GRENFELL TOWER INQUIRY RT

Day 290

June 13, 2022

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Monday, 13 June 2022
(10.00 am)
SIR MARTIN MOORE-BICK: Good morning, everyone. Welcome to today's hearing. Today we're going to hear further evidence from Professor Bisby.
Yes, Mr Millett.
MR MILLETT: Yes, Mr Chairman, good morning. Good morning, members of the panel.
I now call back, please, Professor Bisby.
PROFESSOR LUKE BISBY (affirmed)
SIR MARTIN MOORE-BICK: Thank you very much.
Now, please sit down and make yourself comfortable.
(Pause)
Yes, Mr Millett.
Questions from COUNSEL TO THE INQUIRY
MR MILLETT: Mr Chairman, thank you.
Professor, welcome back. We are going to hear your evidence today in response to questions that I have for you.
We will take scheduled breaks in the normal way, as we have throughout the Inquiry with the witnesses.
Can I just ask you, please, one thing that I always ask all witnesses, and that is to keep your voice up, to speak slowly and clearly, so that the transcriber, who sits over there to your right, can get down everything

you say on the transcript clearly.
A. Sure.
Q. Now, you've produced six reports for Phase 2 of the Inquiry, three of which we referred to last week when you gave your presentation, and those dealt with the experimental work that you carried out. So that was work package 1 and work package 2. Those were, respectively, {LBYWP100000002} and {LBYWP200000001}, dated, respectively, 15 March 2020 and 15 December 2021. I'll call each of those "work package 1 report" and "work package 2 report".
Now, the third report that you produced to the Inquiry when you gave evidence last week was your materials testing report at {LBYMT00000002} of 24 February 2019, updated on 1 June 2020, and that is, as I think you told us, to be read in conjunction with your final Phase 1 report, 21 October 2018, and that is to be found at {LBYS0000001}.
In addition, you've produced to the Inquiry another report, and that is at {LBYP20000001}. Can we please have that up on the screen. Here on the screen now is "Phase 2 - Regulatory Testing and the Path to Grenfell", dated 10 November 2021, updated twice, 4 December 2021 and 1 June 2022, this year. We'll call that your "Path to Grenfell" report.

If we can go, please, to page 12 of that report {LBYP20000001/12}, you will see paragraph 1.16, under the heading "Statements", and there again are the familiar fourfold paragraphs setting out a number of matters which cover the statement.
First, are these your statements in relation to this report?
A. They are.
Q. Secondly, you can see a signature at the bottom, next to the date of 10 November 2021; is that your signature?
A. Yes, it is.
Q. Have you read this report recently?
A. I have.
Q. Can you confirm that the facts and the factual matters set out in it are true to the best of your knowledge and belief?
A. Yes.
Q. And can you confirm that the opinions you give are your honestly held professional opinions?
A. Yes.
Q. Is it true that you provided your expert opinion in this report to the Inquiry in the same way as you would have provided it to an English court?
A. That's correct, yes.
Q. Can we then turn to another report, which is

{LBYP20000003}. This is entitled "Phase 2 - BRE Reconstruction Report", and there is a signature there above the date, 10 May 2022. Is that your signature?
A. Yes, it is.
Q. Can we go, please, to page 4 {LBYP20000003/4}, where we can see paragraph 1.1, and there again the fourfold statements about the report and a signature at the bottom, next to the date. Again, is that your signature?
A. Yes, it is.
Q. Are these your statements about this report in particular?
A. They are.
Q. Have you read this report recently?
A. I have.
Q. And can you confirm that the facts and the matters set out in this report are true to the best of your knowledge and belief?
A. Yes.
Q. Can you confirm also that the opinions that you give in this report are your honestly held professional opinions?
A. Yes.
Q. And, also, that you provided your expert opinion in this report to the Inquiry in the same way as you would have

done providing it to an English court?
A. That's correct.
Q. Right.
Lastly, then, please, if we can turn to {LBYP20000004}, we can see a report entitled "Phase 2 — BR 135 Desktop Assessment Report", and there is a signature there above the date of 30 May 2022. Is that your signature?
A. Yes.
Q. Can we turn, please, to page 7 in that report {LBYP20000004/7}, paragraph 1.2. The four paragraphs we can see there again, above a signature, against the date 30 May 2022. Is that your signature?
A. Yes, it is.
Q. Are these statements here statements that apply to this report?
A. Yes.
Q. And have you read this report recently?
A. I have.
Q. Can you confirm again that the facts and matters set out in this report are true to the best of your knowledge and belief?
A. I can.
Q. And can you confirm that the opinions that you give in it are your honestly held professional opinions?

A. Yes.
Q. And is it true that you provided your expert opinion in this report in the same way as you would have provided it to an English court?
A. That's correct.
Q. Can you confirm, in relation to all of these opinions that I have shown you this morning, that your opinions and conclusions in them have not changed since they were produced to the Inquiry?
A. That's correct.
Q. Now, you've given evidence before, including in relation to your experience and your fields of expertise, and you've set those out in a CV that you provided in your final expert's report for Phase 1 at appendix E. I'll just push that up on the screen so that those who want to look at that can. It's at {LBYS0000001}. That's the final expert report, and if people want to see —— well, perhaps we should go to your Path to Grenfell report at {LBYP20000001/10}. Here, at paragraph 39, under paragraph 1.4, you summarise what you've already told us in the previous report I put up on the screen, and that runs over to page 11. What I want to do is just summarise briefly with you what you say about yourself.
First, is it correct you are currently professor of fire and structures within the school of engineering at

Edinburgh University?
A. That's correct.
Q. And also, within the same school, the head of the research institute for research and environment.
A. Infrastructure and environment, yes.
Q. Infrastructure and environment.
I think, formerly, you were Royal Academy of Engineering research chair.
A. That's correct.
Q. As well as Arup chair.
A. They were linked.
Q. They were linked.
And in the UK, you are a chartered structural engineer.
A. Correct.
Q. And in Canada, a licensed professional engineer.
A. That's right.
Q. And, also, a fellow of the Institute of Fire Engineers.
A. Yes.
Q. Institute of Structural Engineers.
A. Yes.
Q. International Institute for FRP in Construction.
A. Yes.
Q. And, in Scotland, the Institute of Engineers.
A. That is correct.

Q. Institution of Engineers, yes.
I think you have advised various industrial and research organisations in this country, as well as in the US, Canada, France, Switzerland and Germany; correct?
A. Yes.
Q. And that includes, or included, in relation to the development of design codes and guides internationally.
A. That's right.
Q. I think you are also currently co—editor—in—chief of the technical journal, Fire Safety Journal.
A. Correct.
Q. Is it right that your current fire safety and your structural fire engineering research is based on matters including building and infrastructure materials at elevated temperatures, fire—safe structural strengthening and rehabilitation materials, and fire performance of external cladding materials, products and systems?
A. Correct.
Q. I think you have published peer—reviewed articles in those areas, as well as in related areas, including sustainable building design and engineering education.
A. Correct.
Q. Is it also correct —— confirm for me, please —— that

you've got extensive experience of engineering research, consultancy and university teaching, as well as the promotion of public understanding of science and engineering?
A. That's right.
Q. Finally, I think it's right to say -- well, let me ask you -- you have received a number of awards for your commitment to high quality engineering research and for your dedication to the broader academic and research communities.
A. Yes.
Q. Let's then turn to your Phase 2 experimental work.
Last week, we had the benefit of hearing from you, on 9 June, a presentation to the Inquiry on the experimental work that you carried out as set out in work packages 1 and 2; yes?
A. Yes.
Q. There was one matter which I think was an error which I just want to pick up with you before we go on to some questions about work package 1 and 2.
Can we please go to the transcript from last Thursday where you gave your presentation. That is {Day289/179:16-24}. You are describing the experiments where you removed foil facers from the insulation products, and if we pick it up at line 16, you say:

"Of course, we know that while there were exposed edges of insulation within the cladding system at Grenfell Tower, most of the insulation products, whether RS5000 or K15, had foil facers in place. In the case of the Kingspan product, again, the foil facer is perforated.
"I therefore repeated the above experiments, but in each case I retained the foil on the front face of the insulation, including having foil on the front face of the combustible mineral wool insulation."
Now, when you used the word "combustible" there, did you mean combustible mineral wool insulation?
A. No. I mean, I almost certainly will have meant to say non-combustible mineral wool insulation, although, as I said during my evidence, any material that has a heat of combustion, strictly speaking, is not non-combustible. So the mineral wool is non-combustible from a regulatory perspective, but not necessarily from a physical perspective.
Q. Yes, thank you.
Now, I would like to turn, please, to work package 1. Can we go to {LBYWP100000002/5}, paragraph 29. There you say this:
"Under the most severe heating conditions used in my experiments, I observed short lived surface spread of

flame over the polyester powder coating of samples of Reynobond PE ACM."
Are you able to say what the likelihood is that there was some surface spread of flame over the Reynobond PE ACM in the early stages of the Grenfell Tower fire?
A. That's a very difficult question to answer. The footage that we assembled at Phase 1 didn't show any obvious surface spread of flame over those panels in the early stages of the fire. As the fire grew, it's very hard to say where that spread of flame was occurring, whether it was a consequence of burning of the polyethylene core or a consequence of the powder coat. So, I mean, that's a very difficult question to answer.
The amount of energy that would be liberated by any burning of the surface coating would be very, very small in comparative terms, if you compare it to the amount of energy that can be liberated from the polyethylene core. So I wouldn't think -- I think I intimated as such in my report -- that that's a hugely significant observation.
Q. Then if we look at the heading below that, it says "Aluglaze Window Infill Panels". Let's look at paragraph 33 there, still on page 5. You say:
"The Aluglaze window infill panels are comparatively easy to ignite, provided that even a small area of XPS

foam is directly exposed to heating. This is due to the low thermal inertia of XPS foam. It is noteworthy that the low thermal inertia is also the reason that XPS foam is desirable as a thermal insulation in buildings."
Given the conclusions that you have derived from your experiments in relation to the Aluglaze infill panels, are you able to reach any conclusions on the potential contribution of the ignition of the Aluglaze infill panels to the ignition of other elements of the façade?
A. Again, challenging to say definitively. I mean, the reason that comment is in there is because we have evidence from Phase 1, from memory, that suggests that the extract fans that were located within small pieces of infill panel, essentially the same product, in the kitchen windows of the flats, flat 6s, all the way up the building, those extract fans softened and fell out quite early on in the fire, and certainly the footage that we have from the fire of the kitchen window of flat 16 early in the fire suggests that the extract fan had fallen out and, you know, you can see a circular hole in that small panel of window infill panel material.
If the extract fan falls out of that infill panel, then around the circumference of the hole where the fan

was sitting, you will have had exposed XPS foam insulation. That foam insulation is quite likely to have both softened and melted and dripped and ignited, and will have contributed to burning in that location and will have contributed to flaming that is likely to have impinged on the ACM.

So that's quite a long—winded answer, but I think the answer is: it's certainly possible that ignition and burning of the XPS core of the window infill panel that was holding the extract fan will have contributed to some extent.

Q. Are you able to quantify that contribution?

A. No, not in any sort of meaningful way. You know, other —— you have a fire in the kitchen that is quite a well developed fire and is venting flames out the window, and would have been regardless of the burning of the infill panel. So I would say some additional flaming, some additional energy release. Quantifying that, you know, whether we're talking 1% or 10% or 20%, I wouldn't be able to say with confidence.

Q. Moving on to Celotex RS5000, if we go to page 6 of this same report {LBYWP100000002/6}, please, you say this at paragraph 45:

"Furthermore, I have found that without [in italics] its aluminium facer Celotex RS5000 is comparatively very

[in italics] easy to ignite. The PIR foam core of Celotex RS5000 has very low times to ignition — a direct consequence of its comparatively very low thermal inertia."

If RS5000 had lost its aluminium facer, what is the likelihood, can you tell us, of the ignition of the PIR foam if it came into contact with downward flowing XPS?

A. So you have downward flowing XPS and you have Celotex RS5000 without a foil?

Q. Yes.

A. Yes, I mean, I think it's going to ignite. Whether that ignition or the extent to which subsequent burning would be sustained is a more challenging question, but I think, you know, this PIR insulation without a foil facer, when it's exposed to a heat flux of, you know, more than something in the range of 25 to 30 kilowatts per square metre for any appreciable amount of time, ignites very quickly, as we saw in my work package 1 experiment.

Q. So do we take from that answer that the relevant heat flux to make XPS drip and flow would be enough to ignite unfaced RS5000?

A. Again, it would depend on the duration, so it's not necessarily just the magnitude of the heat flux, but I think if you've got burning, dripping, flowing XPS,

then you probably have enough heating to ignite Celotex without a foil facer, yes.

Q. What is the likelihood —— this I think flows, as it were, from the last answer —— of downward flowing flaming XPS coming into contact with non—faced RS5000 in the geometry at Grenfell?

A. I don't think that that likelihood is very high, if I'm being honest. I would have to think quite hard about the configuration, which I don't have in front of me, of the —— so the Aluglaze window infill panels at Grenfell Tower sat within a system of aluminium rails that made up the window assembly. So you essentially have an aluminium framing around those infill panels. So getting the XPS out of the window infill panels, notwithstanding my comments about the small panels that house the kitchen extract fans, you know, there has to be a route for the XPS to get out, if you like, of the aluminium framing.

You've got two aluminium sheets. The XPS between the aluminium sheets would melt and start to flow and drip within the infill panel. As it gets to the bottom, it finds an aluminium frame. The extent to which it can come out of that frame will depend on a whole host of factors. Then, if it comes out of that frame, where it goes, I think you would have to look very closely at

that interface between the aluminium framing and the cladding below the windows.

From memory, I think I probably would consider that reasonably unlikely. I think it would more likely —— if the ACM cladding were still in place, beneath the window, I think I would consider it more likely that that XPS, the melted, dripping XPS, would flow over the outside surface of the ACM, from memory.

Q. And, therefore, not come into contact with RS5000, whether foil faced or not foil faced at that point?

A. I mean, eventually, probably, yes, given that the ACM is probably going to ignite and burn quite vigorously and disappear, and eventually, yes, you're going to find some insulation there. Certainly below the windows, the way the Celotex insulation was cut and formed within the cladding cassettes below the windows, again, from memory, the top edges of the insulation panels, if you like, did not have foil facers on them. They were cut to an angle, so that you get a sort of down slope on the ACM panel below the window. So if the ACM were removed, then you do have exposed Celotex at that location beneath the window.

But it becomes a question of, you know, whether we're in an upward fire spread mode or a downward mode or a lateral, horizontal kind of mode.

Q. If we turn, please, to page 7 of this same report {LBYWP100000002/7} and go, please, to paragraph 49, you say there:
"From my experiments to date, it appears that flat samples of Celotex RS5000 tested in isolation do not significantly spread flame horizontally [in italics] in the absence of an applied external heat flux. Additional experimentation is required to confirm this."
What additional experiments would be required to confirm that, in your opinion?
A. I would want to do a lateral ignition and flame spread type testing, both with and without the foil facer. So it would be similar -- you know, you could do something similar to a BS 476-7 lateral flame spread test. Yes.
I mean, I have to say, based on our experiments, what I expect you would see is that they would not spread flame very enthusiastically at all. Yes.
Q. And in the fire at Grenfell, would the RS5000 have been the subject of an applied external heat flux?
A. Can you repeat the question?
Q. Yes. Would the RS5000 have been the subject of an applied external heat flux?
A. Again, it depends on whether we're talking about -- it depends on where the insulation is on the building, obviously, but, I mean, yes, if you have a large

external fire burning, then you have a large heat flux, yes.
Q. Yes. And the source of that heat flux would have been what, in your view?
A. Early in the fire it would have been burning polyethylene from the ACM. I mean, very early in the fire, as we're talking about the fire getting from the kitchen out into the insulation -- out into the cladding system itself, that source of heat flux could have been the kitchen fire itself. You know, I talked last week about the potential route of fire spread through the side of the window and, in that situation, the kitchen fire would have provided the heat flux. As the fire grows, you've got most of the heat release, as I said last week, is probably coming from the polyethylene, from the ACM. So, in an upward fire spread mode, you're likely going to get the heat flux coming from that fire plume. As the fire reaches the crown, starts to go around the crown and you have dripping polyethylene down the building, then it gets slightly more complicated, in terms of where do you have polyethylene collecting, pooling, generating pool fires, igniting other materials et cetera. At that point it gets complicated, probably beyond the point that I could say for sure, although in every case, as I've said, my view is that the ACM PE and

the burning of the polyethylene is what's contributing the vast majority of that heat flux.
I should also say that, of course, as the fire spread past flats in Grenfell Tower, either up, across or down the tower, it typically ignited fires within the flats, and those fires then burned as, you know, typical, if you like, compartment fires, ventilation-limited compartment fires, and you have fire plumes coming out the window for extended durations of time, given that the fire service couldn't do anything about those fires. So then you have very significant external heat flux coming from the fire plumes generated by those fires over long periods of time.
Now, those heat fluxes and those exposures of the cladding products are on timescales that are typically much longer than those that would be relevant to the external fire spread, and under those -- I mean, it's actually quite an important point, you know. After the fire, when we went to look at Grenfell Tower after the fire and we did, you know, a walk-around survey of the entire external surface of the building, once the scaffolding had been put around the tower, and we examined the insulation, you know, the extent to which the insulation boards had charred or been burned in the fire. You know, the question is the charring of the

insulation that you observe when you walk around the fire (sic), you know, days, weeks, months after the fire has been put out, to what extent is that charring evidence of charring that will have occurred as the fire was spreading, or to what extent is that charring that will have occurred as a consequence of the fires burning in the flats over long durations once the spreading had essentially occurred in the ACM PE was long gone?
So that's quite a long-winded answer to your question, but I think it's important to think quite hard about the durations over which the materials and products that constituted the external wall arrangement, the durations over which their burning occurred, because products that release a lot of energy very quickly are much more hazardous from an external fire spread perspective than products that might contain similar amounts of energy but burn very, very slowly under different circumstances, and that's a very important distinction.
Q. Yes, thank you.
Sticking with page 7 {LBYWP100000002/7}, can we look, please, at paragraph 51, where you say this:
"However, the ease of ignition of Celotex RS5000 may be relevant as regards initial growth of the fire outside the kitchen window of Flat 16, where - without

protection from foil facer or aluminium tape at a cut edge — it could have been one of the first (or possibly the first) cladding materials ignited, thus promoting ignition of other materials that were present at that location (for instance the PE filler/core of the Reynobond PE ACM rainscreen cassettes)."

Can you explain the mechanism by which the ignition of the RS5000 may have promoted the ignition of the PE filler or PE core of the Reynobond PE ACM?

A. I mean, simply that if something ignites and starts to burn, then it's going to liberate energy. That energy is going to go somewhere, and if that energy goes, you know, into the ACM, so to speak, heats the ACM and starts to mobilise polyethylene, which can then ignite, then that would be the mechanism. The mechanism is simply that the burning of the insulation liberates energy that could then be used to heat the ACM and cause its burning.

Q. And what about other elements of the façade?

A. I mean, there were other things in the cavity. You had the uPVC window frames, which would have been adjacent to that location, which can burn. You will have had the EPDM rubber membrane around that location, which can also burn. You had, you know, spray foam, bits of timber, various other things in the cladding system at

that location.

So there's a variety of things that could burn in that location, which is one of the reasons why I say, you know, it's very hard to say with any certainty what was the first item ignited, and whether the first thing ignited would have continued burning in the absence of the other things is really difficult to unpick.

Q. Are you able to quantify the amount of energy that the RS5000 would have allowed to be fed back to the other cladding components?

A. I mean, as I sit here, you know, if we're talking specifically about the configuration that existed at Grenfell Tower, I think no is probably —— I certainly wouldn't want to attempt it as I sit here.

My work package 1 experiments do quantify the types of energy release or heat release that we would expect from the various insulation products, both with and without foil facers, under a range of heat flux conditions, and all of that work suggests that the energy contribution from the insulation products is quite small, and that's probably the best quantification I could give you, you know, comparatively quite small if you compare against something like the polyethylene from the ACM, once it starts burning.

Q. Right. Now, you say "quite small"; do I take it from

that that you are not able to attribute a reasonably precise percentage?

A. I mean, this is something that I've discussed within my team at Edinburgh a lot. One of the challenges is, of course, we've performed experiments where we have quantified a number of things under a range of conditions. None of those conditions are exactly what was at Grenfell Tower; they are all representative of the physics, but we can't say for sure what was happening at Grenfell Tower in the cladding. That's one of the challenges when you go from the lab to reality.

I was discussing this point within my team quite recently, because I expected I'd be asked this question, and, you know, the best I can say is that I think the contribution from the insulation in that initial environment and even to the upward fire spread is probably less than 10% of the overall contribution. Something like that. I mean, it could be 2%, it could be 10%.

Q. Before getting too hung up on figures, are you able to say —— well, two things.

First of all, flowing from that last answer, does the answer to the question I've just asked you depend on where in the building and at what point during the fire, treating it as a single entity, you are looking?

A. I think so, yes. Yes, I mean, the work that I've done to date has focused pretty heavily on the upward, you know, the fire going from a small fire to a big fire in an upward mode. How the fire goes from a small fire to a big fire in the lateral or the downward mode is more complicated, yes.

Q. Just pinning that down a little bit further if I can. You used the expression "going from a smaller fire to a bigger fire". Doing the best you can with a particular point, whether in timing or in quantitative terms, maybe that's the point at which the fire becomes out of control of any reasonable FRS, if that's a possible bridge point, but at that point, what would have been, up to that point, the contribution, in percentage terms, if you can, of the RS5000?

A. Up to the point that the fire is "out of control" and spreading quickly up the building?

Q. Yes.

A. Less than 10%.

Q. Secondly, less than 10%; would you say that that was negligible, or would you say that it was small but still materially contributive?

