QUEENSLAND COAL MINING BOARD OF INQUIRY

Coal Mining Safety and Health Act 1999

Establishment of a Board of Inquiry Notice (No 01) 2020

Before:

Mr Terry Martin SC,
Chairperson and Board Member

Mr Andrew Clough,
Board Member

At Court 17, Brisbane Magistrates Court
363 George Street, Brisbane QLD

On Wednesday, 24 March 2021 at 10am
(Day 21)

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THE CHAIRPERSON: Yes, Mr Hunter?

MR HUNTER: Before we call the first witness this morning, Mr Martin, can I hand up a tender list labelled M.

THE CHAIRPERSON: Yes. Thank you. This tender list marked M and the documents identified in the list will be entered into the evidence.

MR HUNTER: I call Andrew John Self.

<ANDREW JOHN SELF, affirmed: **[10am]**

<EXAMINATION BY MR HUNTER:

MR HUNTER: Q. Mr Self, is your full name Andrew John Self?
A. Yes, it is.

Q. You are a director of Australian Coal Mining Consultants Pty Ltd?
A. Yes.

Q. You hold a degree, a Bachelor of Science with Honours from the University of Nottingham that you obtained in 1982?
A. Yes.

Q. Did you, in that degree, focus on rock mechanics, mine design, surveying, ventilation, mechanical, electrical and electronic engineering, geology and geophysics?
A. Yes, I did.

Q. Do you have a first class mine manager's certificate of competency?
A. The UK version, yes.

Q. Australian Coal Mining Consultants, is that a business that you have operated since 1995?
A. Yes.

Q. Does that have a particular focus on underground coal mining?
A. Underground coal mining, particularly gas ventilation, spontaneous combustion and explosions.

Q. Have you worked elsewhere than here in Queensland

where you're now based?
A. Yes, the UK, Republic of South Africa, New Zealand, the USA, Iran, Iraq.

Q. Prior to your work as a consultant, did you work in underground coal mines?
A. Yes, I worked in operations for 12 years.

Q. And at what level?
A. Sorry?

Q. At what level?
A. I was up to under-manager, statutory under-manager.

Q. I'm going to have to ask you to try and slow down and to speak up a touch, because everything you say has to be taken down by the court reporter.
A. Very well.

Q. We'll need to make sure that we don't cause her undue stress. You're based here in South East Queensland. What familiarity or what level of familiarity do you have with underground coal mining in the Bowen Basin?
A. Quite detailed. That's where probably 50 per cent of my business lies.

Q. Were you engaged by RSHQ to undertake a review of a number of aspects of the operation of the Grosvenor mine?
A. Yes, I was.

Q. Prior to being asked to do that, did you have any familiarity with the Grosvenor mine?
A. No.

Q. Did you have familiarity with other underground coal mines in the same area, that is --
A. Yes, I think all except Grosvenor.

Q. So that includes Moranbah North, for example?
A. Yes.

Q. Can we start, please, with some basic concepts. What we see on the screen, which is slide number 2, is what's known as the Coward triangle?
A. Yes.

Q. Can you explain that to us? What is a Coward triangle

and what is the significance of it?
A. It dates back to early last century. It's about the explosibility or ability to explode of methane-air mixtures.

Q. Just speak up a little, if you would, please.
A. Sorry. This is normal air at this point here. So that's zero methane and roughly 21 per cent oxygen.

Q. You're indicating the top left-hand corner of the triangle?
A. Yes, I am. As oxygen depletes down here we get to what's called the inert zone, so this zone here, as low oxygen, below what's called the nose point, which is roughly 12 per cent at normal temperature and pressure of air, so this area in green here is inert, in other words, it won't perform a chemical reaction.

This area here is called fuel rich inert, so it's too low in oxygen to explode, but it's too high in methane, and this is where the goaf atmosphere often lies, somewhere in this yellow zone.

There in the middle of the triangle there is the explosible zone, but normal oxygen, that's between 5 and 15 per cent, approximately. You can see the explosible range reduces as the amount of oxygen reduces.

To provide a factor of safety, people draw different-shaped buffer zones around the Coward triangle, because obviously we wouldn't want to be just on the edge of explosibility without knowing it. So this is the sort of thing that's used for such as TARPs alarms, et cetera, in order to stay outside that buffer zone, which gives a factor of safety over the explosible range.

Q. We can see that this buffer zone I'm indicating now with the pointer starts at 2.5 per cent methane?
A. Yes.

Q. And you understand that figure of 2.5 per cent is the general body limit for working areas, if I can use that --
A. It was in the UK at that time. I think since 1947, a change in Act and regulations - I think that was the timing - that 2.5 changed to 2 per cent in the United Kingdom and remains there.

