were fabricated from two outer skins of 3 mm "standard" Trespa Meteon boards[580], between which was sandwiched a "foam core" to give an overall panel thickness of about 27 to 28 mm. The particular types of foam cores used are not described, nor is any explanation given as to why three different foam core colours were presented in BRE's earlier BS 476 Part 7 test reports.[581] Laing identifies the balcony panels at Lakanal House as being 13 mm standard grade Trespa Meteon panels.

1099. Crowder's May 2012 report also comments on the significance of the observed downward fire spread for the existing regulations and guidance, noting that "fire spread to the lower floors of Lakanal was due to burning debris, which is not currently specifically precluded by any building regulations and guidance". However, the report does not state the source of the burning debris; i.e. whether it was from the contents of Flats 65 and/or 79 or resulting from the "incandescent spalling" from the window panels that had been observed in BRE's BS 476 Part 7 testing (see Paragraph 1082).

1100. I consider the absence of explicit commentary on the potential links between the incandescent spalling observed in BRE's BS 476 Part 7 testing and the critically important downward fire spread observed during the Lakanal House fire to be a potentially important oversight.

14.3.7. Crowder's Testimony at the Lakanal House Coroner's Inquest

1101. On 18th/19th February 2013, Crowder gave oral evidence at the Lakanal House Coroner's Inquest. I will not rehearse all of the evidence presented, but instead focus only on the *new* information presented at that forum that I consider relevant to BRE's investigation of the external fire spread that occurred at Lakanal House.

1102. Crowder's evidence provides several new pieces of information. For instance, it is stated – with respect to the composition of the window panels – that "the core itself, between the two external layers, is some sort of blown or aerated foam core". Crowder comments that "we believe it's likely to be something similar to a polyurethane", although the evidential basis for this belief is not given.

1103. Under questioning from Mr Maxwell-Scott, Crowder is asked:

---

578 https://www.lambeth.gov.uk/sites/default/files/LakanalTranscriptDay28.pdf.

579 Laing's original witness statement to the Lakanal House Coroner's Inquest is not available to me; I base these comments on excerpts from Laing's witness statement that were included in Crowder's expert witness report {BRE00005881/95}.

580 Trespa Meteon is a particular high pressure laminate (HPL) boarding product that is available as both "standard" and "fire retardant" products. In his witness statement, Laing states that 8 mm fire retardant grade Trespa Meteon boards are able to achieve Class 0, but that similar standard grade boards achieve only Class 2, when tested to BS 476 Part 7.

581 {BRE00005878}

1104. "I understand what you say about the unpredictable reaction of glazing to a fire, and you well illustrate that by reference to the fact that the first window failed after five and a half minutes and the third one failed approximately four minutes later. I think the significance or otherwise will have to be for others to judge, but firstly the short point: would you have expected the glazing to survive intact longer if the material immediately beneath them had not been on fire itself?"

1105. This question contains a useful insight, which is that the presence of combustible materials and products within, or on, an external wall may *not only* contribute to spread of fire within or on the wall, but may *also* contribute to a more rapid failure of other building features (e.g. windows) which might otherwise delay the progress of a fire from one storey to the next. I consider this issue relevant to building regulations for external cladding, and particularly to the continued use of Class 0 – yet combustible – cladding products.

1106. Crowder responds, "yes", but concedes that determining *how much longer* would be very challenging indeed.

14.3.8. Brian Martin's Witness Statement and Testimony to the Lakanal House Coroner's Inquest

1107. On 12th March 2013, Brian Martin – then working for the Department for Communities and Local Government – submitted a written witness statement to the Lakanal House Coroner's Inquest, and on 13th March 2013 he gave oral testimony[582]. In his witness statement, Martin notes that he had been asked to comment on:

1108. (a) whether the external walls of the building were required[583] to have a fire resistance of 120 minutes;

1109. (b) whether or not the bedroom panels (on the lower floor of each flat) were required to have 30 minutes fire resistance;

1110. (c) which panels were required to be Class 0;

1111. (d) the extent to which the guidance on any of these points has been updated or clarified in versions of Approved Document B subsequent to the 2000 version; and

1112. (e) the extent to which there is scope for further clarification on any of these points.

[582] I note that Martin gave his evidence on Day 40 of the 50 day Inquest, and that he had the benefit of having access to all prior testimony; much of this prior testimony, particularly from the expert witness David Walker (a chartered member of the Royal Institution of Chartered Surveyors (RICS)), was incorrect and/or confused.

[583] I note the repeated use of the word "require" within this section of my report. I have used "require" within this section in order to be faithful to the terminology used when Martin gave his evidence. However, given the status of the Approved Documents as guidance rather than regulation, I believe it would have been more appropriate to use the word "recommend" throughout.

1113. On issue (a), Martin notes that there was no need for the external walls of the building to have a fire resistance of 120 minutes, and that it is likely that an "unprotected area" of 100% of the building façade would have been permitted by Approved Document B (2002); i.e. that in general the external wall did not require any "fire resistance" whatsoever in order to prevent fire spread between buildings or to protect the structure of the building itself.

1114. He additionally (and correctly) points out that to require the external walls of buildings such as Lakanal House to be fire resisting to 120 minutes would, in practice, prevent such buildings from having windows.

1115. Notwithstanding the fact that Question (b) appears to be confused, given my understanding that the bedrooms at Lakanal House did not have balconies, Martin notes that, given his answer to Question (a), "the only reason to specify fire resistance would be to protect an escape route".

1116. After considering the relevant guidance documents, Martin concludes that "providing fire resistance to the [evacuation] balcony would not have been necessary as each flat had access to a route which was enclosed in fire resisting construction (the corridor)". He concedes, however, that "a degree of judgement… would be required to decide what was necessary."

1117. On Issue (c), Martin notes that "only those parts of the external surfaces that are themselves above 18 metres in height have to be constructed of Class 0 material."[584]

1118. On issue (d), Martin points out that Approved Document B "was last amended in 2006 and the amendments came into effect in April 2007". He notes that "guidance on the construction of external walls was clarified in the 2006 amendments", including amendments to the sections of the document dealing with external cladding "to avoid ambiguity".

1119. With hindsight this comment is unfortunate, given that one of the key amendments in the 2006 version of Approved Document B was to introduce "filler materials" into Clause 12.7 under the heading of "Insulation materials/products". As previously discussed in Section 13.12.2, the ambiguity of the manner in which these changes were made has subsequently been claimed as a potentially critical source of confusion (and hence a defence for designers) as regards Approved Document B's provisions for external cladding.

1120. I also note the absence of any comments on the specific nature of the 2006 amendments or the reasons that changes were made – i.e. in response to The Edge fire in 2005, where combustible sandwich panel external cladding had also played a primary role in external fire spread.

[584] I again note use of the word "material" rather than "product". I also recall the Nov 2013 email from Martin to Tony Baker (see Paragraph 940), wherein Martin noted that "The problem we have with Class B is that you can have a thin surface that gives you the performance and back it with something less desirable. So *there's no such thing as a class B 'material'*". I assume that the same reasoning would support a view that there's no such thing as a Class 0 "material" either (only a Class 0 "product").

1121. Had the implications of The Edge fire been widely publicised and disseminated, it is possible that fire spread hazards presented by the Lakanal House cladding products may have been more carefully considered before the fire occurred, and remedial actions taken.

1122. Finally, on issue (e), Martin states that “the Department has no immediate plans to update the guidance in the AD B”, aside from making some stylistic changes and “applying the principles of plain English”.

14.3.9. Key Issues Arising from the Fire at Lakanal House

1123. With the above discussion in mind, what I consider most striking about the Lakanal House fire – and its investigation – is the extent to which the investigations and expert evidence presented to the Coroner regarding the window panels (and to some extent the balcony panels) appear to have been confused, at times inaccurate, and, ultimately, largely dismissed.

1124. The transcripts of the final day of the Coroner’s Inquest[585] concisely sum up what I consider to be the main conclusions relevant to failings at Lakanal House in terms of external fire spread:

1125. "The panels under the bedroom windows of Flat 7 were not Class 0, although they were required to be. This was due to a serious failure on the part of SBDS[586], its contractors and its subcontractors.”

1126. “Even if the composite panels under the bedroom windows of Flat 79 had been Class 0, they would not have prevented the spread of fire from Flat 65 to Flat 79. However, if they had been Class 0 the spread of fire within Flat 79 would have been slower.”

1127. A tragic reality of the Lakanal House fire is thus that the cladding products used in the external wall – the composite window panels specifically – failed to meet the recommendations of Approved Document B for Class 0 above 18 metres. It appears that nobody, at any point within the design, procurement, or installation of these panels, seriously considered, or was even aware of, this recommendation.

1128. Since the recommendations of the Approved Document B were not followed, it is tempting to dismiss this fire as not being relevant to questions around the adequacy of the external fire spread provisions given within Approved Document B. Nevertheless, the fact that ADB’s recommendations had not been followed, in conjunction with the apparent confusion among the various experts during the Coroner’s Inquest, were indicative of wider failings of *competence* and *oversight* of fire safety in construction that I believe went on to manifest – in critically important ways – in the refurbishment of Grenfell Tower.

1129. In my opinion, Lakanal House provided a mechanism through which these other, much more fundamental and challenging regulatory failings could have been identified. Instead, the fact that the guidance was not followed at Lakanal house

---

[585] https://www.lambeth.gov.uk/sites/default/files/LakanalTranscriptDay50.pdf.
[586] “SBDS” is a reference to Southwark council Building Design Service.

appears to have provided a means by which these failings were set aside and dismissed.

1130. Martin's oral testimony to the Coroner's Inquest[587] also includes several passages that I believe are relevant to these broader issues of professional competence and regulatory oversight. For instance, the following exchange with Mr Hendy is highly illustrative:

1131. MR HENDY: Mr Martin, having read your evidence and heard what you have said today, we accept your analysis of the way in which Approved Document B applied to the external walls of Lakanal House. Nevertheless, I do want to ask you some questions about where that leads us. I think you were in court, were you, when Mr Walker was giving evidence last week?

1132. A. That's right, yes.

1133. Q. You heard then the analysis of Approved Document B that I put to Mr Walker, and the flaw in that is, although we started at the right place, namely external walls under paragraph 13.3, we failed to take into account Section 4 which, as you've explained to Mr Maxwell-Scott, means that you have to do a further analysis to see whether these are permitted unprotected areas.

1134. A. Yes.

1135. Q. So that analysis was wrong. Likewise, Mr Walker's analysis, his first analysis, which was that one tries to find some kind of analogy with external stairs and so forth, which led him to the view that there was a 30-minute fire resistance necessity, that too was wrong, wasn't it?

1136. A. Yes.

1137. Q. He also, when he came back on the second day, said that the analysis I put was wrong because the Table A2 which specifies 120 minutes and so forth didn't apply to non-load-bearing walls, it was only relevant to load-bearing walls. That, too, was wrong.

1138. A. Yes.

1139. Q. Likewise, his conclusion that panels under the bedroom window should be fire-resistant for 30 minutes was a wrong conclusion.

1140. A. Yeah.

1141. Q. There was a suggestion made outside the formal proceedings of this inquest, merely in discussions amongst interested parties, that Table A2 with its 120-minute fire-resistance didn't apply here because the outside surfaces of Lakanal House were not external walls, they were something else. That too would be a wrong analysis, wouldn't it?

---

[587] https://www.lambeth.gov.uk/sites/default/files/LakanalTranscriptDay40.pdf.

1142. A. Yeah, in my opinion, yes.

1143. Q. Given that there were so many wrong analyses by people who were applying their mind to Approved Document B, do you agree that it might be desirable if Approved Document B could be revisited and reworked so that it was clearer to those who had to apply it as to what the conclusions ought to be?

1144. A. That's an interesting point. Trying to make these documents simple to use is a challenge. Designing buildings is a complex subject. My own experience from dealing with the enquiries that I get is generally most professionals in the industry seem to cope with applying the guidance without too much difficulty. If it was generating the kind of problems that you might imply from the discussions you've had here, I think I would know about it, and I don't.

1145. Q. Well, I don't want to embarrass Mr Walker, he's not here now, but he was a member of the Royal Institution of Chartered Surveyors, he was asked questions on the footing that he was an expert in these matters and yet he managed to get this wrong, and we rather thought that perhaps that might be typical amongst the chartered surveying fraternity that have to apply these regulations?

1146. A. I don't know Mr Walker's background.

1147. Q. Of course.

1148. A. In particular, I think it would be wrong to assume that all chartered surveyors have the same experience and have worked in the same areas. A lot of surveyors will spend much of their time dealing with repairs and refurbishment, that kind of thing, so might not necessarily deal with all aspects of the Building Regulations that you would apply when designing a new building.

1149. Q. Understood. Well, it's a matter for our coroner, who has the power to make recommendations for the future, and we've heard what you've said about the introduction of plain English and designing this document so instead of being two columns it's one column, but it might be something that the coroner might have in mind as recommending that this document really should be re-edited in order that there can be no ambiguities of this kind in the future. What would you say to that?

1150. A. I think the idea that you could have no ambiguities, I think, is -- Well, that's probably -- is a nice objective. I'd be surprised if it's possible.

1151. Q. But nevertheless, there could be some reworking, couldn't there, to increase clarity?

1152. A. Any document can be improved, yeah.

1153. Likewise, the following exchange between Martin and the Coroner is also illustrative:

1154. THE CORONER: … a guidance document really has to take into account, has it not, the ordinary building folk who are going to have to use, or who are invited to use, the document, in order to assist them with questions of this sort?

1155. A. I understand what you're suggesting. We did endeavour to help a little in that respect in the 2006 edition of the Approved Document. Mostly that was focussing on the simpler types of buildings where you might not necessarily expect a professional to be involved.

1156. Q. Well, you're going to have medium and smallish contractors and suppliers involved with all sorts of buildings, aren't you, and ordinary building folk need to know where they can go to get a straightforward answer to the sorts of questions which we've been debating this morning?

1157. A. I understand what you're suggesting.

1158. Q. It's just it seems to me that if you need a specialist engineer to take you through a document in order to get straightforward answers to fairly basic, straightforward questions, then the guidance document isn't really doing what it says on the tin, is it?

1159. A. I think that may be a little unfair. What you tend to find is that different contractors and different manufacturers, and other people involved in the process, learn the bit of the Building Regulations that affect the kind of thing they do. So in practice a lot of them will probably never directly refer to the Approved Document…

1160. So my experience is it's not as big a problem as it appears, but I do recognise that the Approved Document could always be easier to read. The challenge with a document like this is it could well end up being a library full of paper if you tried to cover every eventuality. So it's a balance between those two things.

1161. Q. I see. You said that you're looking at applying some plain English principles to the document.

1162. A. Yes.

1163. Q. Even doing that, that's not going to help someone who is taken through the document, as you've taken us, then suddenly to find that you, in fact, go outside the document to one of two other documents in order to find the answer to what surely is a fairly straightforward question.

1164. A. I'm not convinced it is a straightforward question.

1165. Q. Is it not straightforward for a building owner or a contractor who has been asked to undertake some work to say ‘Well, I've been asked to make some changes to the external faces of this particular block of flats [whatever it is], does it have to be fire-resistant or doesn't it?’ Isn't that a straightforward question?

1166. A. The question's straightforward. If you're experienced with applying the Building Regulations it's not a difficult question, but I appreciate if you read it for the first time it will be quite a difficult subject to get into.

1167. Q. Well, I think the exercise that we've seen in these courts indicates that it isn't a straightforward exercise. In fact, it's quite byzantine, isn't it?

1168. A. I'm probably not the right person to ask, I've worked with it for a long period of time, which to me is why it seems very straightforward, which is why we went through the process I've described in the lead up to the 2006 changes, to ask people who do use it what they think, and the feedback I get is that people don't have a problem with it.

1169. Q. I just query whether applying plain English principles or having one column on a page rather than two columns on a page will actually resolve the sort of difficulty that we've been seeing in this court.

1170. A. The exercise that we -- the document we've most recently applied this to is the document dealing with the design of stairs, and we restructured the guidance as well to make it easier to follow. But it's difficult, fire protection in buildings is a complicated subject, and I don't think you can stop that being the case.

1171. Q. But it's such an important subject that it's one that ought to be accessible to the people who have to use this document.

1172. A. My experience is that it is.

1173. I completely agree with Martin that "trying to make these documents simple to use is a challenge". Indeed, I might suggest that it is not only a challenge, but that it is also – potentially – a serious mistake.

1174. Going along with the ideas that "designing buildings is a complex subject" and that one cannot "stop that being the case", then the provision of simple rules/guidance may – in practice – serve only (or at least partly) to *enable* incompetent practitioners to operate in safety critical aspects of building design that ought better to be reserved for those with adequate competence using more complex rules/guidance.

1175. Indeed, I am surprised that the issue of professional registration of key individuals within the design, approval, and construction processes appears not to have been extensively discussed during the Lakanal House Coroner's Inquest, despite the incompetence that was on display.

1176. I also agree with Martin that "the idea that you could have no ambiguities… is a nice objective", but that "I'd be surprised if it's possible". Indeed, this is a well-recognised and fundamental challenge with all prescriptive regulation in complex technological areas (see Appendix A); such guidance documents tend to

LBYP20000001_0206

continually expand year on year, and eventually become so bloated as to require the services of professional "code consultants" to assist in their interpretation.[588]

1177. Martin succinctly highlights this challenge, stating that "the challenge with a document like this is it could well end up being a library full of paper if you tried to cover every eventuality… so it's a balance between those two things".

1178. In response to the Coroner's final remark in this exchange that "it's such an important subject that it's one that ought to be accessible to the people who have to use this document", Martin states that "my experience is that it is". This echoes Martin's earlier comment that "If [Approved Document B] was generating the kind of problems that you might imply from the discussions you've had here, I think I would know about it, and I don't".

1179. However, it is important to note that Martin's knowledge claims on the above point are based on his personal experiences, rather than any apparent, directed effort to satisfy himself that this his personal experiences were suitably representative of experiences from across the industry[589].

1180. Given his professional background, Martin will have been keenly aware of (at least) the cladding fires at Garnock Court (see Section 13.7) and The Edge (see Section 13.11), both of which clearly demonstrated that in some cases designers and/or contractors were not "getting it right" and/or that appropriate regulatory oversight was not being exercised, and that this had the potential to pose serious risks to public safety.

1181. I believe that in the wake of the Lakanal House fire it would have been appropriate – as would have been appropriate after the fires at Knowsley Heights, Garnock Court, Alpha House[590], and The Edge – for government to make some explicit attempt to determine:

1182. (1) whether the *competence* – or lack thereof – of the various "experts" and witnesses encountered during the Lakanal House inquest was broadly representative of individuals operating in relevant roles across the industry; and

1183. (2) whether the intended processes of fire safety regulation and regulatory *oversight* were broadly being applied across the industry.

1184. Without any obvious attempt to identify, understand, and address these wider failings of *competence* and *oversight*, these factors were free to fester within the industry, and eventually to manifest in the refurbishment and overcladding of Grenfell Tower, and in the design and construction of hundreds (thousands?) of

---

588 Spinardi et al. (2017) have previously commented on this issue.

589 And possibly input obtained during the consultation leading up to the publication of the revised and updated 2006 version of ADB.

590 The Alpha House fire occurred in a highrise residential (social housing) building in Barras Green, Coventry, in 1997, and involved significant external fire spread. However, very little information about this fire is available to me at the time of writing, and the fire does not appear to have been extensively investigated or reported on by BRE or, for that matter, by anyone else.

other residential buildings in England and Wales, with disastrous consequences that continue to play out some four-and-a-half years after the Grenfell Tower fire.

14.3.10. Aside – An Insight into the Tolerability of Fire Outcomes

1185. A useful technical insight is partially concealed within the Jury's comment (at Paragraph 1126 above) that "… even if the composite panels under the bedroom windows of Flat 79 had been Class 0, they would not have prevented the spread of fire from Flat 65 to Flat 79".

1186. If one accepts that this is true, then what is the purpose of Approved Document B's insistence on Class 0 for cladding on buildings above 18 metres?

1187. In answering this question one is forced to confront the realisation that the guidance given in Approved Document B *cannot* be relied upon to *prevent* (in absolute terms) external vertical fire spread in highrise buildings.

1188. Approved Document B *implicitly accepts* that fires will inevitably externally spread vertically upward, from window to window if not by other means. However, Approved Document B *aims* for a situation where the *rate* of this spread is slow enough that the fire and rescue services are able to attend and extinguish the fire before unacceptable consequences materialise. In a building with a "stay put" evacuation strategy, it is therefore also essential that building occupants' ability to evacuate the building be protected *absolutely*.

1189. ADB 2002 was intended to ensure, with a reasonable level of confidence, that the external vertical upward fire spread cannot "out run" the fire and rescue services. And in a tall building, the fire and rescue services would be "chasing" the fire up the building by firefighting internally (i.e. external firefighting is not generally considered an option at height[591]). ADB aimed to do this by requiring National Class 0 (or, since 2002, European Class B-s3, d2). This may have been appropriate for homogeneous products comprised of a single material. However, for composite products with combustible layers of any appreciable thickness, this – very clearly in my opinion – ought to have been called into question as early the 1991 Knowsley Heights Fire, and without question following the 1999 Select Committee inquiry (as it was, for example, by Dr Moore during those hearings).

1190. Approved Document B (2002) did little to explicitly prevent *downward* external fire spread.

1191. Clearly, accepting some likelihood of external fire spread (either up or down a building) has profound implications for all other aspects of a fire safety strategy, notably including fire and rescue service intervention given their typical need to set firefighting bridgeheads *within* a burning building but *below* a fire.

1192. The fact that ADB has never explicitly stated its implicit acceptance of vertical fire spread is, in my view, an important failure of *transparency of intent* that had/has

[591] The question of the height at which external firefighting ceases to be a credible option is an interesting and relevant one; however, as I do not hold myself out as an expert in such matters it is not one that I will comment on here.

significant implications for, in particular, any building with a "stay put" fire evacuation strategy.

14.4. Additional Warnings

1193. During the period 2009-2013, whilst the Lakanal House fire Coroner's Inquest was underway, at least two other fires occurred that (with hindsight) represented significant missed warnings regarding the use of polyethylene filler/core ACM rainscreen cladding products in the UK.

1194. Just nine days after the fire at Grenfell Tower, on 23rd June 2017, CEP Architectural Facades issued a statement[592] noting that CEP had "fabricated (i.e., cut to shape) two of the components in the building's cladding system (rainscreen panels and windows) using materials, and to a design, specified by the Grenfell Tower design and build team".

1195. The CEP statement included three images that they believed would be "helpful to those trying to understand what happened". The first image, included in Figure 28, showed the aftermath of a 2012 fire at Taplow House, Camden, London where the cladding had – as at Grenfell Tower – been Reynobond PE and the insulation was "mineral fibre".

1196. CEP claimed that this first image showed that the fire at Taplow House "did not spread." I note that this statement is incorrect; Figure 28 clearly shows that the fire *did* spread to the cladding, and that portions of the cladding had been consumed as a consequence of this fire.

1197. The second image, reproduced in Figure 29, showed the aftermath of a 2010 fire at Sudbury House, Wandsworth, London where the cladding product was "an aluminium composite material similar to Reynobond PE" and again the insulation was "mineral fibre".

1198. CEP claimed that this second image showed that "the fire was contained". This statement is also incorrect; the image clearly shows that the fire *did* spread to the cladding, that portions of the cladding had been consumed as a consequence of this fire, and that the fire had spread vertically within the cladding.

1199. Given the circumstances surrounding this statement, being issued just days after the Grenfell Tower fire, I am surprised that CEP claimed that these two photos showed "that correctly designed systems using appropriate components contain fires extremely effectively." This statement was incorrect and was not supported by any scientific evidence whatsoever.

1200. Remarkably from my perspective, CEP also claimed that rainscreen cladding products such as Reynobond PE "can be integrated into a safe cladding system", but that "certainly we recommend that in high rise buildings class O [sic] rainscreen panels should only be used in conjunction with a non-combustible insulation material such as mineral fibre".

[592] {ARC00000234}

1201. I am not aware that any test data were available to CEP or anyone else to demonstrate that Reynobond PE was able to achieve a Class 0 classification.

1202. The intimation in the above statement is that the differentiating factor between the fires at Grenfell Tower, versus those at Taplow House and Sudbury House, was the presence of combustible insulation at Grenfell Tower. I disagree with this claim, and I am unaware of any compelling scientific evidence to support it (I provide additional comments in the following sections).

1203. A second intimation in the above is that to be used above 18 metres, rainscreen products need only be Class 0, and that their filler/core need not be a material of limited combustibility – thus demonstrating the confusion around the applicability of Clause 12.7 of Approved Document B even *after* the Grenfell Tower fire.

1204. In any case, prior to the Grenfell Tower fire, and despite being reasonably immersed within the UK fire safety science and engineering community since about 2008, I was (at the time of the Grenfell Tower fire) completely unaware that either of the Taplow House or Sudbury House fires had occurred. I briefly discuss both of these in the following sections.

Figure 28 Aftermath of the 2012 fire at Taplow House.[593]

[593] {ARC00000234}

Figure 29 Aftermath of the 2010 fire at Sudbury House.[594]

14.4.1. The Fire at Sudbury House (2010)

1205. On 1st August 2010 a fire occurred at Sudbury House, a 24-storey block of flats in Wandsworth, London. A summary of this fire was included in BRE's *Communities and Local Government Report: BD 2786 Investigation of real fires* report for the period July 2010 to July 2011;[595] this was prepared for Brian Martin as, by this time, Anthony Burd had moved on to a new role at the British Standards Institution (BSI).

1206. It appears that no on-site investigation of this fire was undertaken by the BRE Fire and Security fire investigation team. The BRE report to government, however, provides the following brief description of this fire:

1207. "**Block of flats, London, 1st August 2010**

1208. Sudbury House, Wandsworth High Street, London. A fire occurred on the fifth floor of a of a 24-storey block of flats at around 11.00. A man, presumed by BRE Fire and Security fire investigators to have been in the flat of origin, was suffering from smoke inhalation and was rescued from the fifth floor and

594 {ARC00000234}
595 {BRE00000945}

another person was rescued from the third floor. The cause of the fire was under investigation."

1209. I am not aware of any further comments on this fire having been made by BRE in any subsequent reporting. Nor am I aware that the nature of the external cladding at Sudbury house was considered in BRE's reporting on this fire.

1210. However, a video showing various photos of this fire, posted on 1st August 2010, is available on YouTube[596]. The fire was also reported at the time by the BBC[597]. The public domain photos of this fire show evidence of significant external fire spread on and/or within the cladding, with external fire spread appearing to have extended (at least) two to three storeys above the flat of origin via the building's external cladding (after venting from open/broken windows). The images also show evidence of melting, burning, dripping, and flowing polymers, with downward fire spread also occurring as a result. The BBC's reporting of the fire also suggests possible downward fire spread to the 3rd floor.

1211. I consider the above to be significant observations with potentially important implications for building regulations and associated guidance.

1212. It has subsequently been reported[598] – albeit not until *after* the Grenfell Tower fire – that Wandsworth Council were aware that "Sudbury House was renovated in 2004 and used the same ACM [aluminium composite material] cladding as Grenfell". Review of the available public domain images suggests that the cladding panels were installed using a "cassette" configuration, rather than a "riveted" configuration.

1213. Thus, the external cladding at Sudbury House in 2010 appears to have been ACM with an unmodified polyethylene filler/core. This being the case, and having reviewed a number of photos showing the progression of this fire, I believe that the (very fortunate) ability of fire and rescue services to get close enough to supress this growing fire when they did may have averted a significant external fire spread event, and that the cladding system at Sudbury house likely represented a serious threat to life safety. I believe this fire represented a "near miss".

1214. I note that the cladding system at Sudbury house was replaced after the Grenfell Tower fire, in 2018, and that Wandsworth Council appear to have moved swiftly to rectify the situation, once the unacceptable hazards presented by the cladding were made more obvious to them (by the Grenfell Tower fire).

1215. At the time of the Sudbury House fire, in August 2010, BRE had been investigating cases of external fire spread, and performing fundamental research on the relevant issues, on behalf of government, for more than three decades (as discussed throughout the preceding sections of this report).

1216. By 2010, BRE had developed the BS 8414 test standard and the BR 135 classification guidance. They had argued for the creation of BS 8414 and BR 135, which eventually made their way into Approved Document B. They had investigated

596 https://www.youtube.com/watch?v=i2jIyq6ZFJk
597 https://www.bbc.co.uk/news/uk-england-london-10831675
598 https://constructionmanagermagazine.com/how-wandsworth-council-acted-prevent-another-grenf/

The Edge fire in Salford in 2006, subsequently advising government of necessary changes to the provisions in Clauses 12.5 to 12.9 of Approved Document B (2006); these changes were made specifically to address concerns around external fire spread hazards associated with the use of polymer-filled metal faced cladding panels.