A. I mean, I guess, again, it depends what we mean by "contributive". I presume in your question that we're talking about the contribution of the insulation via its

combustion, rather than the contribution of the insulation by its presence, if you like.
Q. Yes.
A. Because, as I explained last week, when I gave my presentation, the fact that the insulation has a very low thermal inertia and is very insulating is critical, absolutely critical. So if there had been no insulation there whatsoever, whether Kingspan or Celotex or mineral wool, the outcome may have been quite different; significantly different, more than 10% different. The fact that that insulating material is also contributing energy by its burning is what I'm referring to the 10%.
Q. Yes.
A. So that's probably quite an important distinction for me to make.
Q. Thank you for that clarification.
Let's turn to your report dealing with Kingspan K15, page 9 {LBYWP100000002/9}, please, paragraph 65. Same report, page 9, paragraph 65. You say there:
"However, the ease of ignition of Kingspan K15 may be relevant as regards initial growth of the fire outside the kitchen window of Flat 16 (if it were present in this location) where — without protection from foil facer or aluminium tape at a cut edge — it could have been one of the first cladding materials

ignited, thus increasing the local heat flux and promoting ignition of other materials present (for instance the PE filler/core of the Reynobond PE ACM rainscreen cassettes)."
Are you able to describe for us the mechanism by which the ignition of the K15, as you say, could have promoted the ignition of the PE core of the Reynobond PE ACM as well as the other elements of the façade?
A. I mean, I would give the same answer I gave previously for Celotex effectively, yes.
Q. When you say "could have been", would you give the same answer in response to the question of quantification?
A. That's right, yes.
Q. If we go to page 26 of this report {LBYWP100000002/26}, please, you say this at paragraph 165 at the top of the screen:
"Unlike polyethylene, both PIR and phenolic polymer foam are thermosetting polymers (i.e. they will char on heating rather than melting and dripping or flowing). As a consequence, it is the extent to which PIR and PF foam ignite and spread flame over their surface that is of primary interest, along with the extent to which they do, or do not, continue to contribute to heat release and flame spread over the timescales relevant to consideration of external fire spread during the

Grenfell Tower fire."
Given the absence of melting, dripping or flowing from PIR and phenolic polymer foams, what is the mechanism by which the PIR and phenolic foams contribute to the external fire spread?
A. By insulating the cladding system and making sure that the heat is retained within the system and fed back to the ACM, which exacerbates the burning of the ACM, and by liberating some admittedly small amount of energy via their own combustion, potentially by spreading flame, although I think the flame spread characteristics are probably not that significant, particularly if you had a foil facer in place.
Q. Yes.
Now, if you then turn to page 27 {LBYWP100000002/27}, at paragraph 169 you say, under the heading "Products and Materials under Investigation":
"I decided, however, not to use the cladding products removed and retained from Grenfell Tower for my Phase 2 experimental programme. I made this decision because I felt that I would be unable to guarantee adequate control (by others) either of the chain of custody for these products or the specific origin of the various samples; nor could I be completely certain that the products had not been damaged in some way due to

their installation on the Tower, their in-situ service experience, some exposure to heating during the fire, or mechanical damage during their removal."
Do you consider that, as a consequence of that decision that you have described there, you would have been unable to take account of any alterations or modifications to the cladding products which resulted from the manner in which they were installed or the means by which they were affixed to the façade of the tower?
A. I mean, none of the experiments that I've performed intended or even tried to simulate or reproduce those issues in any way that I would say is directly applicable to Grenfell Tower. We were much more interested in understanding the mechanisms by which the different behaviour -- well, what the behaviours would be and then the mechanisms by which those behaviours would manifest in the products.
So, no, I don't think I would agree with that statement.
Q. Right. But focusing on the consequences of your decision not to use the cladding products removed and retained, did that materially or should that materially affect the conclusions?
A. No.

Q. So do we take it from that that you didn't think it was necessary to take account of the exposure of the PE core resulting from the installation of the product in cassette form?
A. In the experiments that I performed, we did certain things to the ACM panels, certainly in the work package 2 experiments, that were intended to ask questions that were relevant to whether or not the panels were installed in a riveted form or a cassette form. So, for instance, as I showed in my presentation, we intentionally routed the rear face, the face of the ACM panel that was facing in to the cavity, in our work package 2 experiments because we recognised that the opening up, the separation, the removal of the inside aluminium face in a cassette configuration would probably drastically affect the burning behaviour, and that's certainly something that we observed.
We also performed —— and I didn't present the results of these experiments last week —— some of the experiments that are presented in my work package 2 report where we intentionally, if you like, overly routed or overly riveted the ACM panels. So we performed experiments where we looked at the time to escalation, the manner of failure, heat release rates, peak heat release, et cetera, where the ACM panel, in

addition to being the baseline configuration that I showed during my presentation last week, we added, let's say, rivets to the ACM panel. So we intentionally secured the inside face of aluminium to the ACM panel so that we could see what the influence of that would be. And we did that, actually, in a number of configurations. So, you know, we riveted the entire panel and observed what differences in behaviour manifested in the experiments, or we riveted only the top half of the panel and left the bottom half free to open up. We did experiments where we intentionally routed horizontal lines over the aluminium face on the inside of the ACM panel to see what would happen if you had more exposed lines of ACM core and smaller aluminium inside surfaces that could mobilise in a different way, and we did observe differences in behaviour.
So, you know, we've asked —— in those experiments, I asked a number of questions that I think are relevant to understanding why the manner of fixing could matter, and I think have pretty clearly demonstrated, at least for myself, that the presence of rivets and routing can be very important in terms of the timescales over which things occur.
Q. Now, two things.
First, I think you're drawing a distinction, which

I may have blurred accidentally in my answer, between workmanship and in—use experience of the particular panels at Grenfell. Just to be clear, that's what you've excluded under 169 here; is that right?
A. What I've excluded under 169, if you like, is the manufacturing and materiality of the products themselves. So the concern that I'm trying to express in 169 here is a concern that, given that there was a very significant fire at Grenfell Tower and given that that fire lasted for hours and hours, and given that there was a lot of downward mobilisation of polyethylene in that fire, you know, there were significant portions of the building, of the cladding system at Grenfell Tower, that looked relatively undamaged, let's say. The Metropolitan Police Service took all of those products, the undamaged products, and they put them in a warehouse, and they used those products for experiments so that they could understand, you know, what products precisely had been used, what classifications they would achieve, et cetera, et cetera. The Metropolitan Police Service forensics team, working with BRE, did a whole host of things to try to understand those products.
When it came time for us to perform the experiments related to my Phase 2 work at Edinburgh, the question

was whether we should ask the Metropolitan Police Service if we could have a substantial amount of materials that they had stored that had come off the tower, and whether we would be able to get from them a suitable volume of products that would allow us to undertake the work that we wanted to undertake, recognising we were going to need quite a lot of each of the products in order to perform, you know, the very large number of experiments that we ended up performing.
So the two concerns were, one, maybe that much product wasn't available via the MPS, given they needed some of it for their purposes, and we certainly didn't want to deprive the MPS of the product that they would need in order to conduct, you know, criminal work et cetera, and so if we're going to —— so where do we get the product from? And the answer is we get it from the corporate CPs to the Inquiry, but, of course, if one goes down that road, one has to be sure that what one is given by the corporate CPs is fairly representative of what was on the tower.
So that's what I'm expressing there. We recognise that probably we're going to have to go to the corporate CPs to get the products, and we wanted to have some confidence that what we were being given, you know, hadn't been fiddled in any way, let's put it that way.

Q. Right. But were you also seeking to eliminate error in your own methodology by using products which had actually been used as a result of ——
A. Yes. I mean, it's very difficult to know with certainty if any particular piece of cladding that we might obtain from the MPS was actually undamaged or had not been altered in some way, had not been heated in some way during the fire, but that was much more about the thermal history of the sample than it was about the manufacturing or installation history of the sample.
Q. The second thing, just to draw out from what you have just been telling us, is that there is a distinction between non—use of the materials actually used at Grenfell Tower, which you've covered at paragraph 169 and what you have just said about that, on the one hand, and, as it were, pre—designed installation or fixing methodologies, use of bolts or rivets on the one hand or use of cassettes on the other, which were the subject of analysis by your team.
A. That's right, but not insofar as we were attempting to recreate the conditions at Grenfell Tower. We were simply attempting to understand.
Q. Yes.
Can you tell us, I know it is in your reports and your data, but can you summarise for us what you

concluded as a result of the experiments done where rivets where applied?
A. That the presence of rivets substantially —— and obviously with all sorts of caveats about how many rivets and where and of what type, et cetera, et cetera. But if one manages by any mechanism in one's installation of ACM PE panels to prevent the aluminium skins from opening up, either with rivets or with framing or bracketing or, you know, I'm aware that over the years, in standardised testing of ACM products, sometimes little U—sections of metal were put round the edge of panels to try to keep the faces together, that will improve performance.
Now, in our experiments, what that tended to do was to make it take longer for escalation to full involvement of the ACM to occur, but you still do get, eventually, full involvement of the ACM, and you still do get approximately the same total amount of energy release.
So the presence of rivets or the presence of any mechanism that holds the aluminium skins together, what it does is it prolongs the time until things go really bad, until you get a lot of burning and you get this rapid escalation. That's, for me, very relevant to a number of questions and pieces of evidence that the

Inquiry has heard. You know, the fact that riveted systems are apparently able to achieve a class B result in the Euro classification system when tested in an SBI, but a cassette system does much worse. What's interesting about that is that if you let an SBI test run with a riveted system, my expectation is that eventually you would see the same result. It's just that, because of the timescales that are involved, you don't necessarily push the panels to that point.
Again, within my team, my colleagues will hate that I use this terminology, because we argued about it quite a lot as we were doing the work, but I started referring to these ACM products as "tipping point" products. So there's a moment where things go from not so bad to really bad, and if you pass that point, all bets are off, and if you don't, then things can sometimes look like they're not quite as bad as they might be a minute later. That's one of the reasons these products are so dangerous, is because they display this very volatile behaviour.
Q. Yes, thank you.
Now, moving on to page 32 of your report {LBYWP100000002/32}, you explain there —— in various places, but let's pick it up at paragraph 184 —— that you are aware that the Celotex insulation boards used at

Grenfell were, I think, typically produced on two different production lines —— this is paragraph 183 —— called the Hipchen and the Hennecke lines. At 184 you say this:
"Celotex (via Linklaters LLP) have provided the Inquiry with a detailed account of these differences. I have not been table to quantify the possible influences of these differences on the reaction of these two thicknesses of Celotex RS5000 products to heating, aside from a brief comparative evaluation of the response of the RS5080 and RS5100 products supplied to me — this comparison is presented in Section 8.7.3. I do not, however, consider it likely that the temporal variation in manufacturing inputs/processes is significant."
What do you mean there by "temporal variation"?
A. Okay, yes, so I'm not a polymers chemist, nor am I someone who manufactures polymer foams, but the base chemistry of these products didn't change a whole lot. It seemed to me, in reviewing that information, that there were little tweaks and changes and decisions made by the manufacturing operatives in terms of, you know, a little component here, little component there, probably based on things like the temperature in the facility that day, potentially ambient relative humidity

and things like that that might influence manufacturing. I don't know. So, I mean, I would hesitate to put too much stock in that.

If the Inquiry feels that the changes in, let's say, chemical inputs to manufacturing process over time warrant investigation in terms of the possible outcomes for the resulting product, then I would probably insist that the Inquiry ask a polymers manufacturing specialist rather than me.

Q. But it's really the word "temporal" I was asking about.
A. Yes, "temporal", I just mean in time. You know, if you look at the data that we were provided -- again, from memory, it was quite some time ago I looked at this -- there's little adjustments that are made to the manufacturing process in time.
Q. Right.
A. And I felt that that was probably unlikely to significantly alter the outcomes of what we would observe if we took a piece of the product and tested it in some way. You know, it's not going to vary significantly any of the reaction to fire properties that we looked at, in my view, you know, heat of combustion, critical heat flux for ignition, those sorts of things. I wouldn't expect to see differences.
Q. Yes, I see.

If we go, then, to page 58 of your report {LBYWP100000002/58}, please, let's look together at paragraphs 328 and then 330 on that page, under the heading "Effects of Melting and Dripping".

At 328 you say this:

"In my Phase 1 - Final Expert Report I have identified that melting and dripping of burning PE filler /core material from Reynobond PE ACM rainscreen cladding cassettes played a critical role in both the horizontal and downward fire spread experienced during the Grenfell Tower fire. I have also identified that XPS foam insulation that formed the core material within the Aluglaze window infill panels may have been a secondary source of melting and dripping thermoplastic polymer."

Then at 330 you say:

"PIR and phenolic foam insulations, however, are thermosetting polymers which will not melt."

Are you able to explain how your experiments in work package 1 or work package 2 quantify or measure the extent to which RS5000 or K15 may have contributed to the downwards spread of flame?
A. I mean, in a direct way, the RS5000, in a direct way, won't have contributed to the downward spread, in that the RS5000 product itself isn't going to mobilise bits

of itself downward, you know, you're not going to get bits of burning PIR foam mobilising downward and spreading flame by that mechanism. Obviously, the extent to which those products insulate a cladding cavity where you might have other things burning is going to be relevant to the downward mechanism, in that, you know, if you have more heating locally, more melting of ACM, more mobilisation of PE, you're going to get more downward.

So for the Celotex, you know, in terms of the material that made up the core itself, no direct involvement, although a contributory involvement to the other mechanisms of downward, ie the melting of the polyethylene.

With respect to the phenolic, I would say largely the same thing, with the small caveat that we did observe that the phenolic foam or the Kingspan product did have a tendency to spall, to become mechanically detached from the face of the insulation when we didn't have a foil facer there, when there was no foil facer there to keep that material in place. So you would observe pieces of glowing phenolic foam that would detach and drop downward. That is a possible contribution to downward, although, again, you know, you're not talking a huge volume of material. These

pieces of material, in the absence of an applied external heat flux, would go out very quickly. They wouldn't continue to flame.

So it's not a huge issue, but it is a small distinction between those two products that I think is relevant.
Q. Right. Just to be clear, then, your findings were that RS5000 would not produce burning, flaming debris of any kind, but Kingspan K15 would?
A. Yes. I mean, although I would hesitate to say that Kingspan K15 would develop, you know, a lot of burning, flaming debris. I would say that we observed bits of glowing phenolic foam that would detach from the face of the sample and then drop downward, yes.
Q. So it's a qualitative difference, but you can't really say much about the quantitative difference?
A. That's right, yes.
Q. Yes, I see.

Then if we go, please, to ... Well, let me just ask you that: are you able to say or comment on the extent to which melting PE may lead to the involvement of PIR or phenolic foam into the fire through pooling?
A. Significantly, yes.
Q. Yes.
A. I mean, I think pooling of PE on surfaces within and

outside the cladding was very significant at the Grenfell Tower fire.
Q. Yes.
Now, you showed us last week, very helpfully, your drip tray in the work package 2 experiments.
A. Mm-hm.
Q. And we saw that from the video in particular.
Are you able to make any analysis or assessment for an experiment which was designed identically to your work package 2 experiments, but which replaced the drip tray you used there with an exposed edge of a sample of RS5000 or K15 or Rockwool?
A. You mean if instead of having a steel drip tray, we have a piece of insulation there?
Q. Yes. So molten, dripping, burning polyethylene falling on to unexposed(sic) RS5000 or K15 or Rockwool.
A. No. I mean, I'm not able to say anything confidently about that. We certainly didn't do it. We certainly didn't try that to see what would happen.
I suspect that, you know, in that scenario, you've got polyethylene dropping on to a very insulating surface, unless you've got mineral wool, where the polyethylene might actually, you know, wick into the fibres and, you know, I have absolutely no idea what would happen under those circumstances.

But one of the things that's interesting about the drip tray that I didn't discuss last week is when we were developing the experimental programme, as I mentioned last week, the reason we had the drip tray was because if you don't control, if you like, the pool fire that you get, the burning polyethylene pool fire that you get once the polyethylene starts to mobilise downward, you get polyethylene going all over the place, and you get a pool fire that is very hard to control the consistency of from experiment to experiment. So the drip tray was created or was placed in the rig so as to make sure that the pool fire we got was the same every time, and we could ask other questions that were perhaps more interesting in a more controlled way.
When we were doing our initial experiments to kind of finalise the procedure that we were going to use and the exact set-up, we ran experiments where we had the drip tray, but the drip tray wasn't -- I didn't mention it again last week, but the drip tray, you have a steel ledge underneath the ACM. On top of the steel ledge, you have a drip tray. Between the drip tray and the steel ledge, we had a thin piece of ceramic paper, which is essentially an insulating ceramic paper a couple of millimetres thick. When we ran an experiment without the ceramic paper, it didn't escalate; when we ran

an experiment with the ceramic paper, it did escalate. So we always used the ceramic paper.
Now, if we had left the burner in longer, you know, various other questions we could have asked about the extent to which we needed an input of heat to make the experiments escalate, but that fact indicated that the extent to which the polyethylene in the pool fire was kept warm, was insulated, itself as a pool fire, was relevant. So if you have the pool fire developing on a highly insulating surface, then probably it's going to make matters slightly worse.
Q. Yes, thank you.
If we then go to paragraph 331 here, same page, page 58 {LBYWP100000002/58}, you say:
"Melting and dripping of polymer filler/core materials can be expected to play significant roles in the responses-to-heating of both Reynobond PE ACM and Aluglaze window infill panels, since they will influence the extent to which the thermoplastic filler/core materials burn in-situ at the sample location, or rather in some other location once mobilised."
Can you explain what you mean by "since they will influence the extent to which the thermoplastic filler/core materials burn in-situ at the sample location, or rather in some other location once mobilised"? What do you mean by that?
A. I guess, in simple terms, I mean that it matters where the energy goes, or if the energy goes. So these materials, the polystyrene, the XPS and the polyethylene, are quite calorific materials. They have high heats of combustion. Where and when that energy that's essentially locked up in the material is released matters.
So if you have a lot of mobilisation of the polyethylene, the polyethylene in the cladding is no longer where it started, and where it goes matters, you know. So, you know, if the polyethylene drips out of the cladding and into the atmosphere and falls through the sky and lands on the pavement at the base of the building, which we did see some of that, then the influence of that burning polyethylene on the cladding fire locally has been removed. If, however, the polyethylene drips and pools in the shelf at the bottom of a cladding cassette -- you know, these cladding cassettes on the tower, certainly the spandrel panels, you have the face of the panel comes down, it comes in above the window, and then there's a little lip up on the back of that cladding. You've got essentially a perfect container for a pool fire of polyethylene sitting in your cladding. So every spandrel cassette at

Grenfell Tower is essentially a drip tray for burning polyethylene.
Q. On the inside ––
A. On the inside of the cassette within the cladding system, and that's ––
Q. And therefore looking at the foil facing of ––
A. Looking at the insulation, that's right.
Q. –– the insulation.
A. So, you know, you have a very efficient system for creating the worst possible fire in those cladding cassettes. You have a physical means by which to locally collect pool fires of burning polyethylene within your cladding, so that that energy can be released locally in the worst possible way, for upwards spread. Yes.
Q. Now, can we go to page 81 of this report {LBYWP100000002/81}, please, and go to paragraph 422. You have set out some graphs on that page under figure 32, measuring heat release rates for typical samples of ACM. At 442 you say this:
"The heat release rates from these small samples are comparatively low. It is noteworthy that the measurement resolution of the HRR measurements made by the University of Edinburgh's Furniture Calorimeter is insufficient to provide high fidelity data for such low

heat release rates. However this does not affect the conclusions drawn from these data."
Then you go on to say ... yes, I think that's probably enough for my question.
Is it your opinion that a feedback loop existed during the fire at Grenfell Tower?
A. I mean, yes. I mean, there's always a feedback loop when a fire grows, yes.
Q. Yes. Are you able to identify the elements of the façade which would have contributed to or created this feedback loop?
A. Anything that had a heat of combustion will have contributed to some extent to that feedback loop.
Q. Right. What would that include? Can you identify the elements?
A. I mean, in order of decreasing relevance, let's –– I mean, I can try to do that in order of decreasing relevance. I mean, the ACM PE, first and foremost. The insulation products, whether Celotex or Kingspan at any given location.
Q. Yes.
A. Then –– all of it, really. Any timber that might have been there, uPVC window frames, window surround insulation, EPDM membrane, spray foam, you know, anything that could burn will have contributed to some

extent. I mean, very minor in some cases, but yes.
Q. If we go back to page 77 {LBYWP100000002/77} and look at paragraph 411 next, you say there as follows:
"The heat release rate is central to evaluating fire hazard, since it determines the amount of energy released from a material that is available to be transferred back to the fuel via convection and radiation, thereby creating a positive feedback loop and possibly resulting in fire growth and/or spread."
Now, the heat release rate that you have generated, does that come from all of the components or each one individually?
A. I mean, the heat release rate that one measures when one observes a fire is going to represent, typically –– you know, if you're measuring the way we did in the experiments in the lab at Edinburgh, what we're measuring is the total heat release rate that comes from everything that may be burning. So, yes, everything.
Q. And when you say "via convection and radiation", are you describing there –– I don't want to put words in your mouth –– the effects of heating when a pool fire in a drip tray, so to speak, on the inside of the cassette on Grenfell Tower heats the insulation and creates rising heat –– radiates, but creates rising heat?
A. I mean, I think –– which paragraph is that in again?

Q. 411.
A. I mean, yes, I think 411 could be read almost without "via convection and radiation". Those words are probably not necessary. The key idea in that paragraph is that when you have heat release, the heat release rate is telling you how much energy is being released per unit time, and the more energy you have, the more likely it is that that's going to feed back to the fuel and cause the fire to grow. The convection and radiation are just the specific heat transfer mechanisms by which that would occur.
Q. Yes, I see.
If we go on, then, to page 104 of this report {LBYWP100000002/104} and look at paragraph 606, you say there, three quarters of the way down your screen, after the reference to the "Video Bisby":
"Based on the experiments performed on 100 mm x 100 mm samples of Reynobond PE ACM and Aluglaze, I would estimate that the majority of the polymer mass lost from samples incorporating thermoplastic filler/core materials (i.e. 50% or more of the polymer mass lost in all such experiments to date) was due to mobilisation of these polymers downward (i.e. dripping or flowing)."
What would have been the effect of the downward dripping or flowing of the polymer?