Q. We'll come to the position in other countries, but you understand that 2.5 is the limit here in Queensland?
A. Yes.

Q. In terms of where a goaf should be to be safe, what's the ideal position?
A. If we don't have methane, if the goaf is in this region here (indicating), then we've got spontaneous combustion risk, so it's not acceptable. So a methane-rich goaf is actually better. So the place that you want the goaf to be is somewhere in this yellow zone, well to the right. From the yellow zone, if oxygen or air is added, then the atmosphere will move in this direction, so we want to be well to the right here, so you want high methane, low oxygen due to spontaneous combustion risk.

Q. You mentioned the situation in the UK. Is this a table that you've prepared setting out what are the applicable limits in places other than Queensland?
A. Yes.

Q. Do you know why the limit was reduced in the UK from 2.5 to 2?
A. I have research papers on this. It was intended to increase the factor of safety from 2.5 to 2. I have information, which I cannot find at this stage, which shows that the number of explosions per annum, which was in the 10s at that stage, reduced significantly. There was a step change in the number of explosions per annum as a result of the increase in factor of safety.

Q. We see that even in Australia, in New South Wales, the limit is 2 per cent.
A. Now, as far as I can establish - and I've done a considerable amount of research on this - New South Wales has always been 2 per cent since the late 1800s. The regulations and Act were based on the UK. For some reason, New South Wales adopted 2 per cent and Queensland adopted 2.5 per cent.

Q. Are you able to explain - if you can't, please tell us - why Queensland has the figure of 2.5 per cent?
A. I don't know. Only that it was based on the existing legislation in the UK at that time, I would think.

Q. Did you tell us, though, that the UK changed from 2.5 to 2 per cent in the 1940s?

A. In the mid 20th century, yes.

Q. The Coal Mining Safety and Health Act was enacted in Queensland in 1999, so by that point the limit in the UK was already 2 per cent; correct?
A. Yes.

Q. But you can't assist us as to how it came to be at 2.5 per cent for Queensland?
A. It just didn't change. I don't know why.

Q. It had been 2 per cent under the earlier legislation - sorry, 2.5 per cent under the earlier legislation?
A. Yes.

Q. With respect to Grosvenor mine, did you review documentation that was provided to you that showed advice that had been given to the mine with a view to assisting it in managing the amount of methane that would be present in the goaf?
A. I think more in terms of designing a system to manage methane.

Q. And was the first document that you were provided, in terms of time, something that was undertaken by Professor Roy Moreby in 2010?
A. Yes.

Q. Did he use something called Flugge modelling?
A. Yes.

Q. We'll go to the next slide, but before I ask you to explain this in detail, what is Flugge modelling?
A. It was developed in West Germany in the 1950s, '60s and into the '70s. It was designed to establish an empirical model for gas emission so that a specific gas emission, which is the volume of methane released per tonne of coal mined - do you want me to slow down?

Q. It's all right.
A. And use that for predictive purposes in order to design gas drainage and ventilation systems.

Q. And is the result of a Flugge model a graphic that looks like what we can see on the screen on slide 5?
A. Sorry?

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Q. Is the result of a Flugge modelling what we see on the screen here?
A. Yes, sorry, yes, it is.

Q. Can you explain what this document shows us?
A. Yes. We have the coal seams in sequence vertically, from the Fair Hill here down to the lower ones. You see the worked seam, which is the Goonyella Middle, which is that point there. That's actually showing the Flugge and the Winter models, which are different, as you can see. That probably meant that they were applied to different parts or different coalfields. So the Flugge model draws a line at 58 degrees from horizontal vertically, above, draws a line at 25 degrees - there are other angles used.

The idea is - and this is a simplification of how gas emission works - this quadrilateral contains the gas which is desorbed upon mining and which ends up in the goaf or subsequently the ventilation stream. You can see it goes up, and as we get more further away from the coal seam, then it narrows off, so seams in the upper echelons here tend to give less gas on a proportionate basis than seams which are closer to the worked seam, in this region here.

Q. So it's the width of the two arms of the quadrilateral that go towards the top that tells us how much gas is going to be emitted from a particular seam?
A. Yes, it's very much a simplification, because if you look at this, the gas which is in the coal seam at that point there (indicating) will desorb and end up in the goaf. Gas a few metres away won't. Clearly, in the practical environment, it's not like that. So it is a simplification - quite a vast one, actually.

It can be adjusted, and people do that. I've seen situations in the south of New South Wales where, due to isotopic analysis, there's known to be gas coming out of drainage boreholes over here (indicting), and that's well outside either the Flugge or the Winter quadrilateral. So it shows that really, in that particular coalfield, Flugge doesn't work.

Q. This diagram shows us the P seam?
A. Yes.

Q. Is that the seam labelled PL1 on the right-hand side?
A. Yes.

Q. What does it tell us, though, in terms of modelling, at least, about what was predicted from the P seam?
A. According to the Flugge model here, the majority of the P seam from that point there across to that point there (indicating) would be desorbed during longwall mining or extraction and the gas in that coal seam would end up in the goaf.