1217. The Lakanal House fire, which had also involved both upward and downward external fire spread, with consequent loss of life, had occurred the previous year and was – at that time – being investigated by BRE.

1218. The stated objectives of BRE's *Investigation of real fires* project were (selected):

1219. "[1] To monitor and provide timely feedback to CLG from fire incidents on the following issues;

1220. [a] The effectiveness of Part B of the Building Regulations and the guidance in Approved Document B (AD B) in achieving its fire safety objectives, with particular consideration of the impact of the 2006 revisions.

1221. [b] Compliance with Part B of the Building Regulations and its associated guidance and standards and how this affects fire safety in practice where fires have occurred.

1222. [c] The impact of British and European Standards on building products and systems.

1223. [d] The impact of new designs and new methods of construction, and the use of innovative or unusual materials.

1224. [e] The role and use of Fire Safety Engineering approaches and other means of meeting the Building Regulations' requirements.

1225. [2] To identify and indicate any need for research or for changes to Part B/AD B arising out of specific problems highlighted in fire investigations.

1226. [3] To maintain close contacts with other investigators in the Fire and Rescue Services and elsewhere to encourage the exchange of information on unusual fires that will be of benefit to CLG.

1227. [4] To disseminate findings from fire investigations to the Fire and Rescue Service, building designers and owners and others, as relevant.

1228. To improve understanding of how unusual fires develop and grow, particularly in domestic properties, through site investigations where appropriate and through consideration of events in other countries.

1229. Despite the above (appropriate) objectives for this project, I do not believe that any of them have been achieved with respect to the fire at Sudbury House.

1230. On [1a], no comments whatsoever appear to have been made on the effectiveness of approved Document B's provisions for external fire spread. No comments appear to have been made to indicate whether the cladding panels were Class 0 or Class B-s3, d2. No comments appear to have been made to indicate if the core/filler in the ACM was a material of limited combustibility.

1231. Despite a specific objective to give "particular consideration of the impact of the 2006 revisions", no comments appear to have been made regarding the 2006 changes to Approved Document that had been recommended *by BRE* based on the fire at The Edge. If "filler materials" in Clause 12.7 of Approved Document B (2006) was explicitly (and obviously) intended to apply to the core/filler of an ACM cladding product (as claimed by DCLG in the wake of the Grenfell Tower fire), then the fact that the cladding of Sudbury House quite clearly did not meet that recommendation could have been of profound significance to government.

1232. No comments appear to have been made as regards the compliance (or otherwise) of the Sudbury House cladding system with the guidance of Approved Document B, and hence Objective [1b] was not adequately addressed.

1233. No comments appear to have been made to indicate whether the cladding materials and products used at Sudbury House had been classified for reaction-to-fire using National or European classifications, and hence Objective [1c] was not adequately addressed.

1234. No comments appear to have been made regarding the use of PE filled/cored ACM cladding panels – which could perhaps have been considered a comparatively "new" cladding product at that time – at Sudbury House, and hence Objective [1d] was not adequately addressed.

1235. No comments appear to have been made to indicate whether the external cladding system at Sudbury House had been designed and approved on the basis of the so-called "linear route" given in Approved Document B or whether this had been done on the basis of testing to BS 8414 and classification to BR 135 (both of which had appeared within Approved Document B in 2002), and this would have been the version of ADB governing the 2004 cladding refurbishment at Sudbury House.

1236. Indeed, despite the ongoing BRE investigation into the fire at Lakanal House just one year previous, and the possible realisation that building control approval of the refurbishment cladding system had not been sought in that case, no comments appear to have been made regarding the building approvals process for the refurbishment cladding system used at Sudbury House. Hence, Objective [1e] was not adequately addressed.

1237. Given that BRE appear to have paid almost no attention to the fire at Sudbury House, none of objectives [2], [3], or [4] were adequately addressed with respect to this fire. I believe it is important to understand why so little attention was paid to this fire.

1238. The Sudbury house fire primarily represents a missed opportunity to identify what would become (and perhaps already was) a systemic misinterpretation of the intent

LBYP20000001_0215

of Approved Document B. The same systemic misinterpretation that Brian Martin had told the Lakanal House Inquest that, if it were occurring, he "would know about".

1239. As an aside, it is worth considering what might have transpired had those charged with revising Approved Document B in 2006 made some effort to pro-actively notify practitioners (and building control in particular) of the changes made to the external fire spread provisions in the wake of the fire at The Edge. Perhaps someone involved in the refurbishment cladding at Sudbury House would have realised that its cladding presented an unacceptable hazard. Perhaps BRE would have paid closer attention to investigating the 2010 fire and had the awareness to highlight significant concerns associated with ACM PE (which they ought to have been aware of since about 2001/2002, thanks to the CC1924 DETR contract research discussed previously).

1240. Perhaps this could have prevented the application of ACM on countless other buildings during the subsequent 11 years.

1241. Instead, for 13 years, the residents of Sudbury House appear to have lived their lives with no knowledge of the precarious position that their homes were most likely in.

14.4.2. Fire performance of highly insulated residential buildings and modern methods of construction – A literature review

1242. In April 2010, BRE's Tom Lennon and Danny Hopkin issued a report to the NHBC Foundation,[599] entitled "Fire performance of highly insulated residential buildings and modern methods of construction – A literature review".

1243. It is not clear why this work was commissioned, nor why the NHBC Foundation funded it, however it appears to have been motivated by a recognition that "modern methods of construction (MMC) ranging from factory built systems through to innovative site built systems" were increasingly being used within the UK; and that "the increased amount of thermal insulation" in the resulting structures meant that "the (potential) combustible fire load within dwellings is increased and there is an increased potential for fire to spread through the fabric of the building".

1244. The details of the research project and its outcomes are not centrally important to this report, aside from one key statement that is made in Section 3.4.2 of the document which deals with "external fire spread" issues:

1245. > "Traditionally compliance with the regulations has been achieved through reaction to fire tests. Such tests consider issues such as ignitability, flame spread and heat release rate. However, they are generally applicable to external surfaces. Many of the cladding systems now on the market are complex composite or built up systems where an assessment of the characteristics of the exposed surface with respect to flame spread may not provide an accurate picture of performance in a real fire scenario."

---

599 {NHB00000450}

1246. The above statement is a clear warning that the existing reaction-to-fire testing and compliance regime (i.e. Class 0 and potentially also Class B-s3, d2) may be inadequate for addressing the hazards associated with "composite or built up systems".

1247. I note that Sarah Colwell (BRE), Brian Martin (DCLG), and Dave White (NHBC) are all listed as being members of the "project stakeholder group" for this research project, and would likely, therefore, have been made aware of its outcomes.

14.4.3. The Fire at Taplow House (2012)

1248. On 16th January 2012 a fire occurred at Taplow House, a 22-storey block of flats in Swiss Cottage, London. A summary of this fire was included in BRE's *Communities and Local Government Report: BD 2786 Investigation of real fires* report for the period July 2011 to July 2012;[600] this was again prepared for Brian Martin.

1249. It appears that no on-site investigation of this fire was undertaken by the BRE Fire and Security fire investigation team. The BRE report to government, however, provides the following brief description of this fire:

1250. "**Block of flats, London, 16th January 2012**

1251. Swiss Cottage, London. The fire started at about 22:00 on the 17th floor of a 22-storey block of flats. 130 people were evacuated to a nearby community centre. The 17th floor was partially gutted, but fire fighters confined the fire to that floor and brought the fire under control in over three hours. The fire was caused by a candle setting fire to papers, prompting a warning by a London fire brigade spokesman on storing large amounts of paper, magazines and books in dwellings."

1252. I am not aware of any further comments on this fire ever having been made by BRE in any subsequent reporting. Nor am I aware that the nature of the external cladding or cavity insulation at Sudbury house were ever considered in BRE's reporting on this fire.

1253. However, just *one day* after the fire on 17th January 2012, Harley Curtain Wall – as agreed with Rydon Construction – visited Taplow House "to investigate the visual damage to the windows and external cladding". A further abseil survey was undertaken by Harley on 18th January 2012. These investigations resulted in "Harley Incident Reports" being produced on 17th and 23rd January 2012[601].

1254. The second of these reports, Harley's "Fire Damage Report from Abseil Survey", noted that the cladding had been damaged in the fire to such an extent that it would need replacing over three floors, with additional damage that meant that the cladding was "compromised" over a further four floors (seven floors in total).

---

600 {BRE00000947}
601 Exhibit RB/1 Harley Curtain Wall Incident Report Form {HAR00010169}, Harley Curtain Wall: 123 Taplow House, Fire Damage Report from Abseil (sic) Survey {CEP000002285}

1255. The photos of the aftermath of this fire show evidence of some external fire spread on and/or within the cladding, with external fire spread appearing to have extended both slightly above and slightly below the flat of origin via the building's external cladding (after venting from open/broken windows within the flat of origin). The images also show evidence of melting, dripping, and flowing polymers. The Harley abseil report noted that "the hot residue from the burning flat has spread down to the 15th floor on the south elevation. This has stuck to the panels and burnt the PVDF surface". In my opinion this statement is incorrect; the noted residue appears to be polyethylene filler/core from the cladding panels themselves, rather than "hot residue from the burning flat".

1256. Again, I consider the above to be a significant observation with potentially important implications for the Building Regulations, the Approved Documents, and the cladding industry more broadly. That these observations were not made or reported following the fire represents a further missed opportunity for information about the systemic misinterpretation of ADB to be (again) brought to the attention of government.

1257. As already noted, it was subsequently reported – by CEP Architectural Facades, after the Grenfell Tower fire – that the cladding system at Taplow house consisted of Reynobond PE rainscreen cladding panels, used in conjunction with "mineral fibre" insulation. The Harley "Fire Damage Report from Abseil Survey" report comments on the presence of mineral fibre cavity barriers (and intimates as to their effectiveness) and also shows the cladding panels to have been installed in a "riveted" rather than "cassette" configuration.

1258. Thus, the external cladding at Taplow House in 2012 appears to have been ACM with an unmodified polyethylene filler/core. Again, I believe that it is fortunate that this fire did not escalate and cause more widespread damage[602]. And again, I believe this fire to have been a near miss.

1259. I note that Taplow House was evacuated shortly after the Grenfell Tower and that the rainscreen cladding was to be replaced. At the time of writing, I am not aware that the cladding replacement has been commenced; either on Taplow House or on the other three similar tower blocks on Camden's Chalcots Estate.

1260. All of the comments I made in the previous section with regard to BRE's investigation of the Sudbury House fire are also relevant to their investigation of the Taplow House fire. See paragraphs 1218 to 1237.

1261. Despite this missed opportunity, again, I do not believe that any of BRE's objectives for the "*Investigation of real fires*" project for government had been substantively achieved with respect to the fire at Taplow House.

[602] I do not have sufficient information to speculate on the reasons for this, however the "riveted" installation technique is likely to have played a role in mitigating catastrophic escalation of the fire at Taplow House. Refer to my comments at Paragraphs 998 to 1002, as well as to my (upcoming) Phase 2 Work Package 2 Experimental Report for this Inquiry.

1262. The end of year report for contract BD 2786 summarises the observed external fire spread issues observed during the relevant period as follows:

1263. "Two fires (one overseas) have involved fire spread up external claddings. These demonstrate the value of the additional recommendations in AD B".

1264. It is not at all clear, however, which "two fires" the above comment is referring to – certainly not both Sudbury House and Taplow House; and actually I suspect neither of them. Neither is it at all clear what "additional recommendations in AD B" are being referred to.

1265. The report summarises the situation for the period that included coverage of both the Sudbury House and Taplow House fire as follows:

1266. "The findings from this period have reaffirmed the overall effectiveness of the Building Regulations and AD B in providing for the safety of life in the event of fire. Most of the significant issues that have been identified during this study fall outside the scope of these Regulations."[603]

1267. Since both Sudbury House and Taplow House had ACM PE present in the cladding system, and since these were both "near miss" events, I would suggest that any belief that these fires were "re-affirmatory" was a belief falsely held.

1268. I also believe that such a reaffirmation was dangerous. If it *was* known – albeit not articulated in the reports – that these were ACM PE cladding systems, and if it *was* known that ACM PE was not permitted under ADB's so-called "linear route" due to the recommendations of Clause 12.7, then these "near miss" events may have actually given confidence to government. The reaffirmation could have resulted in a view that, although ACM PE *was* in use, it "wasn't actually that bad"; this may have actually made actions that might disrupt the systemic misconceptions within the industry even *less* likely.

1269. I reiterate my comments made in Paragraph 1239.

[603] I note that this BRE report {BRE00000947} also provides summaries of notable international fires, and includes a summary dealing with a 17th July 2012 fire in a 42-storey "Multi-use, multi-storey building" in Istanbul, Turkey. This fire was apparently considered to be of interest to BRE because the fire "started on the ground floor of the 42-storey building, and spread vertically through the external wall insulation, along the entire height of the building". The only major fire that I am aware occurred on that date in Istanbul was an external cladding fire that occurred at the Polat Tower; the BRE fire investigation team appear to be unaware that this fire was attributed to the extensive use of ACM cladding (see Guillaume et al. 2018), rather than to "external wall insulation".

15. System Failure (2013-2017)

1270. Ample evidence existed prior to 2013 that the National reaction-to-fire classification system was problematic when applied to external cladding. It was abundantly clear more than a decade earlier that the existing regulatory application of Class 0, and the BS 476 parts 6 and 7 tests that underpinned it, failed to adequately address the fire hazards associated with some combustible rainscreen products. Ample evidence also existed – both explicit from CC1924 (based on my assessment of that work) and apparently unnoticed from real cladding fires – to clearly show that aluminium composite panels with an unmodified polyethylene filler/core *were* being widely used on residential buildings above 18 metres in height in Britain, particularly in the social housing overcladding sector.

1271. Notwithstanding the above comments, the four year period between the conclusion of the Lakanal House Coroner's inquest and the Grenfell Tower fire was, as has been extensively evidenced during Module 2 of Phase 2 of the Inquiry, characterised by increasing confusion, misinformation, concern, and – critically – inaction.

1272. In my opinion, the period 2013-2017 can only be viewed as demonstrating a total failure of the system of building regulation as regards external cladding design, assessment, approval, procurement, and delivery.

1273. This section presents a non-exhaustive[604] review of some of what I consider to be the most important events during this period; events that I consider to be significant missed opportunities to take action, and to potentially prevent the Grenfell Tower fire and subsequent cladding crisis from occurring.

15.1. Missed Opportunity: Queries from BRE (2013)

1274. On 25th November 2013, BRE's Tony Baker emailed Brian Martin (at DCLG) with a query regarding the applicability of Clauses 12.5 and 12.7 of Approved Document B specifically as regards the use of combustible Class B-s3, d2 rainscreen products:

1275. "Hi Brian,

1276. I hope you are keeping well.

1277. I hope you can help with the following, we are seeing an increasing number of enquiries in which we are being asked for our opinion / interpretation of Diagram 40 and AD-B B4 clauses 12.6 & 7 in relation to the build-up of systems using board finishes and we would like to reach a general understand so we can respond to all parties in the same way.

1278. Systems with board type outer layers – the boards are typically 15-20mm thick and achieve B-s3, d2;

[604] I have not been able to undertake a full review of all available evidence for this period, and I expect that additional evidence will come to light both before and during Module 6 of Phase 2 of the Inquiry. I will amend this report, if necessary, in light of any new evidence.

1279. Clause 12.6 guidance references diagram 40 in relation to the classification of the finish which would be acceptable over 18m as being B-s3, d2 but 12.7 talks about insulation or filler materials which make up the wall being limited combustibility.

1280. As the minimum / maximum surface finish is not defined a debate has opened up within the industry as to whether or not the boards can be called the 'finish' or the 'filler'.

1281. Based on our experience from the original PII programme we would suggest that the a [sic] definition of the surface finish thickness and 'filler' would assist in clarifying this point and would therefore be grateful for your thoughts.

1282. Best regards

1283. Tony"

1284. This email is effectively asking whether a European Class B-s3, d2[605] rainscreen cladding product can be used above 18 metres in accordance with Approved Document B, even if this product includes materials that are *not* of limited combustibility. Baker is asking Martin to provide a definition of "filler material" because "debate has opened up within the industry".

1285. I have already discussed Martin's response to this email – for other reasons – in Section 15.1, however I will reproduce it again in full here:

1286. "Hi Tony

1287. I see where you are coming from.

1288. The problem we have with Class B is that you can have a thin surface that gives you the performance and back it with something less desirable. So there's no such thing as a class B 'material'.

1289. The word filler was introduced because of a particular incident where a polymeric foam was used to keep an aluminium panel stiff. The foam was not used for thermal reasons so it wasn't 'insulation'! (it still burned of course!!!) Sarah will remember the details I'm sure.

1290. I'm thinking out loud here but I think a homogenous Class B board would be fine (effectively a class B material?). But a lamination of board with something else should revert to the limited combustibility criteria.

1291. Does this make sense.

1292. Don't quote me on this yet, what do you think?

605 I note that this question could equally have been asked regarding the adequacy of a combustible but Class 0 rainscreen cladding product.

1293. Brian"

1294. I believe it to be noteworthy that Martin states that "there's no such thing as a class B material", thus indicating his apparent view that Class B can only be applied to "products", rather than to the "surfaces" of products. Martin also notes that "a homogenous Class B board would be fine" but that "a lamination of board with something else should revert to the limited combustibility criteria."

1295. This email exchange suggests that, as early as November 2013:

1296. government was aware that confusion existed within the industry as regards the application of Diagram 40 and Clauses 12.5 and 12.7;

1297. Martin had (privately) expressed a view that "there's no such thing as a class B material", thus indicating his apparent view that Class B can only be applied to "products" rather than to the "surfaces" of products; and

1298. Martin had expressed a tentative view that *all layers* within a composite cladding product, whether or not a Class B product, should be recommended to meet the requirements for limited combustibility (this being – with hindsight – the necessary explicit clarification of Clause 12.7 that appears never to have been publicly made prior to the Grenfell Tower fire).

1299. I am not aware if this email correspondence continued, or if it resulted in any attempts to clarify the applicability of the relevant clauses in Section 12 of Approved Document B.

15.2. Missed Opportunity: The All Party Parliamentary Fire Safety and Rescue Group (2014-onward)

1300. On 28th March 2013, Frances Kirkham, the Assistant Deputy Coroner who oversaw the Lakanal House Inquest, wrote to Eric Pickles, Secretary of State for Communities and Local Government, concerning the inquests into the six deaths that occurred at Lakanal House fire.

1301. One of the recommendations in this letter[606] was that government "review AD B to ensure that it provides clear guidance in relation to Regulation B4 of the Building Regulations, with particular regard to the spread of fire over the external envelope of the building".

1302. In responding to Kirkham's letter[607] on this issue, Pickles states:

1303. "I have noted your concerns about the difficulties that some of those involved in the Inquests had with the implementation of Approved Document B. I can assure you that my department is committed to a programme of simplification. However, the design of fire protection in buildings is a complex subject and should remain, to some extent, in the realm of professionals."

---

606 HM Coroner Rule 43 Letter to DCLG dated 28 March 2013 {CLG00000401}
607 Letter from Rt. Hon Eric Pickles to HM Coroner dated 20 May 2013 {CLG00001954}

1304. In the subsequent years, however, no formal review of Approved Document B appears to have been undertaken, and no new version was published prior to the Grenfell Tower fire in June 2017.

1305. The All Party Parliamentary Fire Safety and Rescue Group (APPG) do not appear to have been satisfied with the apparent inaction of government on this issue; or on other issues, such as consideration of fire suppression systems in residential buildings, arising from the Lakanal House Coroner's inquest.

1306. On 5th August 2014, David Amess, Chairman of the APPG, wrote to Stephen Williams, Parliamentary Under Secretary of State for Communities, to request that government *immediately* amend Approved Document B.[608] Essentially, it was requested that a different standard of performance be applied to "component parts of the external walls of buildings above 18 mtrs [sic] in height", rather than "simply" asking for "a Class 'O' Surface [sic] spread of flame".

1307. The APPG was drawing DCLG's attention to potential problems with the use of Class 0 as a means of mitigating external fire spread hazards.

1308. On 9th September 2014, Williams responded with a brief letter[609] which stated simply:

1309. "I have neither seen nor heard anything that would suggest consideration of these specific potential changes is urgent and I am not willing to disrupt the work of this department by asking that these matters be brought forward."

1310. As I have shown, there was at this point abundant evidence that Class 0 required reconsideration as regards external fire spread considerations. It is difficult to understand how this information appears not to have been brought to Williams' attention.

1311. Unfortunately, by 14th June 2017 nothing had changed to address these concerns, and the ACM PE product used for the rainscreen cladding and architectural crown at Grenfell Tower was – wrongly in my view – the subject of a BBA Certificate which stated that "the panels may be regarded as having a Class 0 surface."[610]

1312. As an aside, but related to the APPG's post-Lakanal activities that I consider relevant to the Grenfell Tower fire, I note that Amess had previously (and

---

608 Letter from David Amess MP to Stephen Williams MP dated 5th August 2014 {CLG00011290}
609 Letter from Stephen Williams MP to David Amess MP dated 9th September 2014 {CLG00011291}
610 I note that I consider this statement {BBA00000047/1} to be absurd on various grounds. Firstly, I am not aware that test data were provided to the BBA that would demonstrate that a Class 0 performance had actually been achieved, and Approved Document B has (since 2002) been explicit in Diagram 40 that "The National classifications do not automatically equate with the equivalent European classifications, therefore products cannot typically assume a European class unless they have been tested accordingly". Thus, a European Class B-s3, d2 classification cannot be used to support these products being "regarded" as Class 0. Secondly, as I have already noted (see footnote to Paragraph 999), the BS 476 Part 6 testing standard is clear that only full products (or products of a minimum thickness of 50 mm, when the product's thickness is more than 50 mm) can be assessed when testing composite products to this standard. To suggest that a composite product has "a Class 0 surface" is therefore nonsensical, regardless of the terminology used in Approved Document B to define Class 0.

presciently) written to Penny Mordaunt, Parliamentary Under Secretary of State for Communities and Local Government,[611] amongst other things to express frustration with what the APPG appear to have viewed as inaction in the wake of the Lakanal House fire:

1313. "3. The APPFSRG's agreement to follow up on issues arising from major fire tragedies with significant loss of life (e.g. Lakanal House, Camberwell and the 1973 Summerland Leisure Centre, Isle of Man)

1314. As you rightly point out, this is a matter for your ministerial colleague, Stephen Williams MP, however the Group has since written to the Minister saying they were at a loss to understand, how he had concluded that credible and independent evidence which had life safety implications, was *not* considered to be urgent, when amendments of much lesser Importance to the Approved Document had been made between reviews.

1315. As a consequence the Group pointed out to the Minister that *should a major fire tragedy, with loss of life occur between now and 2017, in for example, a Residential Care Facility or purpose built Block of Flats, where the matters which had been raised here, were found to be contributory to the outcome, then the Group would be bound to bring this to others' attention*" (emphasis added).

15.3. Missed Opportunity: CWCT "Fire Group" Meetings (2014)

1316. On 24th April 2014 I was contacted by Brenda Apted of The Centre for Window and Cladding Technology (CWCT),[612] inviting me to attend their "initial meeting" to "discuss the issues of fire and facades". This was to be a half-day meeting to discuss a number of issues that had been raised "in recent months regarding fire and facades".

1317. Amongst the issues to be discussed included (partial list):

1318. "Use of combustible insulation in facades, particularly rainscreens. This is causing problems due to the greater thickness of insulation that is required if limited combustibility materials have to be used;

1319. Performance and location of cavity barriers in rainscreen walls;

1320. Performance of composite panels, such as ACM's [sic]; and

1321. Application of fire engineering to facades."

1322. A stated purpose of the meeting was to "establish the adequacy/appropriateness of existing regulations" and potentially to establish a working group to oversee the development of CWCT work in this area.

[611] Letter from Sir David Amess MP to Penny Mordaunt MP dated 20 January 2015 {CLG00000912}
[612] Email from Brenda Apted, CWCT, to Luke Bisby dated 24 April 2014 - CWCT Fire Group {LBY00000377}

1323. This meeting was eventually held on 2nd July 2014, at Arup's 13 Fitzroy Street, London offices. A partial list of individuals recorded as having been in attendance included me, David Metcalfe (CWCT), Sarah Colwell (BRE), Dave Cookson (Kingspan), Alan Keiller (CWCT), Gavin Kerr (Arup facades), Barbara Lane (Arup fire), Brian Martin (DCLG), Ivor Meredith (Kingspan), Chris Mort (Siderise), and Stuart Taylor (Wintech).

1324. The minutes of this meeting are available to the Inquiry,[613] so I will not rehearse them here. Key comments/outcomes noted in the minutes, however, included the following:

1325. **"Combustibility of insulation**

1326. Limited combustibility insulation should be used above 18m when following the prescriptive requirements of ADB Cl 12.7 but other materials, principally foil faced phenolic foam are often used in rainscreen walls. There is a degree of ignorance with some people confusing class 0 with limited combustibility. In other cases building control officers are permitting the use of class 0 materials making it difficult for cladding consultants to enforce the requirement for limited combustibility insulation.

1327. Higher standards of thermal insulation are requiring greater thicknesses of insulation and in some cases this can only be achieved within the designated wall zone by use of combustible insulation. Architects are unaware of the problem and need to allow a wider wall zone to accommodate the greater thickness required with limited combustibility material.

1328. Cavities/openings may be formed in a fire due to melting or deformation of materials. The cavities/openings may lead to unexpected routes for fire spread."

1329. The above comments again highlight the widespread confounding of "Class 0" and "limited combustibility" and note perceived problems more broadly with the robustness of building control processes. Issues with Architects' incompetence in this area are also highlighted.

1330. The minutes go on to discuss issues specifically related to the use of ACM on high rise buildings:

1331. **"Use of ACM on high rise buildings**

1332. ACM refers to aluminium composite material. The normal material consists of two skins of aluminium approx. 0,5mm thick separated by a polyethylene core 2 to 5mm thick. This material generally achieves a reaction to fire classification of class 0 or class B s1 d0. There are versions available with a mineral core which can achieve A2 s1 d0. There are also similar materials available with other metals such as copper used for the facing.

[613] {CLG00019336}

1333. There have been major fires in buildings in various parts of the world including the Middle East and France where ACM materials have been used for the cladding with the ACM responsible for external fire spread.

1334. It was stated that clause 12.7 of ADB is intended to prohibit the use of polyethylene cored ACM in buildings over 18m as they are not classed as limited combustibility. This is not clear from the wording of the current clause. The current clause is preceded by a heading "Insulation Materials/Products" which implies that it only applies to insulation. The wording of the main text refers to filler materials which could be taken to include the polyethylene core, but this is not clear.

1335. It was suggested that clarification could be achieved by means of a FAQ. Approved Documents can be downloaded from http://www.planningportal.gov.uk. The page for each Approved document also has a FAQ section related to that Approved Document. Sarah Colwell agreed to raise this with Brian Martin.

1336. *How would this affect other materials used for rainscreen panels e.g., high pressure laminate?"*

1337. The above comments, in July 2014, clearly articulated to all present at the meeting both the potential concerns associated specifically with combustible ACM cladding products and the confusion within the industry as regards the application of Clause 12.7 *specifically to ACM cladding products*.

1338. The minutes note that Colwell agreed to raise the need to clarify the intent and application of Clause 12.7, via an FAQ to Approved Document B, with Martin. I note that Colwell had been the key individual within BRE who had undertaken and reported on the earlier CC1924 testing for government, more than a decade earlier. Colwell would therefore presumably have been acutely aware of the significant revelations from that work regarding the external fire spread hazards presented by "Aluminium / polyethylene core sheets on aluminium railing".

1339. However, I am not aware if any relevant correspondence or discussion continued between the CWCT and BRE or DCLG, or if any attempts were made to issue an FAQ of to clarify the applicability of the relevant clauses in Section 12 of Approved Document B.

1340. A subsequent meeting – which I was unable to attend – was eventually held on 17th March 2016, again in London, the minutes[614] of which record the following statements (original emphasis):

1341. **"Combustibility of material**

1342. Approved Document B (Clause 12.7) requires insulation and filler material in the external walls of tall buildings to be of limited combustibility. BCA Guidance Note 18 extends this requirement to all material in the wall.

614 {CWCT0000029}

1343. It was accepted that Clause 12.7 was poorly written and open to interpretation. The title of the clause is also misleading ('Insulation Materials/Products'), and this will be changed in the next revision of ADB.