A. Twofold. I mean, (1) it would have removed energy from the local site of burning and taken that energy somewhere else, where else depends where the polymer goes; and (2), you know, in the conditions that we observed, certainly for the ACM PE, that polymer is burning whilst going where it goes, and so if it lands somewhere else and it continues to burn, which it appears to have done, then that's a pretty effective downward fire spread mechanism.
I mean, that's one of the reasons why, at Phase 1, I really focused in on the crown detail at Grenfell Tower. The upward fire spread mechanism is, you know, pretty straightforward. The lateral —— the horizontal fire spread mechanism at Grenfell Tower, which is, you know, quite unusual in terms of things we've observed in other cladding fires that involve these products, I believe is a direct consequence of the presence of the crown, and the fact that the crown provided a mechanism by which the fire could go around the building, and then the downward spread from the crown is what effectively makes the fire goes sideways. You know, the diagonal lines of burning that you saw on Grenfell Tower in the fire, and those diagonal lines, how they progressed around the building, are simply a manifestation of the flowing of PE down from the top

of the building, as opposed to, let's say, a classical lateral fire spread mode across the horizontal surface of the product.
Q. Yes, I follow.
Are you able to quantify the contribution to the intensity or propagation rate of the fire of the downward flowing or dripping polymer from Reynobond, or perhaps also with the Aluglaze, XPS?
A. Am I able to quantify it?
Q. Yes.
A. No. I mean, not in any useful way, I don't think. You know, quantify with respect to what? You know, I think that is the mechanism by which the fire goes down and around the building, I think. In the absence of polyethylene, it simply doesn't occur. You just simply wouldn't get the downward and then horizontal in the absence of the polyethylene.
Q. If we go, please, to page 111 of this report {LBYWP100000002/111}, paragraph 651, you say there:
"I felt it was important to satisfy myself, experimentally, that the ignition and physical/mechanical deformations of Celotex RS5000 PIR and Kingspan K15 phenolic foam insulations were broadly similar to the cases where they were exposed to heating on a cut edge rather than on a flat face with the foil

facer manually removed."
What was the importance of demonstrating the ignition and physical/mechanical deformations of the RS5000 and K15 that you describe in this paragraph?
A. I wanted to make sure that what I felt —— so earlier —— this is the work package 1 experiments. So the work package 1 experiments, as I discussed last week, we did experiments with and without foil facers and we observed how the insulation products behaved under those circumstances. But those experiments were performed by taking sheets of insulation and essentially peeling off the aluminium facers, and so the surface of insulation that was exposed in those experiments was the front face of the foam panel with the aluminium removed.
Now, that is probably, but not definitively , the same situation as you have at a cut edge of the polymer foam, because of the way these products are manufactured, because for the Celotex RS5080 product you have, as I mentioned at Phase 1, in—depth glass fibre meshes that are sort of in the insulation, in depth within the foam, and also the aluminium foil facer is somehow adhered to the foam in a way that, you know, we've not interrogated in any way, so the peeling off may leave some residue of something there.
So there's all sorts of reasons why —— and, you

know, I wasn't —— and we know that the locations in Grenfell Tower where we were concerned about the direct exposure of the polymer foam cores of the insulation products were situations where we had cut edges, not where people had intentionally removed the facers by peeling them off. So I just wanted to make sure that there was no substantive difference in the behaviour under those edge exposure conditions, both because they were the ones that existed actually in the tower, at Grenfell Tower, and because the peeling of the aluminium could potentially result in some differences in behaviour. But we didn't observe anything that I thought was particularly different .
So that work was really just confirmatory. I just wanted to make absolutely sure we weren't missing something.
Q. Yes, I see.
If we go on the same page, please, to 657 at the bottom, you say:
"For Celotex RS5080, ignition occurs within one second of heating exposure, and is followed by pyrolysis of the thermosetting PIR foam with continued minimal flaming. The overall response is sufficiently similar in appearance to this products' response when tested in a face—on heating condition (without a foil facer) that

I do not consider additional characterisation of edge exposure to be warranted. I consider the face-on exposure data to be broadly applicable to edge-on exposure."

What is the significance to the intensity or propagation of the Grenfell Tower fire of the response of the RS5080 which you describe there?

A. What those experiments showed was that, under pretty severe heating conditions, the behaviour of the PIR foam core within the Celotex product, when you actually exposed the cut edge, was broadly the same as it was when we exposed the samples with the aluminium facers removed. So all of the conclusions that I drew with respect to the no-foil RS5000 case in the work package 1 work are relevant. So, you know, easy to ignite, charring, reductions of heat release rates, you know, eventual cracking, maybe a bit of ongoing combustion in the presence of an external heat flux but pretty low heat release rates. All those sorts of things were equally relevant to the side exposure.

Q. Then, Mr Chairman, finally on this topic, before we have the break, if I may, page 116 {LBYWP100000002/116}, please, paragraph 680, you say there:

"Based on my experimental work, I have concluded that in most cases the majority of the PE filler/core

material is likely to have mobilised downward (i.e. dripped) during heating. This is likely to have been accompanied by flaming of the downwardly mobile material and the formation of pool fires where it was able to collect on horizontal surfaces both within and outside the rainscreen cladding system."

Now, there, when you refer to "downwardly mobile material", are you referring, just to be clear, to the burning, dripping, flowing polyethylene core material?

A. Yes, absolutely.

Q. Yes.

What effect would that burning, dripping, flowing material have on the propagation of the fire?

A. It's going to spread it. It's going to grow the fire, it's going to spread the fire.

Q. And pooling?

A. Yes, I mean, pooling of polyethylene means you're going to have a local pool fire burning with significant heat release. That energy is going to go somewhere. If it heats ACM or insulation, it's going to contribute to combustion of those products and you're going to have a bigger fire.

Q. In relation to the horizontal edges, you have described already very helpfully this morning the return internally into the cavity of the cassette, with the lip

that retains flowing, dripping, melting polyethylene. Are there any other horizontal areas within the cavity, other than that return?

A. Yes. I mean, so that was with respect to the spandrel panels that I mentioned that. The column cassettes also have little returns on them, not quite as substantial as the spandrel cassettes, and indeed at Phase 1 I presented some images and some video evidence where you can actually see polyethylene burning in the cladding system, kind of between the cracks of the column cassettes, I think on those horizontal surfaces, you have pooling polyethylene. You can see flaming in those locations, in cassettes that look otherwise intact.

I mean, the other location -- sort of, you know, ironically, given the purpose of cavity barriers -- is on cavity barriers that will have been installed within the system. You know, these cavity barriers kind of protrude horizontally out into the cladding cavity. They're made of a mineral wool insulation, and you could have polyethylene falling on to the cavity barriers within the cladding system, pooling there, burning locally and making matters locally worse for the cladding system, certainly for an upward fire spread mode.

Q. Yes, and that's internally. What about externally? Where would the horizontal surfaces be externally?

A. I mean, you have windowsills and various other locations such as that. On the outside of Grenfell Tower, there weren't actually a whole lot of horizontal surfaces on the outside of the cladding, if you like. Even the windowsill areas were inclined downward as soon as you got outside the glazing. There was almost immediately a downward slope to the cladding cassette.

MR MILLETT: Yes. Well, thank you very much, professor.

Mr Chairman, is now a convenient moment for the morning break?

SIR MARTIN MOORE-BICK: Yes, I think it is, thank you.

Well, Professor Bisby, I think it is time we had our morning break, so we will stop there. We will resume, please, at 11.35. You know the drill: please don't talk to anyone about your evidence while you're out of the room.

THE WITNESS: Certainly. Thank you.

SIR MARTIN MOORE-BICK: Thank you very much. Would you go with the usher, please.

(Pause)

Thank you. 11.35.

(11.19 am)

(A short break)

(11.38 am)
SIR MARTIN MOORE-BICK: All right, Professor Bisby, are you ready to carry on?
THE WITNESS: I am.
SIR MARTIN MOORE-BICK: Yes, thank you.
Yes, Mr Millett.
MR MILLETT: Thank you very much, Mr Chairman.
Professor, can we now turn to work package 2 and the report, which we will find at {LBYWP200000001}. There it is. We looked at it very briefly earlier. It is dated 15 December 2021.
If we go, please, to page 5 {LBYWP200000001/5}, paragraph 32, you say:
"The combustibility of the insulation product used has been shown to be of secondary, or even tertiary, importance based on our experiments (when ACM PE rainscreens are used). The combustibility of the insulation played an obvious role only when large surfaces were unprotected by foil facers, and were thus able to support ignition and widespread surface flaming of the insulation."
Does that mean that where foil facers were damaged or simply not present, such as on cut edges, the insulation did support ignition and widespread surface flaming?

A. Yes, the data that would underpin that paragraph would be data where we looked at the amount of mass that was lost -- sorry, maybe I'll step a couple of steps back.
So, as I explained last week, when we performed these experiments, the ACM panel was mounted on a scale that sat on a load cell, and the insulation products were also mounted on a load cell so that we could measure the mass loss with time as the experiments progressed. That enabled us to -- if you know how much mass is lost, and you know what the heat of combustion of the thing that's burning is, you can, in approximate terms, figure out approximately how much energy might have been liberated by that mass loss, if you like. So you can sort of figure out what the contribution of the different products is to the burning by using mass loss as a proxy measure of energy release, if you like.
When we did that comparison and looked at the loss in mass up to the point of escalation to full involvement of the ACM, we found that the mass loss from the insulation was only significant when its foil facer was removed, and that in some cases the amount of energy that would have been liberated, using mass loss again as a proxy for energy release, would have been about the same as was released from the ACM.
So that's where that comes from. I don't know if

that clarifies the point -- clarifies the question at all.
Q. I was more interested really -- but thank you for that clarification anyway -- in the question of damage to foil facers.
Let me try it slightly differently.
Do you think that, once the exterior cladding is on fire, damage to the foil facing is inevitable?
A. I mean, if the ACM PE is burning, then the foil facer is going to be damaged and removed at some stage, yes.
I mean, we saw that in our experiments. Once you have a significant amount of burning from the ACM PE, the foil facer was typically removed. You know, it would bubble and fray and ultimately fall off, yes.
Q. So taking it step by step, does that tell us that, at some point in the Grenfell Tower fire, the foil facer ceased to be protective against significant mass loss?
A. Yes.
Q. And therefore began to contribute to the total energy overall?
A. That's right. I mean, the -- yes, but, again, when that happens in the process of escalation is quite important. So, you know, at that point the ACM is already well away, let's say, and burning quite well.
Q. Yes. And in answer to that question -- you say it's

an important question -- when did it happen or does it happen in the escalation process?
A. When is the foil facer lost?
Q. Yes, at what (inaudible) point?
A. The foil facers, again, from memory -- without watching all the videos back, I wouldn't be able to say for sure, but from memory, it's in that region when the escalation occurs, either immediately preceding or as the escalation to full involvement of the PE occurs.
Q. We may be able to trace this through a little bit more.
Can we go to paragraph 49 on page 9, please, in this report {LBYWP200000001/9}. You say there:
"The condition that leads to rapid and irreversible fire growth has been identified as the mechanical separation (or otherwise compromising) of the ACM's inner aluminium skin, which exposes a large area of polyethylene to the fire in the cavity. This results in a rapid increase in the energy release from the fire and promotes rapid fire growth."
Is it the case that, once the exterior cladding has attained irreversible fire growth, which you describe here, that will in turn cause the insulation to burn as well, provided it's combustible, regardless of whether it's foil faced?
A. Yes. I mean, I think in a fire -- I mean, never say

never, but I think in a fire of that intensity, if you had an ACM PE rainscreen burning adjacent to a foil-faced polymer foam insulation with a cavity, then that insulation is going to get involved in the fire, definitely, yes.
Q. Then if we turn to page 63 {LBYWP200000001/63}, figure 17, we can see at the top of the page some photographs taken or selections of photographs taken from experiment 21, and you can see the line burner there as the method of ignition.
Do your experiments in work packages 1 or 2 quantify or measure horizontal flame spread from a single point of origin, as was observed at Grenfell?
A. No. No. I mean, I guess I might dispute horizontal flame spread from the point of origin as was observed at Grenfell, depending on what kind of horizontal mechanism we're talking about as well.
Q. Fair enough.
Given the small-scale nature, though, of the experiments in work package 2 and the absence of a whole system test, what conclusion, if any, can you reasonably draw regarding the contribution of the insulation to the spread and the intensity of the fire which did occur at Grenfell?
A. Yes, I mean, that is a very important distinction, and

something that it's important to be clear about is that these experiments were focused on growth of a fire from a small fire to a large fire in an upward fire spread mode. The consequent spread of the fire around and down the building is not addressed by these experiments. You know, it's very important to be clear on that. You know, one of the reasons why I laboured the point a bit in the first session this morning, you know, is to explain sort of what my view of the lateral and the downward is, associated with the burning of the polyethylene, rather than, you know, what we might call a classical horizontal or lateral fire spread over the surface of a product.
Q. If we go to page 121 {LBYWP200000001/121}, paragraph 644 at the foot of the page, it says this, under the heading "Contribution of Insulation to Total Release of Energy":
"The data presented in this figure are the total energy release that can be expected in cases where the cladding is allowed to burn without intervention until local burnout of the ACM (at which point the insulation also typically self-extinguishes, notwithstanding my previous comments regarding ongoing smouldering combustion of the Kingspan K15 insulation)."
What is "local burnout" of the ACM?
A. Yes. I mean, it's perhaps slightly imprecise words, but

what I mean by that is essentially until the polyethylene is not burning anymore at the location of the fire that we're interested in. Yes.
So basically the polyethylene -- there's no evidence of any further burning of polyethylene.
Q. Whether within the panel or anywhere else?
A. Or in the drip tray, yes.
Q. Right.
In relation to the figures of contribution played by RS5000 and K15 of the total energy released until the end of the experiment, I think we probably need the figures for those.
Can we go, first of all, to figure 33 on page 78 {LBYWP200000001/78}. Let's have that up first. You showed us this last week.
Then, again, perhaps have it side by side, page 123 {LBYWP200000001/123}, paragraphs 655 and 656. You give figures there of 20% and 53%, up to, as maximums, likely maximums in a worst-case scenario, for Celotex RS5000 and in 655 and K15 in 656.
Just taking that data and those opinions together, is it right that these experiments were terminated at 20 minutes?
A. Yes.
Q. Now, what would have been the impact on your conclusions

about the fire at Grenfell Tower given that it went beyond 20 minutes?
A. I mean, it's an interesting question. At the end of the 20 -- I mean, 20 minutes was chosen essentially arbitrarily, because in many of the experiments, anything that was interesting that was going to happen had happened or everything had gone out and there was no further combustion that we could observe from the rig beyond 20 minutes. So, you know, all the burning had ceased, if you like. I mean, how that relates to the fire at Grenfell Tower, as I mentioned earlier, at Grenfell Tower, as the fire spread around the building, it ignited compartment fires, which then burned within the compartments for much longer durations, and so you had further thermal exposure to whatever products might have been left on the cladding due to the fire plumes, so insulation in particular. So any insulation that would have been left, after the external fire had kind of spread away, gone away, the ACM was gone, that burning was able to continue because you had fire plumes coming out the windows as a consequence of the flats burning.
Remind me of the question again, sorry.
Q. Well, no, I can build on the answer, I think.
A. Okay.

Q. What was the basis of the assumption, as you say in the last answer, that anything interesting that was going to happen had happened within the first 20 minutes?
A. Ah, right, yes. So, yes, I've remembered now where I was going with my answer.
So in the case of experiments that involve the Celotex product, from memory, you know, by 20 minutes, everything had gone out. There was no further combustion that was observable at all.
In the case of some of the experiments with the Kingspan product, there was, as I mentioned last week, some ongoing smouldering of the insulation that occurred and, actually, in some cases that continued up to 20 minutes, and at 20 minutes we just sort of called it and said, "Okay, we're just going to stop at 20 minutes now". If we had let it run, whether that smouldering or the extent to which that smouldering would have continued beyond the end of the 20 minutes is anyone's guess. You know, the intensity of smouldering tended to decrease with time, so one imagines that eventually it would stop, but we don't know.
I mean, one of the things that was interesting about the experiments involving the Kingspan product, the K15 product, was that, you know, long after the ACM had burned away and there was little evidence of any ongoing

burning of the polyethylene, you still see this smouldering combustion ongoing, and eventually what actually happened is you get smouldering combustion essentially eats its way all the way to the back of the 100-millimetre thick Kingspan product, and you actually have smouldering combustion kind of coming out of the back of the insulation panel in our rig. That was something we didn't observe for the Celotex.
Q. Right. On Grenfell Tower itself, if that had happened, where would that heat have gone?
A. At Grenfell Tower, the insulation was butted up against the concrete of the building.
Q. I see.
A. So it would have gone, you know, to the concrete or would have been -- it would have been slightly different, because the smouldering combustion depends on the availability of oxygen and the extent to which energy is retained within the insulation.
I mean, to sort of highlight that point, one of the things that we observed that was interesting with respect to the smouldering was that the Kingspan products, when tested with the foil facer, seemed to smoulder better, if you like, than when they were tested without the foil facer, and that's because some of the foil facer inevitably remains in place after some

combustion and pyrolysis of the underlying polymer has started, and that foil facer, kind of counterintuitively, once you have some smouldering in the foam behind the foil facer, the foil facer actually keeps heat in the smouldering foam and makes the smouldering worse. So, in that respect, having the foil facer on the K15 product actually made the subsequent smouldering continue for longer than in the case where it wasn't there.
Q. I see.
A. So it's sort of a counterintuitive result.
Q. Well, it may or may not be counterintuitive, but would this be right: that it actually has a double effect; the presence of a foil facer protects the integrity and the combustion of the K15 for longer, but once there's combustion, but the foil facer remains in place in parts, it lasts longer?
A. Yes, the foil keeps energy out, but it also keeps energy in.
Q. Yes, that's an even better way of putting the duality.
Now, as you've said, you used a 20-minute cut-off period. Just standing back and answering the question in very general terms, as we have seen, I think, throughout the Inquiry, the testing regime has tests which have termination times. In general, what are

those termination times based on? What assumptions are made generally about a particular termination time?
A. I mean, typically our experiments were terminated or we chose to terminate experiments when we felt we'd observed what was interesting to observe --
Q. Right.
A. -- in simple terms. So it is essentially arbitrary.
But we would not -- I mean, I would never, as someone who is interested in the way the world works, terminate an experiment if I feel I still have something to learn from it. I mean, that's one of the really important things -- I presume we'll talk later about the testing regime and testing regimes associated with cladding products, but, you know, that's one of the kind of key messages for me overarching relevant to the question of rivets versus cassettes and my comments about the SBI experiment.
If you test an ACM PE product in an SBI and you test it riveted and it achieves some level of performance and you stop the test, and you test a cassette and it achieves some level of performance and you stop the test, you're missing information when you stop that test, particularly on the riveted system. You're missing the escalation, you're missing the shock and alarm of what these systems and products can do when

they are pushed too far, and that is a problem with fire resistance testing, with standardised compliance testing, is because these tests are run for 20 minutes, that means that people can manipulate their products to make it through the allotted time, without you observing maybe something that you might like to observe if you really wanted to understand what was going to happen.

So in our experiments —— that's a very long—winded way, with apologies, of answering your question, but I do think it's an important insight, is that if you want to understand how a product burns, then you should let it burn until you can't burn anything anymore, and that's the criterion that we used.

Q. Thank you, that's helpful.

Now, looking at Grenfell itself, as we know, the fire there spread from immediately outside flat 16 to the crown in the 20—minute period.

Taking all the evidence into account that you've seen, is it your view —— and tell me if this is not the case —— that the contribution of the insulation products to the total energy released by the ACM PE cladding occurred after the local burnout of the fire of the ACM PE?

A. I mean, interesting distinction in words here. I would —— again, I think the words that I've used in

the report are imprecise. Local —— I mean, I've used those words without defining what I mean by local burnout of the ACM. What I would mean by that is until there's no polyethylene burning anymore, but I think perhaps the more relevant question or the better way of phrasing that would be to say until local burnout of the cladding, of the cladding system, because in some cases you did have ongoing combustion of the insulation beyond the point in time when there was no obvious burning of the PE.

You know, it's quite hard, when performing these experiments, to identify with absolute precision when there's no more PE burning. You know, I think in the experiment that I showed last week, I think it was experiment 21, I think, where I showed the full progression of the experiment, highlighted some of the key moments, and I think the moment that we observed the last burning of PE in that was around 18 minutes of the 20 minutes. Whether that is a consistent 18 minutes or whether sometimes it's 8 minutes and sometimes it's 26 minutes, I would have to go back and look at the data to know for sure.

I don't think it's a hugely significant point because, at the end of the day, we're interested in how much energy is liberated by the cladding system, and

we're also interested in the timescales over which that liberation of energy occurs.

Q. When you say "cladding system" in that answer, do you mean the ACM or do you mean ——

A. I mean the external wall arrangement.

Q. The build—up?

A. Yes.

Q. I see.

Can you just help me, is it the case that energy released by the insulation products as part of that external wall build—up, after local burnout, if you like, of the PE ACM, was not relevant to the nature and speed of the spread of the fire at Grenfell?

A. Sorry, could you ask that again?

Q. Yes. Well, let me try it differently.

What was the contribution of the insulation at Grenfell Tower after local burnout of the PE?

A. I mean, I would say pretty minor. I mean, for the Celotex product, it stopped burning —— once the PE was gone, the Celotex wasn't really burning anymore. For the Kingspan product, the burning that was ongoing was much less severe, you know, smouldering and a little bit of flaming. So, yes, I think not very significant would be —— I mean, I'd struggle to put a percentage on it, but not very significant, yes.

Q. Now, if we go, please, to page 127 {LBYWP200000001/127}, I'll show you the paragraph, it's paragraph 685, but you say there that the experiments showed that the arrangements using non—combustible mineral wool insulation grew to full involvement of the ACM more rapidly than for the foil—faced combustible insulation products.