Q. Did Mr Moreby explain his conclusions in the report that you saw in these terms?
A. Yes.

Q. What is an available gas reservoir? What does that mean?
A. It's the area within the quadrilateral, so the area of gas which is available for desorption, which will become goaf gas.

Q. So he then set out a table which described potential SGE - that's specific gas emission - rates with and without P seam?
A. Yes.

Q. Can you explain the figures that are set out in that table?
A. Yes. I'm not going to talk about the first two columns - that's just a different way of expressing SGE, on a square metre of coal seam basis. Most people tend to think about cubic metres of methane which is desorbed per tonne of coal mined. That is not a constant. At lower rates of production, the SGE will be higher. The reason is that coal has more time to desorb at slower rates of retreat. At higher rates of production, then the SGE curve tends to flatten out.

What it's saying is with the P seam, SGE of 12.8 from the roof and very little, 1.6, from the floor, giving a total of 14.4. Without the P seam, the SGE was estimated at 6.6 from roof, and 1.6 again from the floor, because that would not change, giving a total of 8.2 cubic metres per tonne.

Q. So do we understand, then, that what Professor Moreby was saying was that the P seam was likely to be a significant contributor to the gas that was reporting to the goaf?

A. The available gas, yes. Yes, and the Flugge model shows that.

Q. Is this, slide 7, an extract from Professor Moreby's report?
A. Yes.

Q. In it, he refers to the P seam being fully drained to residual gas contents, and what would be there when it was not effectively drained.
A. He's saying there that the P seam accounts for 40 to 50 per cent of total gas emission from coal sources, ie, excluding sandstones, siltstones, et cetera.

Q. Looking at that, what would that suggest to a mine operator about what should be done with respect to the P seam?
A. If you could go back one slide, please? The first thing to note is that 8.2 and 14.4 cubic metres per tonne is not especially high as an SGE. If you wanted to reduce risk considerably, then you would pre-drain the P seam, but you may also think that at 14.4 cubic metres per tonne, we can manage that with conventional pre-drainage, post-drainage and ventilation.

Q. When you say "pre-drainage", what are you referring to?
A. I'm talking about drilling holes into the P seam prior to longwall extraction, extracting the gas to as low a residual gas content as possible, and then effectively taking that coal seam out of the argument.

Q. We'll see some more data in due course, but how did Professor Moreby's modelling compare with the reality of what was being produced by way of specific gas emissions at Grosvenor?
A. Longwall 104 reached 25 cubic metres per tonne by the time the incident occurred, and that was with P seam obviously, because that was partly pre-drained but not to any great extent.

Q. Go to the next slide. Is this again a table from Professor Moreby's report?
A. Yes.

Q. Where he specified what, in his view, were the goaf drainage requirements?

A. Yes.

Q. We know that longwall 104, at least where the incident occurred, was being mined at a depth of just under 400 metres?
A. Yes.

Q. So using his modelling, what was required in terms of goaf drainage capacity?
A. Based on the assumption that 70 cubic metres per second passed across the longwall face as an airflow quantity, assuming that the aim is for 1 per cent methane, and I support that thought, which would mean that 700 litres per second would be diluted by the ventilation system. That's this column here. So if that amount of methane is taken away by the ventilation system, then the remainder, which is this column, must be captured by a post-drainage system, and that is the percentage of gas to be captured divided by the total. So it obviously ranges from 57 per cent to 82 per cent. That then translates into a flow which is required in the post-drainage system.

Q. I'll get you to explain capture efficiency in a bit more detail, if you don't mind?
A. Yes. The total amount of gas is - that's the peak - there. If 700 litres per second are captured by the ventilation system, then if that is subtracted from that number, that's the amount which must be captured by the post-drainage system. The capture efficiency is therefore that number in that column divided by the total amount of gas, which is in that column, which gives that figure as a per cent.

Q. So the highest figure, that was for a depth of 450 metres, was 82 per cent for capture efficiency?
A. Yes.

Q. Is that an achievable level of capture efficiency?
A. I would call that readily achievable with conventional vertical post-drainage holes.

Q. Did you then look at some modelling that was done by GeoGAS in 2011?
A. Yes, I did.

Q. Was that modelling - and we're looking at slide 10

now - based upon some actual boreholes that had been sunk into the various places that are depicted on that plan?
A. Yes, that's where the data came from.

Q. What do you say about the amount of data that would be available from that number of boreholes?
A. I would say that is sparse.

Q. In any event, GeoGAS provided some advice as to how the longwall gas should be managed?
A. Yes.

Q. It suggested, if we look at the first dot point, a surface goaf drainage system that had the capacity to handle up to 7500 litres per second at 80 per cent capture efficiency?
A. Yes.

Q. Again, are those levels readily achievable?
A. Yes, the 7500 litres per second number I think, in hindsight, was low. The SGE numbers which were generated by GeoGAS were similar to those of Moreby. They used a different methodology. They used a pore pressure model, which is a model based on a geotechnical model and it tends generally to produce numbers not too far away from Flugge.