1344. The term 'filler material' was intended to be a 'catch-all' as it was not possible to list all the materials that should be covered by the clause. In addition, there were people arguing that certain materials used in a façade build-up (such as expanded polystyrene in some instances) were not there for their insulating properties, but to 'pad out' the façade, and were therefore excluded from the clause.

1345. This requirement should be applied taking into account Clause 12.5 of ADB;

1346. 'The external envelope of a building should not provide a medium for fire spread if it is likely to be a risk to health or safety. The use of combustible materials in the cladding system and extensive use of cavities may present such a risk in tall buildings'

1347. Note that this clause refers to **combustible materials in the cladding system** rather than specifically insulation, etc.

1348. Conclusion of the discussions – the cladding should not contribute to the spread of fire and that the combustibility clause is intended to include **all materials in the external wall.** An exception may be made for small, isolated components that would not contribute to fire spread"

1349. I note the remarks in these minutes, that Clause 12.7 was poorly written, that the title of the clause was misleading, and that both of these issues would be remedied in the "next revision or ADB". However, at that time I am not aware that any planned revision of ADB had been announced, and I therefore remain surprised that an FAQ was never issued (as had initially been suggested during the July 2014 meeting).

1350. On 27th April 2017, the CWCT issued Technical Note 98, "Fire performance of facades - Guide to the requirements of UK Building Regulations". This document contains, amongst other guidance, the following text relevant to the combustibility of materials used in cladding systems:

1351. "**Combustibility of materials**

1352. Limits on combustibility of materials are given in Clause 12.7 of ADB. Clause 12.7 specifically refers to insulation materials and filler materials but is now being interpreted more generally (see BCA Guidance note 18). Therefore where a building has a storey 18m or more above ground level all significant materials should be of limited combustibility (Class A2 in accordance with EN 13501-1). This includes, but is not limited to:

1353. Rainscreen panels,

1354. Standard ACM panels do not meet these requirements. Limited combustibility ACM panels are available,

1355. Insulation materials,

1356. The only commonly used insulation material that will satisfy the definition of limited combustibility is mineral wool,

1357. ...

1358. These requirements apply to the full height of the wall both above and below 18m, ie [sic] in a high rise building; materials below 18m would also have to be of limited combustibility."

1359. Unfortunately, despite the need for this clarification of the guidance having been evident and articulated to both government and a number of key individuals within the cladding and construction industry in July 2014, neither CWCT Technical Note 98 nor the needed FAQ to Approved Document B were issued in sufficient time to prevent installation of Reynobond 55 PE cladding panels on Grenfell Tower.

1360. It is important for me to say that it is a matter of great personal regret that – despite following up with the CWCT by email on 30th November 2014[615] and 16th July 2015[616] to ask if any actions had been taken or progress been made – I did not, at the time, consider it my role to widely publicise the outcomes of these meetings and correspondence.

15.4. Missed Opportunity: BRE "External Fire Spread" Reports (2014-2016)

1361. In January 2015[617] BRE issued a report and later, in April 2016, a two-part paper on "External Fire Spread" research.[618] The research presented in these documents appears to have been conducted during 2014 and/or 2015. Unfortunately neither the fundamental motivation for the work, nor its purpose, are at all clear, even with hindsight. I note, however, that this research seems likely to have been commissioned not long after the Lakanal House Coroner's Inquest concluded, i.e. in 2013 or 2014.[619]

---

[615] Email from Luke Bisby to David Metcalfe, CWCT, dated 30 November 2014 {LBY00000380}

[616] Email from Luke Bisby to David Metcalfe, CWCT, dated 16 July 2015 {LBY00000382}

[617] {BRE00043751} is dated 9th January 2014, however I assume that this must be a typographical error which should have stated 9th January *2015*.

[618] {BRE00043751}, BRE Report on External Fire Spread - Part 1 Experimental Research - April 2016 {CLG00019445}, BRE Report on External Fire Spread - Part 2 Experimental Research - April 2016 {CLG00019444}

[619] I also note a comment in David Amess' letter to Stephen Williams on 5th August 2014, in which he states the following with reference to the Lakanal House fire: "The BRE simulated tests undertaken on the window sets and panels following the fire at Lakanal house demonstrated that the window panels installed in 2006/2007 burned through in just four and a half minutes, bringing about the death of Catherine Hickman, and leading to the spread of fire which went on to cause five further deaths in the adjoining flat. These panels were supposed to have met the requirements of the Building Regulations Approved Document B but turned out to have only a class 3 surface spread of flame. A simulated test on a class 'O' window set and panels was never undertaken". Amess' letter went on to point out a number of ways in which the performance of the window panels had significantly impacted on the development of the Lakanal House fire, at least according to the Coroner's verdict.

1362. Unfortunately, and I do not express this opinion lightly or without reflecting on the benefit of hindsight, the resulting report and papers are in places incomprehensible, and they appear to lack in any real insights or practical significance.

1363. I believe it would be a distraction for me to present a line-by-line critique of these documents; however, this is not to say that there is no value in reviewing them. I believe that there is considerable value in presenting an overall critique of the information and testing that they present, given their centrally relevant subject matter, their timing, and the fact that they appear to have been commissioned by DCLG.

15.4.1. External Fire Spread – Part 1 Background research

1364. The Part 1 paper[620] discusses previous and (then) current guidance on mitigating external fire spread, and offers three "case studies of external fire spread since the introduction of the BS 8414 test series". The introduction to this paper states that "the aim of this article is to clarify the background to these recommendations, their objectives and intended outcomes".

1365. The historical background to the Building Regulation requirements is stated, however the significance of this background for assessing the tolerability of external vertical fire spread is not explained.

1366. The Knowsley Heights fire is referred to as "one of the most significant of the historical [external] fires; a residential block of flats which had been refurbished with the addition of thermal insulation to the external walls of the block. The fire started external to the block and *ignited the combustible cladding system*, resulting in extensive fire spread across the face of the building (mostly upwards)." However, it is not stated exactly what this significance is.

1367. It is stated that the Knowsley fire "raised many concerns", however the nature of these concerns is not explained.

1368. It is stated that the Knowsley Heights fire "resulted in a change to the test methods used for external cladding systems". This is not entirely true; the Knowsley fire resulted in the research undertaken by Connolly, which led eventually to the development and introduction of the BS 8414 test – following the Garnock Court fire – however this was as an *additional option* for testing the fire performance of external cladding systems, rather than a "change to the test methods".

1369. The 2002 research by Crook and colleagues at BRE (discussed in Section 13.9) is highlighted, noting that work's overall conclusion – this being an *argument from ignorance* – that "the evidence acquired for this project leads to the conclusion that the measures currently called upon through Approved Document B are still commensurate with the risk", because "very few people are killed or injured from fire who are elsewhere than on the fire floor" and "most deaths or injuries on floors other than the fire floor are as a result of smoke". I disagree that the absence of evidence of a problem can be used to conclude that no potential problems exist.

---

[620] {CLG00019445}

1370. The Part 1 paper cautions that "more innovative ways to insulate buildings to improve their sustainability and energy efficiency are changing the external surfaces of buildings with an increase in the volume of potentially combustible materials being applied". However, the report fails to recognise (or point out) that it is not *only* the use of combustible *insulation* that had historically led to extensive external vertical fire spread. For instance, the report fails to point out that the extensive vertical fire spread observed at (at least) Knowsley Heights (1991), Garnock Court (1999), The Edge (2005), Sudbury House (2010), and Taplow House (2012), was likely attributable to the use of combustible (but in some cases Class 0) rainscreen/cladding panels. Indeed, the report fails to mention the existence of the latter three fires, despite the fact that BRE had reported on all of them via their *Investigation of real fires* contracts for government.

1371. In fact, by the time this report was issued for approval – in May 2015 – the only major UK highrise cladding fire that I am aware of that I consider likely to have been demonstrably exacerbated by the presence of combustible *insulation* in the external wall was the Lakanal House fire, and in that case the potential significance of the combustible insulation within the window panels appears not to have been seriously considered by BRE in their investigations (as already discussed in Section 14.3).

1372. The paper provides a summary of "Existing guidance", however in doing so it rather muddies the waters in its recasting of the recommendations of Approved Document B. For instance, it states that "should the construction of external walls [above 18 metres] use combustible materials in the cladding system, then it should meet the performance criteria set out in BR 135 using the full scale test methods BS 8414-1:2002 or BS 8414-2:2005 which involves testing the entire cladding system including the insulation among other components". This is not true, given that the 2013 version of Approved Document B would still have permitted the use of a Class 0/Class B-s3, d2 (but combustible) rainscreen panels – potentially a fire retarded high pressure laminate, for instance.

1373. Indeed, depending on a designer's interpretation of Clause 12.7 of Approved Document B (2013) (as already discussed), a designer might assume that *any* Class 0/Class B-s3, d2 rainscreen product that did not incorporate combustible "insulation materials/products" would have been permissible in accordance with Approved Document B[621].

1374. The paper then presents three "case studies" of "fires since the introduction of BS 8414 test series". The rationale for selecting these three specific case studies – but not selecting, for instance, Lakanal House – is not clear.

1375. Case Study 1 (2008) is as follows:

1376. "A fire occurred in a first floor flat of a 1960s nine-storey block of maisonettes. The external walls of the flats incorporated uPVC window and door units and some of the lower window panels had been replaced with painted metal panels (comprising two sheets of painted metal, possibly aluminium, and a

621 I hasten to add that I do not personally subscribe to this view – although I am aware that some in the industry appear to.

thin layer of adhesive holding the two together). The fire melted the frames of the window units, allowing flames to extend up the exterior of the building. These flames were sufficient to melt the frames and break the window panes of the floors/flats above the flat of fire origin and caused fire and smoke damage within the flats from the third to the sixth floors of the block."

1377. The above description begs a number of important questions as regards the background to the existing guidance, their objectives, and their intended outcomes. No adequate descriptions of the materials or products involved in this fire are given. No links between this fire and the provisions of Approved Document B are given. No comments are made as to timescales over which the fire spread. No comments are made as the adequacy of the external wall as regards the functional requirements of the Building Regulations. No recommendations are made to government on the basis of the observations given. I therefore do not understand what the practical usefulness of this case study is in terms of understanding or mitigating external fire spread via the guidance given in Approved Document B.

1378. Was this external wall compliant with the existing guidance? Should consideration be given to any changes in the guidance? Did the building perform in line with the underpinning acceptance criteria for external fire spread? Did the performance of the external wall in fire have implications for other parts of the guidance or other functional requirements of the Building Regulations? What is the relevance of this fire as regards the implementation of testing to BS 8414-1 (which was apparently the purpose of including this case study)?

1379. Case Study 2 (2010) is as follows:

1380. "A fire started on the balcony of a 12th floor flat of a 16-storey residential block of flats constructed in the 1960s. ... The fire spread from the balcony of origin to the 15th floor and the roof of the building. Several features of the building were attributed to the extent of fire spread including combustible insulating panels (which were clad onto the underside of all of the balconies), cladding panels (which had been installed onto the outer surface of the exterior wall and comprised a mineral fibre board face supported on timber batons, behind which there was a fibrous combustible insulation material) and plastic drain pipes (which were installed at each corner of the building and passed through the concrete floor slab on each floor). There was no evidence of any fire stopping, proprietary seal or sleeve where the pipe passed through the floor slab and which should have been provided to maintain the level of fire resistance afforded by the concrete floor slab."

1381. On this second case study, I can only echo many of the same comments I've made regarding Case Study 1.

1382. Again, was this external wall compliant with the existing guidance? Did the building perform in line with the underpinning acceptance criteria for external fire spread? Should consideration be given to any changes in the guidance? Did the performance of the external wall in fire have implications for other parts of the guidance or other functional requirements of the Building Regulations? What is the relevance of this fire as regards the implementation of testing to BS 8414-1? All of these centrally relevant questions go completely unanswered, and again I struggle to see the practical usefulness of this case study.

1383. I have reviewed a 16th July 2010 BRE "Fires of Special Interest (FOSI) Summary Report"[622] completed by David Crowder and Danny Hopkin, and I have been able to identify this fire as having occurred at Madingley Block, St Peters Street, Kingston-upon-Thames, London. I have also reviewed footage of this fire which is available via YouTube[623].

1384. I consider this fire to be of particular interest, admittedly with hindsight, because it shows lateral, preferential progression of fire *around the top* of a highrise residential building resulting from the presence of a combustible architectural crown. Madingley Block had this, at least, in common with Grenfell Tower. In this case the architectural crown was constructed using a particular glass reinforced polymer (GRP) product[624]; a configuration and product that appear to have been present only at that location on the building.

1385. This fire does not appear to have featured significantly in any of BRE's summary reporting to government via their Investigation of Real Fires reports, and the particularly unusual observation that the fire spread laterally around the architectural crown appears not to have attracted any serious attention.[625] I note that this issue is also not highlighted in the 2016 Case Study 2 summary provided above.

1386. Case Study 3 (2008) is as follows:

1387. "A fire occurred in a flat on the 11th floor of a 22-storey block of flats built during the 1960s and refurbished in 2006/7. This refurbishment included the fitting of a new cladding system to the exterior of the building which comprised an insulated render, the insulation for which was mineral wool and had been tested to and passed BS 8414-1. The fire developed to fully involve the flat of origin and broke out of the windows. The damage to the façade was localised to the immediate vicinity of some of the windows but beyond this the damage appeared to have been limited to surface charring and sooting."

1388. Again I would echo many of the same comments I've made regarding the previous two case studies.

1389. In this case, however, there does appear to be some link between the system on the building and the BS 8414-1 test. It is stated that the insulation within this rendered external wall overcladding system was "mineral wool and had been tested to BS 8414-1". However, the text is confusing and I am uncertain as to whether this means that precisely the same rendered overcladding system had been tested to BS 8414-1, or whether somehow different cladding systems incorporating mineral wool insulation had been tested to BS 8414-1. If this rendered overcladding system was indeed "non-combustible", as stated by BRE, then I struggle to understand why

[622] {HOM00014919}
[623] https://youtu.be/XAt6N2Cjq8I
[624] Recall that the key products at Knowsley Heights and Garnock Court were also GRP.
[625] {BRE00000945/72}

a BS 8414-1 test would have been needed in the first place; a fully non-combustible cladding system would meet the recommendations for the so-called “linear route” in Approved Document B, without any requirement for large-scale fire testing.

1390. The following sections of this paper contain a series of surprising statements. For instance, it is stated that:

1391. “… the Class B-s3,d2 or O [sic] recommendation … [is] intended to limit the rate of fire growth and fire spread and there is no evidence to date to suggest that these recommendations are inadequate.”

1392. I strongly disagree with this statement. By 2016, as outlined in detail within this report, there was abundant evidence to clearly demonstrate that Class 0 (and possibly also Class B-s3, d2) may be inadequate to mitigate external fire spread hazards arising, in particular, from rainscreen cladding products, and that Class 0 ought to be reconsidered.

1393. It is stated in the BRE paper that:

1394. “… high-rise flats are homes, and must provide light and ventilation. Flats must be provided with openable windows unless an (often expensive) alternative ventilation strategy can be provided … and, once open, such windows may offer a route for fire spread, in either direction in or out of the flat, irrespective of the other materials forming the exterior of the building. To prevent vertical spread of fire it would be necessary to ensure that all windows in such buildings were both fire resisting and sealed closed … but would almost certainly conflict with the needs of everyday life.”

1395. Whilst the above is true, it misses a point which I consider to be important, and it seems to (wrongly) imply that there is little point worrying about combustible materials in the external wall given that fire will spread via non-fire rated or open windows “anyway”.

1396. Whilst it is true that in practice it is not typically possible to prevent external vertical fire spread via windows, this is absolutely not, “irrespective of the other materials forming the exterior of the building”. The provisions of Approved Document B are underpinned (at least in principle) by an assumption that external fire spread will not occur “too quickly”.

1397. The presence of combustible materials and products within the external wall has the potential to increase the rate and extent of external vertical (or downward, or horizontal) fire spread, and hence the potential to fundamentally undermine assumptions underpinning various other aspects of the Building Regulations and Approved Documents (most notably, B1 and B5). I find this statement particularly surprising, given that Crowder had testified to this effect during the Lakanal House Coroner’s inquest (see Paragraph 1105).

1398. In concluding Paper 1, it is stated that:

1399. "With the exception of one or two unfortunate but rare cases, there is currently no evidence from these investigations to suggest that the current recommendations, to limit vertical fire spread up the exterior of high-rise buildings, are failing in their purpose."

1400. I am surprised that the "one or two unfortunate but rare cases" are neither named nor described, nor their specific significance stated. I am also surprised (based on the body of evidence that I have presented throughout this report) by the overall conclusion given above, and I do not understand how such a position could/can be taken. It is stated that:

1401. "A number of significant fires, such as those discussed previously, have demonstrated the potential risks."

1402. However the reader is given no help in understanding what these "potential risks" actually *are*; this section of the report is contradictory.

1403. Paper 1 ends with a statement that:

1404. "It was agreed with DCLG to carry out three experiments, to assess the performance of different external façades including non-fire rated double glazing, when exposed to a fire from below, representative of the external face of some buildings. This work did not test the performance of specific products/systems and was not a comprehensive research study but rather a scoping study and as such, the results need to be considered within this context. The findings of this new research will be published as Part 2 of this article."

1405. I struggle to comprehend various aspects of the above statement, and I am left with a number of unanswered questions. Why was this "agreed with DCLG"? What were DCLG or BRE hoping to learn or demonstrate in performing these experiments? What was being "assessed"? What exactly was being "scoped" in this study? What hypotheses were being tested?

15.4.2. External Fire Spread – Part 2 Experimental research

1406. The Part 2 paper[626] is introduced as discussing "an experimental scoping study focusing on the issue of external fire spread, maintaining some similarity to Ashton and Malhotra's work, carried out in 1960 but also calls upon BR 135 and BS 8414."

1407. It is not clear what is meant by "maintaining some similarity" or by "also calls upon" in the above statement. Nor is it clear what specific aspects of "the issue of external fire spread" were intended to be considered in this project. The paper's authors attempt to address their aim by stating that:

1408. "the aim of this research was to carry out three experiments to assess the performance of different external façades including non-fire rated double glazing, when exposed to a fire from below, representative of the external face

[626] {CLG00019444}

of some buildings to inform DCLG Building Regulations and Standards Division."

1409. In my opinion this is a tautological definition of an experimental aim. I refer to my unanswered questions in Paragraph 1409 above. What aspects of the performance of the different external facades were being assessed?

1410. The experimental rig, which involved the use of a modified BS 8414 testing rig within the burn hall at BRE's Watford campus, is described in broad terms, essentially describing tests that use the BS 8414 timber crib fire source and with dimensions very similar to those used in BS 8414 standard tests. One key difference in this test programme as compared with BS 8414 standard testing was the inclusion of "non-fire resisting double-glazing units" within the test rig. The three tests were differentiated from one another by the use of three different "spandrel panels" positioned within the test rig beneath the double-glazed windows; the three spandrel panel products used were:

1411. (1) Experiment 1 – "Fire resisting" panel consisting of a 9 mm thick cement fibreboard which was "sold for internal use". I consider it unlikely that this specific product would ever be used as external cladding on a building – this makes it hard to comprehend how this could be considered as "representative of the external face of some buildings". No ancillary tests appear to have been undertaken by BRE to quantify the thermal, physical, or reaction-to-fire properties of this product.

1412. (2) Experiment 2 – "Class 3" (plywood) spandrel panel consisting of a 9 mm thick sheet of structural hardwood plywood. BRE state that "It was anticipated that the reaction to fire performance would be Class 3 (National class), assuming a density greater than 400 kg/m^3". However, no ancillary tests appear to have been undertaken by BRE to quantify the thermal, physical, or reaction-to-fire properties of this product.

1413. (3) Experiment 3 – "Class B-s2,d0" (stone fibreboard) spandrel panel consisting of an 8 mm thick compressed stone-fibre panel with an "organic binging agent". Neither the specific product name, nor the type of binding agent are provided. It is stated that "this panel, as part of a specific system for external facades, demonstrates a reaction to fire performance of Class B-s2,d0, according to EN 13501-1:2007", however it is subsequently noted that "only the spandrel panel (a single component part of the system), and not the complete system was used". No ancillary tests appear to have been undertaken by BRE to quantify the thermal, physical, or reaction-to-fire properties of this product.

1414. Whilst it is stated that the intention of the experimental work was "to evaluate potential fire spread from one building storey to another", the rationale for the specific choices of glazing and spandrel panel products are not stated anywhere within the report/papers.

1415. The instrumentation used in these tests is described, but again the rationale for the specific choices made is not provided.

1416. Given my criticism of these reports, I do not feel there is much value in describing the test outcomes in detail. However, it is noteworthy that the three tests resulted in drastically different fire durations, burning rates, and imposed heat fluxes being generated by the notionally identical timber cribs used. This calls into question the repeatability of BS 8414 tests more generally, and I believe that this observation was worthy of interrogation and discussion.

1417. The intimation made regarding this issue in the BRE paper is that the differences in behaviour of the fire source were "possibly" due to the moisture content of the timber cribs, but that "the moisture content of the crib wood was not measured prior to the experiments which is a possible explanation for the differences in fire growth in the three experiments". No explanation is given, however, as to why there might be any suspicion or expectation that the cribs might have had differing moisture content. Nor does it appear that any theoretical calculations were undertaken to attempt to verify whether differences in the moisture content of the cribs, within a likely range of moisture values, could credibly alter the burning rates of the cribs so as to lead to the observed outcomes.

1418. These data appear to show that the BS 8414 fire source is actually surprisingly variable in broadly similar testing scenarios. I consider this a significant outcome as regards the reproducibility, and therefore credibility, of BS 8414 testing. I believe this would have been relevant information to highlight to those charged with drafting building regulations (which rely on BS 8414 testing in some circumstances).

1419. As a result of the above, I consider it difficult to draw any meaningful or useful conclusions from the tests presented in this paper, other than to demonstrate the self-evident fact that combustible spandrels are likely to result in windows above a fire being more rapidly compromised.

1420. It is worth nothing that the second paper concludes:

1421. "Overall, the findings from this research show that there is a clear and demonstrable need to ensure that buildings are designed and constructed so that the fire spread across the external surface and within the external façade is inhibited, as required by the Building Regulations. There is adequate guidance available in the public domain to allow this to be achieved."

1422. I do not agree that the findings from this research show this, and – based on the wealth of evidence presented in this report – I cannot understand how this statement could have been considered credible. It is my view, therefore, that the presented research failed to credibly assess the adequacy of the existing guidance, particularly given the data that was available within BRE but which has only more recently come to light outside of BRE and government (i.e., the data obtained during the CC1924 project).

1423. This work failed to highlight the specific external fire spread hazards that had been demonstrated by any of the previous major UK cladding fires (or international cladding fires), despite the fact that BRE had reported on all of these fires to government, and despite the fact that several of these fires had led to changes to the guidance given in Approved Document B.

1424. It failed to highlight the legitimate concerns raised during the 1999 Select Committee inquiry, despite the fact that BRE had provided evidence to that inquiry, and despite the fact that one apparent result of that inquiry had been the implementation of the parallel BS 8414 “route to compliance” within Approved Document B.

1425. It failed to provide clarity on the appropriate interpretation of Clause 12.7 of Approved Document B, despite the fact that individuals within BRE had been aware, at least as early as 2013, that additional clarity was needed in order to prevent application of hazardous (but Class 0/Class B-s3, d2) cladding (notably including ACM with a PE filler/core) on highrise residential buildings in England and Wales.

15.5. Missed Opportunity: Queries from SCOSS (2016)

1426. On 26th February 2016, about two months after a significant external cladding fire at The Address Downtown Dubai Hotel, Dubai that had occurred on 31st December 2015[627], I was forwarded an email chain between Alastair Soane[628] and Brian Martin regarding cladding fires. The chain was forwarded to me by a colleague at The University of Edinburgh, Professor Gordon Masterton[629].

1427. Masterton’s email to me[630] said simply: “Info. Any observations?”

1428. Contained within this thread was an email from Martin to Soane.[631] Soane stated that, given the major fire in Dubai, he had “made an enquiry of Brian Martin who is the CLG fire expert”. Martin’s 24th February response to Soane was as follows:

1429. “Hi Alastair.

1430. If people are getting things right then we shouldn't see a similar incident here.

1431. As I understand it, the problems in Dubai relate to panels of Aluminium Composite Material.

1432. Essentially thin layers of Aluminium sandwiching a polymer core. There are a number of products available, some with fire retardants in the core some without.

1433. ADB gives guidance on this by saying that the external walls should not provide a medium for fire spread in tall buildings.

1434. It then offers two approaches, a set of rules or a full scale test.

---

627 See e.g., https://www.bbc.co.uk/news/av/world-middle-east-35208484
628 Soane is the founder of the Standing Committee on Structural Safety (SCOSS) and remains a driving force behind its activities.
629 Masterton is a colleague at the University of Edinburgh and then Chair of SCOSS; of which I subsequently became – and continue to be – a member.
630 {LBY00000376}
631 {CUK00000013}

1435. In the rules, we deliberately added the word 'filler' to address things that form part of the cladding system that are not insulation but could provide a medium for fire spread.

1436. I think the core of an ACP panel could reasonably be considered to be a 'filler'. So, unless the core material meets the 'rules' then the AD suggests a full scale test."

1437. With hindsight, this email is striking in that it again confirms that government appears – in February 2016 – to have been fully aware of the hazards involved in using ACM PE cladding products, and also aware of that various types of filler/core materials were being used within the industry.

1438. Martin points to the deliberate addition of the word "filler" in Clause 12.7 of Approved Document B to address the use of ACM cladding products with combustible fillers/cores, and notes his view that "I think the core of an ACP panel could *reasonably be considered* to be a 'filler'" (emphasis added). In light of the 2014 discussions that occurred via the CWCT (discussed above in Section 15.3), I am surprised that more definitive language was not used to confirm that Approved Document B specifically recommended that the filler/core of an ACM should be a material of limited combustibility.

1439. In my response to Masterton, I made two specific comments on Martin's email to Soane:

1440. "1) that's a pretty big 'if' in the first sentence.

1441. 2) I think it's questionable as to whether a "full scale test", as currently implemented in the UK, is a realistic assessment method for in-service performance of non-compliant facade materials/systems. It's likely that the materials and systems have been carefully engineered specifically to pass the tests."[632]

1442. I am not aware (at the time of writing) if this email correspondence resulted in any attempts within government to clarify the applicability of the relevant clauses in Section 12 of Approved Document B.

1443. Whilst it was not necessarily my role to do so, and whilst I continued discussions on this issue with Masterton and Soane (within SCOSS) at the time, it is a matter of deep personal regret that I did not subsequently do more to highlight my discomfort regarding the anecdotal evidence of widespread use of ACM PE within the UK construction industry.

1444. With hindsight, I feel that I naïvely believed that any inappropriate use of ACM PE would be extremely limited, that such use would be immediately remedied if and when found, and that there was sufficient competence and diligence from individuals operating within the UK construction industry – and its regulatory processes – to prevent this from becoming a significant problem.

632 {LBY00000376}

1445. It is now abundantly clear that I was wrong to hold these beliefs.

1446. The Inquiry team have also made me aware of an unrelated email thread from the period between 20th January and 18th February 2016, between Nick Jenkins (of Booth Muirie – which was owned by Kingspan Group Limited, but now appears to have gone into liquidation), Sarah Colwell[633], and Brian Martin, in which Jenkins is seeking guidance "in relation to my understanding of the current UK regulations as they apply to wall constructions for buildings over 18m featuring rainscreen panels formed from ACMs".[634]

1447. Jenkins' initial 20th January 2016 email to Colwell is worth reproducing in full:

1448. "Hi Sarah,

1449. I hope this finds you well? We haven't met however I understand that you might be the best person to help me with some clarification I'm seeking in relation to my understanding of the current UK regulations as they apply to wall constructions for buildings over 18m featuring rainscreen panels formed from ACMs?

1450. Last week I attended a Siderise/BRE facades conference on the topic of fire safety. During the day I asked some questions of the panel relating to the permissible use of rainscreen cladding panels formed from various grades of ACM (aluminium composite materials) when used as part of multi layered wall systems for buildings over 18m. There was some ambiguity in the answers provided by the panel.