Now, in light of that conclusion, are you able to tell us whether the theoretical percentage contributions to total energy release attributable to different types of insulation products provides any kind of reliable indication of the relative contributions of those insulation products to the speed and extent of flame spread?

A. With apologies, could you give me the first part of that question again?

Q. Yes. Given the conclusion that you've set out in 685, which is that non—combustible mineral wool insulation grows to full involvement of the ACM more rapidly than the foil—faced combustible insulation, given that conclusion, are you able to tell us whether the theoretical percentage contributions to total energy release provided by each individual insulation product provides any kind of reliable indication of those contributions to the overall speed and extent of flame

spread where you have a PE—cored ACM system?
A. I think what it tells us, as I said last week, is that that contribution in comparative terms is relatively minor, if it exists at all. I mean, obviously the insulation materials are pyrolysing, they are liberating flammable pyrolysis products. Those products, in the present of heat and oxygen, are going to burn, so there is a contribution. You cannot —— I mean, it would be very hard to argue that there is no contribution. That contribution is probably comparatively minor.
But the other thing that —— you know, it's important not to oversimplify the —— I understand the question, but it's important not to oversimplify the complexity of the heat transfer environment within the cavity and the complexity of the interactions between the ACM and whatever is facing the ACM, whether it's foil—faced combustible or non—combustible or without the foil insulation.
That's really nicely shown, and this was the biggest sort of head—scratcher, if you like, for us when we performed these experiments, when you —— I have to be careful to make sure I get this right. When we tested the system with mineral wool insulation and we added the foil, the escalation occurred more quickly. When we tested with the combustible insulation products and we

added the foil, the escalation occurred less quickly. That's because the extent to which the insulation products can liberate energy, the extent to which the surfaces of those products heat, the extent to which the surfaces of those products reflect or re—radiate energy, and the extent to which the surfaces of those products can be heated by convective rather than radiation, rather than radiative heating, you know, the balance of all of those factors changes for each of those products. So saying for sure, "Oh, it must have been the energy liberated by combustion" is actually a very difficult thing to do.
So it's not —— I mean, what I want to say is it's not that simple. It's actually very, very complicated. But I do think it's fair to say that the contribution, as I said last week, to the total energy release of the cladding system, the external wall arrangement, during the course of the 20—minute duration of our experiments —— it's shown here on the graph that's on the screen. Given the combustible insulation, so the three leftmost sets of data, are not that dissimilar from the mineral wool data, the contribution from burning is comparatively minor when you compare with some of the other factors. The insulation, for instance.

Q. Now, if we go back to page 123 {LBYWP200000001/123}, we saw this earlier, and looked at paragraphs 655 and 656. There they are.
Is it right that the percentage contributions to total heat release that you set out there in relation to each of those products, RS5000 and K15, are calculated by expressing the heat released by the insulating product at the end of the experiment at an assumed 100% combustion efficiency, which is divided, I think, by the experimentally measured heat release by the ACM and the insulant at the point of local burnout, which is earlier?
A. I have to scroll up in the report to see —— because we've made a number of comparisons in terms of —— some of those comparisons are based on the mass loss measured during the experiment, some are based on the total mass measured at the end of the experiment. I think in this situation we're talking about the total mass loss from the insulation products.
So to back up a bit, before we ran the experiments, we measure the mass of the sheet of insulation that goes into the rig. So we weigh it. At the end of the experiment, we take that sheet of insulation off the rig and we weigh it again. The difference is the mass lost.
Q. Yes.

A. If you take that mass loss and you multiply it by the heat of combustion, you get the maximum conceivable amount of energy that will have been released by that product, and that maximum conceivable assumes that the combustion is 100% efficient. I think that is the basis upon which these numbers given here in these specific paragraphs are calculated, yes.
Q. Let me try to help you.
If you go back a page, please, to page 122 {LBYWP200000001/122}, on the right—hand side of the screen, you can see what the observations are that are the basis of figure 33 and the methodology you adopted there, just to remind you of what it was, and ——
A. Yes, so that would be based on the full 20 minutes.
Q. Yes. So the question is: is it the case that your calculations do not compare like for like for two reasons, but the first is that they mix different timescales? One is you're measuring total mass loss over the full period of the test, but you're also measuring heat release by the ACM up to the point of local burnout, which is earlier on.
A. We did do the two different things, yes, but I think here we're just presenting the 20—minute mass loss as a maximum conceivable value.
Q. Right.

A. Yes.
Q. Let me ask you slightly differently.
Is there any material flaw in the assumptions where you are measuring heat release up to the point of burnout in relation to the ACM, but up to the end of the experiment through the mass loss in relation to the insulating products?
A. Okay, I think I see what's happening here.
So I think that figure 33 is presenting the area underneath the heat release curve, if you like, for the experiments.
Q. Yes.
A. Whereas the numbers that we're discussing are based on the total mass loss from start to finish, and the question is which of those is the fairer comparison, I think is the question.
Q. Well --
A. And the answer is that the total heat release in figure 33 is the fair question.
When you take the mass of the insulation at the start of the experiment, you run your experiment, and then you take the mass at the end of the experiment, and you assume that all of that mass resulted in liberation of energy, you are, if you like, being unfair to the insulation product, because it's not the case that all

of the mass turns into energy. Right? It is the case that the conditions in which that combustion is occurring are not those that would exist within a bomb calorimeter, which is where you get the heat of combustion from, where you have, you know, 100% oxygen and you have the most efficient possible combustion environment.
Now, how much less efficient the combustion environment in the cladding experiments that we ran is as compared to the bomb calorimeter, I can't say. But I do feel that I've been quite clear in the way I've presented those data to caveat it by saying, "These are the maximum possible values we could ever expect". So this is sort of the worst-case scenario. If we assume that all mass turns into energy, this is as bad as it could possibly be. In reality, it's going to be somewhat less than that.
Q. Are you able to tell us whether the amount of mass lost between ACM burnout and the end of the experiment was material, was significant?
A. I mean, potentially, but only insofar as those are the words that I've used. With respect to what happens on a building, which is why we've done this, then, as I sit here, I think probably in my report, if I had the opportunity to amend the report, I would simply change

the words from "until local burnout of the ACM" to read "until local burnout of the cladding" --
Q. Right.
A. -- and then it would be fine.
Q. I see. So the answer is no, I think, there is no material --
A. In terms of the out -- in terms of my conclusions, no.
Q. Right.
Same question in relation to different combustion efficiencies as between the ACM PE on the one hand and each of these insulation products on the other. Are you not comparing like with like because you're mixing different combustion efficiencies?
A. Yes, probably, yes.
Q. Does that have an effect or impact on your conclusions?
A. No, because I don't think that my conclusions are based on calculations that assume 100% combustion efficiency. No, I don't think so.
Q. Is it the case that if, instead, you did compare like for like by comparing the heat release contribution from the insulation using experimental combustion efficiency measurements at the same points in time, namely at peak HRR, peak heat release, that the percentage contribution in respect of the total heat release from the insulation components would be lower than you've said?

A. It's entirely possible. I'm not sure that that's a relevant question. I mean, we're not interested necessarily in just what happens up to peak heat release. We're interested in how much energy is liberated at that location, period. I mean, you know ... so it's not simply a question of what happens until we get to the peak. It's a question of what happens throughout the full duration of burning.
So, yes, I think the answer is yes, it's possible that the contribution of the insulation up to that point might be less as a percentage, rather than the number I've given, but I just don't necessarily accept that that's an important question.
Q. Now, if we go to page 36 of your report here {LBYWP200000001/36}, paragraph 239, you identify the mineral wool insulation, and you say in the second sentence:
"The specific product chosen was a Rockwool duct insulation/lagging product marketed under the tradename Ductslab."
I think it's right that that was classified as Euro A1 and non-combustible under the national classification system; yes?
A. Yes.
Q. As far as you are aware, is that a foil-faced insulant?

A. Yes.
Q. And marketed in the UK as a rainscreen insulation product; yes?
A. I don't know if it's marketed as a rainscreen insulation product. Yes. I mean, I wouldn't -- it doesn't really matter to me how it's marketed. What I'm interested in is what it is. I'm interested that it's a non-combustible mineral wool with a foil facer.
Q. Right.
Now, I want just to ask you one or two questions about 8414.
We will come to the topic in more detail later, but in relation to the tests done under 8414-1 and carried out by the government following the Grenfell Tower fire, is it right to say that the nature and rate of flame spread on cladding systems incorporating foil-faced PIR and unfaced mineral fibre insulation behind PE-cored ACM have been found to be comparable at large scale and at intermediate scale?
A. Could you run that past me again, with apologies?
Q. Yes. Is it right to say, given the tests done under BS 8414 by the government after the Grenfell Tower fire in 2017, that the nature and the rate of flame spread on cladding systems incorporating foil-faced PIR and unfaced mineral fibre insulation, both in each case

together with a PE-cored ACM rainscreen, have been found to be comparable?
A. I mean, nature and rate, I might -- I mean, I don't know that we necessarily learn that much about the nature and rate from a BS 8414 test, which would be the basis upon which that question is posed, you know, referring to the post-Grenfell DCLG tests, I presume.
Q. Yes.
A. It is the case that, in those tests, the system with mineral wool -- that the test with mineral wool was terminated at a similar time to the tests with polymer foam insulation. But I think, from memory, in those experiments, that the mineral wool was used without a foil facer and the polymer foam insulations had foil facers, so there's a mild distinction there.
Q. Right.
Is it right to say the same thing, that the nature and rate of flame spread on cladding systems incorporating foil-faced PIR and foil-faced phenolic and unfaced mineral fibre insulation, in all cases with PE-cored ACM rainscreen, have been found to be comparable in modelling?
A. I mean, I'm aware that some modelling work has been performed, sponsored I believe by Kingspan. The veracity of that modelling and the extent to which that

modelling has been validated I think is a question that I've not looked at in very much detail. I'm aware that the work has been done and I'm aware that the conclusions of that work have been to suggest that there isn't a major difference.
I mean, Professor Torero, in his report, has commented on that in some detail, and I think those would be very appropriate questions to ask him.
Q. Right.
Now, having regard to all the available evidence you have seen, including your own experiments, are you able to provide us with an opinion about whether the nature and speed of the spread of the fire at Grenfell Tower would have been materially different had unfaced mineral fibre insulation been used as the insulating product behind the PE ACM rainscreen cladding instead of RS5000 and K15?
A. I can only base an answer to that question on the evidence that I have from the experiments that I've performed and, as I said earlier today, my view is that the combustibility of the polymer foam insulations, which is effectively what this question is asking me, will have played a role that was probably something less than 10% of the contribution to the escalation and spread of that fire in an upward fire spread mode.

Beyond that, it's very difficult for me to say one way or another. Yes.
Q. Thank you very much.
Now, I'd like to turn next to a different topic and a different report: your Path to Grenfell report of 10 November 2021. Let's have that back up, please. That is at {LBYP200000001}.
I just want to turn to page 4 in that {LBYP20000001/4} and run through the table of contents with you, where you set out the structure of your report. We can see there that it is divided into three parts, each with references, and an appendix A.
Now, part I is "The Purpose of Testing"; yes? You've set out there three categories of tests, explaining the differences between them and giving examples of fire safety tests in each category; yes?
A. Yes.
Q. So category 1: unrepresentative tests, category 2: model tests, and category 3: technological proof tests.
Then part II, foot of the screen, "The Path to Grenfell", and that's drawing together the various narrative threads relating directly to fire safety testing, research and investigation, as well as Building Regulations and the various pieces of associated statutory and industry guidance; yes?

A. Yes.
Q. Just on that, is it right that you begin that part of your report with an overview of the development of the building regulatory environment in England and Wales, starting in 1919, describing the deployment of particular fire safety tests within those regulations and the relevant guidance?
A. That's right.
Q. Yes. You also, I think, address a number of historic UK cladding fires on high-rise buildings, offering, I think, analysis not only of the fire events themselves, but subsequent investigations into those fires, such as Knowsley and Garnock?
A. To the extent that I was able to, yes.
Q. Yes.
Is it right that you also offer analyses of patterns of risk and vulnerabilities in fire safety which existed at the time of the Grenfell Tower fire in June 2017, as revealed by these different narrative threads? Yes?
A. That was what I attempted to do, yes.
Q. And you discuss a number of what you call "missed opportunities", where the statutory guidance and regulatory compliance testing regime could have been made simpler or less permissive, I think?
A. Certainly, yes.

Q. You've also got, if you turn the page, please, to page 5 -- it goes on, actually, to part III, "Closing Remarks", on page 7 {LBYP20000001/7}, and appendix A on the same page, which starts at page 268, which is about regulatory capture; yes?
A. Yes.
Q. If we turn very briefly to appendix A at page 268 {LBYP20000001/268}, we can see that it's headed "The Purpose and Evolution of (Fire Safety) Regulation". If we go in that to paragraph 1641, at the beginning, you say:
"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."
If you look at 1644, you tell us that:
"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."

That's right, is it?
A. Yes.
Q. You then offer, as we have seen, some closing remarks in part III.
Now, I would like to start with part I, if I can, and can we go, please, in that to page 13 {LBYP20000001/13}, paragraph 53. We start with some simple propositions, I hope. You start:
"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."
You say, if you go on in the same paragraph, a little lower down:
"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.'"
That's a quotation from Pinch 1993.
If we go to paragraph 54, you say:
"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.'"
And you quote from Downer 2007.
Now, you use expressions there, and we'll come back to this point in relation to large-scale testing later, but can you explain, in summary, why it is the case that the question is not whether a test is realistic, but whether it is sufficiently representative?
A. Why is that a relevant point?
Q. Yes, can you explain the distinction, the reasons for your drawing it?
A. Well, I mean, because of what it says in the first line of that paragraph, which is, you know:
"The purpose of testing is to allow an individual or an organisation to use the results ... to make a claim about how a material, product, or system will perform in a real 'in-service' [condition]."
Because one can never devise a standardised test that will reproduce exactly the end-use conditions of products, it's just not a practicable approach to testing, so one has to come up with a test that asks the

questions that allow oneself to make a claim about how the in-service performance is going to be, recognising that the test cannot reproduce reality.
So designing tests that ask the right questions, that are representative of the things that one wants to know about a product, is the trick with these tests.
Q. If we go to page 15 {LBYP20000001/15}, paragraph 64, you explain there as follows:
"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."
Then at 65 you say:
"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."
Just pausing there, what do you mean by "a useful correspondence with real-world performance" as distinct from a test which is realistic?
A. A test that tells you something that you can make use of in order to achieve satisfactory fire safety outcomes.

Q. What's the difference between that and realism?
A. Well, realism is not practicable. I mean, that's the kind of compromise that I'm alluding to in this section. You can't have a test that would realistically -- that would simulate end-use conditions for every product.
Q. I see.
A. So you have to have a test that tells you something useful.
I mean, there's a nice expression about models, right, which is that all models are wrong but some models are useful. You could say something similar about fire tests; you could say, you know, all fire tests are unrealistic, but some of them are useful.
Q. I follow.
Let's go to page 19 {LBYP20000001/19}, and at the top of the page there you identify, during the period 1932 to 2017, three categories of fire test used within the regulatory system in place in that period. You say that there are unrepresentative tests, model tests and technological proof tests.
Now, that taxonomy there, is that your own or is it one that's articulated and recognised in the literature?
A. No, that's a local taxonomy, if you like. It's mine.
Q. It's yours?
A. Well, mine, along with colleagues who I was working with

on these reports. So Graham Spinardi, who I have mentioned in appendix A.
Q. It's Grenfell-specific, your work-specific?
A. Correct, yes.
Q. I see.
Now, am I right to understand that it is important to understand the difference between these types of test, the purpose of developing them and what they were intending to measure or demonstrate in order to understand the limits of their credible use and application?
A. I mean, yes. I think it's important to think about what these different types -- which is why this taxonomy has been written down in this report. I think it's important to think about different types of tests, the basis upon which they were developed, how realistic or representative they are and, therefore, what burden of responsibility lies with those people who use those tests.
Q. Would it be right also to say that certain relevant fire safety tests in the UK were implemented and used in practice in the period before Grenfell in ways which did not align with the intention, the logic and the limitations of the test themselves?
A. That's my view, yes.

Q. Yes. We'll come to some specific examples of that shortly. But is the reason for that non-alignment regulatory influence? Is that one of your rationales?
A. I think -- by "regulatory influence", you mean the influence of regulatory processes by industry, for instance, or ...?
Q. It was a bit of a cryptic question, perhaps.
Is it the case that because the deployment of these tests within statutory guidance and practice, specifically ADB, gave them a specific status, that might have tempted people to ignore or perhaps misunderstand their applications?
A. I think the answer is --
Q. Their limitations.
A. Yes, I mean, I think I would say yes to that. You know, it's clear that the way people were -- it seems clear that the way people were thinking about what following the recommendations of Approved Document B was doing would indicate a misunderstanding of certainly this taxonomy of tests and the way that tests should be -- you know, for instance, the idea that one passes -- sorry, the idea that one performs a BS 8414 test, takes the data from the BS 8414 test, has those data classified in accordance with BR 135 and gets a free pass to use that combination of cladding products in any

variation on any building, is, in my view, a misconception of what that test is and what it's for and how it should be used.
Q. Yes.
Now, turning to the first category, therefore, unrepresentative tests, can you describe for us, in summary, the main properties or characteristics of unrepresentative tests?
A. These are tests that are typically very small, and they are tests that give you a piece of information which is used to try to make some claim, but which is essentially totally non-representative of an end-use condition, which is why I've called them unrepresentative tests. So they're tests where you ask a question; the way you ask the question is totally unrepresentative of any sort of real construction application.
Q. Right.
Now, if we go to page 29 in this report {LBYP20000001/29}, and let's look together at paragraphs 140 to 143, you set out the tests above that at paragraph 133 which, if we can just scroll up, we can see. You've got the BS 476s and the BS ENs there, the oldest of which dates from 1970, and you have set out a list of characteristics of paragraphs 139 to 143 there.

Are the tests that you list under that category those which deal with combustibility?
A. So part 4, part 11, 1182 -- yes, they are.
Q. I think you then provide an overview of the history of the development of combustibility test methods at page 20 {LBYP20000001/20}, paragraph 93, and you describe that as the potential of a material to burn; is that correct?
A. Correct.
Q. So when you say "combustibility", that's what you mean, is it?
A. In --
Q. In the context of these tests.
A. In non-regulatory terms, yes, combustibility to me would mean, yes, the potential of a material to burn. So, you know, in non-regulatory language, combustibility would be a material that can react with oxygen and thereby liberate energy in the form of heat and light, strictly speaking. So anything that has a heat of combustion is, strictly speaking, combustible. So combustibility is, if you like, an on/off switch; it either is or it isn't.
In regulatory terms, the regulatory system chooses to blur that a bit and decide that some materials that have a very, very small amount of combustible content, ie content that could react with oxygen and release

energy, can be deemed to be non-combustible. That doesn't make them non-combustible, it means they are deemed to be such.
Q. Am I right to understand that, by 2017, there were four independent test methods by which a manufacturer could demonstrate that a product was "non-combustible"?
A. Yes, that would be referring to the four that are listed.
Q. That's the four that are listed.
A. Yes, yes.
Q. If we go back to page 23 {LBYP20000001/23} at paragraph 109, and we don't need to read it all out because it's quite long, but is it right that you conclude from your review of the evolution of those various different test methods is that both the definitions of "non-combustibility" and the thresholds chosen for those definitions are arbitrary?
A. Yes.
Q. Yes.
A. Yes.
Q. Specifically, if we go to page 24 {LBYP20000001/24}, paragraph 116, is it right that you explain that there? In the third line you say:
"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."
A. That's right, yes. So, you know, what these -- I mean, I should probably say semi-arbitrary, rather than arbitrary. These lines in the sand that get drawn on, you know, the permissible heat of combustion for a product -- or, sorry, for a material to be considered non-combustible or limited combustibility, those decisions get taken by, you know, committees of people who decide where those lines should be drawn, under the assumption that something that would fall foul of those lines would burn too much and something that would not would not burn too much. But those are judgments that are made by people, you know, it's not a scientific truth, so to speak.
Q. Now, in the third line, just before that sentence, you say "at least partly arbitrary", and then you go on to identify the timing criteria for flaming.
Are there any other criteria which you would say were arbitrary?
A. All of them, I mean, are at least partly arbitrary. You know, so in the part 4 and part 11 tests, the chamber that the sample is lowered into is heated to 750 degrees

Celsius. Why 750 degrees Celsius? Why not 600 or 900? And the answer is because they tried a bunch of different temperatures when they were developing the test and they decided that 750 told them sort of what they wanted to know. Going to 900 was probably a bit difficult because it's quite hard to get something to 900, and going to 600 maybe didn't quite get things hot enough to observe the behaviours that you're interested in. So, I mean, that's an example. The size of the samples. The shape of the samples. Are they cuboid? Are they cylindrical?

If you look at the bomb calorimeter tests, 1716, ISO 1716 for instance, and you look at where the Euroclasses decide to draw the line between A1, A2 and B, those decisions were made by a committee of people sitting in conference rooms in Brussels deciding where that line should be drawn. Yes.

So insofar as these are committee decisions taken by individuals, they are arbitrary. They're not based on science, which is what I mean. You know, they're not -- as I said before, it's not a fundamental scientific truth; it's a decision that's taken.

Q. I see. Yes, that's clear.

Can we go then to page 45 {LBYP20000001/45}, paragraph 224. You say there:

"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."

That last sentence, are you able to clarify what you mean there?

A. Well, if we're thinking about, for instance, the Euro classification, the European classification system, so the European classification system uses ISO -- well, the bomb calorimeter test and the drop tests, similar to 476-4 or 11, to define A1 and A2 classifications, which are, you know, the non-combustible, limited combustible classifications. Once you get down into B and lower down, B, C, D, E, those tests aren't relevant anymore, because the products don't -- well, they're not non-combustible or limited combustible. So the differentiation between the combustible products is made not on the basis of the potential energy contribution on heat combustion; it's made on the basis of their reaction to fire in an SBI, predominantly. Yes.

Q. I follow. So you're really just focusing on the upper

end of the scale in that sentence?