Q. The next dot point which has a red box it around talks about maximising longwall ventilation quantities. What's that a reference to?
A. It just means to put the maximum amount of airflow across the longwall face for dilution purposes. What it doesn't mention is that basically or mainly dust will limit the velocity which is allowable across a longwall face due to people, and that limits - in that seam section, 70 cubic metres per second, which is what was available at Grosvenor, is probably about the maximum that you'd want to pass.

Q. It also says, though:

> *... placing the rear of block ventilation shafts on return particularly during extraction of the inbye portion of each panel.*

A. Yes.

Q. We know that the fan at the rear of the block was a forcing fan?
A. My understanding is there's an exhausting fan at that location as well as forcing fans. My understanding was that the exhaust fan ran for around about a week after the start of longwall production and then reversed across to the downcast shaft with cooling.

Q. Can you explain why putting the rear of block on return would be something that you would do, particularly during extraction of the inbye section of the goaf?
A. I'm not sure why they referred to the inbye section, but placing that fan shaft on exhaust will apply a positive pressure in the direction of the perimeter road, ie, from the longwall face to the perimeter road.

I can probably explain this better on the diagrams that are coming up, I think. It's all about the cross-goaf pressures.

Q. Sorry, the cross?
A. Cross-goaf pressures, ventilation pressures.

Q. The last dot point referred to:

> *Consider additional pre-drainage of the P seam in some areas and to a lesser extent the QB and GU seams.*

A. Yes.

Q. Did you understand that the P seam had been, to some extent, drained by Arrow Energy?
A. Yes.

Q. But that was prior to this document being generated?
A. Yes.

Q. So what was being suggested here, as you understand it?
A. GeoGAS are suggesting that the P seam should be pre-drained in addition to existing pre-drainage, and to a lesser extent the QB and GU seams - "GU" is Goonyella Upper.

Q. Is drainage of the P seam something that's generally done in that part of the world?

A. No, it's not. I should say, the P seam varies in thickness. In some areas it might be 300mm thick, which would be a very difficult pre-drainage target, in order to keep the drilling in that seam section. It thickens up towards Moranbah.

Q. So if it wasn't normally done, can you understand or do you get a sense of why GeoGAS were suggesting that it should be in this case?
A. No, I do not.

Q. You also saw a report or a gas management assessment that had been undertaken by Palaris in 2020?
A. Yes, I did.

Q. In fact the report is dated not long before 6 May.
A. Yes.

Q. Did that analysis involve looking at actual data from previous longwalls?
A. Yes, it did.

Q. Including longwalls 102 and 103?
A. Yes.

Q. Do we see at the top table the fourth item down is the specific gas emissions?
A. Yes, it is.

Q. What's the figure - it's at 150ktpw? What's that?
A. Thousand tonnes per week.

Q. So assuming 15,000 tonnes per week --
A. 150.

Q. Sorry, 150 - 150,000 tonnes per week. We have longwall 102, the specific gas emissions were 19 cubic metres a tonne; but for 103, they were 25?
A. Yes.

Q. So what's that, about a 25 per cent increase?
A. Yes.

Q. And the amount of methane being produced was increased as between the two longwalls?
A. Yes.

Q. The reference to "PDCE Range", is that a reference, as you understand it, to what was desirable or what was achieved?
A. I think that is what's achieved.

Q. The "Goaf Drainage Purity Range", what's that a reference to?
A. That relates to the proportion of the drained gas, which is methane. You can see from 102 to 103 that reduced considerably.

Q. What implication does that have or what does that mean, if the gas drainage purity decreases?
A. It means that you've got to drain a higher proportion of total flow in order to achieve a given flow of methane.

Q. So does that mean, in layman's terms, that the goaf drainage wells have to work harder?
A. Yes.

Q. Does that have a risk, when the goaf drainage wells work harder?
A. Yes. The harder you work a goaf drainage system, the more likelihood of pulling oxygen or air into the goaf.

Q. And how does that come about - that is, pulling air into the goaf?
A. Because you're pulling a higher flow in total, which means there's a higher likelihood of picking up oxygen or air from the periphery of the goaf.

Q. So the graph that is below that table, what does that show?
A. The chart? Yes, this is showing specific gas emission on the Y axis with kilotonnes per week on the X axis. As I said a little bit earlier, you can see at lower production rates, much higher SGE, and again that's due to there being more time for gas to desorb as the longwall face moves slowly. And as we get up into the sort of numbers which you would expect in a modern longwall, it's starting to flatten out or it has flattened out considerably.

Q. Palaris proposed a life of mine gas management strategy?
A. Yes.

Q. The third point there is gas drainage of the GM seam, and you understand that was actually done?
A. That's a given.

Q. That's the seam being mined - yes?
A. Yes, because of outburst risk mitigation.

Q. They also recommended gas pre-drainage of the P seam, at least in areas where the P seam is at virgin gas content and longwall emissions are forecast to be the greatest?
A. There's a caveat on the end of that. I don't really know what they mean by that.