1451. I believe this ambiguity stems from some people making the assumption that in the absence of BS8414-2:2005 test evidence or a fire engineering analysis of walls featuring ACM rainscreen panels that compliance can be achieved for such wall systems by either:

1452. 1. Meeting the guidance given in paragraphs 12.6 to 12.9 of AD B2 by restricting insulation product, filler material (not including gaskets, sealants and similar) etc. used in the external wall construction to materials defined as being of limited combustibility as defined in Table A7, Appendix A of AD B2 or

1453. 2. providing cladding in accordance with Diagram 40 of AD B2. This stipulating that if a boundary exists less than 1000mm away and/or the building has a height of over 18m then a cladding material meeting Class O (national class) or B-s3, d2 or better European class is recommended.

1454. In my understanding compliance is not achieved via an if either 1 or 2 are satisfied scenario, rather only via an if 1 and 2 are both satisfied scenario? I think this is a logical, especially following the recent evidence of fire spread up the facade of a number of buildings in the Middle East with combustible

[633] Recall Colwell's central role in the DETR Contract No. CC1924 project more than 15 years earlier.
[634] {BLM00000041}

cladding panels. A simple read through the Approved Document however would not tell you this.

1455. If my understanding is correct and the scope of 12.7 extends to also include the external cladding and the 3mm thick core associated with 4mm ACM is to be considered a filler material then as far as I'm aware the only ACMs available to the UK market that meet the AD B2 definition of being materials of limited combustibility are Alpolic A2 and Alucobond A2. Both of these products are classified as A2-s1, d0 in accordance with BS EN 13501-1:2007.

1456. In our experience of supplying fabricated ACM rainscreen panels to specialist cladding contractors in the UK market we are rarely asked to provide such A2 rated ACM materials. The vast majority of ACM panels we are asked to provide for architectural application are either Alucobond plus, ALPOLIC/fr, or Larson fr products all of which are classified as B-s1, d0 in accordance with BS EN 13501-1:2007 and thus whilst they can be classified as products that are hard to burn are not accepted as being of limited combustibility in accordance with Table A7, Appendix A of AD B2.

1457. In many instances it is not even the B-s1, d0 rated ACM panels we are asked to supply but standard polyethylene core material ACM that burns quite efficiently. What's more I'm aware of many tall residential buildings recently constructed in the UK where such panels are installed in combination with various foil faced rigid foam thermal insulation boards which are also not accepted by as being of limited combustibility in accordance with Table A7, Appendix A of AD B2.

1458. As a responsible supplier Booth Muirie/Euroclad would like to put a guidance note out to the market written specifically on routes to compliance in relation to the use of ACM rainscreen cladding panels and associated thermal insulation products used as part of multi layered built-up wall systems. Before we publish any such guidance we are ensuring that we have our facts straight. With that in mind I would very much appreciated [sic] your thoughts on my understanding of the current regulations.

1459. I look forward to hearing back from you.

1460. Best regards,

1461. Nick Jenkins

1462. With hindsight, I consider this to be an extraordinarily clear and precise articulation – some 17 months before the Grenfell Tower fire – of the systemic misunderstandings and misapplications of Approved Document B that I consider to be at the core of the Grenfell Tower Inquiry; and about which government had been broadly aware of since at least 2013.

1463. The Inquiry have provided me with a video recording of the "Q & A Session" from the "Siderise/BRE facades conference" that Jenkins is referring to here.[635] This conference held just one week earlier, on 13th January 2016, and was sponsored by (amongst others) Siderise, BRE, the BCA, and Arup. The panel chair is Andrew Kay (Siderise), and the panelists are Steve Evans (NHBC, however representing the BCA), Stephen Howard (BRE Global), and Lars Anders (Priedmann).

1464. I would strongly suggest to the Chairman and the Panel that this (rather extraordinary) video should be considered as essential viewing.

1465. I will not rehearse the full contents of the video here; however I note that I consider Jenkins' later assessment that there was "some ambiguity in the answers provided by the panel" to be an extreme understatement. Jenkins' question to the panel had clearly outlined the three available grades of ACM panels then available for use within the UK market, their drastically different reaction-to-fire properties (with the PE filled/cored products noted as burning "very aggressively"), the fact that all such products were (in Jenkins' view) able to achieve Class 0, and the fact that there was (then) "a lot of ambiguity" in terms of what was acceptable as regards classification and requirements for non-combustibility.

1466. Jenkins suggests that "there is a real concern there, that actually, perhaps none of the materials supplied in the UK, with the exception of perhaps two projects to my knowledge, actually meet the requirements of the definition of limited combustibility". Jenkins also appears to indicate that he "could name tens of projects that have…" before being cut off by Evans; I assume that Jenkins' sentence would have ended with "… ACM PE cladding on them".

1467. The responses provided by the panel appear at times confused, incorrect, and deeply worrying. Evans appears to confirm that, as at 13th January 2016, both the NHBC/BCA and DCLG were well aware that "there could be instances… could be… where we have polyethylene filled panels on buildings over 18 metres" and that "this is something we have found as a building control industry".

1468. Apparently unsatisfied, Jenkins presses the Panel even further, asking: "so to be clear, if we have non-combustible insulation – a mineral wool insulation of one kind or another – in combination with an external cladding which has a Class 0 surface spread of fire [sic], that is acceptable under the current regs?"

1469. Evans responds, nodding, that "it would meet the *Building Regulations*" (emphasis added).

1470. Jenkins concludes by pointing out that "in that scenario, *you could have an exact repeat of the Dubai fire in any number of the buildings that we've supplied product to in London*" (emphasis added).

1471. Jenkins' questions in this context give a strong impression of an attempt at "whistleblowing" what he considered to be a significant problem for the UK cladding

[635] This video is {SIL00010066}, and appears to be professionally produced and formatted such that it may have been intended for use in Siderise's promotional activities. It is notable that this video does not currently appear to be publicly available, and I do not know if it was ever made public after the conference.

industry. With hindsight, I consider the extent to which his concerns were brushed aside by the panel to be deeply troubling.

1472. Colwell does not initially respond to Jenkins 20th January 2016 email, and on 1st February, Jenkins writes again – this time also invoking the opinions of Steve Evans (NHBC) and David Metcalfe (CWCT):

1473. "Hi Sarah,

1474. Regarding my email of 20th Jan I received an auto reply at that time from which I understand you returned to the office last Tuesday. Could you please acknowledge receipt of my query and advise when I could expect to receive a response from the BRE on the matter.

1475. I have received feedback from Steve Evans of the NHBC/BCA and also David Metcalfe of CWCT who have both confirmed that they think my interpretation of the Building Regs in relation to the use of combustible materials in high rise buildings is correct – i.e., to meet the requirements, paragraphs 12.6 - 12.9 and Diagram 40 need to be followed.

The question still remains however as to which materials/components have to meet the requirements of paragraph 12.7. Previously 12.7 was interpreted to mean simply the insulation had to be of limited combustibility (although this was not always adhered to). From recent meetings and discussions the general understanding is now that the scope of 12.7 extends to also include the external cladding. The BCA guidance agrees with this. David's thoughts are that this is logical, especially following the recent evidence of fire spread up the facade of a number of buildings in the Middle East with combustible cladding panels. A simple read through the Approved Document however would not tell you this.

1476. We awaiting [sic] feedback and confirmation from the BRE as this is a perquisite to us issuing/publishing any much needed guidance note to the industry.

1477. Kind regards,

1478. Nick Jenkins"

1479. As an aside, I am surprised that Steve Evans of NHBC would agree with Jenkins' email to Colwell, given that just 5 months later, in July 2016, the NHBC published their own guidance on *Acceptability of common wall constructions containing combustible materials in high rise buildings*.[636] This document effectively stated that wall and facade constructions using "Aluminium Composite Panels" would be acceptable to NHBC without the need to provide an "Option 3 assessment", providing that the aluminium composite panels were "minimum Class B (in accordance with BE EN 13501:1)" and "provide a Class 0 surface spread of flame".

636 {KIN00000516}

LBYP20000001_0242

1480. That document also contained "restrictions on use", which noted that:

1481. "the use of polythene or polythene [sic] / mineral cored aluminium composite panels which do not achieve a minimum Class B combustibility classification fall outside of the scope of this guidance note. Such products are unsuitable for use in high rise situations."

1482. Notwithstanding the fact that Class 0 is not a "surface spread of flame" classification, or the fact that Class B is not a "combustibility classification", the above NHBC acceptance contradicts the requirements set out in Jenkins' email to Colwell, but which Jenkins claims is endorsed by Evans. At the time of writing I am unaware of any test evidence that could have changed Evans' views on these matters between February and July 2016 (assuming that Jenkins' statements are true).

1483. After a further email from Jenkins on 9th February, Colwell responds that she "will follow try and look at it this week and comeback [sic] to you." However, on 12th February Colwell responds that "we have now had a chance to look at your email and I would suggest that you contact Brian Martin at DCLG … with regard to this request as they are the body with responsibility for this document and therefore any interpretations associated with it".

1484. On 16th February, Jenkins forwards his email to Martin, noting that "this matter is currently the topic of much discussion in the construction industry and if one thing is evident, that is there is much confusion and misunderstanding". Later that same day, Martin responds:

1485. "Hi Nick

1486. Its for the designer and the building control body to consider if Requirement B4 has been met.

1487. ADB give [sic] guidance on this by saying that the external walls should not provide a medium for fire spread in tall buildings.

1488. It then offers two approaches, a set of rules or a full scale test.

1489. In the rules, we deliberately added the word "filler" to address things that form part of the cladding system that are not insulation but could provide a medium for fire spread.

1490. I think the core of an ACP panel could reasonably be considered to be a "filler". So, unless the core material meets the "rules" then the AD suggests a full scale test.

1491. However, if the designer and building control body choose to do something else then that's up to them.

1492. I'm on the road at the moment so drafting this from memory.

Brian"

1493. I note the striking similarity between this email, and that sent to Soane on 24th February 2016 (see Section 15.5). Jenkins responds to Martin, again that same day:

1494. “Hi Brian,

1495. Many thanks for your prompt response. In light of the fires that have taken hold of a number of buildings clad in ACM panels in recent years I also think that the core of ACM panels should most definitely be considered as a "filler". Some ACM cores meet the rules of ADB however the ones commonly used in the UK at present don't.

1496. To the best of my knowledge there have been no full scale 8414 tests carried out to date of any wall constructions featuring any type of ACM panel. I am aware that 2 manufacturers of ACM have plans to have such tests carried out. This however unfortunately means that no existing buildings in the UK over 18m tall that feature ACM panels currently meet the B4 requirements. There are many such buildings and their numbers are growing.

1497. Whilst I appreciate it is for the designer and building control body to consider if requirement B4 has been met, I do think the current situation is of grave concern. Surely this justifies the requirement for a less ambiguous statement of the rules?

1498. With the above in mind do you think it would be worth setting up a meeting with the relevant bodies and experts represented to review the current presentation of the rules?

1499. Regards,

1500. Nick”

1501. Martin responds the following morning:

1502. “Thanks Nick

1503. I’m not sure the text is really all that ambiguous, given that it must cover <u>all</u> forms construction. People often argue that it isn’t clear when they are trying to justify doing something that is clearly wrong. I’m not entirely sure that even the ACM products that have “flame retardant” cores would meet the rules of thumb in the AD so it’ll be interesting to see if any of them get through an 8414 test.

1504. But that’s just my opinion. We’ve recently commissioned a survey of Part B users with a view to feeding into the next revision. In the first instance it might help if you put your views into that please.

1505. There is a meeting of the CWCT group to talk about cladding and fire safety, its run by Bath University, maybe you could ask them if you can get involved. Brenda Apted, details below [omitted], is organising things”.

1506. To which Jenkins then responds that evening:

1507. Hi Brian,

1508. Yes I think you are probably right in that people are claiming ambiguity to suit their needs. What I can't get my head around however is how buildings, that clearly include products that neither:

1509. 1. meet the rules as set in AD B2 out or

1510. 2. have been the subject of a full scale 8414 test,

1511. are achieving building regulation compliance completion certification?

1512. Is it that:

1513. a) the certification has been wrongly awarded? Thus pointing to a requirement for better informed/educated certifying officers or

1514. b) have they not achieved certification and are thus subject to indemnity policies to cover the risk?

1515. I have completed the survey and also spoken to David Metcalf of the CWCT re forward inclusion in the CWCT group to talk about cladding and fire safety. I've already been in discussion with David regarding this matter. I think that perhaps the most straight forward way to better communicate the rules in any amended document would be by the inclusion of some annotated illustrations of commonly used multi layered wall constructions.

1516. I do believe that ACM's classified as A2-s1, d0 in accordance with BS EN 13 meet the rules of thumb. In this regard I have a meeting tomorrow with ARUP to run through the validity of test methods and associated data that have led to their classification.

1517. I too will be very interested to see how the lower B-s1, d0 rated "flame retardant" cored ACM panels which represent the majority of the product we supply perform when it comes to the 8414 tests planned by their manufacturers. It would also be interesting to see by way of comparison how a construction featuring products that, according to the rules, negate the need for full scale 8414 testing would perform. Of course this would only happen as part of some noncommercial research as no manufacturer is going to fund such tests on products that the rules say don't require full scale testing.

1518. In the meantime we intend to construct a guidance note/statement of Booth Muirie's interim position which will err on the side of caution. It is our hope that in publishing this guidance note and diagrams, perhaps jointly with the BCA that we can educate and provide clarity of the rules as they specifically relate to the commonly used multi layered wall build-ups featuring ACM cladding panels.

1519. Your input and/or review of this document would be very welcome.

1520. Regards,

1521. Nick"

1522. The final email from Martin to Jenkins in this thread, on the morning of 18th February 2016, is as follows:

1523. "That sounds like a good plan to me. I'd be happy to help where I can.

You are right, of course, constructions complying with the rules of thumb may well fail an 8414 test. In an ideal world we'd make the test mandatory but that would be too costly to justify.

Please keep me posted.

Brian"

1524. I note – without criticism – the remark regarding the explicit compromise between safety and cost in the above email.

1525. Within this email thread, Jenkins is clearly expressing "grave concern" that:

1526. (1) there is widespread confusion in the industry as regards the applicability of Clause 12.7 of Approved Document B to ACM cladding products;

1527. (2) that in his considerable experience in the cladding industry he is rarely asked to provide A2 rated ACM cladding products;

1528. (3) that the vast majority of panels that Booth Muirie install are "FR products" but would not meet the recommendations of Clause 12.7 for limited combustibility of the filler/core material;

1529. (4) in "many instances" Booth Muirie are asked to supply ACM PE cladding products, and additionally this is in combination with combustible insulation that also fails to meet the recommendations of Clause 12.7;

1530. (5) that in the cases noted in (4), Jenkins is not aware that these designs are generally underpinned by any robust testing evidence (e.g. BS 8414 tests); and

1531. (6) that there are many such buildings, and their numbers are growing.

1532. With these warnings in mind, I have trouble understanding Martin's response to the Standing Committee on Structural Safety, just one week later, on 24th February, when he states – responding to questions from Soane about the possibility that a highrise cladding fire involving the use of combustible ACM cladding, similar to that which occurred at The Address Downtown Dubai on 31st December 2015, could occur in the UK – that "If people are getting things right then we shouldn't see a similar incident here".

1533. Jenkins (at least) had made it clear, just *one week* earlier, and 17 months before the Grenfell Tower fire, that people in Britain were not "getting it right" with respect to precisely this issue.

15.6. Missed Opportunity: Fire at Shepherd's Court (2016)

1534. On 19th August 2016 a fire broke out in the kitchen of a flat on the 7th floor of Shepherds Court, a 20-storey block of flats in Shepherds Bush Green, London, and spread up the exterior of the building to the 11th floor via open windows and its cladding.

1535. Figure 30 shows a photo of the aftermath of this fire. The similarities between the fire damage experienced at Shepherds Court with that experienced in 1999 at Garnock Court are striking (compare with Figure 15), with fire spreading externally vertically along a vertical line of windows, and involving additional flats as it progressed vertically up the building.

Figure 30 Aftermath of the 2016 fire at Shepherd's Court.[637]

1536. The rate of external fire spread at Shepherds Court, however, appears to have been significantly less rapid than at Garnock Court; at Shepherds Court the fire progressed up the building over four floors during the course of about 45 minutes,[638] whereas at Garnock Court the fire spread vertically over eight floors in about 15 minutes (see Paragraph 634). As at Garnock Court, the problematic cladding appeared to be associated with the "spandrel zone" immediately below the kitchen windows of each flat; however, at Shepherds Court these spandrel panels

[637] LFB Fire Investigation Report: Shepherd's Court fire on 19 August 2016 ('redacted') {LFB00000089}
[638] {LFB00000089}

were mounted within full storey-height window frame assemblies, as had been the case at Lakanal House (see Paragraph 1020).

15.6.1. The LFB Investigation

1537. The London Fire Brigade (LFB) conducted an extensive investigation of this fire[639], and – to their credit – appear to have immediately recognised the significance of the "spandrel" cladding panels as regards the observed external fire spread. Following the incident, the LFB commissioned informative *ad hoc* (and non-standard) fire testing by Bureau Veritas[640] on an unaffected facade panel that had been removed from the building. The aim of this testing was "to provide further information with regards to the behaviour of the facade panels in a fire".

1538. The Bureau Veritas testing report states that the panels consisted of (from back to front) a 10 mm thick backing plywood layer to which was bonded a blue unhalogenated[641] polystyrene foam insulation product. The front [i.e. outward facing] surface of the complete panel was a metal sheet approximately 1mm in thickness; presumed to be steel. The total thickness of these composite cladding panels was approximately 31 mm, and the edges of the complete panel had been enclosed by a thin metal foil.

1539. A series of ad hoc flame exposure tests were performed by Bureau Veritas, which confirmed that the blue foam insulation material was combustible and its propensity for melting, and forming burning droplets.

1540. Bureau Veritas clearly articulated the outcomes of their testing as follows:

1541. > "The flame tests showed that small ignition sources, acting in a localised fashion, would not significantly threaten the integrity of the panel, and would be unlikely to ignite a panel. However, as a fire develops and grows further, it is possible that a wide flame front could end up acting on the steel sheet of the panel. The heat from the flames would be conducted through the steel sheet and would therefore melt away the blue foam layer underneath. This would occur in a progressive fashion as the fire develops and would ultimately lead to the steel sheet not being held in place by sufficient bonded blue foam. The weight of the steel sheet would then ensure that it would become detached from the remainder of the panel (likely fall away) and expose the heat damaged blue foam and plywood layers to the developed flame front. This situation is likely to have occurred to the panels above the flat of fire origin when the living room windows of the flat of fire origin failed during the fire at this scene."

1542. Based on the outcomes of the Bureau Veritas testing, the LFB developed a "Post Fire Report"[642] in which they outlined their views on the compliance of the cladding

---

[639] Bureau Veritas Report: Examination of Cladding Panels – Flat 28 Shepherds Court, 21 Shepherd's Bush Green, W12 {LFB00000087}, {LFB00000089}, Summary of Findings from the fire investigation at Shepherd's Court {LFB00003517}, Post-Fire Report: Shepherd's Court Fire {LFB00024243}
[640] {LFB00000089}
[641] Meaning that this particular polystyrene did not incorporate halogens, which are often used as fire retardants in such foams.
[642] {LFB00024243}

products used at Shepherds Court, and the implications of this fire for Building Regulations and associated guidance.

1543. Shepherds Court had been originally constructed around 1970,[643] however the windows and spandrel panels had been refurbished in 2006[644] – notably, at about the same time as Lakanal House. The LFB note that in this case the applicable version of Approved Document B would have been the 2002 version, providing guidance to the Building Regulations 2000.

1544. In their report, the LFB note that the Building Regulations 2000 required that:

1545. "the external walls of the building shall adequately resist the spread of fire over the walls and from one building to another, having regard to the height use and position of the building".

1546. This requirement raises the obvious (and subjective) question of how much resistance to the spread of flame is considered "adequate". The LFB therefore also note that Approved Document B 2002 (Clause 13.7) stated that:

1547. "the external envelope of a building should not provide a medium for fire spread if it is likely to be a risk to health or safety" and that "the use of combustible materials for cladding framework, or of combustible thermal insulation as an overcladding or in ventilated cavities, may present such a risk in tall buildings, even though the provisions for external surfaces in Diagram 40 may have been satisfied.

1548. In a building with a storey 18 m of more above ground, insulation material used in ventilated cavities in the external wall construction should be of limited combustibility.

1549. Advice on the use of thermal insulation material is given in the BRE Report Fire performance of external thermal insulation for walls of multi-storey buildings (BR 135, 1988)."

1550. Unfortunately, the LFB did not perform any National or European reaction-to-fire classification tests on the Shepherds Court window panels, and so it is not possible to state whether the panels were able to achieve Class 0 /Class B-s3, d2, in accordance with Diagram 40 of Approved Document B.

1551. Additionally, whilst the testing performed by Bureau Veritas demonstrated that the panels could not have been considered to be materials (products) of limited combustibility / European Class A2 or better, strictly speaking, in 2002 there was no recommendation for it to be so, given that the polystyrene insulation in the panels was not used as an "overcladding", nor was it used in a "ventilated cavity".

1552. Assuming that it may have been possible for the panels to achieve Class 0, to claim that this product was *not* used in accordance with the functional requirements of the Building Regulations, the LFB were forced to fall back on the more general

[643] {BRE00000959}
[644] {LFB00024243}

guidance that "the external envelope of a building should not provide a medium for fire spread if it is likely to be a risk to health or safety".

1553. The above requires a subjective evaluation, and is not helped by the text of the Approved Document in Paragraph 1547 above, because it can easily be argued that *any* fire spread is *by definition* a risk to health and safety (however remote that risk might be). Applying this part of Clause 13.7 in absolute terms would therefore recommend the *exclusive* use of non-combustible cladding materials – and this is clearly not the intent of Clause 13.7 as written.

1554. Based on the above logic, I believe it would be relatively straightforward to claim that the Shepherds Court cladding panels – assuming they could achieve Class 0 / Class B-s3, d2 – complied with the recommendations of Approved Document B (2002). However, as already discussed (in Paragraph 405), compliance with Approved Document B is *not* deemed-to-satisfy the requirements of the Building Regulations; it instead "tends to negative liability".

1555. So in this case one must revert to the Building Regulations 2000, and ask, "did the external walls of the building adequately resist the spread of fire?"

1556. This is a crucial question, and in my opinion this question sits at the very heart of the Grenfell Tower Inquiry, alongside the following:

1557. How much "resistance to the spread of fire" is considered to be adequate? What would inadequacy in this regard look like[645]?

1558. If a product complies (or is seen or claimed – rightly or wrongly – to comply) with Approved Document B, but nonetheless "contributes to external fire spread", as all materials and products with *any* organic content that could be exposed to heating above their pyrolysis temperature will do, where must a designer draw the line between adequate and inadequate?

1559. And most importantly, *who* should be required to *know* how to draw that line[646], *who* should be empowered to assess and/or approve where that line is drawn[647], and what regulatory mechanisms exist[648] to ensure that those drawing, assessing, and approving such lines are *competent* to do so?

1560. The LFB appear to recognise the uncertain and subjective nature of the above questions, yet conclude with a surprisingly weak statement:

1561. "In accordance with the applicable guidance at the time of the refurbishment and based on the evidence currently provided to us, the material included in the facade panels may have provided a medium for the fire to spread along

[645] As discussed earlier in this report (Paragraph 1044), it would appear – with reference to the BR 135 criteria for classification of BS 8414 tests – that the answer to this question may be that any fire which does not spread to the floor above in less than about 15 minutes, or the floor above that within about 30 minutes, is considered to represent "adequate" external fire spread performance.
[646] The designer, who should be a member of a formally regulated professional group, and should be legally required to take on the liability associated with the design decisions that they take.
[647] A rigorously regulated, competent, independent, and empowered building control authority.
[648] Effectively none, at present.

the external envelope of the building. It therefore may not meet the recommendation of the applicable guidance and consequently the applicable legislation… it is highly likely that the facade panels do not meet applicable legislation at the time of the refurbishment".

15.6.2. The BRE Investigation

1562. BRE also investigated the Shepherds Court fire,[649] albeit only via a "desk based investigation based on media reports and reports published on the LFB's website". This was done as part of BRE's ongoing *Investigation of Real Fires Project* for the period April 2016 – March 2017, under contract for Brian Martin at the Department for Communities of Local Government.

1563. The BRE investigation report notes that the fire "spread vertically up the external façade of the building" and that it "affected five floors". The report notes that "it is clear from the footage that part of the building's façade contributed to the external fire spread", and that "it was possible to see burning debris falling from the building as the fire spread up the façade".

1564. Surprisingly given the above, the BRE report fails to provide any useful information on the composition of the window panels.

1565. In commenting specifically on "external fire spread" considerations associated with this fire, the BRE report notes the building had undergone refurbishment, but fails to provide any of the relevant dates or constructional details; stating only that if the window panels had been installed after 1985 then they would have been applicable to any one of a number of versions of Approved Document B. On this basis, BRE note that the window panels would therefore likely have been recommended to be Class 0 at the time of refurbishment.

1566. BRE go on to state that:

1567. "As this fire involved the external façade from Floor 7 to Floor 11, the surfaces of the window panels should have been Class 0 (or European equivalent). Video footage of the incident suggests to BRE investigators that this may not be the case".

1568. I do not understand the logic of this statement, particularly given the information contained within the reports of the LFB investigation discussed in the previous section. By 2016 there was no reason to believe that a Class 0 product would not contribute to external fire spread; indeed, quite the opposite based on the information presented within this report, virtually all of which was available to the BRE fire investigation team.

1569. The BRE report concludes by pointing briefly at Lakanal House as a "known related incident", stating that, in that case "the fire spread from the flat of origin vertically up the external façade of the building and material also dropped down causing fires on lower floors". However the striking similarities between Shepherds Court and

[649] {BRE00000959/157}

LBYP20000001_0251

Lakanal House, both of which were refurbished in 2006, or indeed with Garnock Court almost two decades earlier, are not discussed.

1570. Each and every "final report" for each of BRE's "Investigation of Real Fires" projects[650] for Government between 2001 and 2015 had (incorrectly in my view) contained the following summary text, verbatim:

1571. "The findings from this project have reaffirmed the overall effectiveness of the Building Regulations and AD B in providing for the safety of life in the event of fire and most of the significant issues that have been identified during this project fall outside the scope of these regulations".

1572. However, the 2016[651] report – which is an "End of Year Report", rather than a "Final Report" [652] – concludes less definitively:

1573. "Overall, the findings from this period have reaffirmed the overall effectiveness of the Building Regulations and AD B in providing for the safety of life in the event of fire. All of the significant issues that have been identified during this study relate to innovative construction products and techniques which have not yet been considered in relation to the regulations of AD B."

1574. It is not at all clear precisely what "innovative construction products and techniques" are being referred to in this comment, nor why they "have not yet been considered in relation to the regulations of AD B". I consider this to be a surprising statement, given the fundamental objectives of the *Investigation of Real Fires* projects.

[650] 2001-2004 {HOM00046460}, 2004-2006 {BRE00000936}, 2007-2009 {CLG00019142}, 2010-2012 {HOM00001090}, 2012-2015 {HOM00001635}.
[651] {BRE00000959}
[652] I have not been provided with any "Final Reports" for the period beyond 2015. I do not know if these reports exist.

16. Summary

1575. What emerges from this overview of the development of England's building regulatory environment, and the major cladding fires that have occurred during the same period, is a picture of increasing freedom for industry and increased regulatory complexity. This is coupled with a profound lack of competence of actors involved at all stages from regulation to design to construction to investigation, and apparent complacency/inaction from Government.

1576. This system, on the eve of the Grenfell Tower fire, does not appear to have been the product of a single organising mind, but rather the net result of many individual decisions taken within, and constrained by, a wider context and competing priorities. Over this period, there were many opportunities where the guidance and tests *could* have been made simpler or less permissive; however, in each case there appear to have been powerful commercial and ideological incentives to increase complexity whilst also increasing flexibility.

1577. What appears not to have been a focus, however, was ensuring that the requisite concurrent increases in practitioner competence were also realised, monitored, or assured.

1578. During the investigations that followed the Knowsley Heights fire (1991), the emphasis appears to have been on how to *enable* the use of combustible materials and products – rather than on restricting their use in light of what had occurred. In the early 1990s, needing to show its value to government and with the threat of privatisation hanging over it, I believe that BRE had a significant organisational incentive to enable overcladding solutions whilst being seen to mitigate their fire risks – rather than to prohibit their use. This led eventually to the BS 8414 test methods and BR 135 classification document, along with the revenue streams associated with performing BS 8414 tests and assessing cladding systems' abilities to meet the requirements of BR 135 (either by test or by desktop study).

1579. Following the Knowsley Heights fire, the National reaction-to-fire classification system leading to the Class 0 material and product classification, which had been developed based on a reference scenario linked to growth of a fire within a compartment, rather than on the outside of a building, remained unchanged.