A. Yes, I mean, what I'm trying to tease out there is that the heat of combustion is used to draw a line that those who drew the line considered to be, based upon my assessment -- I wasn't in the room -- quite a conservative line. You know, a material that has a heat of combustion of less than 2 megajoules per kilogram, to use my language from last week, is not a very burny material. No matter what you do to that material, the amount of energy you're going to liberate is comparatively small.

So, you know, you could have drawn that line at 10 megajoules per kilogram or 30 megajoules per kilogram, but they didn't, they chose 2, and the reason is because they wanted a conservative line despite the fact that they were acknowledging that they were allowing some contribution to burning, just very, very small.

Q. Right, and you say that consideration doesn't apply once you're down into B, C, D and --

A. Yes, I mean, you could have defined B, C, D and E. You could have said, "Well, if something can only be given a B if, in addition to achieving X and Y in the SBI test, it has a heat of combustion less than 15", or something. But they didn't do that, right? They just

set heat of combustion aside once they were down into the lower ratings.

Q. Let's turn, then, to the model tests, which is the second category of fire tests that you describe.

Am I right to understand that small-scale model tests are modelled on and underpinned by larger-scale research based on more realistic scenarios?

A. Typically, yes. I mean, that's the way that I've outlined them here, yes.

Q. Is it right that those scenarios, those scenario tests, are intended to be representative of real fire hazards which might be present in real buildings?

A. The models that are chosen as the basis for the model tests, yes.

Q. And the measurements in those small-scale tests are intended to -- is this right? -- correlate with the outcomes observed in the more representative scenario tests?

A. That's right. The hope when developing a model test is that one takes a model that is relevant to the fire. So the best example is the single burning item test in the European classification system. I mean, the BS 476-6 fire propagation test is also a pretty good example. Both of those test methods, the classifications that drop out of them are linked to a fire burning in the

corner of the room. So the model that is the scenario is a fire burning in the corner of a room, and then the hope is that you can make a test that doesn't require the burning of a fire in a room to infer what would happen if you used that product in a room with a fire in the corner, and then you don't have to burn a room every time you want to know the answer, you can do a BS 476-6 test instead, and still differentiate between products in a way that is faithful to what would occur in the room.
Q. Yes, and I think your report gives three tests which fall into that category: the BS 476-6, BS 476-7 and the SBI test, EN 13501-1.
A. Yes.
Q. Now, I think each of those tests has been described previously to the Inquiry by Dr Lane and others, so we don't need to go through the methods or the apparatus or the associated classification systems, but I just want to ask you one or two specific questions.
Is it right -- and I think it is right -- that for all three sets of tests, they can only be strictly applied to products, rather than materials, unless a product is homogenous?
A. Strictly, yes.
Q. Yes. Can you explain -- and this may be a very basic

question -- what is the difference between a product and a material?
A. I mean, that's quite a -- I'm sure we could argue this point all day.
When I think about it, it has to do with the homogeneity of the sample. So a product is often going to be something that is made up from different materials. In the context of this Inquiry, the most important case would be like a flat, layered product, like a foil-faced foam insulation or an ACM product. So if you take, for instance, foil-faced insulation. You've got a polymer foam, that is a material, and you've got aluminium foil-facers, those are materials. Now, it's slightly muddy in that case because the foil facers, certainly of the Kingspan product, are not just foil, there's fibres and various other things in there. But, you know -- and so for an ACM product, the aluminium skins are a material, the core or filler is a material, polyethylene, and so the product is a composite.
But you could have a product that is also a material. So a high-pressure laminate cladding panel which is uniform in composition throughout, homogeneous in composition throughout, is just the panel of a material. Right?

Q. Yes.
Now, you say in your report that -- and this is paragraph 178 on page 38 {LBYP20000001/38} -- these tests can only be strictly applied to products. You use the word "strictly" there. Why is it that those tests are to apply to products, strictly, rather than materials? What is the basis for that?
A. Because what you're doing in the model test is trying to assess how products are going to perform in a model scenario. What is relevant to the model scenario is not necessarily the material response, but it's the product response. You know, you've developed a model of a room. The reason you've got a room with a fire in the corner is because you want to understand what's going to happen in rooms lined with that thing if there's a fire in the corner. Right? You want to understand how quickly that fire is going to grow and whether that fire is going to progress to flashover. So there's no point in taking the core of an ACM and testing it on its own in a room corner test, because that's not representative of the end-use condition. It's not sufficiently representative of the end-use condition. It's not helping you answer the relevant question, if that makes any sense.
Q. Yes, I see. I'm really after the distinction between products and materials.

Why do these tests only apply strictly to products and not to homogeneous materials?
A. I think because they're model tests. Because they are tests that are supposed to be asking questions about performance of products in fire scenarios, you know, in the scenario that you've used to develop your test.
Q. We know that part 6 says so. Part 6 of BS 476 actually says that it applies to products.
A. That's right.
Q. What is the logic, though? I know that it's a model test, but just to say that it's a model test explains why it only applies to products and not materials is somewhat circular. What's the underlying rationale for the distinction?
A. With respect to the part 6 test, the underlying rationale -- I mean, I don't know. Again, I wasn't there. I wasn't born yet when that part 6 test was developed, I think in the 1950s originally. But the rationale from my perspective is that, taking the part 6 test as an example, the part 6 test is asking questions about the ability of a product to contribute energy to a fire. So it's asking questions about the amount of energy that a product will liberate when heated in a compartment fire within a room, and about the timescales over which that occurs.

Mr Chairman, you look like you want to say something.
SIR MARTIN MOORE-BICK: Well, it struck me, listening to this exchange, that maybe one ought to be thinking in terms that the test is only designed to be applied to products. It's a test that was conceived in order to test products. Would that be right?
A. Yes. I mean, again, I wasn't there, but based on my understanding of what the test is, what it does and the questions it asks and answers, I would agree with that, certainly.
SIR MARTIN MOORE-BICK: I think Mr Millett's question was perhaps slightly tempered by the fact that you used the words "can only be applied to products".
A. Okay.
SIR MARTIN MOORE-BICK: It can be applied to any material that you choose to apply it to, I assume.
A. Go for it, yes.
SIR MARTIN MOORE-BICK: So wood, for example, or even a PIR insulation board without any foil facer, you could put through this test, couldn't you?
A. You could put -- well, you can put --
SIR MARTIN MOORE-BICK: That would be a homogeneous product.
A. Yes, yes, I mean, certainly, you can put anything you like through the test, yes, absolutely. Whether putting

that thing through the test makes sense in terms of the questions you want answers to --
SIR MARTIN MOORE-BICK: Quite.
A. -- and in terms of the regulatory outcomes that would eventuate is maybe a secondary question.
SIR MARTIN MOORE-BICK: Quite.
A. But, I mean, I think where I was going in my answer to Mr Millett was to say that the reason that I think these products can only strictly or credibly be applied -- or these tests can only strictly or credibly be applied to products, in the case of the part 6 test, is if one is interested in understanding the contribution of a product to a fire in a room -- the perfect example is within the evidence to this Inquiry, that, for instance, there were insulation manufacturers, Kingspan, who were performing BS 476-6 tests on the foil facers alone, with some notion that, you know, getting a class 0 rating for the foil facer meant that the product with an underlying insulation would be class 0. That is just utterly absurd, not least because the facer has perforations in it, but because the underlying foam insulation will contribute to the fire that you get in a room, which is the model scenario that you're interested in assessing. So to test the foil facer on its own is just completely and utterly nonsensical and could never be defended, in

my view.
So that's sort of why I say that. It's so that we don't get situations like people testing foil facers on their own and claiming that that tells them something useful about the reaction to fire for a product, unless of course you're selling foil.
MR MILLETT: Just picking up your example, which I think is one you've used in your report, actually, at page 180 {LBYP20000001/180}, at paragraph 994. Let's go to paragraph 995, where you say this:
"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."
Then you have a footnote at 537:

"In my opinion, the BS 476 Part 6 ... testing standard is absolutely clear [in italics] that the Part 6 test method is to be used to assess the 'fire propagation' performance of products [italics]. I am not aware that Kingspan sell aluminium foil facers (on their own) as distinct products for the construction industry ..."
Then if we turn the page, please, to the foot of page 181 {LBYP20000001/181}:
"... 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 ... 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 [with measurements] ... regardless of the specific definition of Class 0 given in Approved Document B."

Now, that's a long footnote addressing a potential interpretation of the regulations and Approved Document B. Is your reasoning based on your scientific experience or just on a reading of the language?
A. My reasoning for what?
Q. Your view.
A. For the assertion that it's absurd to test the foil facer alone?
Q. Correct.
A. I mean, I would argue that you don't need much experience to make that assertion, frankly. As you can sense from the language I've used here, when I discovered that this was going on, I was absolutely incredulous. I could not believe that this was going on. I simply -- I refused to believe that it was happening until I saw the evidence.

So, yes, I mean, I guess it is based on my technical knowledge, but I think, to me, it's plainly obvious that you just can't do that.
Q. Now, am I right to understand that for all three of the model tests, BS 476-6 and 7 and the SBI tests -- there

are four of them, I think, in total, actually -- which you talk about in this part of your report, the real fire relevance, the "reference scenario", was a fire growing inside a compartment or a room or a corridor within a building?
A. That's right.
Q. Not an external wall?
A. Correct.
Q. Now, we know that national class 0, achieved by a combination of results from tests carried out under parts 6 and 7 of BS 476 or, after 2002, the Euroclass regime, were the classifications recommended in ADB for external walls over 18 metres in height. Do you know why?
A. Do I know why ...?
Q. Do you know why or do you know the rationale for using class 0 as a classification regime, or class B as a classification standard, for an external wall, given the reference scenario was a fire inside a room or a corridor?
A. No, I don't know why. I mean, it's a very important question, and I'm a bit surprised that I have to say no, I don't know why. I mean, I know why the tests came into existence, and I know how they came into existence, and I know, you know, the structures of the committees

and the experimental underpinning research and all of those things. Why class 0 was able to persist, let's say, for so long within the English regulatory system, I don't know. I mean, I have some views. I presume we'll talk -- which I've intimated about in this report, but no.

And with respect to the European classification system, you know, in the development of the European classification system, you know, from the late 1980s through until 2002, when they became -- when they were inserted into the Approved Document B, based on my understanding of what was going on in those years, there was an understanding or at least a hope that a classification system for products that was based on different reference scenarios that would be relevant to external cladding would also -- that that would occur, you know, an activity would be undertaken in order to define a classification of products that would be more relevant to a reference scenario involving external cladding, but that never occurred. Why that never occurred is a very important question, and I don't know the answer to it.
Q. Right. Thank you.

Let's go to page 39 of your report {LBYP20000001/39}, then, paragraph 193. You start at

189 by identifying three important conclusions which can be drawn from the development of the model fire tests. First, you say they were created on the basis of underpinning research and a body of knowledge.

"Second, the classification thresholds are essentially arbitrary in terms of fire safety outcomes ..."

Then:

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

Then at 193 you say:

"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 calculation; the 'reference scenario' used was (and is) far removed from the circumstances of a cladding fire potentially resulting in promotion of external fire spread."

My question showing you all of that, is this: why does that matter?
A. Why does it matter? It matters because the physics that we are interested in, that govern the way a fire grows and spreads on the outside of a building, are very

different than those that would be experienced inside a room.

I mean, to give you one example, all of those tests that I've discussed previously, the maximum heat fluxes to which the product samples would be exposed would be considerably less than we would expect in a cladding fire scenario, if you have a fully developed fire venting from a compartment. So the products are not exposed to representative heat fluxes, would be just one example of one of the differences.

But, you know, the scale, the mechanical issues -- I mean, Professor Torero I think outlined a whole host of reasons why cladding systems are complicated in his presentation last week, and all of those factors are relevant.

I mean, I would also just add that -- I, Mr Millett, have also noticed that the screens have gone blank, a mild confusion.

Q. I wasn't going to stop you.

A. But, I mean, I think it's also worth noting that, you know, it's important for me to say that just because a test is based on a model scenario that is not the scenario that you're interested in doesn't mean that the test has no value. You know, it's not that BS 476-6, 7, SBI tests tell you absolutely nothing of interest; they

have the potential to tell us lots of interesting things about the way products behave when they are exposed to fire. But they're not asking the question in a way that is immediately relevant to the scenario that we're interested in.

To me -- you know, which is what I would say about all experiments, or test methods, rather -- what is important is not criticising this test or that test because, you know, it uses a different model scenario, but how are people using the outcomes of these tests? How are people understanding the questions that these tests are asking? How are they using their understanding of how these tests are performed and their understanding of the outcomes to make decisions about what is okay or what is not okay on the outside of a building? So it's about -- we have a mantra in my research group at Edinburgh, which is, you know, the test is the test; it's what people do with the test that is worthy of our scrutiny, or more worthy of our scrutiny.

So I wouldn't want to get too hung up on that reference scenario business. It's important to be aware of it and it's important for the people who use the tests to be aware of it, but it doesn't mean that the tests are useless, and I would be quite careful about

saying that.

Q. Understood.

Let's see if I can just explore this just a little bit more.

Can we go, please, to page 174 {LBYP20000001/174} and go in that to paragraph 958 there. You say:

"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."

Then you say this in italics:

"These two scenarios present fundamentally different thermal and mechanical conditions to the exposed materials/products."

You say they're fundamentally different; the question is whether those fundamental differences matter. In other words, does the fact that class 0 or SBI tests might tell you something, does it matter that they are telling you something in the context of the application of the relevant product to the external wall build-up as opposed to a room?

A. Yes, it does matter. But what matters is not that it's different; what matters is that the person who is using what is observed, the outcome, thinks about the extent to which the differences might matter, given that they're going to use that result for some other purpose, if that makes sense. It may be quite a mild distinction.

SIR MARTIN MOORE-BICK: But isn't that partly because the circumstances in which the test is carried out brings with it a host of undefined factors which do actually have a bear on the outcome? So if you light a fire on the inside of a building, in a room, you've got various factors in play, and a fire on the outside is subject to different factors, so you're not actually going to be comparing the same thing, are you?

A. Absolutely, and what's important from my perspective is that the people, the practitioners who are using these tests, have some understanding of that, have some understanding of, you know, where did this test come from?

I mean, to give you an example of the tests on foil facers and my disbelief that that was going on, I immediately sort of asked myself: who on earth was running these tests? Who on earth was performing tests on foil facer stapled to calcium silicate board on behalf of Kingspan and didn't know to ask the question: "What are you guys doing? This is not appropriate." And who signed these reports off, recognising what was going on, and didn't say, "Well, hang on, this is not appropriate, you cannot be doing this". Right? And I'm still not sure I know the answers to those questions.

But that's the issue. The issue is not that a BS 476 test is never useful. The issue is that somebody somewhere within this process of building regulation and oversight needs to be the person who stands up and says, "No, this is not okay, we cannot be doing tests like this", and that didn't happen, and that's the issue.

MR MILLETT: Just going to the differences, though, do the fundamental differences between the thermal and mechanical conditions for a room corner test, SBI or the 476-6 and 7 tests on the one hand, and the use of a product on the external wall of a high-rise building, did they go so far as to invalidate the assumptions of the underlying research and reference scenario?

A. The --

Q. In other words, did the fact that the product was going to be used on the external wall of a high-rise building mean that the differences between its application there and the circumstances in which it was tested were so

fundamentally different that the assumptions underpinning the test were inapplicable?

A. I think the assumptions -- hm. I mean, I can only answer this question in a more general way.

I don't believe that it is ever okay to blindly apply the results of a compliance test. So if someone wants to take results from a test that was developed on the basis of a fire burning within a room, and they want to take the product, assessed on that basis, and put it on the outside of a building, then, yes, they absolutely must think about the ways in which their application of the product might differ from the test scenario in which it was evaluated. And, yes, if you're going to use a product that is tested on the inside of a room with a small fire burning in a corner and then you say, "Okay, well, now I'm interested in how that product is going to react when it's vertically oriented on the outside of a building and exposed to a plume from a post-flashover compartment fire", very, very different scenarios, and, yes, you had better think very hard about whether the assessment from the room corner test or the model that's based on the room corner test is relevant, and probably it's not, in a bunch of ways.

MR MILLETT: I have one question flowing from that, Mr Chairman. May I ask it before I call for the break?

SIR MARTIN MOORE-BICK: All right, Mr Millett.

MR MILLETT: What is there in Approved Document B, when it presents class 0 as the applicable classification standard or class B as the applicable classification standard in diagram 40, which tells you, the building designer, that you have to ask yourself those questions?

A. In Approved Document B? I mean, off the top of my head, now you've asked the question, I'd want to go back and read through Approved Document B. I can't point to a specific clause that says that, but I don't necessarily believe that Approved Document B is obliged to say it.

MR MILLETT: That's another matter. But thank you, professor.

Mr Chairman, is now a convenient moment for the break?

SIR MARTIN MOORE-BICK: Yes, I think it is, Mr Millett. Thank you very much.

We'll break there so we can all get some lunch, professor. We'll come back, please, at 2.05, and usual thing: please don't discuss your evidence with anyone while you're out of the room.

THE WITNESS: Thank you.

SIR MARTIN MOORE-BICK: Thank you very much.

(Pause)

Thank you, Mr Millett. 2.05, please.

(1.07 pm)

(The short adjournment)

(2.05 pm)

SIR MARTIN MOORE-BICK: All right, Professor Bisby?

THE WITNESS: Yes, thank you.

SIR MARTIN MOORE-BICK: On we go then. Thank you very much. Yes, Mr Millett.

MR MILLETT: Thank you, Mr Chairman.

Professor, we were talking about class 0 earlier as an external wall classification, given its internal room or corridor reference scenario, before the break. Afterwards, or later, we will come on to the differences between the national and the European classification systems and the underlying tests that underpin them, but on this particular point, you have an observation.

Can we go, please, to page 174 in your report {LBYP20000001/174}, paragraph 957 at the top of your screen, and you say this:

"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."
Then we have 958, which I read to you before.
Now, what do you mean by "loosely applicable" in paragraph 957 there?
A. I mean that products are installed on a surface and there's a fire involved. You know, it is a test that does assess the way the products react to a fire and the extent to which they'll burn, so it's not entirely remote, if you like. The products are being subjected to a fire. It's that simple, really.
Q. Right. I mean, that's no more than saying that it's a fire test.
A. Absolutely.
Q. Right, I see.
Can I then turn to technological proof tests, which is the third category of test that you describe in your report. I think you would include in that the BS 8414 series, would you?
A. Yes.
Q. Is it right that the test apparatus and the method are designed to imitate as closely as practicable a real-world use scenario?

A. That's my understanding, yes.
Q. You characterise those tests if we go to page 44 {LBYP20000001/44}, please, paragraph 216. I'm summarising here, really, but you characterise them as used when there's little scientific understanding of how various materials or products might behave on a real building; yes?
A. That's right, yes.
Q. Is it right that we should understand that, in the absence of such an understanding, the closeness of the resemblance of the test rig to a real-life building is important in allowing designers to make judgments about how a particular system would behave in the event of a real fire in that building?
A. In my view, yes.
Q. Are there any other factors in play?
A. With respect to what?
Q. With respect to the resemblance between the test rig and a real-life building? In other words, not just subjective judgments, but other things too.
A. I'm not sure I follow the question.
Q. All right. Let's see how we go with the next paragraph.
Can we go to page 45 {LBYP20000001/45}, paragraph 222, and you say there:
"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."
Can you expand on that and, in particular, in relation to BS 8414. In particular, why do they place reliance on the end user in the way you've described?
A. Because the outcome of a technological proof test or the observations that would arise if you conducted a technological proof test are going to be -- the reason you're doing the technological proof test is because of the complexity of the system that's in play, and that complexity also means that small changes in the system could lead to differing outcomes, and so if you perform a technological proof test and you observe an outcome, the extent to which the same outcome would be observed if that external wall arrangement, to use, you know, sort of the terminology of the Inquiry, would manifest on a building in the case of an actual fire is something that you have to think very hard about.
You know, I think that's why there are some statements in BR 135 that kind of draw that out, and they warn users, quite specifically, that this test is

only applicable to what you've tested, and if you're going to take this result and you're going to apply it on an actual building out there in the world, you need to make some assessment, make some judgment, as to whether or not the result that you get in the BR 135 assessment is going to lead to what you consider to be adequate fire safety outcomes in the real world.
Q. We'll come back to that very topic later.
If we go to paragraph 226 at the foot of page 45, you say this:
"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 result 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."
Now, is it right, in other words, that in your view, Approved Document B and BR 135 made it clear that the user of the test had to ensure that a particular test

result was applicable to a particular building situation?
A. Certainly BR 135, yes, and I think Approved Document B kind of in an overarching way, you know, given its legal status as guidance, rather than the law.
Q. Well, that's the next question. How, in your opinion, did ADB itself do so, even implicitly?
A. You know, ADB, there are statements both within the Building Regulations and within ADB that, you know, there's no requirement for a user to meet the requirements of —— or to meet the recommendations —— to adhere to the recommendations of Approved Document B, and designers can do things whatever way they want. The Building Act itself basically says that if one —— and prior editions of ADB basically have said that, you know, if one wants to do that, that is fine, but in the event that something goes wrong and you're found not to have followed the rules, then, you know, you're on your own. If you have followed the rules, then there is a tending to negative liability associated with those actions. So there is some kind of comfort in following the rules of ADB, but it is not an absolute defence of behaviour, if you like, or of design decisions, if that makes sense.
So, you know, the approved documents don't require

you to do anything and, by virtue of that, I don't see that they can be used as a bulletproof defence of actions. You might follow the recommendations of the approved document and still end up with a system that does not adhere or does not adequately resist the spread of fire on the outside of a building.
Q. Now ——
A. It's conceivable that that could happen.
Q. In that last answer, you used the word "rules", at least twice.
A. I probably misspoke then.
Q. Well, I was going to see if I could understand why you misspoke.
A. Sure.
Q. Why did you refer to them as rules?
A. You would have to show me the transcript to see where I did it in order for me to ——
Q. I can read it back to you. I'm just interested in what lies underneath this. You say:
"... prior editions of ADB basically have said that, you know, if one wants to do that, that is fine, but in the event that something goes wrong and you're found not to have followed the rules, then, you know, you're on your own. If you have followed the rules, then there is a tending to negative liability associated with those

actions."
A. Yes.
Q. I just wonder whether, when you use the word "rules", even you, professor, might be indicating some kind of underlying tacit understanding of how ADB was supposed to work.
A. I mean, it's possible. I'm not in a position of ever having used ADB in my practice, so I can't tell you how I would have thought about Approved Document B prior to the Grenfell Tower fire, but I have always known, or at least to the extent that I've ever thought about it, that the building regulation system in the United Kingdom was functionally based, and that the consequence of the Building Act was that designers are free to do whatever they want, if you like, provided they can meet the requirements that are stated within the Building Regulations, and that I suppose, in practice, provided that one can get the necessary approvals for what one sets out as a designer, one can do those things. If something goes wrong down the road, how one would defend oneself I think is sort of relevant to that, that status of the approved documents.
But, I mean, yes, it's easy to slip into using the word "rules", because whilst they are not, I guess, formal —— I'm not a lawyer, of course, but whilst

they're not formal legal rules, it is not prescriptive, deemed to satisfy guidance, they are —— if you like, they are effectively written as rules, so yes. Yes. I mean, I think that's a misuse of language, for sure, on my part.
Q. But a helpful explanation nonetheless, thank you.
Can I take you, then, to paragraph 225 which starts at the foot of the previous page, page 45 {LBYP20000001/45}. You say there, it's really a third of the way through the paragraph:
"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')."