Q. What is it about that statement that is difficult to understand?
A. The first bit:

> *Gas pre-drainage of the P seam using SIS where the P seam is at virgin gas content ...*

So where it's not being pre-drained prior to longwall mining, they're suggesting that it should be pre-drained, and they're saying "and longwall emissions are forecast to be greatest". I think if you're going to pre-drain a seam such as the P, you would just pre-drain it. You wouldn't try to cherry-pick and pick out the areas where you thought you had to.

Q. We see at (vi) "Uni-directional cutting". We've heard evidence earlier about cutting bi-di and uni-di.
A. Yes.

Q. What's the difference and what difference does it make to SGE?
A. In uni-directional cutting the shearer takes a proportional the coal seam each time it passes across the face and on the repeat run it takes out the floor, the bench left behind, which means it has to do two runs up and down the face to get one shear of coal off. In bi-di cutting, the whole seam is taken each pass and it is therefore more productive and it would therefore create more gas.

Q. At (vii), there's a description of the desirable goaf drainage system. The last point under (vii), though, is:

P seam pre/post-drainage laterals ...

A. Yes.

Q. Do you understand what was meant by that statement?
A. Yes, I do.

Q. Can you explain?
A. That would be a borehole or a series of boreholes in branches which are drilled into the P seam either from surface or from the worked Goonyella Middle seam. Those boreholes would pre-drain the P seam prior to longwall extraction. As the longwall approached, they would then turn into post-drainage boreholes, which would be truncated by the longwall, which means that they would extract gas from the roof above the Goonyella Middle seam.

Q. The last point on that page is:

Sufficient post-drainage infrastructure to support:
[Capture efficiencies] between 60-90% [and] ... flows up to 17,500 litres per second ...

A. Yes.

Q. Can we talk about the last one first. What do you say about that sort of flow rate from a goaf drainage system?
A. That's a large number compared to convention.

Q. The capture efficiency between 60 and 90 per cent, are those realistic numbers?
A. When we're talking about 90 per cent, this is an average figure which has to be achieved; it's not the peak. I think plenty of conventional vertical post-drainage systems will achieve 90 per cent. Sorry, I'm accelerating again. Very few systems would average 90 per cent.

Q. There was a section of that Palaris report that addressed the post-drainage system capacity. We've got a reference in the first dot point to the active goaf zone capture requirements and the total longwall gas capture requirements. What's the difference between those two?
A. I'm not sure. There are other sources. There can be sources from all the longwall goafs. There is rib emission, which derives from coal ribs as the air passes

towards the longwall face. That may be what the second one is saying. But the difference between 88 per cent and 90 per cent, they're not really practically different.

Q. We'll see in due course the actual PDCE, the post-drainage capture efficiency, that was achieved at Grosvenor?
A. Yes, we will.

Q. Have you done some of your own calculations about what was required, given the actual data?
A. Yes, I have.

Q. Can you explain what we see here on this chart?
A. Yes, I can. If we take 25 cubic metres per tonne SGE, which is roughly what it was on 104 at the time of the incident, there's nothing to say that number wouldn't have increased, as 103 did, as it came out.

On the X axis we've got tonnes per day and on the Y axis we've got litres per second of pure methane. So if we pick a production figure of 25,000 tonnes per day, then the average methane emission will be somewhere around 7000 litres per second, and the peak will be expected to be somewhere around 11,000 litres per second.

That peak figure may be higher. I have a lot of data which shows the ratio between peaks and means. It tends to range 1.3 to 1.8. This is based on 1.5. That's the amount of methane gas which has to be managed by the goaf drainage system and the ventilation system.

Q. Over the page, then, did you calculate the ventilation and post-drainage requirements for that figure of 25 cubic metres a tonne?
A. Yes, this is assuming 70 cubic metres per second airflow quantity across the face, running at 1 per cent. I favour 1 per cent as a design basis, because you will get peaks. Ventilation tends to be peakier than post-drainage systems, and it wouldn't be unusual to average 1 per cent and peak at 2 or even more. So I think 1 per cent is a supportable and defensible case for ventilation methane contribution.

So if 700 litres per second are captured by or yielded into the ventilation system, then the red line shows at various tonnes per day rates how much the post-drainage system has to capture. So if we're operating at 25,000 tonnes per day, we're going to have to capture 10,000 litres per second in the post-drainage system.

Q. And that 10,000 litres per second, is that 10,000 litres per second of all gas or --
A. Pure methane.

Q. Pure methane?
A. Yes.

Q. So what will be the overall capacity need to be - a figure that's higher than that?
A. It could be double that.

Q. Did you then calculate the capture efficiency that would be needed, again assuming that 25 cubic metres a tonne specific gas emission?
A. Yes, I did.