1580. Rather than addressing the fundamental hazards presented by the combustible (but Class 0) rainscreen cladding at Knowsley Heights, focus was instead placed on recommendations for cavity barriers. This focus enabled the continued use of combustible rainscreen cladding.

1581. After Garnock Court (1999), when the Select Committee inquiry had recommended the *replacement* of small scale tests with a large scale test, government opted instead to modify the rules on insulation, but to also offer large scale testing (via BS 8414 and BR 135) as an *alternative*, effectively to enable continued (indeed increased) use of combustible insulation in external walls at height.

1582. Thus, the status quo remained largely unaffected – albeit with (in principle) a new regulatory hurdle in place for some materials and products that partially addressed parliament's recommendations. However, this also created a new "route to compliance" that – with hindsight – was plagued with pitfalls and the potential for gaming, misunderstanding, misuse, and misapplication.

1583. Again, the national reaction-to-fire classification system remained unchanged, despite additional compelling evidence – not least from the 1999 Select Committee inquiry evidence and hearings – that application of Class 0 to address hazards associated with external fire spread, even where Class 0 was competently understood and applied, ought to be reconsidered.

1584. When the harmonised European reaction-to-fire testing standards and classification system – which was also developed based on a reference scenario linked to the growth of fire within a compartment, rather than on the outside of a building – were introduced in 2002, government again opted to retain the *status quo* rather than revisiting (or shelving) the standards of performance that they had until then (apparently) considered appropriate for cladding and the external wall. Indeed, the new European system was imprecisely benchmarked against the existing National classification system, enabling the use in England of certain composite products that would not be considered permissible under the European system.

1585. In the context of meeting its European obligations whilst not disrupting the *status quo* by placing new constraints on English industry, for government this decision was a technical solution to a political problem.

1586. Again the National reaction-to-fire classification system remained unchanged, despite additional, compelling evidence – from Connolly's post-Knowsley research (1994) at BRE, from WarringtonFire's RADAR 2 reports (2000), and most strikingly from BRE's research performed under Contract No. CC1924, which had been commissioned by government specifically to address these issues (2000-2002) – that application of Class 0 to address hazards associated with external fire spread, even where competently understood and applied, ought to be reconsidered and most likely revoked for a range of composite cladding products.

1587. Throughout the entire period of the existence of Class 0 (and indeed up until the Grenfell Tower fire), there appears to have been considerable confusion within the construction industry, government, and other relevant stakeholders including testing houses and regulatory authorities as to the true meaning of Class 0. The fact that whilst a non-combustible material or product was – by definition – Class 0, the converse was not necessarily true, appears not to have been widely understood.

1588. The widespread confounding of "Class 0" with "non-combustible" appears to have been a serious problem since at least 1991, and openly discussed with government since at least 1999.

1589. After The Edge fire (2005), the wording of the relevant clauses in Approved Document B was "clarified" – without fanfare – via the now infamous "Clause 12.7" (or its textually identical predecessors). This was evidently done so as to address specific fire hazards associated with composite metal-faced cladding panels used in external cladding applications. In principle, if this clarification had been clearly articulated and widely discussed within the industry, it had the potential to address many of the hazards associated with the use of combustible Class 0 cladding materials and products.

1590. However, in practice, the effect of these "clarifications" was – unfortunately – to create ambiguity and to generate considerable confusion around the applicability of the relevant clauses in Approved Document B to cladding components other than "Insulation Materials/Products". Government and BRE were both aware of this confusion, around application of Clause 12.7 and the "filler material" terminology, at least as early as 2013. However, despite multiple communications to highlight the relevant concerns between 2013 and 2017, it appears that little or no action was taken by either government or BRE to seek to highlight or mitigate this confusion or the resulting significant hazards; hazards that are of central relevance to the Grenfell Tower fire.

1591. After Lakanal House (2009), despite considerable confusion being apparent, both from fire safety "experts" and from construction industry practitioners, regarding reaction-to-fire classification systems, regulatory requirements for cladding and external walls, and application of the relevant clauses within Approved Document B, government opted to make no changes or clarifications to the guidance; the national reaction-to-fire classification system again remained unchanged.

1592. Between 2009 and 2016 numerous warnings or missed opportunities occurred that could have resulted in regulatory changes that might have prevented the Grenfell Tower fire. Fires that occurred at (at least) Sudbury House (2010), Taplow House (2012), and Shepherd's Court (2016) *could* have further highlighted the need for reconsideration of the external fire spread guidance within Approved Document B. The fact that the construction industry was in fact not "getting it right", and that the regulatory system was unable to prevent inadequately safe cladding designs from being designed, approved, or constructed *could* have been addressed. Research reports by BRE in 2010 and 2016, and a number of email queries to government, *could* have instigated a fundamental reconsideration of the guidance.

1593. The evidence heard by the Inquiry to date – during Module 2 in particular – has also shown that misapplication and "gaming" of regulatory compliance tests was occurring at least as early as 2005, and that the quality and credibility of reaction-to-fire and cladding compliance testing appears to have continued to deteriorate in the years leading up to 2017. For instance, evidence of misapplication and gaming of testing to (at least) BS 476 Part 6, EN 13823, and BS 8414 has been presented. Products and systems were being developed and designed in order to pass compliance tests, rather than to necessarily perform in service.

1594. During the period 1984 through to 2017, the independence and rigor of building control activities was continuously eroded due to changes resulting from the introduction of privatised building control via approved inspectors. A culture shift in building control had gradually occurred, from one of building control actors "policing" developers to one of them "working with clients" under commercial duress. This resulted in a "race to the bottom" in the resulting practices within the construction industry.

1595. Heseltine's 1979 desire "to see a system of [building] control which embodies the principle that anyone who carries out work, or causes it to be carried out or authorises it, should be responsible for the outcome"[653] appears not to have been realised across the construction industry during the subsequent four decades, with disastrous effect.

1596. In an effort to increase the "freedom" of industry, the regulatory system became more permissive. While many were apparently keen to embrace that freedom, others (mis)interpreted the Approved Documents as being deemed-to-satisfy. No regulatory mechanism was put in place to ensure that those dispensing fire safety advice had the requisite *competencies*.

1597. During essentially all of this period, apparently in an attempt avoid disrupting the *status quo* or generate additional burdens on industry, legacy standards were routinely retained within the guidance – thereby adding multiple routes to compliance and generating confusion (or enabling those who sought to capitalise on confusion). These multiple routes to compliance, when combined with widespread incompetence, inadequate oversight, and a perceived absence of liability, made misinterpretation, misapplication, and "gaming" easier, more attractive, and therefore more likely.

1598. Finally, and fundamentally, this analysis shows that while the guidance in Approved Document B could have been clearer and/or more restrictive, it was the structure and overarching philosophy of the wider regulatory framework that created and perpetuated – and indeed encouraged – the conditions in which the (ambiguous) guidance could be misinterpreted, misapplied, and/or exploited in the service of generating profit whilst avoiding (thus far) liability for inadequate design decision-making.

[653] "The Future of Building Control, Speech by the Secretary of State for the Environment, 10 December 1979, to the National House-Building Council." 1979.

17. References for Part II

Ardill, J. 1987. Cladding Plan to Rescue Icy Tower Blocks. *The Guardian*, May 6, 1987.

Babrauskas, V. 2017. Engineering Variables to Replace the Concept of 'Noncombustibility'. *Fire Technology*, 53: 353-373.

Balfour, A. 1936. *Report of the Departmental Committee on Fire Brigade Services*. London.

Billington, M.J. 1986. Building Control — An Update. *Property Management*, 4(2): 116-19. https://doi.org/10.1108/eb006616.

Briggs, P. 2002. The Impact of Changes to Approved Document B to Accommodate the New Euroclass Reaction to Fire Classification Systems. *The Architects' Journal*, 215(20): 13.

Brookes, A. and Stacey, M. 1988. Overcladding an Uncertain Panacea. *The Architects' Journal*, 187(4): 67.

BSI, 2002a. *Fire classification of construction products and building elements - Classification using test data from reaction to fire tests*, BS EN 13501-1:2002.

BSI 2002b. *Fire performance of external cladding systems - Test methods for non-loadbearing external cladding systems applied to the face of a building*, BS 8414-1:2002.

BSI, 2002c. *Reaction to fire tests for building products. Building products excluding floorings exposed to the thermal attack by a single burning item*, BS EN 13823:2002.

BSI 1987a. *Fire tests on building materials and structures. Method for determination of the fire resistance of elements of construction (general principles)*, BS 476: Part 20: 1987.

BSI 1987b. *Fire tests on building materials and structures. Methods for determination of the fire resistance of loadbearing elements of construction*, BS 476: Part 21: 1987.

BSI 1987c. *Fire tests on building materials and structures. Methods for determination of the fire resistance of non-loadbearing elements of construction*, BS 476: Part 22: 1987.

BSI 1987d. *Fire tests on building materials and structures. Methods for determination of the contribution of components to the fire resistance of a structure*, BS 476: Part 23: 1987.

BSI 1987e. *Method for determination of the fire resistance of ventilation ducts*, BS 476: Part 24: 1987.

BSI 1982. *Fire tests on building materials and structures - Method for assessing the heat emission from building materials*, BS 476: Part 11: 1982.

BSI 1972. *Fire tests on building materials and structures. Test methods and criteria for the fire resistance of elements of building construction*, B.S. 476: Part 8: 1972.

BSI 1970. *Fire tests on building materials and structures. Non-combustibility test for materials*, BS 476: Part 4: 1970.

BSI 1968. *Fire Tests on Building Materials and Structures, Part 6. Fire Propagation Test for Materials*, BS 476: Part 6: 1968.

BSI 1953. *British Standard Specification, Fire Tests on Building Materials and Structures*, BS 476: Part 1: 1953.

BSI 1945. *Amendment No. 2 : July, 1945 to BS 476: 1932*, Addendum, Surface Spread of Flame, PD 374, 1945.

BSI 1932. *Fire-Resistance, Incombustibility and Non-Inflammability of Building Materials and Structures (Including Methods of Test)*, BS 476:1932.

Castleman, H.G. 1938. The Development of Construction under the London Building Acts. *The Structural Engineer* ,16(3): 111-22.

Cecil, R. 1994. Will they never give up. *The Architects' Journal*, Jan 19; 199, 3; p. 19.

Colwell, S. and Baker, T. 2013. *Fire performance of external thermal insulation for walls of multistorey buildings*, BR 135 3/e.

Colwell, S. and Martin, B. 2003. *Fire performance of external thermal insulation for walls of multi-storey buildings*, BR 135, 2/e.

Connaughton, J. and Mbugua, L. 2003. Faster Building for Industry: NEDO (1983). *Construction Reports 1944-98*. Wiley Online Books. https://doi.org/https://doi.org/10.1002/9780470758526.ch9.

Courtney, R. 1997. Building Research Establishment Past, Present and Future. *Building Research & Information*, 25(5): 285-91. https://doi.org/10.1080/096132197370264.

Cowan, R. 1987. High-Rise Comes in from the Cold. *The Architects' Journal*, 185(19): 14.

Davies, C. 1983. Lines on Rules. *The Architects' Journal*, 178(43): 45.

Dennis, R. 2008. 'Babylonian Flats' in Victorian and Edwardian London. *The London Journal*, 33(3): 233-47. https://doi.org/10.1179/174963208X347709.

Dickinson, M., Ham, S., Burberry, P. and Penton, J. 1992. Building Regs Revised Documents Approved. *The Architects' Journal*, 195(4): 38-41.

Drysdale, D. 2011. *An Introduction to Fire Dynamics*. 2/e. Wiley.

Drysdale, D. 1988. *An Introduction to Fire Dynamics*. 1/e. Wiley

Duell, J. 1986. Publications Review: New Form of Agrément Certificate. *The Architects' Journal*, 183(16): 89.

Dunleavy, P. 1981. *The politics of mass housing in Britain, 1945-1975 A study of Corporate Power and Professional Influence in the Welfare State*. Clarendon Press.

Elder, A.J. 1972. Reviews Seventh Change to Regs. *The Architects' Journal*, 155(2): 69.

Fleischmann, C.M., Pagni, P.J. and Williamson, R.B. 1994. Quantitative Backdraft Experiments. *Fire Safety Science 4*: 337-348. doi:10.3801/IAFSS.FSS.4-337

Guest, C.W.G. 1957. *Report of the Committee on Building Legislation in Scotland*. Edinburgh.

Guillaume, E., Fateh, T., Schillinger, R., Chiva, R. and Ukleja, S. 2018. Study of fire behaviour of facade mock-ups equipped with aluminium composite material-based claddings, using intermediate-scale test method. *Fire and Materials*, 42: 561–577.

Hackitt, J. 2018. *Building a Safer Future - Independent Review of Building Regulations and Fire Safety: Final Report*.

Hamilton, S.B. 1958. A Short History of the Structural Fire Protection of Buildings Particularly in England. *National Buildings Studies, Special Report No. 27*, London.

Harrison, H.W., Hunt, J.H. and Thomson, J. 1986. *Overcladding External Walls of Large Panel System Dwellings*. BRE Press, Garston.

Herpol G.A. 1972. Noncombustibility—its definition, measurement, and applications. In *Ignition, heat release, and noncombustibility of materials (ASTM STP 502)*, American Society for Testing and Materials, Philadelphia, pp. 99-111.

Hird, D. and Fischl, C.F. 1954. *National Building Studies Special Report 22, Fire Hazard of Internal Linings*.

Hird, D. and Karas, G.C. 1955. A method for classing the fire hazard of internal linings and their treatments. *Fire Research Note No. 166.*

Holroyd, R. 1970. *Report of the Departmental Committee on the Fire Service Cmnd. 4371*. London.

Hutton, G.H. 1966. RSH Building Regulations Under Fire. *The Architects' Journal*, 144(17): 1013.

ISO 1993. *Fire tests — Full-scale room test for surface products*, ISO 9705:1993.

ISO 1990. *Fire tests — Building materials — Non-combustibility test*, ISO 1182:1990.

ISO 1975. *Reaction to Fire Tests for Products – Non-Combustibility Test*, ISO 1182: 1975.

ISO 1973. *Building materials — Determination of calorific potential*, ISO 1716:1973.

ISO 1970. *Noncombustibility Test for Building Materials*, ISO Recommendation R 118:1970.

JFRO 1947. *Fire Research 1947 – Report of the Fire Research Board with the Report of the Director of Fire Research for the Year 1947*. Department of Scientific and Industrial Research and Fire Offices' Committee.

Joseph, D. 1920. Higher Buildings for London. *Journal of the Royal Institute of British Architects*, 27(May): 301-308.

Langdon-Thomas, G.J. and Law, M. 1966. *Fire Note 8: Fire and the External Wall.* Ministry of Technology and Fire Office's Committee Joint Fire Research Organisation, London.

Laurence, P.M. 1923. *Report of the Royal Commission on Fire Brigades and Fire Prevention*. London.

Law, A. and Bisby, L. 2020. The Rise and Rise of Fire Resistance. *Fire Safety Journal*, 116: 103188.

Law, A. and Kanellopoulos, G. 2020. The Rise and Fall of the UK's Spandrel Panel. *Fire Safety Journal* 115: 103170.

Law, M. 1963. *Heat Radiation from Fires and Building Separation*. Fire Research Technical Paper No. 5, HM Stationary Office, London.

Malhotra, H.L. 1986. *Fire Safety in Buildings*. BRE Press, Borehamwood, p. 12.

Matheou, . 1996. Fence in a Cut-Throat World. *The Architects' Journal*, 203: 18.

Messerschmidt, B. 2008. The Capabilities and Limitations of the Single Burning Item (SBI) Test." In *Fire & Building Safety in the Single European Market*, Edinburgh, 70-81.

Mierlo, R. and Sette, B. 2005. The Single Burning Item (SBI) Test Method - A Decade of Development and Plans for the Near Future. *Heron* 50 (January).

Minogue, J. 1967. Call for a Plain Guide to the Law on Building. *The Guardian*, March 1, 1967.

Mitchell, T. 1977. Government Pressed on National District Surveyor System. *Building Design*, No. 364: 9.

Morgan, P. 1991. How Building Materials Behave in Real Fires. *Fire Safety Systems in Buildings – A One Day Symposium*, Hong Kong Polytechnic, September.

Prince, R.E. 1915. Tests on the Inflammability of Untreated Wood and of Wood Treated with Fire-Retarding Compounds. In *National Fire Protection Association Proceedings of Nineteenth Annual Meeting*, 108-114.

Read, R.H.H. 1994. *A Short History of the Fire Research Station, Borehamwood*. BRE Press, Garston.

Rogowski, B.F.W. 1970. *The Fire Propagation Test: Its Development and Application*. Fire Research Note No. 739, Joint Fire Research Station.

Rogowski, B.F.W, Ramaprasad, R. and Southern, J.R. 1988. *Fire Performance of External Thermal Insulation for Walls of Multi-Storey Buildings*, BR 135 1/e.

Ruddock, T. 1996. Charles Holden and the Issue of High Buildings in London 1927-47. *Construction History*, 12: 83-99.

Ryber, B. and Hedskog, F. 1998. *The Classification Systems for Surface Lining Materials Used in Buildings in Europe and Japan*. Lund, pp. 21.

Shennan, P. 1991. Towering Inferno. *Liverpool Echo*, April 5, 1991.

Spinardi, G., Bisby, L. and Torero, J. 2017. A Review of Sociological Issues in Fire Safety Regulation. *Fire Technology*, 53: 1011-1037.

Stephenson, J. 2005. *Building Regulations Explained*. London, CRC Press LLC, http://ebookcentral.proquest.com/lib/ed/detail.action?docID=199402.

Sundstrom, B. and Goransson, U. 1988. *Possible Fire Classification Criteria and the Implications for Surface Materials Tested in Full Scale According to ISO DP 9705 or NT Fire 025*. SP Rapport 1988:19.

Watts, G. 1997. The National Centre for Construction in the UK. *Building Research & Information*, 25(5): 279–84.

White, N. and Delicatsios, M. 2015. *Fire Hazards of Exterior Wall Assemblies Containing Combustible Components*. SpingerBriefs in Fire, Fire Protection Research Foundation.

Wickström, U. 1993. *EUREFIC European Reaction to Fire Classification, Summary Report of the EUREFIC Programme*. Boras.

Willmore, D. 1998, *Edwin O Sachs, Architect Stagehand Engineering and Fireman*, Theatre research.

Woolson, I.H. 1904. *Report of Proceedings of the International Fire Prevention Congress*. Brown, New York.

Part III: Closing Remarks

18. Drivers

1599. In this report, I have aimed to contextualise the process of regulation, the roles that testing may play within a regulatory framework, and how England's building regulatory system for fire safety developed in the decades prior to the Grenfell Tower fire. It is my hope that this wide ranging context will help the Chairman and the Panel to understand and interpret my evidence, and also the evidence of others.

1600. The context that I have set out elucidates the drivers that exist within the practice and regulation of fire safety within building regulation. It is my suggestion that the same fundamental drivers and behaviours that existed *prior* to the Grenfell Tower fire must also be expected to manifest in the *aftermath* of the Grenfell Tower fire.

1601. I believe that in order to truly learn from the Grenfell Tower fire, and to set in place a regulatory system and industry practices that together can prevent a similar tragedy from happening in the future, it is necessary to consider how the current policy responses may have been (and indeed may be being) shaped by the same drivers that delivered the Grenfell Tower fire.

1602. I have provided this narrative, discussion, and analysis in the hope that it will assist the Chairman and the Panel to formulate effective final recommendations.

1603. The analysis presented in this report has shown that, over the decades prior to the Grenfell Tower fire, the key regulatory and industry drivers were as follows:

1604. Architects and government researchers were pressing for "freedom" in building design, to be unconstrained by prescriptive rules.

1605. Product manufacturers sought "performance standards" that would allow easier access to the market.

1606. Upon the introduction of new or improved performance standards or testing methods, product manufacturers repeatedly sought to retain legacy standards in order to avoid re-testing to new (potentially more onerous) standards.

1607. Designers sought to reduce their liability for their designs, and may have been facilitated by:

1608. government creating a certification scheme (Agrément) for new products; and

1609. government failing to commence Section 38 of the Building Act for civil liability of designers.

1610. Government sought to create a self-funding system of building regulation by:

1611. introducing competition into the building control industry; and

1612. removing the legal mandate for prescriptive rules to be followed (thereby removing the practical necessity for such rules to be regularly updated and maintained).

1613. In Appendix A of this report, I describe how harmful effects of business practices can be seen as 'externalities' whereby the firms in question avoid paying for the adverse consequences of their activities. I note that regulations seek to internalise these costs by requiring industry (and individuals and public sector organisations) to ameliorate the harmful consequences.

1614. Part of the stated motivation for the Building Act 1984 was to create "a system of control which embodies the principle that anyone who carries out work, or causes it to be carried out or authorises it, should be responsible for the outcome".

1615. The Grenfell Tower fire and the "cladding crisis" that it has precipitated have demonstrated that, in many cases, those charged with commissioning, designing, constructing, and approving buildings have (thus far) successfully externalised the costs of their bad practices. The Grenfell Tower fire and the "cladding crisis" have, in many cases, led to those externalised costs being paid for by building residents through remedial works, additional fire safety precautions, property value losses, or with their lives.

1616. There are some cases where businesses involved with construction have either sought to – or been obliged to – "do the right thing"[654]. Similarly, MHCLG has – at the time of writing – made up to £5B in funding available to pay some of these costs. The cladding crisis, however, represents a policy question that relates to how to pay costs *now* for adverse activities that occurred *in the past*.

1617. The more central question, in terms of my evidence to the Inquiry, is how to prevent an event such as the Grenfell Tower fire from happening again in the future. Framed within the ideas on the purpose of regulation that I have presented in Appendix A, the key question is thus how to create a regulatory (and testing) system that requires industry (and individuals and public sector organisations) to *internalise* these costs – rather than leaving them to be inflicted on residents.

[654] https://questions-statements.parliament.uk/written-questions/detail/2018-09-13/174629

19. A License and a Mandate

1618. Michael Heseltine's 1979 ideas[655] on risk ownership were, fundamentally, reiterated by Dame Judith Hackitt as part of her May 2018 report on "Building a Safer Future".[656]

1619. Hackitt stated that "the principle of risk being owned and managed by those who create it was enshrined in UK health and safety law in the 1970s, following the review conducted by Lord Robens, and its effectiveness is clear and demonstrable". She went on to note that "the principles of health and safety law do not just apply to those who are engaged in work but also to those who are placed at risk by work activities, including members of the public.".

1620. Hackitt suggested that "it should be clear to anyone that this principle should extend to the safety of those who live in and use the 'products' of the construction industry, such as a multi-occupancy building, where the risk of fire exposes residents to danger."

1621. Hackitt then stated that "this report recommends a very **clear model of risk ownership**, with clear responsibilities for the Client, Designer, Contractor and Owner to demonstrate the delivery and maintenance of safe buildings, overseen and held to account by a new Joint Competent Authority (JCA)."

1622. This suggestion by Hackitt, to assign risk ownership to those involved in the construction and maintenance of buildings is one possible mechanism for internalising costs. It is, however, fraught with difficulty. The primary problem with this approach is that which had already been identified by Heseltine in 1979[657] – that "with the lapse of years, architects retire, and builders may disappear. But the local authority is always there to be sued". As Malhotra foresaw[658], it has taken decades for the effects of "flexibility" to manifest; in the construction industry the timescales for costs to arise are long.

1623. Is it credible to expect organisations to internalise costs whose timescales for realisation are as long as a career? Unfortunately, it may take another few decades to find out.

1624. I do not hold myself out as an expert on the drafting of legislation, and I will not, therefore, attempt to analyse the Draft Building Safety Bill and its Draft Regulations. However, I would suggest to the Chairman and the Panel that in making any recommendations, they ought to be alert to industry's demonstrated, ingenious capacity to avoid accruing liability from their actions.

---

[655] The future of building control; speech by the secretary of state for the environment, 10 December 1979, to the National house-building council
[656] Building a Safer Future, Independent Review of Building Regulations and Fire Safety: Final Report, May 2018, p 6.
[657] The future of building control; speech by the secretary of state for the environment, 10 December 1979, to the National house-building council, paragraph 9.
[658] Malhotra, Fire safety in buildings, BRE, December 1986, para 1.20.

20. Setting Industry Less Free

1625. Over many decades, the enabling of "innovation" in support of economic gains appears to have been central to regulation and practice. Flexibility has been key to enabling the use of innovative materials, products, and systems. Notwithstanding the post-Grenfell "ban" on the use of combustible building materials and products in the external walls of certain highrise buildings, the current functionally-based building regulatory system is the ultimate embodiment of this ideal.

1626. Again, Hackitt's recommended approach reiterated the same ideology that underpins the Building Act 1984 – in her recommendations she sought a regulatory system that was "truly outcomes-based (rather than based on prescriptive rules and complex guidance)".

1627. Central to the issues that I have identified in this report is the process of technological innovation. The hazards of new materials, products, and systems appear to have been insufficiently understood or, where they were understood, overlooked in the interests of innovation (and economy).

1628. Similarly, in an effort to maintain the *status quo* for industry, technological innovations in standardized testing resulted in an accumulation of test methods – rather than in evolution and improvement – with tragic and foreseeable consequences.

1629. One mechanism to reduce the hazards presented by technological innovation would be to increase the costs of undertaking such innovation. The functional requirements allow industry to rapidly bring new products to market and to be applied "in compliance" with the Building Regulations. Prescriptive rules constrain such innovation and increase the costs and times of creating new materials, products, and systems. Prescriptive requirements are contrary, however, to the idea that a regulatory system should be truly outcomes-based.

1630. It is my observation from the evidence presented in this report that, certainly since the 1960s, there have been regular calls for both "freedom" and "clarity" – I would suggest to the Chairman and the Panel that, in the context of prescriptive regulation, these characteristics are mutually exclusive.

21. The Role of Government

1631. At the time of the Grenfell Tower fire, the Permanent Secretary for the Department of Housing Communities and Local Government was Melanie Dawes. Under examination by the Public Accounts Committee on Monday 14 June 2021, Dawes – having moved on to become Chief Executive of Ofcom – characterized her view of her department at the time of the fire.

1632. ***Dawes:*** *… as Dame Judith Hackitt said in her review just six months after the fire, the regulatory system for building safety was not fit for purpose at the time of the fire. A culture had grown up in the industry of not respecting safety standards, and there was a failure of regulatory oversight, including by my former Department, for several decades before the fire. We can see the consequences of that for not just the community and those directly affected, but the wider industry and, indeed, ordinary leaseholders who are still grappling with the costs and the uncertainty created by the ongoing uncertainties around cladding.*

1633. *For me, this does prove the importance of good regulation. Ultimately, in this case, this was about helping an industry to manage collective risks that no single company could be responsible for alone. I think good regulation would have meant we created accountability in that industry, rather than just published standards in isolation. I do think there are a lot of lessons to learn here. Above all, an independent regulator, the Health and Safety Executive led by Sarah, will oversee the new system that the Government is bringing in.*

1634. ***Chair:*** *You were permanent secretary when this tragedy happened. Most of us would not think of MHCLG as a major regulatory Department. Could you summarise how you feel this slipped through the system? How was it that nobody really had proper oversight of safety in this sector?*

1635. ***Dawes:*** *I don't think my former Department saw itself as a regulator in that sense. I think my colleagues saw themselves as responsible for setting standards. Of course, Ministers agreed those standards; they agreed the rules, agreed the approved documents, and, from time to time, changed the overall legal framework with Parliament. I don't think it was explicit what that oversight was aiming to achieve, and there were not systems and processes in place for looking at what was going on in that industry—for whistleblowing and for seeing and understanding risk. Those are all things that you would expect a good regulator to do, and it is sometimes rather difficult to expect Government Departments to do them. That is why I think that one of the lessons is that regulatory bodies—for whom that is their bread and butter, and who are judged on that—are the right people to discharge these responsibilities, with, of course, Ministers and Parliament still setting standards and agreeing the overall policy.*

1636. I have included Dawes's post-Grenfell analysis within this final part of the report because she introduces a distinction between the "setting of standards", and the activity of "regulating". Her view suggests that her department did not regard itself as a regulator, but nevertheless felt that it could set standards.

1637. Again, this logic follows the model set-out by Heseltine for a system with "minimum Government interference". Instead, considerations such as "setting industry more free" and "increasingly flexibility" appear to have dominated the "setting of standards"; or – tragically – the lack thereof.