Now, I'm interested in what you say there when you say that -- sorry, then you go on to say, as we've seen already, that the manner in which 8414 was actually used in practice was more as a non-representative or model test.

Taking those two paragraphs together, are you able to tell us what you really mean by 8414 being used more as a model test?

A. Being used in a way such that if one is able to -- not that this language is used, but "pass" an 8414 test, you know, achieve a classification under BR 135 for an 8414 test, it is viewed as a result that can be relied upon to give a great deal of confidence that, when applied to a building, the outcome in the event of a fire would also be positive, if you see.

Q. And therefore it's treated, but mistreated -- is this your view -- as a model, really, rather than as a representative test, which is what it was designed for?

A. Yes. Yes, that's right. Yes. It's treated as a -- you know, a non-representative test, a pass/fail result is something that I'm willing to call a pass/fail result. A technological proof test is something where I'm not happy to call it a pass/fail result. A model test is somewhere in the middle, where there's this discretion.

So it's a question of the level of discretion, the onus of responsibility and discretion on the end user, with an increasing level of onus and responsibility on the end user -- the user of the test, as you go from non-representative through to model through to technological proof test.

So the technological proof test requires a great deal of responsibility and awareness from the user, and that was not in my -- as far as I can tell, that was not deployed out there in the industry, it seems to me.

Q. I'm going to examine 8414 in a little bit more detail shortly but, before we do, can I just ask you, arising out of the last series of answers, this: our class 0 and the European classes that give rise to class B, both of which are placed within diagram 40, are those model tests or are they technological proof tests?

A. They're model tests.

Q. They're model tests?

A. Yes.

Q. So moving on to the next stage then, we find those, don't we, identified in Approved Document B at paragraph 12.5, which says you can either follow what is called the linear route, 12.6 to 12.9, or satisfy the performance criteria derived from tests under BS 8414; yes?

A. That's right.

Q. Is it your opinion that, in expressing satisfaction of the guidance in that way, the person using Approved Document B is being presented with two alternatives that are not strictly alternatives: one is a model test, but its alternative is not also a model test, it is a technological proof test?

A. Yes, that's a very good insight. Yes, I think that's true. I think that that type of language could create the false impression within the user community of ADB that there is an equivalence of, let's say, approach in terms of how one uses those two routes, let's call them. I think that's probably a fair -- yes. I'd not thought of it that way. It's a good insight.

Q. Let's move on to BS 8414, then, and at a later stage we'll look at the performance criteria.

Can we go to page 42 of your report {LBYP20000001/42}, please, and paragraphs 210 to 211. You say there:

"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 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."

For completeness, at the end of paragraph 5 of your report on page 2 {LBYP20000001/2}, if we skip back to that, please, it's the same point. You say there at the end of paragraph 5:

"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."

Now, in that description, in both those paragraphs, when you refer to "people", who are you referring to?

A. I'm referring to the people who are making design decisions.

Q. What about the people who are creating the regulatory regime in the first place? Do you include them as well?

A. Yes, those -- and I've discussed this somewhere in the report, I can't remember where exactly -- those people do have a responsibility in terms of both articulating clearly for the users all of these embedded assumptions and intents that sit behind the test methods, and in setting, let's say, the pass criteria or setting the bars that need to be met in a way that is credible given what the test is doing for you. Right?

So I set this out in the report. So the unrepresentative tests, they -- so if you were to say, "I'm only going to allow A2 products and I'm going to do bomb calorimeter tests, which are non-representative tests, and I'm going to pick a very, very low heat of combustion as my criteria that I can use", well, then, I'm pretty confident that the user of that result doesn't really need to know how a bomb calorimeter works, doesn't really need to know much about what bomb calorimetry is, but needs to understand a little bit about heat of combustion. But if they adhere to the less than 2 megajoules per kilogram or whatever it is, then probably your outcomes are going to be not so bad. Right? Because it's quite a conservative test and is not representative.

But at the other end of the spectrum, when you have BS 8414 tests, I mean, understanding exactly how adequacy is defined in those tests is a bit of a challenge, as I'm sure we'll come to, but you can have much less confidence that the outcome of that test will lead to a satisfactory outcome, because it is less conservative and more complex and more fraught with challenges, and more difficult to take from the lab out

there into the real world. So that's kind of what I'm alluding to here.

But, yes, you're right. There are responsibilities and expectations that we must place both on those people who use the tests and on those people who set those tests out for use by others, I think. Absolutely, yes. I think maybe that latter point probably doesn't come through as strongly as it ought to, reading this back now. Yes.

Q. Now, building on that, can we then go to page 13 {LBYP20000001/13}, please, paragraph 54. This covers a point that we've seen already. You explain here that the key issue is not whether a test is realistic, but whether it is sufficiently representative.

You go on to quote from Downer, and I've read that to you already. This is footnote 8 in paragraph 54. I'll read it again, halfway through the paragraph:

"... '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.'"

Now, looking at the engineer who was to make this determination that you describe, who is this person? What is their minimum level of academic qualification

that they need to have reliably to be able to consider the design of a test which you would expect to be adequate when testing a cladding system?

A. Are you asking me who it is in practice in England or are you asking me who I think it is, who I think it ought to be?

Q. Well, the latter.

A. I mean, it's not for me to say, I don't think. You know, I'm just an academic engineer who works at the University of Edinburgh who has opinions about the levels of competence that people ought to have.

In my view, there ought to be some mechanism by which society, all of us, can have some confidence that the people who we are going to charge with making those assessments and decisions as we move from the lab to the real world know what they're doing, have some fundamental technical understanding, have some, you know, moral and ethical standards that they're operating with, have some uncertainty about the things that they know and are willing to be thoughtful about that uncertainty, you know, to demonstrate competence and an awareness of their own incompetencies, and how one -- I mean, to me, this is, in a way, the issue of everything I've done with respect to this Inquiry: how do we as a society ensure that the people that we charge

in making these decisions have the relevant competencies? How do we define them? How do we assess them? How do we police them? And what do we do when people don't display them or have them? You know, what measures do we put in place to make sure that society can have that confidence? If we're going to have a functionally-based building regulation system that permits anyone to do anything, what do we do to make sure that that doesn't go horribly wrong? That is a very fundamental question.

But, I mean, I can't sit here and tell you: the only people who should be doing this should be people that have this degree in this subject area, this -- you know, they've passed these examinations, they undergo this amount of annual CPD training as recorded by some regulatory authority. But the idea that we should regulate and register the people who are making these decisions is very fundamental to my views now.

I'm not sure if that's a long-winded and slightly peripheral answer to your question.

Q. It's certainly an answer to the question as interpreted as I put to you, the latter, but try the former: who are the people now? Looking at the body of available expertise out there, as at June 2017, were those qualifications defined or assessed or policed in a way

which you, in your opinion, would consider satisfactory or satisfactorily safe?
A. No. I mean, they're —— I mean, what controls are there? There are effectively no controls over who can claim to make that assessment. The only control that seems to exist in practice is the tolerance of the approving authority, whoever they are, and therefore the competence also of the approving authority, which is also not very well controlled, as far as I can tell.
Q. When you say "approving authority", do I take it you mean building control officers?
A. Yes, typically —— I mean, if we're talking about doing something to a building, building a building or doing something to it, to the extent that what's being done requires building control approval, then yes.
Q. Let's go to page 41 of your report {LBYP20000001/41}, please, paragraph 203. You've covered mock—ups and the representative nature of the 8414 test itself. You say at paragraph 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."
Now, in light of that litany of variables, do you consider that the BS 8414 test rig, as required, and the example test rig shown at A1 of the third edition of BR 135, which we can look at if we need to, should have been designed as it was, in other words omitting all windows or apertures?
A. Do I consider that it should have been designed that way?
Q. Yes. Was it an appropriate design, given that it is a rig which has no apertures or windows at all?
A. It depends what you want to do with the result. I mean, yes, sure. Yes. I mean, I can't criticise BS 8414 for all of the reasons that I've mentioned there, and, you know, as I've said before, the test is the test. We can criticise it for being unrealistic and we can say: well,

I want to use the result of an 8414 test in a building that has windows and those windows are this size and shape and they are directly one above each other and this is the storey height, and I build a rig and I test it. But if you go down that path, quite quickly you realise that every time you want to build a building, you have to build it and burn it down, and that's not going to work out there in the world, so we have to make compromises. But when we make compromises, we have to be clear about what those compromises are, and we have to be clear about the extent to which we're going to demand that the people who take the result then understand those compromises and account for them when they go off into the real world.
Q. I follow.
A. So I think no.
I mean, to take the window example as an example. So let's say I decide, "Well, okay, that's unrealistic and I want to have windows in my test rig", so I put some windows in my test rig. Well, what kind of glass do I put in? Do I put single glazing? Do I put double glazing? Do I put toughened glass? Do I put, as is common in buildings now, reflective films on the outside of the glazing to help me with building energy performance that might impact on the radiative

properties of the glass? You know, all of these questions.
And it's important to recognise that if I'm interested in evaluating the fire performance of, let's say, a cladding system that might incorporate combustible products, either insulation or rainscreen, and I displace some of those products by inserting windows into my rig, maybe I've actually made it more likely that I'll pass by inserting windows and not less, because I've displaced fuel, fuel that would otherwise be there and burn.
So, you know, as soon as you start tinkering with a test like this, the potential for tinkering in a direction that is not what you hoped or, you know, more worryingly, the potential for tinkering by people who might seek to tinker to their advantage, is immense.
So BS 8414, whilst being unrealistic in many respects, and, as I've said, it can only be truly representative of a BS 8414 test, so unless my building is literally an 8414 test rig, then I have to ask the question: how might my building, how might this system, this overall build—up of products on my building, given that the joints are going to be in different places, the windows are going to be in different places, the cavity barriers are going to be in different places, the

fixings might be different, maybe I have a wing wall, maybe I don't, all those questions, you have to -- and this is why I say you can't just take a BR 135 classification, point at it and say: everything's fine. You have to think about how this is going to be applied to your building, and I think BR 135 is very clear about that. It says: this is the classification based on a BS 8414 rig, not on a building, and if you're going to put it on a building, you had better think about it.

Now, granted, it doesn't give you a huge amount of help in terms of how one would do that, but that's why the people who are doing this type of work need to be competent if we're to have any faith in the outcomes.

Q. Can we just look at BR 135, then, please, {BRE00005555/2}. Let's have a look at the first page, please, first of all. The second page is the one which tells you this is the third edition.

If we go in it, please, to page 26 {BRE00005555/26}, we can see the rig design there. You can see in it, under "Test Method", that's an example of a test facility, and the principle of the test.

If you go, please, to page 28 {BRE00005555/28}, there is the warning. Under the three bullet points, it says:

"The classification applies only to the system as

tested and detailed in the classification report. The classification report can only cover the details of the system as tested. It cannot state what is not covered. When specifying or checking a system it is important to check that the classification documents cover the end-use application."

Now, is that what you're referring to when you say in your last answer that you need to think about it?

A. Yes.

Q. In fact, where it says it cannot state what is not covered, would it be right for an engineer, reading that, to understand that actually what is covered is pretty limited, given all the other variables you've referred to -- the geometry, the fixing joints, the apertures, the windows, matters of that nature -- so that actually the test rig as tested and covered by the classification report is some way away from the end-use application, even if the materials and the geometry of the use of the materials in relation to each other is the same?

A. Yes, I mean, that's certainly how I read it and have always read it, to the extent that I've looked at it. I mean, I've had to accept that my reading of things appears kind of atypical in this community, but that's certainly how I've always read it, yes.

Q. So forgive the simplicity of this question or perhaps the bluntness of this question, but what's the point of BS 8414 as a test, as a system test, if it is unrepresentative of the end-use building to such a degree? What help does -- a test is a test, but what does it actually tell you?

A. It can tell you what is -- it can tell you what would be a really bad idea, is what it can tell you.

Q. Right.

A. And it can't tell you much more than that.

MR MILLETT: Right.

SIR MARTIN MOORE-BICK: Sorry, before we go on, can I just check with you: this paragraph here that you've just been asked to look at is the only paragraph that you are aware of, is it, which tells the end user or the user of the test that he's actually got to think about the results he's got from the test and how they apply to his building, not just to accept the pass as a pass as if it were a model?

A. I think it -- I would want to check the rest of the document before saying definitively, but I think yes. I think this is probably the only place where it would be stated explicitly -- and it's not even that explicit here, if we're being honest with ourselves -- at least that it's stated here, certainly intimated, I think,

I -- as I say, I have always read it that way, but I have had to realise I am a bit unusual.

SIR MARTIN MOORE-BICK: Yes.

A. I do think that, as I've said, if one understands one's role as a designer within the broader regulatory system, and one considers the Building Regulations and the Building Act, that one should recognise one's professional responsibility, regardless of what BR 135 says. Even if BR 135 was completely and utterly absent, there would still in my view -- any competent professional should understand that they just cannot blindly follow rules or recommendations and hope that that's them dispensing reasonable skill and care.

I mean, we just cannot accept that from the engineering community, and that I just -- I would refuse to accept a view that competent professionals practising engineering in safety critical area should be permitted to say, "Oh, well, the document never told me so".

I just can't. I can't accept that.

SIR MARTIN MOORE-BICK: It sounds to me from what you have just been saying that you would feel more comfortable if the warning, which I think you're saying it really is intended to contain, were much more explicit.

A. It would certainly be helpful if it were much more explicit, and it may well have prevented some of the

sort of misconception around the use of this document, the application of this document, I think.
SIR MARTIN MOORE-BICK: Would it also follow, in your view, that it may or may not be appropriate for ADB to advise people that they can satisfy the Building Regulations by getting a pass under BR 135?
A. Yes, I mean, if that's how one reads ADB, yes.
SIR MARTIN MOORE-BICK: All right, thank you very much.
A. It would have been helpful if clause 12.5 said -- although, you know, I think as I said before the break, I am not sure ADB is obliged to say this, but given what we have observed about the behaviour of people within the industry, perhaps it would have been helpful for ADB to say in a number of places, "Just to remind you, everyone, even if you follow the rules in this document, that's still not you home free, so to speak, you still have to think about" -- not rules, apologies, Mr Millett, recommendations of Approved Document B, "Even if you follow these recommendations that are set out in Approved Document B, it is still on you, as the competent professional, as the designer". And I think that the more people out there in the world can be reminded of that, and to the greater extent that people out there in the real world can be held responsible for design decisions that they've made, all the better.

MR MILLETT: Do I take it from that series of answers to the Chairman that, actually, the putative competent fire safety engineer or a competent fire strategy relying on this document would not need to have this spelled out to him, even if it is a spelling-out, they would know it intrinsically?
A. My view is that they ought to, yes.
Q. They ought to.
Were you aware that this paragraph was added to appendix A at the same time as appendix B was introduced in this third edition in 2013 and had been absent from the second edition, which only contained annex A in very much similar form, in 2003? Did you know that?
A. Possibly. I mean, as you're telling me, I'm thinking, "Oh, that's interesting". I'd want to go back and look.
Q. Okay.
Let's just move on, then, with the question of windows.
First of all, are you able to offer us a view, in simple terms, on which would tell you more about the potential for external fire spread: a rig with window gaps or a rig without?
A. I mean, it would tell you -- it might tell you different things. Yes.
Q. Let's go to figure 2, please, page 11 of this document

{BRE00005555/11}, which is BR 135, third edition.
Here is a photograph under figure 2 of Garnock Court, Irvine, and you can see the fire damage from the windows directly in line with the vertical fire spread.
A. Mm-hm.
Q. Yes?
If we go down to page 13 {BRE00005555/13}, figure 3 is a graphic representation of a fire scenario with fire climbing the building and re-entering the building via windows; do you see?
A. Mm-hm.
Q. Under "Mechanisms of fire spread", it says:
"The key stages associated with fire spread on the outside of a building envelope are ..."
Then they're in order:
"▪ initiation of the fire event.
"▪ fire breakout.
"▪ interaction with external envelope."
Then across the column:
"▪ fire re-entry.
"▪ fire service intervention.
"These stages are discussed below, and are illustrated schematically in Figure 3."
You can see the process there: the secondary fire is

entering through the windows on each floor, or through apertures, at least, on each floor.
That's dealing then, isn't it, with re-entry of fire into the building through windows; yes?
A. Mm-hm.
Q. That's the assumption here.
A. Yes.
Q. As it travels vertically.
Now, given that BR 135 is overtly directed at the hazard posed by cladding fires and re-entry, is it right to say that some compromises to reproducibility appear to have been necessary in its design? My question is: is this not a pretty major compromise, when the rig itself doesn't have any windows to let fire back in?
A. Okay. My understanding of what BS 8414 and BR 135 testing is trying to tell you/us/them, whoever is using it, is whether or not, or perhaps the extent to which, a combination of cladding products on the outside of a building is likely to contribute to the upward progression of fire. It's not a test that is trying to tell you necessarily whether or not that contribution to the upward progression of fire is going to go in a window. I think the assumption is that if the cladding system contributes to the upward progression of fire, that is going to make it more likely that more

windows will become compromised, if that makes sense.
Q. Yes, it does. I see.
In what way does the 8414 test series actually test for the risk actually depicted here in figure 3, given those five key mechanisms/stages?
A. Only insofar as one assumes that if you have a fire spreading up the outside of a building and it finds a window, that it's likely to enter that window.
Q. Right. So is it right that, in your understanding, BR 135 appears to consider a specific risk which the associated test, BS 8414, doesn't in fact seek to address, namely fire re-entry?
A. Yes, it doesn't address it explicitly, in that it doesn't reproduce that, but in order -- I mean, the problem is that, in order to address it explicitly, you would end up with a litany of further questions about the particular characteristics of the windows, which would become an impossibility. You know, even if you said, "Okay, we're not even going to have glass there, we're just going to have a big void", then what are you going to put inside the void to check whether ignition occurs? Do you have curtains? And if you have curtains, what are they made of? And do you have a sofa? And, you know, it just goes on and on.
So I guess I just -- I mean, I'm perfectly happy to

sort of be critical of the BS 8414 test in terms of how it's used and various other aspects of it, but to criticise it for not having windows I just don't think makes any sense.
Q. And you've given the reasons for that. My question is slightly different though.
Is there not, though, a mismatch between the mechanisms of fire spread addressed in BR 135 on the one hand, which does address fire re-entry, or at least the key stages of fire spread externally involving fire re-entry on the one hand, but the BS 8414 test not doing so?
A. I take the point. I think that if I were to try to argue on behalf of BR 135 -- I'm not quite sure why I'm doing that, but if I were to try to argue on behalf of BR 135, I would probably say that if the cladding system is seen to result in upward progression of the fire, you know, 5 metres above the hearth, then that is giving you an indication that there's a larger potential that you're going to get break-in to of a fire -- of a window above the fire of origin, if you like. So it's indirectly addressing the question, in a way.
Q. I see.
I don't want to put words in your mouth, but does it come to this: that the mechanisms for fire spread

addressed by BR 135, which is not just a list of criteria, it has some background to it as well, which includes fire re-entry through windows, include but not exclusively include the mechanism for interaction with external envelope?
A. Sorry, you'll have to ask me that question again.
Q. Yes, let me try that one again.
Is the right way of reading these two elements together -- BS 8414, the test, and BR 135, the criteria document on the other -- that the criteria document goes further than the test, because BS 8414 tells you only about interaction with the external envelope, it doesn't tell you anything about fire re-entry?
A. I think that a classification of a system to BR 135, after having performed a test on that system to BS 8414, equally doesn't go any further than what the 8414 test is telling you.
I'm not sure I'm answering -- I'm not sure I either understand nor am answering the question, Mr Millett.
Q. Let me try this the other way round.
If you met the performance criteria on the basis of test data derived from BS 8414-1 and 2, would that eliminate the risk of fire re-entry?
A. If you were to meet the criteria?
Q. Yes.

A. No. No, it wouldn't.
Q. Why not?
A. Because your real building has windows, probably.
Q. Yes. And what is there in either the BS 8414 rig design or BR 135 to tell the designer that?
A. Explicitly? Nothing. From memory, nothing.
Q. Let's talk about 1919 and the path to Grenfell. I want to pick up from part 2 of your report.
You've given us a detailed overview of the evolution of the building and testing landscape and the regulatory regimes in place from 1919 onwards.
We land, I think, in the mid-1980s at page 90 {LBYP20000001/90}, if we can pick that up. At page 90, paragraph 442, you tell us:
"There had, therefore, been a fundamental shift in the way designers could practice[sic]. 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".

You then go on at 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'."