Q. Can you explain what we can see here?
A. Yes. I described post-drainage capture efficiency earlier. This is a sign of how efficient the post-drainage system would need to be in order to capture the amount of gas required, as shown on the previous slide. Again, at 25,000 tonnes per day, which is somewhere around Grosvenor's plans, we need 93.5 per cent post-drainage capture efficiency in order to maintain the tailgate at less than 1 per cent.

Q. How realistic, in your view, is a capture efficiency of between 93 and 94 per cent?
A. I think that is more a peak figure which would be achieved.

Q. How achievable is that peak figure?
A. As a peak - achievable.

Q. Did you also undertake an analysis of data that showed what gas was being produced by different seams at different depths?
A. Yes.

Q. You were listening, I believe, and you heard Mr Williams, who gave evidence on Monday, say that, in his view, the amount of gas produced did not increase with depth?

A. This is gas content in situ. There are some anomalies. If you look at the P seam, for example, it's higher in the sequence than the Goonyella Middle seam but has lower gas content overall. But you must note the scatter in the data, these points have a large amount of scatter. The GL seam, Goonyella Lower, which is the lower of the sequence, has the lowest gas content of all this coal seam. So the normal expected increase in desorbable gas content with depth has is being obeyed.

Q. Is not what, sorry?
A. Not being obeyed. That would make things unpredictable, I would say.

Q. So which one is the P seam?
A. It's the one which is --

Q. Can you mark that one?
A. That one there, so it's that line there.

Q. Did you look at some of Grosvenor's own data about gas make?
A. I did. This was supplied by Williams.

Q. And did you compare the gas make for 103 with 104?
A. Yes.

Q. What does this chart or graph tell us?
A. This is distance of face retreat on the X axis comparing longwall 103 and longwall 104, and the cumulative gas make in metres cubed per tonne on the Y axis. This activity at this point here is not unusual. As the face is commencing production you would expect variability, which is down to the strata caving in an abnormal fashion, establishing a normal caving pattern.

The 103 behaviour - the slight variations up and down are not to be taken too seriously, but the 103 pattern of gradually increasing specific gas emission with distance is fairly normal. The increase of 104 from very low figures just after face start, up to much higher figures after 100 metres, and then a gradual increase and then a step change is abnormal.

Q. Is that why you have used a figure of 25 cubic metres a tonne for the calculations that we've been looking at?
A. Yes.

Q. So we can see, then, that the difference between the two, at least from about 250 metres of retreat onwards was something in the order of 7 to 10 cubic metres a tonne?
A. Yes.

Q. Is that a significant difference?
A. Oh, yes. I said earlier the predicted figure of 14.4, or numbers around that point, would not - I think most gas and ventilation people would not be overly concerned about that. They would think they could manage that with conventional systems. When we get up into the 25 numbers, it would start to raise alarm bells.

Q. Did you look at the post-drainage capture efficiency of longwall 104?
A. Yes.

Q. And what does this chart or graph show?
A. It shows peaks up to 90 per cent and slightly greater than 90 per cent, but it shows mainly that the post-drainage capture efficiency was between 80 and 90 per cent, and probably the average - I've not calculated it - I would say it's low 80s, maybe 83 per cent.

Q. How would you describe the problem, if I can use that term, that confronted the mine operator in terms of the amount of gas, specific gas emissions, that were being generated by longwall 104?
A. Obviously longwall 104 was creating more gas than was expected. The post-drainage capture efficiency needed to be over 90 per cent and wasn't consistently there. The excess gas, which would have to go somewhere, between the achieved PDCE and the required would have to go to the ventilation system or it would have to be captured by some other method.

Q. We know that there were a number of high potential incidents in the tailgate of longwall 104 in the lead-up to the explosion?
A. Yes.

Q. Is there any connection, in your view, between the recurrence of those incidents and the figures that we've been speaking about in terms of how much gas was being generated at 104?
A. I think so. The system would be designed for

a certain SGE. When that SGE didn't eventuate, and it was much higher, then the post-drainage capture efficiency required to keep the tailgate gas concentration down to acceptable levels would increase. The post-drainage capture efficiency being achieved I don't think was high enough to achieve that.

Q. Did you also have a look at the ventilation system design?
A. Yes.

Q. Am I right in thinking that there is an ongoing process of regularly surveying the ventilation system to determine whether or not it's fit for purpose?
A. That's required legislatively. The legislation is rather vague. It says the ventilation officer must produce a report on the ventilation system monthly. Most mines, in fact I would say all mines, go well beyond that in terms of the survey detail they put into it and the analysis they do on the data.

Q. The next slide, slide 25, do you understand this to be a view of the tailgate, or the inbye end of longwall 104 taken from a ventilation plan?
A. Yes.

Q. It shows us the locations of some of the goaf seals?
A. Yes.

Q. There's one here in 38 cut-through, one here at 40-41 cut-through on the tailgate side, and some here across the rear?
A. Yes, there are seals all around the periphery of the goaf.

Q. This area here where I have the cursor, which is the top left-hand side of the screen, is that where you understand the downcast fan to have been installed?
A. Yes.