1638. I believe it is clear from the evidence I have presented in parts I and II of this report that government representatives had been repeatedly made aware of the limitations of the tests cited by the guidance given in the Approved Documents, of the need to revisit the recommendations in the guidance specifically as regards external fire spread; of the need to issue clarifications to the guidance so as to assist industry in "getting it right"; of the external fire spread hazards presented by combustible rainscreen cladding generally and ACM PE cladding specifically, and of its widespread use particularly in social housing overcladding projects.

1639. Government representatives also appear to have been broadly aware of problems with regulatory oversight and fire safety competence within the industry; they were aware that industry were not "getting it right" and that industry were not uniformly demanding or obtaining the requisite reaction-to-fire performance from cladding products and systems. They had been provided with compelling evidence that products were being used on buildings without achieving the recommended reaction-to-fire performance; and that buildings were therefore being designed and/or constructed with potentially inadequate safety.

1640. It thus appears that DCLG (and its predecessors) may not have had a sufficient organisational apparatus with which to act on such information – even where the individuals involved may have understood the significance of the warnings. Or indeed, that there may simply have been a view that it was not for DCLG (or its predecessors) to act. It remains to be seen – hopefully during Module 6 of the Inquiry – whether this was the case.

Appendix A: The Purpose and Evolution of (Fire Safety) Regulation

22. The Purpose of this Appendix

1641. Whilst I do not hold myself out as a social scientist, or as holding any particular expertise in science and technology studies (STS), I have had a demonstrated academic interest in the roles of regulation and education in fire safety engineering design, practice, and enforcement for more than a decade. I have also published peer reviewed papers in both areas, as noted in Section 31.

1642. As noted elsewhere in this report, I believe that – in any root cause analysis of the Grenfell Tower fire – it is crucial to try to understand the purpose, motivations, and evolution of the fire safety regulatory landscape that existed in the decades leading up to 14th June 2017.

1643. Drawing on the social science literature, and co-authored with my colleague and long-time collaborator Dr Graham Spinardi, who has published extensively on regulation within the STS literature, this Appendix provides the background context necessary to understand the conflicts, incentives, and compromises that are inherent within any regulatory system; it also shows how industries may (and invariably do) seek to exploit regulatory systems for their own benefit.

1644. The evidence presented in this Appendix also underpins some of my interpretation of the evidence that I present in parts I and II of this report; however I have placed it in an appendix because I do not hold myself out as an independent expert in this area.

23. Introduction

1645. Governments typically regulate to ensure societally acceptable outcomes. Such regulation can address financial behaviour (e.g. avoiding anti-competitive monopolies or providing customer rights), as well as technological outcomes that impact on health, safety, and the environment. Technology brings many benefits but also some risks, and regulation ideally aims to achieve a societally acceptable balance of benefits over risks. As summarised by the UK Better Regulation Task Force: "The job of government is to get the balance right, providing proper protection and making sure that the impact on those being regulated is proportionate."[659]

1646. Failure in regulation can occur because of unexpected phenomena, where the performance of a technology is insufficiently understood. In some cases, this can be due to unforeseen "black swan" type events, particularly when new technologies are introduced or an existing design paradigm is pushed too far.[660] In other cases, it may be due highly complex systems that are vulnerable to what Perrow has termed "normal accidents".[661] However, failure can also result if regulatory oversight is weak and/or is influenced (or "captured") by vested interests that undermine regulation to the extent that it no longer reflects the broader societal consensus.

1647. In the light of the Grenfell Tower fire on 14th June 2017 that resulted in at least 72 deaths, it is crucially important to understand the extent to which any failures in UK fire safety regulation can be attributed to *regulatory capture*. And if so, what can be done to ensure that fire safety regulations better serve the public interest, potentially at the expense of the interests of industry.

1648. What follows sets out an analysis of some of the issues facing regulation of technology, before summarising the key theories of regulatory capture. The main contours of the history of UK fire safety regulation are then traced, setting out the ways that this appears to have been shaped by shifting societal and political views.

1649. The following section discusses the extent to which vested interests may have been able to shift the balance of UK fire safety regulation in favour of industry and away from broader societal interests as represented through representative politics. The focus then shifts to a specific potential avenue for regulatory capture – that presented by the inevitable reliance on expert knowledge and advice in the formulation and enactment of regulation. Finally, one potential solution to this dilemma is offered, by setting out a framework for regulation whereby key roles in the production and application of technical knowledge are underpinned by formalised *professional status*.

---

[659] BRTF 2003, 1.
[660] A classic example is the British Comet airliner which suffered crashes in 1954 that were attributed to the unanticipated metal fatigue that resulted from cabin pressurisation cycles. As Petroski (2018) argues 'success through failure' may be an unavoidable feature of engineering innovation. See also Downer 2011.
[661] Perrow 1999.

24. Regulating Technological Impacts

1650. Regulation of the impact of technologies (which can mean a single artefact such as a computer or pharmaceutical drug, or a complex technical system such as a nuclear power station and its associated infrastructure) has historically been driven by changing societal attitudes to health and safety, as well as concern about the environment. In economic terms, the harmful effects of business practices can be seen as negative "externalities" whereby the firms in question avoid paying for the consequences of their activities (such as river pollution or the ill-health of workers). Damage to the environment or to individuals is thus borne by the wider society. Regulations seek to internalise these costs by requiring industry (and individuals and public sector organisations) to ameliorate the harmful consequences.

1651. Three key choices face society in pursuing such regulation. First, what outcomes are desired with regard to balancing the benefits and disbenefits of a technology? Second, where in the lifecycle of a technology should one intervene to achieve these outcomes? Third, what means of intervention best achieve the desired outcomes?

1652. The first of these choices depends on knowledge of technological outcomes. Some harmful impacts may be obvious and persistent (e.g. effluent outflows causing pollution), others may be more intermittent (e.g. seasonal smog), whereas others still may be very infrequent but potentially catastrophic (e.g. building and infrastructure failures caused by extreme events such as earthquakes). Perceptions of risk will thus vary greatly, and ideal governance structures would enable a society to balance (and shape) these perceptions with a more rational and informed understanding of risk.

1653. Rare but catastrophic risks pose a particular challenge because they may be so infrequent that data from actual events is rare, and perhaps of questionable relevance to current conditions. A probabilistic assessment of risk for such events may mean that a possible, albeit very unlikely, disaster scenario is overlooked. As Tsunio Futami, a former director of the Fukushima nuclear plant that suffered a catastrophic nuclear accident in 2011, noted: "We can only work on precedent, and there was not precedent. When I headed the plant, the thought of a tsunami never crossed my mind."[662]

1654. Even when there is a precedent, events that are infrequent may fade from memories. Coupled with the tendency for immediate day-to-day concerns to override potential, occasional risks, this means that the "lessons" of a disaster can soon be forgotten, particularly if what was learned was complex or ambiguous. Moreover, there can be a tendency to adopt "stable door" solutions that fix a specific problem without addressing more systemic failings. As Dame Judith Hackitt's *Independent Review of Building Regulations and Fire Safety*, instigated following the Grenfell Tower fire, notes: "Any attempt to modify details of the

[662] Quoted in Perrow (2011).

regulation without addressing the clear systemic failings would be akin to adding a paint job and decorations to a fundamentally non-roadworthy vehicle."[663]

1655. Focusing only on stable door solutions can result in a cycle whereby a disaster prompts a strong reaction (perhaps even over-reaction), with some specific remedies aimed at preventing a reoccurrence of the same disaster, but then a gradual slide into complacency due to the absence of any significant further disasters. This cycle was described by structural engineer Henry Dewell in the context of the aftermath to the 1906 San Francisco earthquake (and fire):

1656. "Then there results an immediate realization of the necessity for more stringent building regulations; the engineer and architect are called upon to suggest proper revisions for greater safety, and the building codes of those cities affected by the disaster are revised. After which, the cycle of events pursues its course. The ruins are cleared away; damaged buildings are repaired and new ones built; no more disasters occur; the race between expense and profit is under way, and little by little the more stringent regulations are less completely enforced, and then allowed to lapse. This has been the history of California cities since 1906."[664]

1657. Fire safety regulation presents a similar challenge because major fire disasters that result in multiple fatalities are rare in societies such as the UK, which has a long history of fire safety regulation. A major disaster that results in many deaths typically requires a number of failings all to align at one time, any of which by themselves could potentially be inconsequential. This means that poorly designed buildings, or buildings that have not been maintained properly or are not used in an appropriate manner, may exist for many years without these failings manifesting in a major fire. Unsafe buildings may only become recognised as such following a disaster, as evidenced by the way that, by December 2018, 437 other high-rise buildings in the UK had been identified that were considered to have cladding systems that would not meet then current Building Regulations guidance – and, by implication, did not meet the intended safety standard.[665]

1658. It is thus not enough to assess fire safety performance retrospectively through analysis of statistics of fire deaths and casualties. Absence of a disaster does not necessarily mean that regulations are working; it may only mean that the conditions have not yet arisen that reveal a regulatory failure.

1659. To summarise, a first challenge for regulation is to identify the systemic causes of the problem, and to find some measure of performance that provides greater visibility to latent failings that constitute "waiting-to-happen" disasters that may only manifest rarely, and where society may thus be prone to cyclical complacency.

1660. The second societal choice concerns the point or points in the lifecycle of a technology where intervention can best achieve the desired outcomes. In many cases, the harmful impacts of a technology are the result of industrial processes

[663] Hackitt 2017, 7.
[664] Dewell 1929, 97.
[665] MHCLG 2019.

whereby regulation can be localised to the production site (e.g. industrial effluent harming the local ecosystem). However, regulation may also be deemed necessary not just for the production process, but also for the product itself. For example, the various industrial activities that go into making the components of aircraft, as well as the final assembly of complete aircraft, will all be subject to the local regulations for environmental impact, worker safety, etc. However, for many people the most important regulation of civil airliners concerns the airworthiness of the final product.

1661. Manufacturers of airliners must therefore obtain design approval for any new aircraft model, and must ensure that every aircraft of that type then produced adequately matches the approved specification.[666] However, airliner safety relies not just on certification of the aircraft *design* as airworthy; it is also necessary to ensure that aircraft *users* (the flight crews, maintenance teams, etc.) use the technology in an appropriate manner. Ensuring the *right people* have the *right expertise* for their roles is thus a critical aspect of regulation.

1662. For many consumer technologies it is not possible to extend regulation to use because, in general, it is not possible to tightly control peoples' behaviour (even if this was considered appropriate). In the case of buildings and fire safety, it has generally been the case that while regulation should apply to the *design* of family homes, there should be no further regulation as to how people then *use* those homes. Premises considered to pose higher risks, including residential apartment buildings, have typically been subject to *some* post-construction regulation, but it still remains the case that such regulation has limited or no jurisdiction over what happens inside individual dwelling units.

1663. Finally, the third key issue for regulation concerns the method used to achieve the desired outcomes. Regulation of technology can be achieved in two main ways.[667] *Prescriptive regulation* operates by setting rules as to how a technology should be designed and used. *Outcomes-based regulation* sets the performance outcomes that must be achieved, but does not prescribe the means used to provide this desired performance. Prescriptive regulation depends on the ability to formulate rules that are sufficiently unambiguous in application (and conservative in approach) so as to compel the desired performance outcomes across a wide range of potential cases. The key expertise with rules-based regulations thus resides in understanding to what extent, and how, following rules can result in desired performance outcomes without leaving significant loopholes and grey areas.

1664. Prescriptive regulation can be thought of as based on "the letter of the law", whereas outcomes-based regulation can be thought of as based on "the spirit of the law". However, while conceptually distinct, in operation these two approaches encompass a spectrum of practices because rule-based regulation inevitably requires *interpretation* as to when and how to apply the rules, whereas regulation focussed on performance outcomes rarely happens without some formal *benchmarks* or guidance.

---

666 Downer 2010.
667 See Coglianese and Lazer 2003; Spinardi 2016, 2019.

1665. A key issue with prescriptive regulation is that practitioners need to know what outcomes they are trying to achieve in order to interpret regulatory rules appropriately. As Law and Beever have argued with respect to regulation of fire safety: "When there are simple and arbitrary rules there are always more arguments and disputes than when an engineering approach is adopted, because the underlying assumptions are forgotten or not understood."[668]

1666. The key challenge with rules-based regulations stems from the significant difficulty of making rules that are watertight in interpretation. What is known as "meaning finitism" in the sociology of science literature argues that no rule can be fully self-contained because "nothing in the rule itself fixes its application in a given case".[669] In other words, any attempt to cover all potential instances whilst making rules unambiguous will only result in more voluminous regulation (as has happened, for example, with the US International Building Code that now extends to over 700 pages of relevance to fire safety alone).

1667. The unavoidable need for interpretation (by what are called "code consultants" in the USA) means that prescriptive regulations are vulnerable to those who deliberately seek out loopholes in order to subvert the intent of the rules. Moreover, even those with good intentions may not achieve the intended outcomes if they blindly follow rules without understanding the intention of those rules.[670]

1668. Thus, a key concern with prescriptive regulation consisting of "simple rules" is that individuals who lack any deep or fundamental understanding of the rules might use them in situations where they were never intended to (or ought not) apply. There is considerable evidence of precisely this sort of thing occurring, for example in fire safety testing and approval, in the years leading up to the Grenfell Tower fire, as described in Part II of this report.

1669. Although prescriptive and outcomes-based approaches to regulation should be seen to form a spectrum of practices rather than distinct and separate alternatives, they do offer differing opportunities for regulatory capture. Prescriptive regulations can be most clearly affected when the legislation, regulations, standards and guidance (i.e. the "rules") are *created*, whereas outcomes-based (more commonly referred to as "performance-based" in fire safety engineering) regulation can offer opportunities for regulatory capture in the *implementation* of the regulations.

1670. In principle, there would thus appear to be two main avenues for regulatory capture to operate within fire safety regulation: in a centralised way on the drafting of legislation, regulations, standards, and guidance, or in a dispersed way on the enforcement of outcomes-based performance requirements or the interpretation of rules-based regulations.

[668] Law and Beever 1995.
[669] Barnes 1995, 202.
[670] Hirschhorn 1993; Bieder and Bourrier 2013.

25. Theories of Regulatory Capture

1671. Regulatory capture has been a longstanding concern. For example, in 1955 Bernstein raised concerns about the extent to which regulatory agencies go through a "life cycle" where initial enthusiasm is negated by inexperience and the vagueness of relevant legislation, whilst maturity leads to declining enthusiasm with oversight "determined in the light of the desires of the industry affected".[671] According to this view, "politicians and regulators end up being 'captured' by special interests, usually the producers they are intended to regulate. As a result, laws and regulations serve not the public interest, but those special interests."[672]

1672. The most straightforward view of regulatory capture centres on the power of industry to influence how regulations are first framed, and then implemented. This can happen at the level of political lobbying aimed at shaping legislation, or by attempts to moderate the way that regulatory authorities implement the regulatory practices that stem from that legislation. Although there is some overlap, the first of these opportunities for regulatory capture can be seen to happen primarily through "lobbying" while the second can be considered as mostly due to the "revolving door" phenomenon.

1673. Lobbying can result in regulatory capture through its influence on the legislative process, whereby this may shape the legal framework in which rules, standards, and subsidies are created. A classic statement of this view was set out by Stigler in 1971 when he argued that "as a rule, regulation is acquired by the industry and is designed and operated primarily for its benefit."[673] Stigler focusses on direct economic benefits that regulation offers industry (e.g. subsidies, tax breaks, market protection), arguing that the nature of political representation based on elected representatives cannot compete with the more persistent and coherent influence of industry. In his discussion of market access, Stigler thus argues that "every industry or occupation that has enough political power to utilize the state will seek to control entry."[674] For example, industry can provide funding or other resources to politicians that support a preferred regulatory stance, as well as influencing voting patterns through advertising or other "educational" techniques. The power of vested interests in influencing political decision-making in this way is central to the political process. Any industry or occupational group that did not engage in such lobbying would likely be seen to be negligent.

1674. Perhaps some of the more controversial forms of lobbying are what can be termed "insider lobbying" whereby political representatives such as MPs work on behalf of industry to promote the industry's views. Employment of MPs by outside interests (in industry and other sectors) may be justified as beneficial to the work of Parliament because it is claimed to bring greater knowledge of those sectors into the work of legislation. The main mechanism to police this practice is the *Register of Members' Interests* whereby politicians are required to register any financial gains from such work, although the penalties for non-compliance are not severe. In

[671] Bernstein 1955, 87.
[672] Dudley and Brito 2012, 15.
[673] Stigler 1971, 3.
[674] Stigler 1971, 5.

addition, politicians face the threat of electoral rejection if their commercial activities excite public criticism or censure, but this may be an ineffectual remedy in constituencies where a party has a large majority or if other issues have greater prominence in voters' minds. Moreover, the apparent extent of the pharmaceutical industry's attempts to build a "hidden web of policy influence", by covertly funding UK "all-party parliamentary groups", shows that that vigilance is needed to enact rules to constrain lobbying in the face of industry ingenuity.[675]

1675. In regulatory matters, as in other areas, parliamentarians are likely to represent a range of interests, both of their constituents and of other interest groups, including industry. An idealised view of the role of parliamentary debate could see legislative outcomes depending more on the quality of the debate, and on general public opinion, rather than on the strength (and wealth) of any particular sector. However, as discussed further below, much of the debate central to regulation (certainly in the case of fire safety) involves technical matters for which "common-sense" solutions may not achieve the stated outcomes. The quality of parliamentary debate about such matters, and therefore the quality of the resulting legislation, will then depend on the technical advice provided to participants by subject matter "experts", and those with deeper pockets may be able to exert more influence through their ability to marshal "evidence".

1676. The other main mechanism of regulatory capture focusses on the way that the behaviour of regulatory authorities is shaped by the existence of a "revolving door", whereby those who work in an industry then take jobs with the regulator of that industry, or vice versa. This form of regulatory capture can overlap and reinforce lobbying of parliamentary activities (particularly if the revolving door involves politicians or civil servants), but it is mostly seen to be a concern for enforcement by regulatory agencies.

1677. Thus, Makkai and Braithwaite argue that this "revolving door" means that regulators may be overly lenient because of "identification with the industry, sympathy with the particular problems that regulated firms confront in meeting standards, and absence of toughness."[676] Revolving door movements of personnel are commonplace in many sectors,[677] including fire safety, perhaps not surprisingly given the shared knowledge and expertise involved. The risks of regulatory capture are clear if regulators who used to work in industry act more favourably towards their former colleagues because they identify with their commercial challenges, and are influenced by existing personal relationships, with the result that they "tend to be less tough in their attitudes to regulatory enforcement."[678] Other regulators may be similarly soft in enforcement if they "are seduced by prospects of moving to more lucrative employment in the industries they were regulating."[679]

1678. There is an argument in favour of the revolving door that is essentially the same as that for MPs having second jobs in industry; that experience of "the real world"

[675] Campbell 2021.
[676] Makkai and Braithwaite 1992, 61.
[677] Makkai and Braithwaite 1992, 62.
[678] Makkai and Braithwaite 1992, 61.
[679] Makkai and Braithwaite 1992, 62.

benefits the work of government by providing first-hand experience of the realities of commerce. The argument has also been applied to civil servants, with, for example, the Commission for Smart Government arguing that "Whitehall must become more permeable to talent, not less, if Government is to operate more effectively."[680] Thus, it is claimed that there is "nothing wrong with people going from the public into the private sector, improving understanding across a divide which in Britain can feel like a gulf."[681]

1679. However, it would be wrong if such movements of people undermined regulatory oversight. Although the "revolving door" movement of personnel has been widely documented, there is less clear evidence of its effects on regulatory outcomes. Makkai and Braithwaite found only a small (albeit significant) correlation of sympathy and understanding of regulators of nursing homes in Australia with reduced toughness.[682] They conclude that "the effects are sufficiently weak that … it would be misguided public policy to put any limits on recruitment from the industry or on leaving the regulatory agency to work for the industry."[683]

1680. Another analysis of the revolving door phenomenon, this time in Brazilian health regulation, concludes that: "Almost half of the executives who worked at Brazil's two main federal health regulatory agencies either started or ended up working for private companies regulated by those agencies."[684] However, although it is argued that this "has the potential to reduce the quality of government's regulation and public health policymaking", no evidence is provided to demonstrate that this is the case.[685] Stronger effects were observed in another context, where analysis shows that patent examiners at the US Patent and Trademark Office "grant considerably more patents to the firms that ultimately hire them."[686]

1681. It can be concluded that there is widespread evidence that industry engages in lobbying and makes use of the revolving door in order to seek to shape regulations to their benefit. There is less evidence to indicate how effective such attempts at regulatory capture are. It may not be feasible to prohibit industry from having any contact with legislators and regulators, and so the challenge is how to moderate and police the resulting influence. To some extent, industry's attempts to influence political outcomes can be seen as part of the normal political process. But there may be good reasons to have legal constraints to limit spending, set guidelines for movement of personnel, and to outlaw secretive attempts to influence regulatory policy.

[680] Cavendish 2021.
[681] Cavendish 2021.
[682] Makkai and Braithwaite 1992, 66.
[683] Makkai and Braithwaite 1992, 72.
[684] Scheffer et al 2020.
[685] Scheffer et al 2020.
[686] Tabakovic and Wollman 2018.

26. Regulatory Capture due to Reliance on Knowledge and Expert Advice

1682. What is more insidious, and less easy to police, is the extent to which regulatory capture may be achieved by "technical" rather than "political" means. While many aspects of regulatory capture can potentially be minimised through the stringent application of rules on the behaviour of politicians and other public servants, the reliance on technical knowledge in formulating and applying regulations poses a more intractable problem. This specialist technical knowledge matters for regulation because of the need to know about the performance of technologies in order to assess their potential harms and ameliorate them. Regulators need to know about the performance of technology. To what extent does a drug cause side-effects relative to its benefits?[687] Do genetically modified crops risk contamination of natural eco-systems?[688] Are civil airliners safe enough to carry passengers?[689] Or, indeed, does combustible cladding and/or insulation pose an unacceptable risk on high-rise residential buildings?

1683. Evidence of performance is gleaned from usage and testing, with hypotheses, methods of data collection and analysis shaped by theoretical understanding, and expert advice sought to reach consensus about the most appropriate regulatory action. However, this is not straightforward because all the approaches involved in learning about the properties of technology requires judgment and negotiation to reach consensus.

1684. Judgments about whether tests are sufficiently *representative* of real-world usage (see Part I of this report), and about the weight given to different types of evidence, are therefore central in the production of knowledge claims[690] about the effects of a technology. Regulators rely on these knowledge claims to make decisions about the extent to which a technology might pose societal risks, and about what actions should be taken to mitigate such risks. Because this knowledge embodies complex judgments, and because of the "tacit knowledge"[691] involved, those within the "core set"[692] of specialist practitioners are likely to be seen as the most trusted experts.

1685. However, while those in the core set may have the most relevant expertise, their institutional locations may make them more susceptible to commercial and organisational bias; this is likely to matter because the "facts" do not simply speak for themselves, but rather are constructed and mediated according to the interests of the experts involved. Moreover, while discussion of technology's effects can be

687 Abraham and Sheppard 1999.
688 Levidov 2001.
689 Downer 2010.
690 The term "knowledge claim" essentially means what is says – claims based on knowledge. But the implication is that the knowledge can have varying sources and limitations. This terminology is used to indicate that a scientific/technical measurement or theory is an outcome of specific choices with regard to experimental methods and theoretical perspectives, and should not be considered to be universally applicable "fact". The term is used in this report to problematise scientific claims that might otherwise be taken as "facts" and to imply that attention should be paid to the ways in which the claim was constructed (e.g. what empirical evidence was collected from operational use or experiments and tests, how was it analysed, what theories underpinned analysis and test design, etc?).
691 MacKenzie and Spinardi 1995.
692 Collins 1985.

LBYP20000001_0277

framed narrowly in terms of technical performance, regulation usually encompasses judgments of societal attitudes towards risks and benefits. For example, in deciding whether to approve a new drug, regulators must balance not only assessments of drug trial evidence, but also potential benefits versus side-effects. Sufferers of terminal illnesses are, perhaps unsurprisingly, more focused on the potential benefits of drugs than on any harmful side-effects.[693] Decisions about how to frame regulatory legislation and how to implement it in practice thus embody a range of judgements both about technical evidence and about individual and societal attitudes to risk.

1686. In principle, technical knowledge and expert advice could be provided by government laboratories. However, the huge array of national laboratories that the UK supported in the post-World War II years has now almost entirely gone, with most of the remnants operating as privatised entities. Even in the unlikely event that society was prepared to fund a large parallel regulatory research infrastructure to keep abreast of technical knowledge across all relevant technologies (which would probably mean almost all technologies), it is unlikely that this could match the technical knowledge involved in the industrial application of state-of-the-art research.

1687. This is an issue of broad concern for many forms of regulation, as the effectiveness of regulation depends significantly on the *competence of the regulator* to assess that which is being regulated, and this concern is all the more pressing because rapid innovation in science and technology is coinciding with the increasing use of "light touch" regulation and a hollowing out of State research capabilities in many parts of the world. While the readiness of societies to pay for a large technical infrastructure has diminished, our reliance on technical knowledge has increased. If this results in regulators having insufficient expertise to do their job effectively, then this may call into question "the idea that pro-business deregulation was not merely in the commercial interests of industry, but ultimately for the greater good."[694] The resulting "expertise asymmetry"[695] between regulators and industry thus amounts to a form of regulatory capture whereby industry has a large measure of control over the "facts" upon which regulatory judgements are made.

1688. Even at the post-war peak of the "technocratic state" regulation relied heavily on knowledge produced and interpreted by industry. For example, the US regulator of aviation safety, the Federal Aviation Administration (FAA) long ago realised that it could not maintain state-of-the-art expertise in all the relevant technologies, never mind carry out adequate testing, to provide assurance of the safety of new airliner designs. Only those involved in the development of aviation technologies have sufficient knowledge to judge what is safe or not. For this reason, the aviation industry largely self-regulates, because the FAA delegates much of the task to industry employees known as Designated Engineering Representatives. Downer thus argues that in this case "high-technology regulators contend with an intractable technical problem by turning it into a more tractable social problem, such that,

[693] Epstein 1996.
[694] Davis and Abraham 2013, 6.
[695] Spinardi 2019.

despite appearances to the contrary, the FAA quietly assess the *people* who build aeroplanes in lieu of assessing *actual aeroplanes*."[696]

1689. Similarly, pharmaceutical regulators such as the US Food and Drug Administration (FDA) rely heavily on industry expertise. In many cases of drug approval, the regulators not only rely on drug trial data provided by the drug companies, but also on the adjudication by experts (typically from academia) who have potential conflicts of interest because they are in receipt of research grants from drug companies and/or are shareholders. Indeed, the regulators themselves may have "direct and indirect financial interests in pharmaceutical companies", potentially resulting in "permissive regulation".[697]

1690. Regulatory capture by technical means can manifest in two main interrelated ways: through the control and interpretation of data; and through the shaping of regulations and standards. At the most fundamental level, those who are most heavily engaged with a technology are likely to know most about its performance. They will carry out testing as part of the development of the technology, including specifically for regulatory compliance, and they are likely to collect data on operational use. For example, the so-called "yellow card" system provides a means for reporting adverse drug reactions in the UK, although the voluntary nature of this system, and the complexity of many patients' drug regimes, apparently limits the value of the data thus collected.[698]

1691. The "facts" about the performance of a technology, including about its potential harms, are thus likely to be mostly generated by the industry that is also seeking regulatory approval in order to market that technology. Much of this data collection is likely to be shaped by regulatory requirements rather than by a general interest in a technology's overall properties. This focus on "regulatory science" raises the concern that "scientific practice in such an area may become bureaucratised and/or standardised to the extent that it loses contact either with more fundamental research (e.g. regarding underlying mechanisms of causation) or indeed 'real world' circumstances of application."[699] Innovation may thus be focused more on meeting regulatory requirements (e.g. passing tests) than on achieving overall societal outcomes. Moreover, industry control over the resulting data may mean that it is only made public when it is necessary for regulatory compliance or commercially useful. Commercial (or regulatory) secrecy may hinder both public scrutiny and the normal scientific practice of peer review.[700]

1692. For example, historically pharmaceutical companies have not published data from all their drug trials; if a candidate drug performed poorly in a trial, the results could be quietly shelved, with perhaps another trial then carried out with a different dosing regime.[701] Likewise, companies seeking to rate their products in standard fire tests have never been required to publish the results of all the tests. A product could be repeatedly tested until one specimen achieved a "pass", thus achieving an official

[696] Downer 2010, 84, emphasis added.
[697] Abraham and Davis 2009, 590.
[698] Abraham and Sheppard 1999, 807-808.
[699] Irwin et al 1997, 18.
[700] Irwin et al 1997, 18.
[701] See, for example, Turner et al 2008.

rating at that level, even if many previous tests had failed to reach the required level of performance.