Now, that's the background to what I now want to show you, which is 444, and you say this:

"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."

I just want to focus on the last part of that paragraph there.

Why do you say that finding ways to circumvent the statutory guidance was the intent of the system?

A. Because the point of a functionally-based regulatory system is to promote innovation and flexibility -- one of the points is to promote innovation and flexibility, and so provided you can "demonstrate" that your product or system meets the functional requirement, then you don't need to follow any particular performance standard or test method. You know, it's up to you to meet the requirement -- the functional standard in whatever way you choose. And that removal of "deemed to satisfy" routes, let's say, to compliance with the Building Regulations was, you know, quite explicitly the point of these changes to the regulatory procedures.

You know, to remove these constraints that were quite, you know -- it's quite difficult to update a test standard and change things as a consequence of new products and things. So if you want to promote innovation and flexibility in the interests of industry, then it does make sense to allow people to do what they like.

Q. So are you saying that instead of having a prescribed system where people would look for loopholes with which to circumvent, you created a new, open-textured, flexible system where you no longer needed to do that?

A. Yes, I mean, you could argue that the system was created specifically to enable people to circumvent the rules.

Q. And how could they demonstrate safety other than by reference to adherence to a classification system based firmly on reliable tests and reliably applicable outcomes?

A. In practice?

Q. In practice.

A. They would make some justification and they would write that up as their design and they would seek the approval of the approving authority, and if the approving authority said that they were satisfied, then I guess you would build it.

Q. At what point would you know, to a reasonable degree of certainty, whether or not you had met the functional requirement?

A. In practical terms?

Q. Yes.

A. With respect to fire safety?

Q. Yes.

A. If you had a big fire and everything went horribly wrong.

Q. Right. So while that happened, you would be taken to have complied, until it happened, when you suddenly realised that you hadn't?

A. Mm-hm.

Q. Now, at page 91 {LBYP20000001/91}, we have Malhotra. You start the quotation in the previous paragraph -- in fact, let me show you what Malhotra says at paragraph 446 actually {LBYP20000001/90}. I've jumped ahead a little too far.

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

That's a quotation from Malhotra in 1986.

Then you say this at 447 {LBYP20000001/91}:

"447. Malhotra concludes:
"448. 'It will be perhaps another 2 or 3 decades before the consequence of this approach can be seen'."
Now, we can see that Malhotra was only a year or so out in his prediction; yes?
A. Mm-hm.
Q. What was it then, do you know or do you think, that Malhotra saw which people did not see in the intervening 30 years?
A. I don't know, again because I wasn't around and I never met Malhotra, unfortunately. But, to me, this quote expresses concern. It expresses a concern that, you know, this shifting to individual corporate designer contractors for adequacy, without some appropriate level of oversight, has the potential to cause significant problems, but that because we're working in fire safety, and because severe fires are thankfully rare, it might take a long time in order for the chinks in the armour, if you like, to manifest. Yes.
I mean, when I found this quote, I thought: wow, yeah; spot on.
Q. Let's move on to some of the missed opportunities that you identify to address key problems relating to the regulation of and industry practices prevailing in testing, design and construction of external wall

systems.
We start, I think, with Knowsley in 1991, 5 April, Liverpool, about which we have heard some evidence in the course of Module 6.
Let's go, please, to page 95 of your report here {LBYP20000001/95}, paragraph 470. You say there:
"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'."
That is a quotation from Shennan, 1991.
"There were no fatalities and the fire brigade were eventually able to bring the fire under control."
If we go to paragraph 465, you confirm there, page 94 {LBYP20000001/94} that:
"The rainscreen used at Knowsley Heights was a glass fibre reinforced polymer (GRP) sheeting product with an aggregate finish on its outside face ... The product's marketing literature suggested that the polymer used was a polyester polymer resin. The GRP rainscreen was a product called 'Cape Stenni' sheeting, and was presented as being a 'Class 0' product."
Now, I think you've reviewed the BRE's 1992

investigation report into that fire, written by Penny Morgan and others; yes?
A. Yes.
Q. For reference purposes, that is at {BRE00035385}. I think you have also looked at her witness statement; yes?
A. Yes.
Q. That's at {BRE00043866}.
Your report at page 95 {LBYP20000001/95} at paragraph 472, foot of the page, you say this:
"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 the rainscreen cladding and the (mineral fibre) insulation. 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."
If you go down to page 98 {LBYP20000001/98} and paragraph 486, you say there:
"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. 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.
"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."
Now, why is your reaction one of surprise and alarm?
A. There have been two moments in this Inquiry when I've thought -- when I've been speechless, and one was when I read that it was GRP cladding at Knowsley Heights. The reason that I was speechless was because I was aware of Knowsley Heights, had been for many years, and I'd read BR 135 and various other reports and things over the years, and the problem at Knowsley was the absence of cavity barriers. Right? That's what I believed. That's what I was told. Because that's the problem,

that's the narrative of Knowsley: the narrative of Knowsley is that there were unobstructed cavities all the way up the building and that's why there was a big fire.

Now, my professional background, I come from a structural engineering background, and the way I got into fire was because I was interested in using GRP materials in structural engineering applications, and they burn quite nicely. So my route into this profession was through understanding the way GRP burns. So when I, for the Inquiry, thought -- when I was asked to look at the regulatory regime and the testing, I thought, "Right, where do we start? We start at Knowsley, so let's go back and look at Knowsley". I looked at Knowsley, and as soon as I started reading the documents that had been provided to me about Knowsley and I realised it had been GRP, I thought to myself -- well, the question here: what was burning ten storeys above the refuse, if this was a non-combustible cladding system and it had no cavity barriers? Can I really get flame extension ten storeys up an unobstructed cavity due to fuel only being at the base? I immediately went and spoke to my colleagues and said, "Guys, am I crazy, but does it seem pretty unrealistic that you get fire coming off the top of

a building due to refuse burning at its base, even if you have an unobstructed cavity?", and they agreed with me.

So, you know, the fact that -- and then I started to look for mentions of the combustibility of the cladding over decades, and I found none. And then I looked at all of the work that came after Knowsley and I looked at trying to understand how class 0 kind of perpetuates within the system, trying to understand the sort of slightly odd British focus on cavity barriers in these systems that doesn't exist in many other jurisdictions around the world, and it all goes back to Knowsley, and it all goes back to Knowsley in the absence of any significant discussion about the GRP cladding.

So I can't remember now what the question is, but, to me, that was really, you know, a sit-up-straight moment, and I've tried quite hard to understand why. Like why was it not mentioned?

Q. Have you found an answer?

A. No.

Q. Now, if we go to page 99 {LBYP20000001/99}, paragraph 496 you say:

"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 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."

Are you able, professor, to offer any possible or plausible scientific basis which could justify or explain the omission of any discussion of the combustibility of the GRP cladding from BRE's work?

A. Only that those who investigated the fire on behalf of BRE may have not understood themselves that something that is class 0 isn't necessarily non-combustible. Right? So those who investigated the fire on behalf of the BRE may have been operating under the misapprehension that class 0 means won't burn, and if they were, then you can kind of understand. They wouldn't have considered that the rainscreen could possibly have contributed if they thought it was non-combustible.

Now, they would have been wrong to think that, but

nonetheless they may have thought that. So, you know, Penny Morgan, for instance, may not have realised that class 0 and non-combustible are not the same thing.

Q. Well, let's look at her witness statement, which is I think one of those things that you read, {BRE00043866/21}. If we go, please, to paragraph 115, she says -- and this actually answers a question at the foot of page 20 {BRE00043866/20}, which we need to look at, at paragraph 114. If we could just pick that up, I'm sorry. The question at the foot of 20 is:

"Did you understand the fact that the GRP rainscreen cladding applied to the external walls of the Knowsley building had achieved Class 0 to relate to the combustibility or otherwise of the product? Please explain your answer."

At the top of page 21 {BRE00043866/21}, she says this:

"To the best of my recollection, I understood that the GRP rainscreen cladding had achieved Class 0, which did relate to the combustibility of the product."

Then if you go to page 22 {BRE00043866/22}, I'll show you two things. Page 22, paragraph 125, she says:

"While I cannot recall due to the passage of time, I assume that I did consider the cause of the vertical fire spread to be a matter of significance, as a ground−based fire had spread over what was purported to be non−combustible cladding."

Now, what do you make of that evidence?
A. It would appear that she doesn't understand the distinction between class 0 and non−combustible.
Q. Do these passages that I've read you from her statement throw any light on the state of knowledge −− assuming her to be representative for the moment −− in fire engineering circles in the early 1990s about the limitations of class 0 and the risks of external fire spread presented by products like GRP?
A. Well, I wasn't there, so I can't really speak to whether or not this view would have been typical. It does seem to me that, over the years, there has been quite a lot of confounding of these two concepts, yes.
Q. The two concepts being ...?
A. Class 0 and non−combustible.
Q. When you say "confounding", you mean conflating?
A. Sorry, conflating, yes.
Q. It's the same thing, but people understand "conflate" better than "confound".
A. Yes.
Q. Can we then go to page 99, paragraph 491 of your Path to Grenfell report {LBYP20000001/99}. You have quoted from the passage I have just read to you, and then you also

quote at 490 from a later BRE report which says this, I'll just read this to you:

"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)."

Then you say at 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."

For what reasons do you consider that this fire was the most significant of the historic external fires in the years between 1991 and 2017?
A. Because of what it ought to have caused people to think about but didn't, apparently.
Q. What interrogation do you think should have been carried out into what you describe as the key issues?

A. Those who were investigating this fire ought to have tried to understand the extent to which the escalation of the fire vertically was a consequence of the continuous cavity or a consequence of the combustibility of the rainscreen, rather than focusing, as far as I can tell, uniquely on the continuous cavity.

You know, I mean, Knowsley Heights is why, as far as I can tell, we have such a strong focus on the use of cavity barriers. If, after Knowsley, someone had stood up and said, "Well, actually, a significant proportion of the adverse outcome at Knowsley was because we had a class 0 combustible rainscreen", then maybe we wouldn't have had, well, many other fires, including Grenfell Tower. You know, I think it's impossible to overstate the importance of what was missed here.
Q. And in paragraph 491, where you say "failure to ... make the necessary changes to the relevant guidance", what are you referring to? What are the necessary changes that should have been made?
A. A reconsideration of class 0.
MR MILLETT: Right.
SIR MARTIN MOORE−BICK: Presumably the GRP panels from Knowsley were removed and examined, were they?
A. Well, I don't know. I mean, Knowsley was reclad, as far as I'm aware. I certainly don't think, and hope, that

those panels are not on Knowsley Heights still −− although I have to say, given what we have observed, it wouldn't surprise me if they were.
SIR MARTIN MOORE−BICK: I ask the question because, if they were removed and examined, fire damage to the internal faces would have been apparent, wouldn't it?
A. Yes, I mean, there are photos in the fire investigation report, BRE's investigation report, that clearly show what someone who understands the way GRP burns would expect. You see −− GRP is glass reinforced polymer, glass fibres that are placed inside a polymer matrix, I think polyester probably would be typical for this era, and when they burn, the polyester burns off and the glass fibres remain, and you end up with stringy glass fibres, you end up with a mess of −− a tangle of glass fibres that is what was pre−existing inside the resin before the polymer burned off, and in the photos after Knowsley, you see it, you see glass fibres hanging all over the place. You see partially burned rainscreen cladding panels. It's abundantly clear what has happened. The polyester resin −− assuming it was polyester −− the polymer resin has burned away and has left the fibres. There is ample evidence of exactly what occurred.

So the rainscreen panels at Knowsley Heights did

burn, there is no question.
SIR MARTIN MOORE-BICK: But people didn't really pick it up; is that what you're saying?
A. That's what it appears, yes. As I say, for me, when I realised they were GRP panels and I went back and looked at the photos and realised what I was looking at, you know, having had in my head all these years that Knowsley had a non-combustible rainscreen and the problem was the absence of cavity barriers, again it was just one of those moments where I just thought: what? This cannot be. This cannot be the truth.
Yes, it's absolutely clear to me that the fact that the rainscreen at Knowsley Heights was GRP was one of if not the reason why that fire spread.
MR MILLETT: Mr Chairman, one more question before the break, if I may.
In your experience and knowledge of GRP, does it or did it routinely achieve a class 0 classification?
A. I couldn't say. One of the things that's interesting about -- and I couldn't say because it depends on, you know, the type of polymer, what fillers or fire retardants you might have in the polymer, the ratio between fibres and polymer. There's all sorts of reasons why it's quite difficult to say whether something would or would not.

What's interesting about the Knowsley panels is that they were GRP panels, but they had an aggregate outer surface, as is mentioned in the reporting, and so they had little stones that were kind of, I guess, pressed in or formed into the outer surface to make it look like it was a render or, you know, a rough cast kind of finish to the outside of the building, and I can imagine that, if the rainscreen product at Knowsley were tested in BS 476-6 and 7, the presence of that rough cast stone finish would assist the product to achieve potentially class 0.
What's interesting is that, after Knowsley, one of the changes that was made, quietly, to the guidance was that rainscreen panels need to achieve class 0 on both the outside and inside faces, and so I believe that it's plausible that the reason that change was made is because somebody realised but did not say that the rainscreen panels at Knowsley were not class 0 inside the cavity, and that's one of the reasons why the fire spread so quickly. But that's conjecture on my part.
MR MILLETT: Yes, thank you.
SIR MARTIN MOORE-BICK: Is that a good point?
MR MILLETT: Yes, Mr Chairman, thank you.
SIR MARTIN MOORE-BICK: Good.
We'll have the afternoon break at this point, then,

Professor Bisby. We'll come back at 3.35, please, and usual rules apply. All right?
THE WITNESS: Thank you.
SIR MARTIN MOORE-BICK: Thank you very much.
(Pause)
Thank you very much, Mr Millett. 3.35, please. Thank you.
(3.21 pm)
(A short break)
(3.38 pm)
SIR MARTIN MOORE-BICK: Right, ready to carry on?
THE WITNESS: Yes, thank you.
SIR MARTIN MOORE-BICK: Thank you very much.
Yes, Mr Millett.
MR MILLETT: Yes, thank you very much, Mr Chairman.
Professor, in the exchanges before the break, you said that there were two moments in your work for the Inquiry which left you speechless. You explained what one of them was. I'm afraid that, during the break, the press of curiosity has become too much for us. What was the other?
A. The other was when I discovered what had been tested in the cc1924 project in the early 2000s.
Q. Right. Somebody behind me has just won a bet.
A. Ah, okay, congratulations!

Q. Now, in relation to Knowsley, if we go, please, to page 100 {LBYP20000001/100}, paragraph 500, you say there that:
"Knowsley Heights was a pilot scheme for the Estates Action programme, wherein government investment was intended to support local improvements; it was a pilot scream 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."
Are you able to tell us from your review of the history and the documents relating to it whether there may have been some other reason for the investigation into the classification of GRP not being picked up as a feature?
A. Of the Knowsley investigation?
Q. Of the Knowsley investigation.
A. I mean, I've tried quite hard to think of an alternative reason, other than what we might call the potential for embarrassment or the self-interest of the parties

involved in that scheme in one way or another. I've not been able to come up with one that I consider plausible.
You know, it may be the case that Penny Morgan, who -- you know, my understanding of her background is that she didn't necessarily come from fire science or even a physics or engineering background, that she may not have understood what she was looking at. But, I mean, other people who were within the organisation, the BRE, at that stage, these were the top fire scientists in the country. If any of these people looked at this evidence, I can't see how they would not see what I saw the moment I looked at it.
So I am at a bit of a loss to explain it, other than -- I mean, the statements I've made here, and there is also -- obviously we -- Graham Spinardi, who works in my team, went to the archives at Kew and started looking at some of the files at Kew and uncovered, you know, this memo that the Inquiry has seen that alludes to certainly the potential for some embarrassment, in my view, around the fire at Knowsley Heights.
Q. Was GRP, whether Cape Stenni or otherwise, in wide use at the time, the late 1980s/early 1990s?
A. That would have been a period when GRP was -- I mean, certainly in that period, people were using GRP on buildings for -- you know, it's a modern material,

a space age material, and people were using it for cladding panels and various other things at that time. Yes, certainly there were a number of buildings in London that were clad with GRP that didn't age particularly well over the years.
Q. Moving on, then, to a little bit later in the decade, 1994, Raymond Connolly, can we go, please, to page 109 of your report {LBYP20000001/109}, and at paragraph 568 you address the full-scale fire test research which was carried out as a result of the fire at Knowsley by the BRE, through Dr Raymond Connolly, which led, I think, to a report from him in 1994, about which the panel has heard some evidence --
A. That's right.
Q. -- during the course of this module.
Now, is it right that you consider that the primary focus of that research work, which included ten full-scale tests, was on cavity barriers?
A. It appeared to be interested primarily in cavity barriers, yes, on reading it.
Q. At paragraph 569 you observe -- and I'm summarising -- that one of the tests, namely test 2, carried out on a system incorporating class 0 GRP rainscreen cladding, appeared to be an almost exact reconstruction of the cladding system used at Knowsley.

A. Certainly very similar, yes.
Q. What observations recorded from that particular test do you consider to be significant?
A. From the test 2?
Q. From test 2, yes.
A. From memory, I mean, that test 2 escalated quite rapidly and went off the top of the rig. You know, it behaved in much the same way that one would have expected, given what had occurred at Knowsley.
Q. You go on to say at 572 that -- this is Connolly:
"... 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' ..."
Yes?
A. Yes, that's Connolly being quite clear, yes.
Q. Yes. Then at 350 there's a footnote. You conclude, and I'll read it aloud:
"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."
A. That's right, yes.
Q. Are you aware of anything done within government at the time from your reading of all the material about that?
A. No. I mean, other than potentially, you know, the requirements on cavity barriers being enhanced. It's conceivable that those involved felt that implementing a greater requirement for cavity barriers would address the problems. I don't know what basis they would have had for that belief, but it's possible that they held it.
Q. Focusing on Dr Connolly's conclusions at paragraph 572, which I have just read to you, how significant was that conclusion?
A. I mean, I think it's a hugely significant conclusion, yes.
Q. You go on to say that Dr Connolly concluded that it was necessary to consider the system as a whole, and that there was still a need for full-scale testing to determine appropriate cavity protection. I'm summarising your paragraphs 576 to 577.
Is it fair to say, professor, that the focus on cavity barriers and protection reflects the report as a whole, Dr Connolly's work as a whole?
A. That he was focused on cavity barriers?

Q. Yes.
A. Yes, I mean, the kind of -- what I'm left with, when I look at that work in the context of Knowsley Heights and some of the reputational issues around it, is this idea that cavity barriers could be a way to address, either wholly or in part, the poor performance that had been observed, yes.
Q. The focus was on cavity barriers and protection rather than the risks presented by using what appeared to be class 0 rainscreen material?
A. Yes. What is surprising is that it doesn't appear that anybody said, you know, "Well, hang on, maybe we just should not use combustible rainscreens. Maybe we should find some other way to restrict the reaction to fire behaviour of rainscreen products. You know, maybe, in addition to class 0, we should have some other requirement, or maybe we should develop a bespoke requirement that is applicable to rainscreen systems and how they might behave in a fire scenario". But it doesn't appear that anyone did that, other than to argue that a BS 8414 test -- what would eventually become the BS 8414 test -- that a large-scale test was needed.
So it doesn't appear that anybody thought, "Well, let's think about restricting the combustibility of rainscreens, let's instead think about ways we can

satisfy ourselves by other means or other assessment techniques that we can still use these products in ways that would be adequate, as far as we're concerned".
You know, and there is a kind of narrative that flows through this, from Knowsley Heights all the way through to the parliamentary inquiry and subsequent, that what is needed is a large-scale test, rather than what is needed is some further restriction on the combustibility or the extent to which rainscreen products might contribute to a fire. Yes.
You know, there were two paths or two lines of thought that could have been followed, and the one that was followed, you know, uniquely was the large-scale testing path.
Q. Yes. Let's see if I can just tease out a little bit more on that.
Can we go, please, to paragraph 111 of your report and look at paragraphs 580 to 581. You say in 580:
"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."
Now, do you consider the fact that whether a class 0 rainscreen was or is appropriate should have been asked or investigated at that point?
A. Yes.
Q. Notwithstanding that that was not the focus of the Connolly report, is it your opinion, professor, that the experiments identified significant potential hazards associated with the use of a class 0 product?
A. Yes.
Q. Had Connolly been asked to consider the question, do you consider that he would have been justified in concluding, based on his tests, that class 0 was not a suitable measure for assessing the hazard posed by an external cladding system, with a view to satisfying functional requirement B4?
A. Yes, I mean, I think he says as much in his report, yes.
Q. Is there a scientific justification for not asking Dr Connolly to investigate that question?