Q. On the surface, but forcing air down into the mine at that point?
A. It's there. It's at the end of that stud there.

Q. What do you say about the desirability of having a downcast fan there with the seal arrangements that we know were in place?

A. My preference is for an exhausting shaft at the back. We don't operate bleeders in Queensland. A genuine bleeder, if the shaft was there, then seal or seals would not be in place. That would mean that it would be a genuine goaf bleed as practised in the USA widely, which would mean that the airflow coming into the maingate end of the longwall face here, there would be a general pressure differential across to the upcast shaft here. We don't do that, and we don't do that for reasons of spontaneous combustion risk. So all seals around the goaf are in place.

Having said that, if we're on intake at this point here then the tendency is for these seals, all the way around, to generally breathe in, unless the barometric pressure is reducing rapidly, in which case they may breathe out some of the time.

Q. What does "breathing in" mean in terms of a goaf seal?
A. It means that the pressure in this perimeter road here is higher than the goaf here, which means there is leakage through the seal. It goes from intake into goaf.

Q. So that's fresh air getting into the goaf?
A. Fresh air.

Q. And is that an undesirable thing?
A. No, we don't want air getting into the longwall goaf for spontaneous combustion risk management reasons. There's another side to that, I guess, which is if this is an exhausting shaft, these seals would then breathe out, which is obviously the opposite from breathing in, which means that if you take a sample with a bag and pump, then what you will read is the goaf atmosphere coming out into the heading. If that seal is breathing in, then a bag sample has a very high probability of reading exactly what is leaking through that seal, which is fresh air.

Q. So does that mean that when you do take samples from a seal that's breathing in, you're not going to get a representative sample of what's in the goaf?
A. It compromises the validity of that sample, yes.

Q. There are some slides that show that, which we will see in due course.
A. Yes.

Q. This is a wider view of the same plan. Does it show the 400 metre sensor in this area here?
A. Yes.

Q. You understand, though, that there was also gas travelling down this heading here, C heading, that I'm indicating on the left-hand side?
A. Yes.

Q. Which did not then return to B heading until further outbye?
A. Yes.

Q. Meaning that it bypassed that 400 metre sensor?
A. Yes.

Q. What do you say about the desirability of that approach? Firstly, what I mean is the bypassing of the sensor?
A. It means that the sensor is not picking up the full tailgate gas flow.

Q. Did you have a look at the various surveys that had been conducted on longwall 104?
A. Yes, I did.

Q. Does this table set out what you were saying before about the general level of compliance with the time frames specified in the Act and the regulations?
A. It's not a compliance issue. There's a requirement to do a monthly survey. The sign-off of that survey is not legislated. It shows that there's a lag between the survey being conducted and the sign-off by the ventilation officer and the underground mine manager.

I think generally speaking - I've spoken to people in the industry about this kind of thing - generally, you would expect the ventilation report to be signed off within about a week, and you can see that some of these sign-offs by the VO were up to 42 days. The April survey at the bottom there was conducted in late April and wasn't signed off by the mine manager until 15 June. It's not an extremely important issue, but the ventilation survey and report will tell us about the health of the ventilation system, and that will allow action to be taken if things aren't as they should be.

Q. Have you yourself prepared some slides that will assist us in understanding how the ventilation system as installed worked?
A. Yes.

Q. How you would have, if you were designing it, configured the arrangement?
A. Yes.

Q. And do these slides also explain to us the concept of the goaf, the goaf fringe, and so forth?
A. Yes.

Q. This first slide is number 28. Can you explain what we're looking at here, please?
A. Yes, if you look at the legend, the light grey is goaf, the dark grey is solid coal, the red roadways are returns, which are generally heading from right to left, the blue is the intake. Number 9 shaft is shown there horizontally. It is it's obviously not. It is vertical. VCDs, ventilation control devices, are shown in black line. I've not differentiated between ventilation control devices because it's not important to what I'm about to say.

The ventilation system is reasonably straightforward. Airflow down number 9 shaft, which is cooled, which is obviously a heat management strategy, so that cool air travels around the periphery of the goaf to the cut-through there. That joins airflow up maingate B heading from that point there, which then splits at that point. So-called return air - it's not really return air but it's a homotropal heading, which contains the conveyor belt; and then the quantity which is going to pass the face heads up C heading, across the face - that's not green for any reason other than if you mix red and blue, you get green - into the tailgate.

There's also a flow, a small flow - the ventilation model showed about 1 cubic metre per second, and that's credible - which travels not turning left into the tailgate B heading but travelling right and through a cut-through here, with a stopping with a door in it, and then turning left and then going down all the way down to the confluence of 103 and 104, when C heading joins up with B heading and then travels outbye to the 3-4 cut-through monitoring point.

Q. So what we're looking at here, is that an R for regulator?
A. That's a regulator, which in this particular case is a stopping with a door in it.