1693. As well as largely producing and controlling access to data about a technology's performance, industry is also likely to have the knowledge needed to translate societal requirements for regulation into technical specifications. Politicians should make judgements about whether to regulate, and what the purpose of that regulation should be, but they are unlikely to have the technical expertise to specify detailed rules, guidance, standards, and test methods. Such matters require technical specialists, many if not most of whom may be (at least indirectly if not directly) on the industry payroll. Regulations that are established without such industry involvement may be unworkable, may result in unintended consequences, and may potentially end up being overly harmful to the broader societal benefits produced by that industry. However, too much delegation to industry in establishing the technical content of regulations may result in regulatory capture, even if it is possible to posit an idealised state of "co-production".[702]

1694. In general, the centrality of specialised scientific and technical expertise to regulation also means that even if expert advice is not directly provided by industry, it is likely to come from within a community with a shared understanding and viewpoints. Specialists in a particular discipline are likely to have taken the same sorts of university degrees, learned the same theory and methods, attended the same conferences, and so on. They will identify with their field of interest, and "the closer regulators and expert advisors are to sharing industry interests, the greater their tendency to share industry's positive expectations."[703]

1695. This risk of regulatory capture in such situations overlaps with that posed by the "revolving door' but hinges more on shared cultures and understanding rather than on employment aspirations or long-term friendships. In some cases, these shared interests are a result of poor choices of governance, whereby regulatory agencies are also tasked with promoting the interests of industry. This can create a clear conflict of interest where the same agency is both "policeman" and "salesman". For example, concern about its dual role of promotion and regulation was one of the factors that led to the abolishment of the US Atomic Energy Commission in 1974, with the creation of the Nuclear Regulatory Commission (NRC) to take over the regulatory role. However, even though it contravenes its mandate it has been noted that "the NRC's role in promoting its regulatory model around the world can easily turn it into an advocate for US nuclear technology."[704]

1696. The NRC example can thus be seen as a case of what has been termed "agency capture", where a regulatory agency shares the interests of an industry to the extent that it acts to promote that industry.[705] Another US example concerns the role the FAA has in regulating civil air transport safety with regards to airport security. The hijackings at the heart of the 9/11 terrorist attacks highlighted weaknesses in the system, with a member of the Gore Commission set up after the

[702] See Slayton and Clark-Ginsberg 2017.
[703] Abraham and Davis 2007, 411.
[704] Berkowitz and Rampton 2011.
[705] Niles 2002.

attacks arguing that: "The wrong people regulated airport security. The FAA is incompetent because it's an agency that promotes aviation commerce *and* security. It's a conflict."[706]

1697. A key problem identified with the FAA's approach to security regulation was that responsibility was mainly delegated to airports and airlines, with little in the way of central requirements or oversight. As Niles argues: "The two main features of this regulatory structure – the delegation of authority to airlines and airports to make and enforce their own security programs and the lack of significant specific requirements for what must be included in these programs – provides substantial advantages to the private interests of the regulated industry at the expense of the public interest in avoiding the kind of tragedy that occurred on September 11."[707]

1698. This points to a crucial concern where deregulation has devolved the enactment of regulation to industry practitioners. If regulatory requirements are only stated in general terms and there is little or no central oversight, then individual expertise and attitude is all-important. This is likely to matter because outcomes-based (i.e. performance-based) regulation relies on judgements about performance rather than adherence to prescriptive rules. In the case of building safety, such judgements encompass considerable latitude if the regulatory requirements are stated in vague, subjective terms. For example, a requirement that a premises should be "safe" does not provide an unambiguous goal because it is not possible to eliminate all potential hazards, and indeed not desirable to do so in the face of competing societal demands on resources.

1699. In the case of building regulations, experience in New Zealand highlights the risk of enabling a performance-based approach to regulation without ensuring that practitioners are able, or willing, to make appropriate judgements about performance. In the mid-1990s, after the introduction of performance-based building regulations, many houses were built in a style – known as monolithic-clad or Mediterranean-style – that proved unsuited to New Zealand's climatic conditions. By 2002 it was clear there was a crisis of "leaky buildings", prompting government inquiries.[708] Amongst the factors identified "was a race to the bottom in building approval standards especially as they related to alternative designs".[709] The leaky buildings crisis provided clear evidence that the performance-based regulations provided poor regulatory oversight. The problem was that "de facto standards for performance of cladding systems were established by the marketplace, with those standards falling short of what was intended by the performance-based code".[710]

1700. In summary, it can be concluded that reliance on technical expertise may create potential avenues for regulatory capture. Along with the role of industry or industry-friendly experts in guiding policy and the development of regulatory guidelines, standards, and testing methods, the most significant form of regulatory capture can

[706] Quoted in Niles 2002, 439, emphasis added.
[707] Niles 2002, 433.
[708] Easton 2010.
[709] May 2003, 395.
[710] May 2003, 398.

be seen as happening through the devolvement of judging performance to individual practitioners.

1701. Having briefly surveyed the main concepts with regard to regulatory capture, including the specific challenge of reliance on industry data and expertise, this report now turns to the relevance of these concepts to UK fire safety regulation prior to the Grenfell Tower fire.

27. Fire Safety Regulation and Representative Politics

1702. Before looking specifically at the role of regulatory capture in fire safety regulation in the UK, it is important to recognise that regulation is never a neutral and purely technical matter. As with all forms of regulation, fire safety regulation is the result of political as well as technical choices, reflecting broader shifts in societal attitudes. Democracies vary in the way that they provide electoral representation, but by their very nature political parties are likely to be influenced by sectoral interests.

1703. In general, the UK governance of fire safety is marked by a historical shift from early regulations that focussed primarily on property protection, and particularly the risk of conflagration, to an increasing emphasis on life safety. Early cities with widespread use of timber construction were vulnerable to fires that caused great damage to property and commerce. Regulation emerged locally to address this threat of conflagration, with, for example, the 1666 Great Fire of London leading to one of the first building codes focussed on fire safety. But in 1938 Sir Samuel Hoare, Secretary of State for the Home Department, summarised the period following 1666 as "thinking a little bit about the protection of property, apparently thinking not at all about the safety of human life."[711]

1704. Concern about the safety of individuals only began to gain significant traction in the 19th century. With the industrial revolution bringing increasing urbanisation, the prevalence of infectious diseases such as cholera (and the loss of productivity thus caused by ill-health) was linked to the living conditions of the working classes. Cramped housing with poor ventilation, lack of sunlight, and inadequate water supplies and sanitation were seen as central to the problem, with fire safety measures incorporated into proposals to provide comprehensive improvements in health and safety.

1705. Universal suffrage was yet to be established, and thus the resulting Parliamentary consideration of national building regulations in the early 1840s is likely to have had an inbuilt bias towards the wealthier segments of society. Despite powerful arguments based on the need for reform, the proposed national building bill failed to attract sufficient support, with opposition in part based on commercial interests. Thus, "an excellent opportunity to establish the principle of one building Act for the United Kingdom was missed… due to extensive objections by vested interests."[712] According to Ley's exhaustive history of English building regulations, "it was the desire to maintain a steady flow of housing with good profits in building and in investment, which resulted in most of the fierce opposition to the bill."[713]

1706. It would be more than a century before the UK finally adopted national building regulations (first in Scotland, then in England and Wales). In the meantime, the first move towards concern for life safety rather than only property protection came in the form of regulations that set requirements for "means of escape" for certain classes of building through what has come to be known as *post-construction*

[711] Hansard, HC Deb 10 May 1938 vol 335 cc 1429 http://hansard.millbanksystems.com/commons/1938/may/10/fire-brigades-bill
[712] Ley 2000, 19.
[713] Ley 2000, 18.

LBYP20000001_0283

regulation. This occurred first in the UK with the Factory and Workshop Act 1901, and then later with the Public Health Act 1936.

27.1. Post-Construction Regulation (Briefly)

1707. Implementation of these early means of escape regulations depended on judgements made by those tasked with enforcement (initially District Councils). However, no detailed description of what constituted a satisfactory means of escape was provided. For example, with the Factory and Workshop Act 1901, the main stipulation was that relevant premises should be provided with "such means of escape in the case of fire for the persons employed therein *as can reasonably be required under the circumstances of each* case".[714] The only specific requirements were that these should "be maintained in good condition, and free from obstruction", and that doors must open outwards and that they "must not be locked or bolted or fastened in such a manner that they cannot be easily and immediately opened from the inside".[715]

1708. Means of escape provisions were also contained in the Public Health Act 1936. Section 59 of the Act covered a range of premises in which people might congregate (such as theatres, restaurants, shops, clubs, schools, and place of worship), and gave power to the local authority to reject plans (or prohibit use of) any relevant buildings that were "not provided with such means of ingress and egress and passages or gangways *as the authority deem satisfactory*".[716] Section 60 applied to "any building which exceeds two storeys in height and in which the floor of any upper storey is more than twenty feet above the surface of the street or ground on any side of the building" if the building was also let as flats, used as an inn, hotel, boarding house, hospital, nursing home, boarding school, children's home or similar institution, or used as a restaurant, shop, store or warehouse with sleeping accommodation on upper floors used by persons employed on the premises. The requirement for Section 60 was that such buildings should be "provided with such means of escape in case of fire *as the local authority deem necessary*" from all storeys above twenty feet above ground level.[717]

1709. Concern about the limitations of these regulations led to discussions about reform in the early 1960s that highlighted key issues with ensuring adequate fire safety during the lifetimes of buildings. It was clear that many more types of premises needed to be covered by such regulations, and the debate within the relevant government departments (the Home Office and the Ministry of Housing and Local Government) centred on the extent to which such regulations could be *prescriptive* in nature, and who should *enforce* them. It was agreed that "it is impracticable to lay down detailed legal standards for existing buildings, since the degree of risk often varies according to the use to which the building is put."[718] Instead, it was considered appropriate that: "It should be left to the enforcing authority to impose 'tailor-made' requirements."[719] The enforcing authority could make judgements

[714] FWA 1901, 8, emphasis added.
[715] FWA 1901, 10.
[716] PHA 1936, 44, emphasis added.
[717] PHA 1936, 46, emphasis added.
[718] A.F.A. Sutherland to K.P. Witney, Home Office, 27 March 1962. AT 49/1.
[719] A.F.A. Sutherland to K.P. Witney, Home Office, 27 March 1962. AT 49/1.

about what constituted adequate provision in any particular case, and what was a reasonable expectation with regard to the costs of making such provisions.

1710. Because *judgement* was required, the effective enactment of this legislation required some understanding of the desired outcome, while raising potential concerns about organisational bias. In general, the perception in the early 1960s was that District Council inspectors were more concerned with the commercial success of businesses in their jurisdiction, but had poorer understanding of fire precaution requirements. Enforcement of means of escape in factories and warehouses was therefore shifted from District Councils to Fire Authorities in the 1959 revision of the Factories Act, and it was noted that: "It was the poor record of enforcement by the district councils which led, as much as anything, to the transfer to fire authorities of responsibilities for securing proper means of escape in factories; and there is a strong feeling in certain sections of the fire services that unless powers are vested in the fire authorities they are likely to remain largely unused."[720]

1711. The concern was "that many district councils, because they have no responsibility for fighting fires, pay less attention to fire prevention than they should or are reluctant to impose expensive requirements as to means of escape on local property owners."[721]

1712. However, the counter to these concerns was "that the district councils have more intimate knowledge of their areas and the property contained in them than many fire authorities can have, and are less likely to make unreasonably exacting demands" and that it "would also be vexatious to occupiers, who have customarily to deal with district councils on general matters of building construction, sanitation and other public health measures, if they had to deal with another set of authorities on the fire prevention provisions of the Public Health Acts."[722] Reference was also made to the "usual objection to letting fire authorities loose on existing buildings (the danger of arbitrary and expensive requirements based on too narrow an outlook)."[723] It was also argued that "it would be undesirable if the body preparing guidance were unduly weighted in favour of fire brigade interests [as] there had been a tendency for these interests to ask for too high a standard of precautions in the past."[724]

1713. The conclusion of the 1960s discussions about enforcement was that: "Because so much is left to the enforcing authority our view would be that this should be the fire authority, not the district council. We have recently reviewed the enforcement of the fire provisions of the Factories Acts in consultation with the Superintending Inspectors and it is becoming clear that the fire authorities are in general

[720] 'The Scope of Fire Prevention Legislation, Note by the Home Office', attached to letter from G. H. McConnell, Home Office to J. H. Street, 5 December 1961. AT 49/1.
[721] 'The Scope of Fire Prevention Legislation, Note by the Home Office', attached to letter from G. H. McConnell, Home Office to J. H. Street, 5 December 1961. AT 49/1.
[722] 'The Scope of Fire Prevention Legislation, Note by the Home Office', attached to letter from G. H. McConnell, Home Office to J. H. Street, 5 December 1961. AT 49/1.
[723] 'Scope and Content of the Draft Building Standards (Scotland) Regulations, Note by the Department of Health for Scotland, attached to H. F. G. Kelly, Department of Health for Scotland to P. D. Coates, Ministry of Housing and Local Government, 8th February, 1962. AT 49/1.
[724] Committee on Fire Prevention Legislation, FPL (Third Meeting), minutes, held 20 March, 1962. AT 49/1.

conducting more thorough means of escape inspections and are issuing better certificates than did the district councils. There is likely to be much less divergence in standards in different parts of the country than there was before 1960."[725]

1714. These means of escape regulations suffered from the perception that their requirements "were insufficiently defined and so lent themselves to arbitrary use".[726] The eventual assignment of enforcement to the fire services can perhaps be seen as an implicit societal choice to favour fire precautions over economic interests.

1715. Fire authorities thus became the sole enforcers of means of escape regulations, and their role in ensuring appropriate fire safety provisions in existing buildings was consolidated in the Fire Precautions Act 1971. As with the earlier Acts, the Fire Precautions Act 1971 stipulated that a fire certificate needed to be issued by the regulator (the relevant Fire Authority) before the premises could be used. This Act provided more detailed guidance than the early Factories and Public Health Acts, but still left much to the discretion of the enforcing fire service personnel. This discretion became a key concept in UK health and safety legislation when the need for proportionality became enshrined more broadly in the Health and Safety at Work, etc Act 1974, which required employers to assess and mitigate risk on their premises 'so far as is reasonably practicable' (SFAIRP).

1716. The apotheosis (some might say the nadir) of the application of this approach to post-construction fire safety regulation came with the Regulatory Reform (Fire Safety) Order (RRFSO) 2005. In what can be seen as a triumph for those favouring deregulation, the RRFSO 2005 shifted the responsibility for fire safety onto the "responsible person" (the employer or whoever has control of the premises), and eliminated the requirement for the fire services to issue fire certificates. Instead, most premises became *self-regulated*, with the fire authorities only checking compliance for what *they* considered high risk cases. These fire authority enforcement activities are determined by local analysis using an integrated risk management plan (IRMP).[727]

1717. Although this may be seen as the legitimate endpoint of the development of a political consensus favouring the market over regulation, it raises serious concerns as to whether devolving responsibility in this manner provides adequate fire safety.[728] The existence of legislation (i.e. the RRFSO 2005) may give the *appearance* of regulation, when in fact this is not the reality for most premises where the maintenance (or even existence) of appropriate fire precautions is likely to go *entirely unchecked* by any regulatory authority.

27.2. Regulation of Building Design

1718. In parallel, national building regulations were finally promulgated in the 1960s, during the post-war period of relative political consensus with regard to the role of

[725] A. F. A. Sutherland to K. P. Witney, Home Office, 27 March 1962. AT 49/1.
[726] 'The Scope of Fire Prevention Legislation', FPL (1st Meeting), held on 19th January 1962. AT 49/1.
[727] Guidance documents on IRMP are available at: https://www.gov.uk/government/collections/integrated-risk-management-planning-guidance.
[728] Spinardi et al. 2019; Baker 2018; Bullock and Monaghan 2014.

the state. The 1965 Building Regulations set out a range of prescriptive requirements according to building types. For example, for structural fire precautions, buildings were classified into eight different "purpose groups" (such as office, shop, factory, etc) with requirements for "fire resistance" of elements of structure (such as columns and beams) further specified according to the building's dimensions.

1719. Whereas post-construction regulation requires some flexibility to deal with a variety of occupancy usages in existing premises, regulation of building design starts with a blank slate, and thus can insist on more rigid requirements. As already discussed, prescriptive regulations set rules that building designers must follow, and so in principle it is in the drafting of the legislation that the main opportunity arises for regulatory capture (more on the potential influence of vested interests in the next section). In practice, however, it may be exceedingly difficult to write rules that are unambiguous, and those charged with enforcing building regulations must make *judgements* about whether and how any particular rule applies in any particular instance.

1720. The 1965 Building Regulations were no exception in this regard. Both they, and their lengthier and more detailed 1976 revision, comprised legislation that was considered inflexible, amongst other critiques. As noted in Part II of this report, although some aspects of the 1965 Regulations featured functional statements, fire precautions were presented as prescriptive requirements .In principle, approval of a project required the design to fit within the classifications set out in the regulations. Projects that could not, due to physical limitations (e.g. the shape and size of the building plot) or which used innovative techniques or materials/products not envisioned in the regulations, posed a challenge. Such projects could be approved if the regulations were waived or relaxed, but relaxation might require approval by the Secretary of State, and became so commonplace as to be considered an undesirable burden on central government. Amongst the specific disadvantages of prescriptive regulations listed in an analysis of how to reform the Building Regulations in 1981 was the: "Frequent need for relaxation – it is impossible to provide for all situations so that relaxation is often necessary for any departure from the basic requirements."[729] The prescriptive and centralised nature of this procedure also ran contrary to emerging political ideologies of government that emerged in the late 1970s.

1721. With regard to building regulations, the main ideas of the UK government that came to power in 1979 were set out in a speech by Secretary of State for the Environment, Michael Heseltine, in December 1979. This proposed the key criteria for reform as "maximum self-regulation", "minimum Government interference", "total self-financing", and "simplicity in operation".[730] The resulting *White Paper on The Future of Building Control in England and Wales* was presented to Parliament in February 1981.[731]

[729] J. Cane, SEC/BRAC to Department of the Environment, "Recasting the Building Regulations", April 1981. AT 49/108.
[730] The Future of Building Control in England and Wales, February 1981, Cmnd 8179, HMSO, London, p. 4.
[731] The Future of Building Control in England and Wales, February 1981, Cmnd 8179, HMSO, London.

1722. The White Paper noted that the "present system of building control produces safe buildings in which fire and serious structural failure is rare", but argued that "the system is more cumbersome and bureaucratic than it need be", and is "inflexible for many purposes, inhibits innovation, and imposes unnecessary costs".[732] Thus, the White Paper noted that the "Government are also clear on the need to provide for greater self-regulation by the private construction industry and building professions, and have devised a certification scheme to achieve this".[733] This certification was intended to enable private certifiers (later known as approved inspectors) to act in lieu of the local authorities with regard to checking that building plans complied with the Building Regulations.[734]

1723. Amongst the criticism of the previous building regulations was that they were:

1724. "too complex, so that their purpose is obscured and they are therefore unwillingly complied with;

1725. expressed in inappropriate language so that many users find them difficult to understand;

1726. inflexible so that time consuming relaxation procedures have to be used too often to adapt them to real cases; and

1727. unable to keep abreast of technical developments."[735]

1728. One of the main problems that was perceived with the existing prescriptive regulations was that they comprised Statutory Instruments that needed to be expressed in legalistic language; this made them hard to use by construction industry practitioners, and considerable time and effort were needed to obtain Parliamentary approval, making revisions infrequent. They were inflexible not just because they set out prescriptive requirements, but also because innovative building materials/products and techniques could not be introduced in a timely manner.

1729. The solution to this inflexibility was to shift to more general "functional requirements" that expressed the overall aims of the regulations without specifying the means. The Building Act 1984 enabled the Building Regulations 1985, which set out four functional requirements for fire safety: B1 "Means of escape", B2 "Internal fire spread (surfaces)", B3 "Internal fire spread (structure)", and B4 "External fire spread" (a further fire safety requirement relating to access and services for firefighting (B5) was added in the 1991 revision of the Building Regulations).

1730. These functional requirements were supported by *guidance* in the form of "Approved Documents", and in the case of fire safety Approved Document B set out

[732] The Future of Building Control in England and Wales, February 1981, Cmnd 8179, HMSO, London, p. 4.
[733] The Future of Building Control in England and Wales, February 1981, Cmnd 8179, HMSO, London, p. 4-5.
[734] Private Certification for Building Control. The Structural Engineer, Vol. 60A, No 9, September 1982, 292-293 and 305.
[735] The Form of the Building Regulations, Draft letter on consultation, attached to A. G. Watson, CID(BR) to PS/Mr Stanley, 13 May 1982. AT 49/142.

what was, in effect, a revised version of the prescriptive rules of the earlier Building Regulations. As with the RRFSO 2005, the Building Act 1984 marked a decisive shift towards deregulation. In principle, the Building Act 1984 freed designers from the need to follow prescriptive rules, enabling them to choose whatever design they desired so long as it was judged to meet the functional requirements of the Building Regulations.

1731. This shift away from the requirement to follow prescriptive rules has raised concerns that it shifts governance of risk from the public to the private sector, if decisions about acceptable levels of safety become a matter for the design choices of architects, engineers, or contractors rather than being societally mandated in requirements set by government.[736]

1732. However, in practice most designers continued to use the Approved Documents *as if they were* the Building Regulations. As the 2018 Hackitt Review has noted, more than three decades after the introduction of this system of building regulation underpinned by approved documents, "the cumulative impact of the Approved Documents changes an outcome based system of regulation to one that is often inferred by users to be prescriptive."[737]

1733. By providing rules-based guidance in the form of Approved Document B, the government also appear to have subverted the essence of the Building Regulations in another key manner. Because designers and approving authorities could continue to design and regulate according to prescriptive rules, they did not need to *understand* how these rules related to the functional requirements. A fundamental flaw in the move to functional regulations (at least as far as fire safety was concerned) appears to be that no measures were put in place to ensure that practitioners (neither designers nor approving authorities) gained and maintained the technical *competence* necessary to make safe use of the design freedom that stemmed from the ability to use "first principles" fire safety engineering design.

1734. The second key change introduced by the Building Act 1984 was that the move towards "private certification" meant that in England and Wales local authority building control no longer retained a monopoly over building design approval. The Act enabled private approved inspectors to carry out this regulatory role. Although this introduced an element of competition to the provision of building approval, it raised concerns about conflicts of interest and a "race to the bottom".

1735. As Trevor Clements of Hertfordshire Building Control put it, "The poacher can choose his gamekeeper."[738] And while competition was intended to speed up approval time and reduce costs, the consequence of this was seen by many as: "It has been a race to the bottom on fees – and you get what you pay for."[739] As with the shift away from prescriptive rules for building control, the move to allow private certification represented a political choice; it cannot be seen as being substantially due regulatory capture, and indeed if anything industry appears to have been

[736] Brannigan 1999.
[737] Hackitt 2018, 26.
[738] Quoted in Thomson 2021.
[739] Quoted in Thomson 2021.

broadly sceptical of this move. Instead, it appears to have been a consequence of broader economic thinking that rose to dominance during that era. The effect, however, was that building regulation depended less on rules established and enforced by regulators and regulatory agencies, and more on dispersed expertise throughout the construction industry.

28. UK Fire Safety and Regulatory Capture

1737. Two key points arise from this brief history of the development of UK fire safety regulation. First, a regulatory approach is never neutral; it is a product of social and political choices. In the UK, these choices have seen a shift over the years from an initial emphasis on property protection and the risks of conflagration to one more focused on life safety. Second, fire safety regulations have, in recent decades, seen increasing emphasis on enforcement based on *dispersed discretion* rather than on centrally mandated *rule-following*. While there are good reasons that not all the specific requirements of fire safety regulation can be prescribed in legislation, this increasing shift to decentralise judgements about fire safety has significant implications with regard to the need to take steps to ensure adequate *competence* amongst the relevant practitioners.

1738. The trend in fire safety thus appears to reflect the broader social and political consensus for deregulation from the 1980s onwards. To the extent that this might be considered as at least partly a result of regulatory capture, it appears to be a phenomenon that is common to most forms of regulation, and not just to fire safety.

1739. Regulation always involves a balancing of outcomes (benefits and harms), based on societal priorities that are implicitly reflected in electoral choices. However, these "revealed preferences" (Wolski et al 2000) may not necessarily align with more scientific calculations of risk cost-benefits, and the electorate can be expected to make their choices based on a wide range of issues and judgements rather than on any single specific considerations related to regulation of safety. Nevertheless, the regulatory choices made by UK governments over the last forty years appear to have reflected a political consensus towards deregulation.

1740. Vested interests (not just commercial, but also those of unions, professional organisations, and other interest groups) can be expected to lobby governments on behalf of their preferred regulatory approaches. However, if all such interests are expressed openly, and have rough parity in terms of access and resources, then it may be that no single interest dominates to the extent that regulatory capture occurs. It is the job of government to collate and assess differing views, and some (possibly extensive) consultation with interested parties typically precedes any significant change in regulatory legislation.

1741. For example, the deliberations about "recasting the building regulations" in the early 1980s involved several rounds of consultation. In some cases these resulted in a variety of conflicting opinions, in others there was more agreement, however around a position contrary to government intentions. Thus, the consultation process about private certification of building control was unsupportive of government plans, with minutes of a meeting of the Building Regulations Advisory Committee (BRAC) noting in September 1982 that – "of the 125 responses to the consultation none had expressed unconditional support. Marginal support had been expressed by only 8 respondents."[740] However, this did not deter the government from pressing ahead, because as the Chairman of BRAC noted, "Government policies were for maximum

[740] BRAC (82) M4, Department of the Environment, Building Regulations Advisory Committee, Minutes of Fourth Meeting, held 29 September 1982. AT 49/123/1.

self regulation for the construction industry and that certification was seen as an important product of policy."[741]

1742. Government can thus ignore consultation feedback (or lobbying) if it feels it has a strong electoral mandate. More typically, it has to arbitrate between lobbying that encompasses a wide range of different, sometimes opposing, views. This can be seen in an example that shows how industry rarely operates as a single, homogenous interest group in pushing for a preferred approach to regulation, with a range of other interest groups also likely to be involved.

1743. The 1979 Manchester Woolworths fire that resulted in 10 deaths led to pressure to legislate for regulations on the flammability of furniture upholstery, and was "the subject of intense lobbying".[742] Tests to assess compliance involved both open flames – "the match test" – and smouldering cigarettes, but the former was initially removed from the regulations "after protests from furniture manufacturers".[743] However, this industry pressure was ultimately unsuccessful and "the match test" was reinstated by the time the legislation was passed as the *Furniture and Furnishings (Fire Safety) Regulations 1988.*

1744. Ironically, subsequent concern over the harmful effects of the chemicals used in flame retardant materials has led to a campaign to ban the use of flame retardants in the UK (as they are in other parts of the world). The case for using such chemicals has been undermined, it is argued, by other fire safety improvements (particularly the very rapid increase in the use of smoke alarms), along with increasing concerns that fire retardant materials may undermine their life safety benefits through the production of toxic smoke in domestic fires.[744] Although a 2014 government consultation recommended changes to the regulations, it has been claimed that "the process of updating the legislation had been put on hold after significant opposition from both the furniture and the chemical industries".[745]

1745. Industry lobbying thus may not always seek to reduce regulations, as some vested interests operate in support of the "health and safety industry" (when it aligns with their commercial interests). Industry does not speak with a single voice, and within the construction industries different sectors will compete to promote their own particular approaches, bringing both technical arguments as well as public sentiment to bear in their efforts at persuasion. Thus, claims about fire safety performance can be at the heart of the promotion of different materials/products (e.g. steel versus concrete), or in lobbying for regulations requiring "active" fire safety precautions such as sprinklers as opposed to "passive" structural design approaches.