A. I mean, I would have asked the question, is all I can say, and I would have expected anyone in the room, so to speak, to have a discussion about that question. Maybe they did. I don't know. Maybe they did have that discussion. Maybe they talked it over and they decided, "Well, no, instead what we're going to do, because we can't come up with an alternative approach here that's based on small-scale or medium-scale tests, and we don't want to restrict the industry, we don't want all of a sudden there to be this problem of all these rainscreen products that are being used to reclad high-rise tower blocks, we don't want to create a problem, so we're going to really push hard for a full-scale test as an alternative and we're going to get rid of class 0 and we're going to do it with a large-scale test".
You know, it seems that is what was being argued for in those years between this and the parliamentary inquiry, the 1999 inquiry, that the goal was to supplant or replace class 0 with a large-scale fire test that would be used for all products and systems. Now, obviously that's not what happened, as it happens, but ...
I see your question. I would have wanted to ask that question about class 0 quite carefully, because the

thing that's important to recognise about class 0 that seems to get a bit lost in the conversation is that class 0 covers all manner of products, with all manner of particular hazards associated with them, you know, whether they are composite products, what types of metal faces they have, how thick those faces are, whether the cores are foamed or solid polymers or metallic honeycombs with adhesives or whatever, you know, whether the faces are metallic or cementitious, come to that. So the problem with class 0 is that it just simply cannot address the responses of the full range of products that it was being applied to, and a view may have been taken that a large-scale test could do that and, therefore, a switch to a large-scale test may be appropriate.
Q. Now, let's look to see how Dr Connolly describes the approach.
Can we go to his statement at {BRE00047667/12}. I'm afraid there aren't paragraph numbers on this page, but let's pick it up at the top. He says at (f):
"As outlined previously, Test No. 2 confirmed that the guidance in Approved Document B relying on Class 0 as a sufficient measure of fire performance was inadequate unless also associated with the guidance requiring provision of cavity barriers, which were

problematic for reasons of dampness control. Rather than raising a concern, Test No. 2 validated the need for a full-scale fire test to allow for an examination of an integrated external wall system rather than an individual component-by-component based specification. As an alternative outcome, had Class 0 rated materials exhibited sufficiently robust fire performance at full-scale, then the need for cavity barriers and/or full-scale testing would have not been necessary. In this context, I would respectfully suggest that the BRE research programme was significant. With the benefit of hindsight, it is recognised that a component-by-component specification would have been an alternative and valid approach to have adopted subject to that specification being entirely one of 'non-combustible' materials. Such an option was never thought of by me at the time as being necessary and I never heard any other person involved in the research suggesting at the time that such an approach was potentially necessary."
Now, it looks from that that Dr Connolly considered that the tests confirmed the need for a full-scale test, and that small-scale component testing would only have been a valid alternative approach if comprised of entirely non-combustible materials or products. Do you

agree with that?
A. No. No, I don't. I mean, another way of reading the result of test number 2 is that test number 2 is telling you, "Don't use these rainscreens", and it's telling you that pretty forcefully, actually.
Q. What does that tell you about what test --
A. Well, it means you don't necessarily need -- I mean, there's this weird -- yes, there's this strange kind of sort of one-way set of blinders that people appear to have on in this period where, when something went badly, what it was showing was the need for a full-scale test, as opposed to it was showing that you shouldn't use that product. So in all of the narrative throughout this period, there's this strange kind of single-mindedness pushing towards this idea that the way to solve this problem was with a large-scale fire test.
You'll have to remind me, it escapes me at the moment, but was there a test number 2 that was performed but with cavity barriers? I can't remember off the top of my head.
Q. I don't believe so.
A. Okay. But from memory, there were a number of tests that involved cavity barriers, and many of those were deemed inadequate as well in this study.
So, you know, what Dr Connolly seems to be saying

here is that test number 2 confirms that we need a large-scale fire test, and if we do a large-scale fire test but it incorporates cavity barriers, then there seems to be this presumption that everything would be fine. But having not performed that test, I don't think, I'm not sure on what basis he's arguing that that's the case.
Q. This would, wouldn't it, treat small-scale tests and large-scale tests as functional equivalents?
A. In what respect? I'm not sure I follow.
Q. Well, in the sense that they would both arrive at the same point, namely that you could use this particular product or material if you passed, or didn't fail.
A. Yes, if you're going to stick with class 0, yes.
Q. Yes.
A. Yes, if you're going to stick -- but my argument is that they shouldn't have stuck with class 0, they should have done something different, or at least thought very hard about doing something different.
Q. Now, he says it's with the benefit of hindsight that a component-by-component specification with non-combustible materials would have been an alternative and valid approach. But what was it that the scientists like Dr Connolly did not know in 1994 that they came to know later so as to be able to invoke the wisdom of

hindsight, as he does?
A. You know, I would disagree with that statement. I don't think you need the benefit of hindsight to make that statement.
Q. Is it fair to say that, in fact, no hindsight was needed, given what the Knowsley Heights fire demonstrated about what class 0 panels could do in the event of an external fire?
A. Presuming that Dr Connolly had been briefed on what had occurred at Knowsley, yes, I would agree with that.
Q. Can we go back to your report, then, at page 40 {LBYP20000001/40}, please, paragraphs 195 to 197. You say there in 197:
"One approach would have been to revisit the reference scenario and (re)develop new model tests."
Just pausing there, is that a reference to class 0?
A. Yes.
Q. "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'."
Was that work of revisiting the reference scenario and developing new model tests ever carried out?
A. Not that I'm aware of, no.
Q. Was it your view that it ought to have been carried out?
A. It ought to have been very seriously considered and I would have expected that consideration to have been, you know, written down and documented somewhere.
Q. And given what happened, what is your opinion of the appropriateness of continuing to use class 0, developed as it was for an internal reference scenario, in the context of assessing the safety of external cladding systems?
A. It should not have been. It should have been reconsidered. I mean, it should have been reconsidered

immediately after the Knowsley fire.
Q. If we go to page 253 {LBYP20000001/253}, paragraphs 1578 to 1580. I won't read it all out to you, just remind you of what you said there under the summary. 1578, 1579 and 1580, you summarise your views there.
Just on the basis of what you say there, is it your view that the continued use of class 0 in the context of the safety of external cladding systems represented a hazard to life safety?
A. Yes.
Q. Do you consider that the focus on mitigation obscured the extent to which the continued use of class 0 was a hazard?
A. Yes.
Q. And what ought to have changed after Knowsley and Connolly, given what they showed?
A. What ought to have changed? I mean, the machine of government regulation, you know, BRE, the relevant government departments, should have removed class 0 as the means by which cladding products could be assessed and accepted for use on the outside of buildings. They should have thought about the products that were being used across the industry, how those products react when exposed to heating and what that means for the performance with respect to external fire spread.

Now, they might claim that that's what the BS 8414 test was trying to do, and that, had the BS 8414 test been implemented as an alternative to class 0, rather than as a parallel stream or a parallel approach to class 0, it would have addressed those issues, and maybe it would have. It's hard to say with hindsight.
You know, if you test ACM PE on an 8414 test, notwithstanding all my comments about complexity and differences in behaviour, I defy you to pass that test.
Q. Let's turn to Garnock Court, 1999.
A. Sure.
Q. 11 June in that year. 14-storey block of flats in Irvine in Scotland, overclad as part of a refurbishment. Again, GRP; yes?
A. Yes.
Q. If we go to page 123 of your report {LBYP20000001/123}, paragraphs 634 and 635, under the heading "Garnock ... (1999)", you describe the fire in paragraph 634, and then in 635 you say:
"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 cladding was not a ventilated rainscreen and the cladding system therefore also did not (and did not need to) incorporate cavity barriers ."

Now, it is right, I think, as with the fire at Knowsley Heights, the Garnock Court fire was investigated by the BRE on behalf of central government.

A. Yes.

Q. This time the Department of the Environment, Transport and the Regions, as I think it had become; yes?

A. Yes.

Q. It was reported as part of the August 2000 Investigation of Real Fires report done by the BRE under contract with the government; yes?

A. Yes.

Q. And also the subject of reports prepared by the BRE for the Procurator Fiscal's Office and for Irvine Council, both in Scotland; yes?

A. That's my understanding, yes.

Q. And you've read those reports; yes?

A. I have.

Q. If you go, please, to 637, just in the middle of your screen {LBYP20000001/124}, you say:

"The fire investigation report issued by BRE to DETR

(in August 2000) described Knowsley Heights' refurbishment GRP cladding in considerable detail, as follows ..."

And then you set all that out.

Then you say, a couple of paragraphs on at 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 ..."

Then you say this at 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."

Is it fair to say that the report into the Garnock Court fire contains less detail as to the nature of the GRP cladding than the Knowsley Heights report?

A. Contains less detail? I would say it contains probably a bit more.

Q. A bit more detail?

A. Yes. It at least makes it clear what we're dealing with.

Q. Right.

You say at 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."

Are you able to tell us how you reached that conclusion, that the GRP spandrel panels were the primary contributor to the rate and extent of the external fire spread at Garnock?

A. I mean, largely based on the information that's given in the BRE's report. The only thing on the outside of the building that's there that's combustible is these GRP panels. These are, you know, pre-formed GRP spandrel panels, essentially. I imagine they're quite polymer rich at their surface, and I can imagine that they would burn pretty enthusiastically, based on my knowledge of GRP.

Q. You go on to say at paragraphs 642 and 643, at the foot of page 124 and over to page 125 -- and I'm summarising -- that no further testing on the spandrel panels and no explicit comment was made in the DETR report as to whether the panels were class 0 or whether there were any implications for the Building Regulations

in England. You say you consider that surprising.

Have you seen any evidence in the form of a document or a witness statement that would provide what you might consider to be a tenable explanation for those omissions?

A. No.

Q. If we go to page 133 {LBYP20000001/133}, then, paragraph 701, you observe that testing on the spandrel panels was carried out between August 1999 and May 2000 under confidential contract to North Ayrshire Council; yes?

A. Mm-hm.

Q. So some testing was done?

A. Later.

Q. Later?

A. Yes.

Q. But not by central government, only under contract to the local council?

A. That's right. I believe that work was done on behalf of the local council and in some way in association with the Procurator Fiscal.

Q. Yes.

Can we go to the next page, page 134 {LBYP20000001/134}, paragraph 703. You say there:

"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. 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. I have noted what I consider to be some potentially significant differences."

And you've done that.

You then go on to say at 705, in the last line or last sentence:

"The removal of mentions of Class 0 from the reports to DETR appears to have been performed intentionally."

Now, you opine there that the removal of mention or the omission of a mention of class 0 was intentional. To be clear, are you offering no more than a lay view of the evidence as opposed to your expert opinion?
A. If you —— I mean, if you perform —— I mean, I suppose so. If you perform a side—by—side comparison of the two reports, what's striking is that they are, in the relevant sections, verbatim, or almost verbatim, and yet, you know, the sentence that deals with class 0 or

the specific set of words that deals with class 0 has been removed from the reporting to government but is present in the North Ayrshire reporting. I suppose that's a lay assessment.

What is interesting to me or what I'm puzzled by is why that information is considered sufficiently uninteresting to government that it should be explicitly removed from text which is otherwise verbatim.
Q. What is the significance of the omission of the mention of class 0 in the report that went to government?
A. That it, by its omission, does not flag the issue of class 0, you know, that it appears to not want to draw attention to class 0. Yes, I mean, that's all I can really say about it.

You know, I've watched, obviously, much of the testimony that's been given in Module 6, and I recognise a number of the witnesses were kind of questioned about this discrepancy and none of the witnesses were able to give a very suitable rationale for why that discrepancy existed, which I think is also a bit puzzling.

The only explanation that I have been able to come up with is that, in the reporting to government, which I think occurred —— sorry, the reporting to North Ayrshire Council was, I believe, temporally earlier than the reporting to government, where those

relevant sections of text are included, and it may be that, in the intervening time period, certain decisions had been taken and certain replacement products had been installed that meant that the mention of class 0 was not necessary anymore. But it is striking by its absence from any of the reporting to government, in my view.
Q. We come on, then, to the select committee's recommendations and the government's response as another missed opportunity in your list, I think.

I'm not going to ask you any questions about the evidence given or whether you agree or disagree with the recommendations, but if we look at the recommendations themselves, you summarise those on page 133 {LBYP20000001/133}, if we can go back to that, please, at paragraph 697. We could see that there. In the middle of the paragraph, you record as follows:

"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)."

I think we can agree that that recommendation was not subsequently acted upon as a fact, but you then go

on at 720 on page 137 {LBYP20000001/137}, if we go to that, please, to note that:

"'Class 0' was not mentioned within the government's response to the first report of the 1999 Select Committee inquiry."

Is that the Nick Raynsford response of 6 April?
A. I believe so. I would have to check the reference somewhere on that page. Yes, I see that.
Q. Right.
A. I think so, yes.
Q. Yes.

In your view, was the failure to implement the select —— well, let me put it neutrally, perhaps: how would you characterise the failure by government to implement the select committee's recommendations?
A. How would I characterise it? Foolish. Irresponsible.
Q. A missed opportunity?
A. A missed opportunity, for sure.
Q. I want then to ask you, finally on Garnock, what we should have learnt from it.

Can we start with that question, with page 138 {LBYP20000001/138}, the following page, paragraph 726. You say this:

"Given that Garnock Court's GRP overcladding fell significantly short of meeting the recommendations 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 existence guidance, rather than the existing guidance necessarily being inadequate. It is not clear what accepts 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."

Does it follow that, in your view, there was nothing about the circumstances of the Garnock Court fire that suggested that a large-scale test was required?

A. The Garnock Court fire itself, that's right, yes, I would agree with that statement. The Garnock Court fire showed that someone had put something on the outside of a building that you should not put on the outside of a building and that everyone knew you shouldn't put on the outside of a building.

Q. Right. So was the lesson from Garnock not that there was something wrong with class 0 per se, but there was something wrong with adherence and enforcement of the regulatory system as it stood?

A. And/or the competence of those people who were doing

that type of work, yes.

Q. Right.

You say at paragraph 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."

Standing back, and on a full and fair view of what transpired at Garnock Court -- namely, as you say, inadequate adherence to the guidance rather than inadequate guidance itself -- was elimination of class 0 justified?

A. Not on the basis of Garnock Court, but on the basis of evidence that was heard during the select committee inquiry, I think certainly some pretty deep thought about reconsidering class 0 would have been appropriate. You know, the evidence given by Dr Bob Moore, for instance, a number of comments made by various people who gave evidence in that inquiry, who were highlighting

concerns around class 0, concerns around the use of small-scale tests for a variety of reasons and, you know, that's the basis upon which I think there was a missed opportunity. It's not that Garnock Court -- what's interesting about Garnock Court is that a fire that happened for quite a straightforward and obvious reason precipitated a select committee inquiry that then ended up asking the really important questions. They were unrelated to the fire that had initiated the inquiry, but nonetheless were questions that had been asked and demanded some response, in my view.

Q. Yes, thank you.

Is it your view that introducing large-scale fire testing as an alternative, a choice, as an alternative way of demonstrating compliance with the functional requirement was not an appropriate response?

A. Yes, I think that's -- I think it actually made matters worse.

Q. Why worse?

A. Because it introduced, you know, another way that people who couldn't get through the class 0 route might be able to get through. You know, it opened up opportunities for people to attempt to game the regulatory system which otherwise wouldn't have existed, you know. If all you have is class 0 to try to game, then certain

products would just never be able to do it. But if you have large-scale testing as well, then other products might be able to get through the alternative route.

Q. We'll see that shortly, perhaps, with the introduction of the Euroclass regime and the work done around that. Let's go to that, then.

You have explained a little bit about the European SBI, single burning item, test. We know that in 2000 a decision of the European Commission led to the adoption across Europe of the European reaction to fire system, EN 13501-1, to harmonise methods of classification, and you've covered that in your report at paragraph 600.

Am I right in thinking that EN 13501 is a composite classification system?

A. That's correct, yes. It depends on a number of tests.

Q. There's a number of tests. The single burning item test, which is EN 13823, is one of a number of tests used to classify products or materials under the Euroclass system.

A. That's right.

Q. You tell us in your report that although the British Standards test methods used to establish national class 0, which is 476-6 and 7, and the SBI test are very different tests, they are nonetheless strongly allied,

or aligned perhaps, conceptually; is that correct?
A. Yes. I mean, they are both model tests and they are both -- part 6 and 7 are separate tests and SBI is a single test notionally based around a reference scenario of a fire growing in the corner of a room, as we discussed earlier.
Q. Yes. In terms of the alignment you referred to, both sets are focused, as you say, I think, on a fire in an internal reference scenario.
Can you describe what the differences between the tests are?
A. Other than by explaining what the tests are, not really.
I mean, if you look at the BS 476-6 test, you know, you have a little plate of material in a little box and you heat it and you measure how much heat comes off it, essentially.
In the part 7 test, you have the lateral flame spread, so you've just got a flat sample and you have a heat flux exposure that decreases as you move along the sample, and you ignite a fire at one end and you see how far the fire goes. Quite straightforward.
The SBI test is a more complex test, is a model that looks more like, if you like, the model that it's intending to simulate, and captures and kind of mixes a lot of the physics that would be more separately

interrogated in part 6 and 7.
So, you know, part 6 is about how much heat is coming off or out of a product; part 7 is about flame spread across a product; SBI is doing both of those things and others in a single test method.
Q. What is the significance of the differences?
A. Well, the significance of the differences between 476-6/7 versus SBI?
Q. Yes.
A. I mean, they're very different test methods. They're measuring similar things in different ways. I mean, one good example would be that the SBI test uses oxygen consumption calorimetry to measure heat release rates, to calculate the various limits that define the class limits in the Euroclass system. The part 6 test measures temperatures and uses the measure of temperature as a proxy for energy release, rather than measuring energy release directly.
So, you know, there's a whole host of differences that, again, are relevant to how one uses the outcomes or thinks about using the outcomes in a real-world application.
Q. Dr Debbie Smith of the BRE told us that they were completely different tests, like comparing an apple with an orange; both items of fruit but they are different.

That's what she told us at {Day235/185:7-13}. Would you agree with that characterisation?
A. I could go along with that, yes, both fruit but different fruits, sure.
Q. Right.
A. Yes.
Q. Let's then turn to composite panels with combustible cores.
Is this right: that there were concerns in 2000, when harmonisation was being considered, about the adequacy of the SBI test adequately to reflect the fire hazards presented by metal-faced polymer-filled core panels?
A. There were concerns -- I wouldn't be able to date the concerns, I don't think, but there certainly were concerns during the development of the SBI, and subsequently, that the SBI did not do a good job of predicting the outcomes of the scenario tests upon which it was calibrated. So the SBI did not do a very good job of assessing the fire hazards associated with metal-faced foam-core panels, for instance, sandwich panels, yes.
Q. Right. Let's lack at page 116 {LBYP20000001/116} and see if we can pin this down. On page 116, there is paragraph 607 and 608. At 607 you say this:

"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 - was felt by some to be dangerously misleading."
You have footnote 386 there, which is a reference to Messerschmidt, 2008.
Now, is that a quotation of what Birgitte Messerschmidt said in 2008?
A. Use of the word "exotic" is a quotation, yes, and, I mean, that's probably a paraphrase of what she will have said, yes.
Q. Right.
A. So the 2008 reference is to an event that was actually held in Edinburgh shortly after I moved to the University of Edinburgh, and Messerschmidt gave a talk at a conference that had been organised by the University of Edinburgh, and she set out her concerns as someone who had been involved in the process of developing the SBI test through the preceding decades.
Q. Right. Can you recall whether her views were well-respected and shared commonly, or was she regarded as perhaps something of a Cassandra?

A. No. I mean, I certainly respected her and I think everybody in the room respected her. Whether that's a representative sample of the community is hard to say.
The only caveat that is probably worth mentioning is that, at the time, Birgitte Messerschmidt was working for Rockwool, who are a mineral fibre manufacturer, and the products that the SBI did not well predict were polymer foam-cored products, so products that will likely have been manufactured by her competitors. But I think she would have been totally open about that; I don't think she was trying to hide that fact from anyone.
Q. Are you able to shed any light on, first, whether the Birgitte Messerschmidt views, if I can put it that way, as you've described it here, were any part of the British mainstream in the early noughties and beyond?
A. I think there was a recognition in some parts of the community that metal-faced sandwich panels in particular had the potential to cause significant problems in real fires but, from a regulatory perspective, were able to achieve classifications that were perhaps more positive than they might deserve when faced with the reality of fires, if that's a diplomatic way of putting it.
Q. It's diplomatic to the point perhaps of inviting a further question: which parts of which community?

A. Well, so, for instance, colleagues at Edinburgh in the years after 2008 were involved in a research project where metal-faced foam-cored panels were tested in room corner tests, so tests with boxes made -- room-sized boxes made of metal-faced sandwich panels. Those sandwich panels were very slightly damaged, you know, with a small hole or something in the metal skin, and the outcomes of those tests were not good. So it didn't take much of a chink in the armour of the metal-faced sandwich panel to demonstrate very poor fire behaviour.
And, you know, one can argue, as was argued by the manufacturers of those products at the time, that that was not a fair thing to do, because the regulatory tests that were giving them their very nice ratings said that they were okay and these tests seemed to indicate that they weren't.
So -- and this is the problem, it's the fundamental problem when you set up an unthinking, incompetent regulatory system, is that people will make those arguments and they will succeed. They will hide behind a test that allows them to do something that everyone knows they shouldn't.
MR MILLETT: Mr Chairman, I've come to the end of part of this topic, but I'm reluctant to start on the next one, which is the final element of the harmonisation regime,

which is quite long and we will not finish before 4.30.
SIR MARTIN MOORE-BICK: Would it be better to finish there?
MR MILLETT: It would be better to finish there. I am confident that we will finish Professor Bisby's evidence at some stage during the morning of Wednesday, given we are not sitting tomorrow.
SIR MARTIN MOORE-BICK: Right, thank you.
Well, Professor Bisby, it is a little earlier than usual, but it sounds as though it would be a sensible point at which to stop. I think you were already arranging to come back on Wednesday, were you not?
THE WITNESS: Yes.
SIR MARTIN MOORE-BICK: So it sounds, from what Mr Millett is saying, that you will be away, shall we say, by lunchtime, or can hope to be away by lunchtime. You can never quite be sure of these things.
THE WITNESS: Yes.
SIR MARTIN MOORE-BICK: All right. So we will break there, and we will look forward to seeing you again on Wednesday. We are not sitting tomorrow, as you know. I think it is probably right that I should remind you not to talk to anyone about your evidence or anything relating to it over the break, since it's a long one.
THE WITNESS: Certainly. Sure.
SIR MARTIN MOORE-BICK: All right? We'll look forward to

seeing you again on Wednesday. 10 o'clock Wednesday morning.
THE WITNESS: Thank you.
SIR MARTIN MOORE-BICK: Thank you very much.
(Pause)
Well, thank you, Mr Millett. As I indicated a moment ago, we shall not be sitting tomorrow in recognition of the fact that tomorrow is the fifth anniversary of the fire. So we shall resume hearings on Wednesday morning at 10 o'clock, when Professor Bisby will be back to answer some more questions.
MR MILLETT: Yes, Mr Chairman, thank you very much. Thank you.
SIR MARTIN MOORE-BICK: Good, thank you very much.
10 o'clock on Wednesday, please.
(4.27 pm)
(The hearing adjourned until
Wednesday, 15 June 2022 at 10.00 am)

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