1746. For example, the broader housing industry mostly opposed the (ultimately successful) arguments in favour of making sprinklers mandatory in new residential

[741] BRAC (82) M4, Department of the Environment, Building Regulations Advisory Committee, Minutes of Fourth Meeting, held 29 September 1982. AT 49/123/1.
[742] G. R. Nice to T. J. Griffiths, 3 March 1980. DSIR 4/3859.
[743] G. R. Nice to T. J. Griffiths, 3 March 1980. DSIR 4/3859.
[744] McKenna et al 2018.
[745] https://www.fidra.org.uk/flame-retardants-in-our-furniture-uk-regulations-and-ten-years-of-imminent-change/.

buildings in Wales. In opposing the proposed Welsh legislation, the National Landlords Association argued that the proposed Order "has the potential of producing an inflexible 'one-size-fits-all' regime for new residential premises that requires no real consideration of what fire risks actually exist. The Order (as it currently stands) has the potential to be seen as a panacea for achieving fire safety to the exclusion of other, more tailored solutions, that might be more effective for particular circumstances."[746] In contrast, sprinkler manufacturers and their industry body (the British Automatic Fire Sprinkler Association, BAFSA) formed a powerful pro-sprinkler lobbying alliance with some politicians and current and retired fire service personnel.[747]

1747. Just as lobbying is carried out on behalf of many interests, so too the actors that pass through the "revolving door" will reflect different sectors with regard to attempting to influence the creation and implementation of regulatory approaches. There does not appear to be any empirical data on the extent to which there is a revolving door between fire safety regulatory agencies and industry, or on its effects. Anecdotal evidence suggests that in practice the most common transfer of people in fire safety involves former fire service personnel moving either into industry or into other regulatory roles. This brings a particular perspective to fire safety based on the experiential knowledge gained from firefighting and visiting fire scenes, and on the application of code-based regulations (e.g. Approved Document B) rather than on fire science.[748]

1748. The concern with a revolving door between the fire services and other fire safety roles is not so much that it serves the vested interests of business, but rather that it perpetuates a narrow view of what expertise is considered adequate. The case of Carl Stokes, who was employed as a fire risk assessor at Grenfell Tower, is suggestive of an attitude that the experiential expertise gained from a role as fire fighter confers broader expertise that qualified him for a wider range of fire safety roles.[749] However, what the Grenfell Tower fire has highlighted is the critical need for key fire safety roles (particularly those who carry out building design and those who subsequently carry out fire risk assessment during a building's lifetime) to have appropriate, most likely specialist and possibly regulated, expertise.

1749. While industry (and other interests) can be expected to seek to exploit any opportunities for both lobbying and the revolving door exchange of personnel, such activities can be seen as an extension of a social and political process. The competing interests involved mean that no single interest group is likely to achieve regulatory capture so long as there is sufficient openness and transparency. Where the role of vested interests is clear, other interests can present competing viewpoints, and contest the way that regulations are created or implemented.

1750. What is more challenging is where vested interests "speak" not through explicit statements that encapsulate their commercial goals, but rather through technical

---

746 National Assembly for Wales, Proposed Domestic Fire Safety LCO Committee, National Assembly for Wales (Legislative Competence)(No.7) Order 2008, Committee Report June 2008, 8.
747 See Davies 2013.
748 See Law and Spinardi 2021.
749 Booth 2021.

arguments and advice in which their overall aims are hidden but implicit. Industry lobbying and the revolving door constitute one form of regulatory capture, but a more insidious, and perhaps harder to avoid, avenue of influence stems from the extent to which regulation relies on "expert knowledge".

LBYP20000001_0294

29. Knowledge, Expert Advice, and Regulatory Capture in Fire Safety

1752. Technical data and arguments are often expressed in ways that appear as "facts" to the layperson. However, fire safety knowledge claims are highly contestable because they rely on a wide variety of data sources collated and interpreted by different types of experts. Fire fighters make claims based on their experience fighting fires and visiting fire scenes, fire scientists (and *some* fire engineers) use the scientific method based on experiments and tests, and regulators and most construction industry practitioners mostly view traditional rules-based fire precautions (as still embodied for example in Approved Document B) as being the most important "facts".[750]

1753. Fire safety regulation has evolved to focus on life safety (though many of the provisions limit fire spread and so also address the earlier concerns with conflagration and property protection), and casualties can provide a measure of performance. However, such knowledge about "performance" can only be inferred retrospectively through collection of relevant data (such as fire incidence and casualties). It also can only indicate patterns of correlation, with causal relationships harder to substantiate.

1754. For example, the general trend of reducing numbers of building fire deaths since the early 1980s (in England from 755 in 1981/82 to 253 in 2018/19[751]) could be used to claim that the parallel deregulation of fire safety regulation has been markedly successful. A more plausible explanation for the reductions in fire deaths in this period lies with the shift to a proactive approach by the fire services, and the resulting increase (for example, in Great Britain from 8% in 1988 to 86% in 2008[752]) in the ownership of domestic fire alarms.

1755. The other limitation with reliance on fire statistics as a measure of performance is that this only provides an aggregate, retrospective picture of what has happened across society as a whole. It can help guide the revision of regulations and building practice (for example, by highlighting a common failure mode across a particular class of building designs), but it does not provide data that are useful in the design process to assure adequate prospective performance in a specific new building or renovation. Performance data that are useful for individual building designs instead rely primarily on the testing of materials, products, and elements of structure, and in fire safety, as in other industries, the production and interpretation of such test data largely rests with the industry itself (see Part I of this report for a detailed discussion of regulatory fire safety testing).

1756. The contested nature of fire safety knowledge means (perhaps more so than in many other policy domains) that there is considerable scope for regulatory capture. At the highest policy level, whoever can gain access to provide trusted expert advice can shape political judgements about the overall thrust of regulations, while

[750] Law and Spinardi 2021.
[751] Home Office 2019, 8.
[752] DCLG 2012, 11.

the detailed drafting of legislation relies on data and expert interpretation, much of which is likely to be provided by the industry that is being regulated.

1757. In fire safety the significance of technical expertise for regulatory capture operates in both centralised and dispersed ways. At the centralised level of the framing of legislation, and even more significantly, the standards that underpin the legislation, a large proportion of the relevant expertise resides in industry. The committees formed to decide on new fire testing standards via the British Standards Institution (BSI), for example, comprise a membership largely drawn from industry, as does the Building Regulations Advisory Committee (BRAC) that has been central to revising fire safety regulations since 1962. Academic membership of such committees may appear to offer some "independent" voices, but as in the pharmaceutical case, genuine independence from industry is likely to be rare with most successful fire safety academics working closely (as they probably should) with industrial partners, and with some "revolving door" movement of personnel between the public and private sectors. Moreover, in 1981, as part of the hastening deregulation of building regulations, "the balance of the [Building Regulations Advisory] Committee was *intentionally* altered to give the private sector a bigger say."[753]

1758. While it is appropriate that industry should be involved in setting standards that it will have to use, and that universities should work closely with industry to push forward the development and application of new knowledge, the (not insignificant) challenge is to do so in a way that does not enable industry to undermine the intent of regulations. Although governments cannot support all the scientific and technological activities necessary to inform regulation, they need to nurture *some* core fire safety expertise in order to create, maintain, and update suitable regulations, standards, and guidance. Such expertise, independent of industry, is critical if government is to adjudicate amongst the advice it receives from the (probably) partisan and (certainly) self-interested views expressed by relevant practitioners from industry and the fire services.[754]

1759. The UK built a world-leading fire research organisation in the post-war period – known for much of its existence as the Fire Research Station. However, from at least the mid 1960s there were explicit tensions between research into fundamental science that was needed to underpin policy decisions and regulatory mechanisms, and providing pragmatic support to industry in the form of standard testing. For example, concern about regulatory testing capacity in 1966 led to complaints about how too much focus on fundamental research was crowding out work that served industry's needs, and "that the Station's work tended to be orientated away from testing in the direction of research of a comparatively pure nature and that this tendency would not be offset until the Station's scientists and physicists were leavened by a number of architects/structural engineers."[755]

---

[753] A. G. Watson to PS/Minister HC, 'Review of Non-departmental Public Bodies – Building Regulations Advisory Committee, 20 November 1981. AT 49/113.
[754] Law and Spinardi 2021.
[755] Kendall, F. 1966. Note by PS/Parliamentary Secretary, 18 February. National Archives, HLG 118/610.

1760. The balance between fundamental research and pragmatism swung decisively in favour of the latter when the Building Research Establishment (which had subsumed the Fire Research Station in 1972) was privatised in 1997. In the House of Commons Select Committee inquiry set up after the 1999 Garnock Court cladding fire, Peter Field, then Deputy Director of the Fire Research Station, was questioned as to why his organisation had not carried out tests on such external cladding systems. His response (which I have previously highlighted in Part II of this report) noted one consequence of privatisation:

1761. "We are a private sector organisation; we are not part of the government … in days gone by … this work was done and would have been done in the public interest without the need for formal contract. One regrets there are now commercial pressures that require clients to place formal contracts before we can undertake work."[756]

1762. Following the privatisation of BRE, the UK no longer nurtures a wide-ranging fundamental fire safety research programme, nor can the government call on any significant depth of in-house fire safety expertise. This makes it harder for government to discriminate between competing advice from industry and other organisational lobbies, and thus more vulnerable to regulatory capture.[757]

1763. The other requirement for technical expertise stems from the dispersed nature of UK fire safety regulation, whereby much of the responsibility for assessing fire safety performance is devolved to the judgement of individual practitioners (rather than based on checking against centralised prescriptive rules). As Hackitt notes, an outcomes-based approach to regulation depends on adequate *competence*, so that "those undertaking the work, and those appraising it, will need to have sufficient levels of skills, knowledge and expertise to make appropriate judgement calls."[758] The plan to establish a new building safety regulator set out in the proposed Building Safety Bill indicates that the need for more regulatory expertise has indeed been acknowledged – at least in principle, if not yet in practice – following the Grenfell Tower fire.

1764. To be equipped to resist regulatory capture this new regulator (which is intended to be the Health and Safety Executive (HSE), taking on a new role) needs to develop and sustain adequate fundamental technical expertise. This raises two concerns: first, whether sufficient, appropriate competence will be nurtured in ways that enables its application to regulation; and second, even if adequate competence is developed initially, whether this will be sustained in the future.

1765. To be in a position to provide adequate oversight, the new regulator needs to be more than a shell organisation. The new regulator needs personnel able to assess designs that may make use of the full range of fire safety engineering disciplines. It would not be enough for the HSE to apply its existing competences and personnel

[756] House of Commons 1999, 16.
[757] Law and Spinardi 2021.
[758] Hackitt 2018, 26.

LBYP20000001_0297

to the challenge; new, well-qualified staff will be needed, both initially and in the future.

1766. The failures of competence exposed by the Grenfell Tower fire are not simply organisational failures; they appear to have stemmed from a genuine absence of competence, ethics, and professionalism in appropriate roles within "the system". If the new Building Safety Regulator is only concerned with design approval for a small number of buildings (what have been designated as Higher Risk Buildings) then it may be plausible that sufficient new government funding will be made available (and sustained) to provide competence for adequate oversight. However, such an *a priori* categorisation of one form of building as "higher risk" appears exactly the kind of prescriptive "stable door" approach that Hackitt specifically warned against.[759] It is not at all clear that it can be known in advance whether innovative design approaches might introduce new risks in other categories of buildings.

1767. This leaves two further concerns. First, a focus on genuine technical competence (rather than fluency in regulatory "Codespeak"[760]) may help overcome the potential risks of "expertise asymmetry" between regulators and designers, but this does not address the more fundamental problem identified by Hackitt[761]; that of a widespread "expertise deficit" with regard to fire safety across the breadth of the construction industry.[762] Second, new funding to build technical competence in fire safety regulation is welcome (even if restricted to a narrow category of HRBs), but there must be concern as to the permanence of any financial commitment. Because political and public concern for fire safety is likely to be cyclical – strongly responding in the immediate aftermath of disasters, but then gradually becoming complacent – there is a risk that initial support for increasing the technical capacity of fire safety regulation (and indeed its design and management) is transitory.

1768. What is really needed is a way of embedding (and perhaps enforcing) higher levels of technical competence more broadly across relevant roles in fire safety design and management.[763]

759 Hackitt 2017, 7.
760 Law and Spinardi 2021.
761 Hackitt 2018.
762 See Spinardi 2019.
763 I note that The Warren Centre (Australia) has published a thorough discussion of the competencies that ought to be considered when thinking about requirements for professional roles in fire safety and fire engineering. See: https://www.sydney.edu.au/engineering/industry-and-community/the-warren-centre/fire-safety-engineering.html.

LBYP20000001_0298

30. Professional "Vested Interests" and Regulatory Capture

1770. If it is judged that expert knowledge is important to the implementation of outcomes-based regulation, then suitable experts are needed to carry out specific roles. Herein lies perhaps the most significant oversight in the way that UK fire safety regulations have been changed over the last forty years. The deregulatory approach taken in the Building Act 1984 and the RRFSO 2005 devolved regulation away from the centre, making the expert judgment of individual practitioners critical. However, little was done to develop or require appropriate expertise for key roles. The result, as Hackitt concluded, is that "competence across the system is patchy".[764]

1771. To the extent that construction industry practitioners are also driven by commercial interests, this presents an obvious opening for regulatory capture. There are good arguments as to why an outcomes-based assessment of individual projects is preferable to relying on "one-size-fits-all" prescriptive rules (as outlined above), but the effectiveness of such an approach relies, as Hackitt also notes, on having sufficient competence to judge fire safety performance (along with the requisite ethics and professionalism).[765] In their deregulation of fire safety regulation, UK governments provided increasing freedom from following strict rules, but did very little to assure adequate competence amongst key practitioners.

1772. In the case of the Building Act 1984, this deregulation freed individual designers from the constraints of prescriptive rules, allowing them to choose innovative design approaches and new materials/products, so long as they were *judged by the regulatory authorities* to have met the functional requirements. However, the existence of the guidance provided in Approved Document B meant that designers could continue to follow a prescriptive approach without needing to understand or even consider how, or indeed whether, a given design *actually met* the (subjective) functional requirements.

1773. So long as the prescriptive solutions contained in Approved Document B were sound and uniformly conservative, this was not a problem, unless designers chose (or were allowed) to exploit the inevitable loopholes and grey areas. Such permissive compliance was possible because few practitioners (either designers or regulatory authorities) had the competence to understand *how* Approved Document B's solutions were *intended* to meet the functional requirements. In addition to those seeking to exploit grey areas in Approved Document B, others sought to bring the tools of first principles fire safety engineering to create alternative solutions that could be *argued* to meet the functional requirements (more later).

1774. A regulatory environment for building control thus evolved after 1985 in which building design regulation could be based on claimed adherence to Approved Document B, on fully engineered alternative solutions based solely on meeting the functional requirements, or on a hybrid of the two in which a mainly Approved Document B compliant design incorporated some elements of first principles

[764] Hackitt 2018, 11.
[765] Hackitt 2018, 26.

engineering to overcome the perceived limitations of the Approved Document. For example, in order to create more saleable or rentable floor space within a high-rise building in a small city centre plot, a designer could argue to increase travel distances to exits beyond those specified in Approved Document B, for example by making use of smoke control systems in corridors and/or stairways.

1775. Such "fire safety engineering" can involve the use of complex, state-of-the-art knowledge across multiple disciplines (combustion science, fire and smoke dynamics, structural performance, and human behaviour). Designs are typically based on the use of mathematical modelling tools, that are claimed to represent the underlying processes in these varied domains in order to demonstrate, for example, that building occupants would be able to evacuate before a fire makes building conditions untenable. However, although many such models are available "off-the-shelf", their outputs can vary greatly according to the expertise (or incentives) of the model users. As Johansson notes: "Many fire models are easy to obtain and easy to use, this means that they can be used in a careless or incorrect manner. This is problematic because errors due to misuse can be difficult to discover."[766]

1776. It is critical that model users (both engineers and those providing regulatory oversight) understand the limitations of both the underlying science and the models used to represent it.

1777. However, at present, fire safety engineering is not a "protected profession" in the UK and thus *no qualifications are required* to practice as a "fire safety engineer". Accreditation by the Institution of Fire Engineers (IFE) provides *some* assurance that an individual may have appropriate qualifications, with the highest level of accreditation being that of a Chartered Engineer (CEng). However, while CEng accreditation provides a "badge" for individuals to suggest that they have competence in fire safety engineering, there exists no mechanism by which to ensure that tasks which require a high level of competence can *only* be completed by individuals accredited to such a level of competence (even assuming that this is sufficient). And there currently appears to be little appetite from the professional institutions to alter the status quo in this regard.

1778. Similarly, the effectiveness of the RRFSO 2005 in ensuring adequate post-construction fire safety hinges substantially on the quality of fire risk assessments, but it appears that no mechanisms were put in place to *require* those carrying out these assessments to have appropriate levels of competence. For most buildings, the RRFSO 2005 shifted the onus of post-construction fire safety regulation onto the building's "responsible person". The responsible person is required to take "such general precautions as will ensure, so far as reasonably practicable, the safety of any of his employees" and "in relation to relevant persons who are not his employees, take such general fire precautions as may reasonably be required in the circumstances of the case to ensure that the premises are safe."[767] The responsible person must also carry out a fire risk assessment so as to "make a

[766] Johansson 2014, 9.
[767] RRFSO 2005, s.8. (and noting that absolute safety is, as a matter of fact, not possible).

suitable and sufficient assessment of the risks to which relevant persons are exposed for the purpose of identifying the general fire precautions."[768]

1779. Because most premises are no longer inspected by the fire authorities, the quality of the fire risk assessment is crucial to the effectiveness of what amounts to self-regulation of post-construction fire safety. Lacking a "suitable and sufficient" fire risk assessment it would not be possible to remedy failings in fire precautions or to incorporate risk control measures in an effective management system.

1780. Although the responsible person bears ultimate responsibility for carrying out a risk assessment and ensuring the provision of fire precautions, they can employ a specialist fire risk assessor to do this. Competence to do this is defined as having "sufficient training and experience or knowledge and other qualities to enable him properly to assist in undertaking the preventative and protective measures".[769]

1781. However, as Hackitt noted, "there are no statutory registration or accreditation requirements".[770] In England, anyone can call themselves a fire risk assessor and operate as such. Existing *voluntary* approaches to provide assurance of competence for fire risk assessors include registration to a professional body such as the Institution of Fire Engineers or third-party certification by a certification body that is accredited by the United Kingdom Accreditation Service (UKAS), but the qualifications provided are neither necessary nor (apparently) checked by any overall regulatory body.

1782. The Building Act 1984 and the RRFSO 2005 thus devolved regulation to practitioners *without providing credible mechanisms to ensure those practitioners were competent*. The key practitioners responsible for fire safety (designers and fire risk assessors) not only were not required to have any specific qualifications, but they also did not need to be members of any professional bodies or even of a registration system. Professional status or registration are therefore important, not only because they provide assurance of relevant qualifications, but also because they imply adherence to *ethical standards* and/or *professional codes of conduct*.

1783. One way to combat the risk of regulatory capture in a system that depends on the judgement of "experts" in designing and managing fire safety would be to legislate for key roles (designer and risk assessor) to require – via formal registration – practitioners to have and maintain appropriate competencies.

1784. Professional status offers some protection against regulatory capture because a professional organisation should police the behaviour of its members. A profession's claims to a monopoly over a particular activity rest on an implied social contract whereby the profession works not only for its members but also (indeed foremost) for the public good.

1785. Putting legislated mechanisms in place to align a requirement for professional status with key fire safety roles would embed a barrier to regulatory capture because the need for appropriate accreditation should not only require a suitable

[768] RRFSO 2005, s.9.
[769] RRFSO, 2005, s.18(5).
[770] Hackitt 2017, 17.

level of competence, but also an adherence to a professional code of practice. Professional status can thus constitute a form of "vested interest" that is built around competence, ethical behaviour, and professionalism in a way that can embed safety into the construction industry that can endure beyond the typical cyclical response to disasters.

1786. Similarly, fire risk assessors could be compelled to be members of a certification or registration system (such as the Gas Safe Register provides for gas engineers). Even when memories of the last disaster fade, when fire deaths are low year on year, when public and government sentiment err towards reducing budgets for safety, the ingrained behaviour of key professionals and tradespeople can continue to act as a balance to commercial pressures to cut corners on safety.

1787. In considering the main body of this report, I believe that the ideas presented in this appendix should be borne in mind so as to build a coherent picture of the interrelationships between stakeholder incentives, testing methods, regulatory approaches, and the resulting fire safety outcomes.

LBYP20000001_0302

31. References for Appendix A

Abraham, J. and Sheppard, J. 1999. Complacent and Conflicting Scientific Expertise in British and American Drug Regulation: Clinical Risk Assessment of Trizolam. *Social Studies of Science*, 26(9): 803-843.

Abraham, J. and Davis, C. 2007. Deficits, Expectations and Paradigms in British and American Drug Safety Assessments: Prising Open the Black Box of Regulatory Science. *Science, Technology, & Human Values*, 32(4): 399-431.

Baker, A.J. 2018. *'Suitable and Sufficient'? UK Regulation of Post-Construction Fire Safety*. Doctoral Thesis, University of Edinburgh.

Barnes, B. 1995. *The Elements of Social Theory.* London: UCL Press.

Berkowitz, B. and Rampton, R. 2011. Exclusive: US Nuclear Regulator a Policeman or Salesman? Reuters (April 18).

Bernstein, M. 1955. *Regulating Business by Independent Commission*. Princeton: Princeton University Press.

Bieder, C. and Bourrier, M. (eds.) 2013. *Trapping Safety into Rules: How Desirable or Avoidable is Proceduralization?* Boca Raton: CRC Press.

Booth, R. 2021. Grenfell fire risk assessor added letters after his name, inquiry hears. *The Guardian,* 25 May.

BRTF 2003. *Principles of Good Regulation*. Technical report, Better Regulation Task Force: UK Government.

Brannigan, V.M. 1999. Fire Scenarios or Scenario Fires? Can Fire Safety Science Provide the Critical Inputs for Performance Based Fire Safety Analyses? *Fire Safety Science – Proceedings of the Sixth International Symposium*, 207-218.

Bullock, M. and Monaghan, A. 2014. Code compliance or fire engineering for life safety design – have we moved on? *International Fire Professional*, April.

Campbell, D. 2021. Drugs firms giving MPs "hidden" funding, research shows. *The Guardian,* 25 June.

Cavendish, C. 2021. Closing the 'revolving door' would weaken government further. *Financial Times,* 24/25 April.

Coglianese, C. and Lazar, D. 2003. Management-Based Regulation: Prescribing Private Management to Achieve Public Goals. *Law & Society Review,* 37: 691-730.

Collins, H.M. 1985. *Changing Order: Replication and Induction in Scientific Practice,* Sage.

Davies, C. 2013. Why don't homes have sprinklers? *BBC*, 15 May. https://www.bbc.co.uk/news/uk-politics-22271677

DCLG 2012. *Fire Statistics, Great Britain, 2011-2012.* https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/36467/FSGB_2011_to_12.pdf

Dewell, H.D. 1929. The Earthquake Resistance of Buildings from the Standpoint of the Building Code. *Bulletin of the Seismological Society of America*, 19: 96-100.

Downer, J. 2010. Trust and Technology: The Social Foundations of Aviation Regulation. *The British Journal of Sociology*, 61(1): 83-106.

Downer, J. 2011 '737-Cabriolet': The Limits of Knowledge and the Sociology of Inevitable Failure. *American Journal of Sociology*, 117(3): 725-762.

Dudley, S.E. and Brito, J. 2012. *Regulation – A Primer*. Mercatus Center, George Mason University.

Easton, B. 2010. Regulatory Lessons from the Leaky Home Experience. *Policy Quarterly* 6, 42-47.

Epstein, S. 1996. *Impure Science: AIDS, Activism, and the Politics of Knowledge*. Berkeley: University of California Press.

FWA [Factory and Workshop Act] 1901.

Hackitt, J. 2017. *Building a Safer Future. Independent Review of Building Regulations and Fire Safety: Interim Report*, Cm 9551, December.

Hackitt, J. 2018. *Building a Safer Future. Independent Review of Building Regulations and Fire Safety: Final Report*, Cm 9607, May.

Hirschhorn, L. 1993. Hierarchy versus Bureaucracy: the Case of a Nuclear Reactor. In K. Roberts (ed.) *New Challenges to Understanding Organisations*, London: Macmillan

Johansson, N. 2014. Numerical Experiments and Compartment Fires. *Fire Science Reviews,* 3:1-12.

Home Office 2019. *Fire and Rescue Incident Statistics, England, year ending March 2019.* https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/823920/fire-and-rescue-incident-mar19-hosb1419.pdf

House of Commons 1999. *Potential Risk of Fire Spread in Buildings via External Cladding Systems, Environment, Transport and Regional Affairs Committee*, HC-741-i.

Irwin, A., Rothstein, H., Yearley, S. and McCarthy, E. 1997. Regulatory Science – Towards a Sociological Framework. *Futures*, 29(1): 17-31.

Johansson, N. 2014. Numerical Experiments and Compartment Fires. *Fire Science Reviews,* 3: 1-12.

Law, A. and Spinardi, G. 2021. Performing Expertise in Building Regulation: 'Codespeak' and Fire Safety Experts, *Minerva.*

Law, M. and Beever, P. 1995. Magic Numbers and Golden Rules. *Fire Technology,* 31(1): 77-83.

Ley, A.J. 2000. *A History of Building Control in England and Wales 1840-1990*. RICS Books.

Levidow, L. 2001. Precautionary Uncertainty: Regulating GM Crops in Europe. *Social Studies of Science*, 31(6): 842-74.

MacKenzie, D. and Spinardi, G. 1995. Tacit Knowledge, Weapons Design, and the Uninvention of Nuclear Weapons. *American Journal of Sociology, 101*(1): 44-99.

Makkai, T. and Braithwaite, J. 1992. In and Out of the Revolving Door: Making Sense of Regulatory Capture, *Journal of Public Policy,* 12(1): 61-78.

May, P.J. 2003. Performance-Based Regulation and Regulatory Regimes: The Saga of Leaky Buildings. *Law & Policy,* 25: 381-401.

McKenna, S.T., Birtles, R., Dickens, K., Walker, R.G., Spearpoint, M.J., Stec, A.A. and Hull, T.R. 2018. Flame retardants in UK furniture increase smoke toxicity more than they reduce fire growth rate. *Chemosphere,* 196: 429-439.

MHCLG 2019. Building Safety Programme: Monthly Release Data (10 January).

Niles, M.C. 2002. On the Hijacking of Agencies (and airplanes): The Federal Aviation Administration, "Agency Capture," and Airline Security. *Journal of Gender, Social Policy & the Law,* 10: 381-442.

Perrow, C. 1999. *Normal Accidents: Living with High Risk Technologies* (Updated Edition). Princeton.

Perrow, C. 2011. Fukushima, risk, and probability: Expect the unexpected. *Bulletin of the Atomic Scientists*, April 1.

Petroski, H. 2018. *Success through Failure: The Paradox of Design*. Princeton: Princeton University Press.

Slayton, R. and Clark-Ginsberg, A. 2017. Beyond regulatory capture: coproducing expertise for critical infrastructure protection. *Regulation & Governance,* September.

Spinardi, G. 2016. Fire Safety Regulation: Prescription, Performance, and Professionalism. *Fire Safety Journal,* 80: 83-88.

Spinardi, G. and Law, A. 2019. Beyond the stable door: Hackitt and the future of fire safety regulation in the UK. *Fire Safety Journal,* 109: 102856.

Spinardi, G., Baker, J. and Bisby, L. 2019. Post Construction Fire Safety Regulation in England: Shutting the Door Before the Horse has Bolted", *Policy and Practice in Health and Safety*, 17(2): 133-145.

Spinardi, G. 2019. Performance Based Design, Expertise Asymmetry, and Professionalism: Fire Safety Regulation in the Neoliberal Era", *Regulation and Governance*, 13(4): 520-539.

Scheffer, M.C., Pastor-Valero, M., Russo, G. and Hernandez-Aguado, I. 2020. Revolving Doors and Conflicts of Interest in Health Regulatory Agencies in Brazil. *BMJ Global Health,* 5(4). http://dx.doi.org/10.1136/bmjgh-2020-002325

Stigler, G.J. 1971. The Theory of Economic Regulation. *The Bell Journal of Economics and Management Science*, 2(1): 3-21.

Tabakovic, H. and Wollman, T. 2018. Revolving Doors and Regulatory Capture. *Vox: The Centre for Economic Policy Research.* https://voxeu.org/article/revolving-doors-and-regulatory-capture

Thomson, C. 2021. Explainer: How did inspectors rate flats with fire safety problems as safe? *Eastern Daily Press.* https://www.edp24.co.uk/news/housing/why-did-fire-inspectors-sign-off-unsafe-buildings-7851914

Turner, E.H., Matthews, A.M., Linardatos, E., Tell, R.A. and Rosenthal. R. 2008. Selective Publication of Antidepressant Trials and Its Influence on Apparent Efficacy. *New England Journal of Medicine*, 358(3): 252-260.

Wolski, A., Dembsey, N.A. and Meacham, B.J. 2000. Accommodating Perceptions of Risk in Performance-Based Building Fire Safety Code Development. *Fire Safety Journal*, 34: 297-309.