Q. And the black lines are meant to refer to the various goaf seals?
A. Yes.

Q. Which in some cases were double seals?
A. Yes.

Q. This section here, is this the same section that we saw on the preceding plan, slide 26?
A. Yes.

Q. This heading here, which passes or bypasses the 400 metre sensors?
A. Yes.

Q. So if we move from slide 28 to slide 29, what are you intending to show here?
A. The tailgate end of the longwall face is the point of lowest pressure, which means that all flows will head in that direction. It's not entirely true, because the pressure at that point there in C heading would be similar not massively different.

Q. Why is that the point of lowest pressure? That may be a really basic question.
A. It is, yes. The ventilation system is designed to send clean air, fresh air, to the maingate end of the longwall face, across the face. So if you want air to flow in that direction, then that has to be the lowest pressure of any.

Q. So what does that mean in terms of the goaf? Perhaps we can explain that with the next slide.
A. Yes. That wiggly yellow line there is intended to represent methane. Methane, because of the pressures, is higher in this area than it is at the tailgate end, and the methane will naturally migrate to that point there. It will also migrate to other parts of the face, but the emphasis will be methane travelling to that point.

Q. Slide 31. You've got the yellow line reflecting methane but also a red arrow. What's that depicting?

A. This is the contentious ventilation system design which seems to have caused some angst in social media. This system is what I would call a back over return. It is not at all unfamiliar to me. Throughout my career in the United Kingdom, most faces were advancing, so in this case this would not be going that way, it would be going that way. But if we had retreat faces, which are more desirable from many points of view - we didn't have the luxury of that heading; we only had one heading in the maingate, one heading in the tailgate, so for that reason we would create what was called a snicket.

Q. A snicket?
A. A snicket in the goaf, which means that we would support part of this goaf down here and across at that cut-through, but there is no cut-through, so it would then migrate back out.

The purpose of that would be the same as this, which is to force some of the airflow coming across the face not to go past the AFC drive, the shearer, et cetera, which are obviously potential ignition sources, but to cause mainly methane, some air, to travel in this direction and bypass.

The conditions that we operated in in those years would not be tolerated now in terms of methane concentration and where people worked. So the purpose of this is a more robust version of a back over system from the 1980s, which is to cause a proportion - and as I said before, a small proportion, maybe 1 cubic metre a second, maybe a few more, maybe 3 - to bypass this critical area here and then travel inbye along the goaf edge through this regulator, which is designed to control the amount of airflow, which it is doing that, and then into C heading and out.

Q. And this is the situation that was in place at Grosvenor at the time?
A. Yes.

Q. Could we have a look at slide 32, then.
A. Yes, I do have some problems with the design as it is. Go back one, please?

Q. Sorry.
A. This area here is not ventilated. There's a seal at that point there, intake to return, the airflow going

through that regulator would then turn left and go down C heading, so we've under-ventilated a road here.

So if you go to the next one again, I would place a seal where it's shown. So every time it went past a cut-through, I would seal off the remaining dead heading, if you like, inbye of that point, so that this area here is effectively goaf. Concerns about the methane concentration as shown in that heading - I have no idea what the concentrations were, but it would concern me.

Q. So how desirable is it, if you're going to use a system such as this, that there be a sensor in that heading?
A. I can only tell you that I would want to monitor it.

Q. Slide 33. Again, this is not the situation that obtained at Grosvenor, but what are we looking at here?
A. This is what I would do. I know - I can think of reasons why you wouldn't do that. There's a certain amount of airflow which has been cooled, which is an extremely expensive exercise, so you want the cooled airflow to travel around here and enter the longwall face and cool the longwall face, in other words, to keep atmospheric conditions acceptable for humans to work. So I understand why you wouldn't want to waste that.

My version of this system would be there would be a regulator at that point there. I would spill some of the air coming down number 9 shaft. I would put that into C heading. I would dilute methane at that point with a view to diluting that methane down to statutory levels.

Q. Again, you would monitor the gas concentrations at least for methane?
A. The reason for monitoring the return would be that you would know if the system was working. If the system wasn't working, you've got the choice of over-regulating that, to reduce the amount of gas coming out of the goaf - sorry, I'm going fast again. So the actions available - if we monitor methane in this heading here and it's too high, ie above stat levels, then we can increase regulation at point R there, which would reduce the amount of air travelling across here, which would reduce the amount of methane which is being dragged out of here. That methane would then have to go past this critical area, so you would not want to do that. But if you wanted to get the methane concentration

down in here, there's a balancing act between the amount of regulation at that point and therefore the amount of methane exiting the goaf, and the amount of regulation at this point which would control the amount of fresh airflow which is coming into this heading, which would then mix at that point and take the methane concentration down to the required or design level.

Q. Can we go to the next slide. This next series of slides step us through the various flows in the goaf itself?
A. We've been talking mainly about gas management to this point, and I say in other slides that we can't manage gas and not manage spontaneous combustion, and vice versa. Both have got potentially catastrophic consequences and we have to manage both.

Spontaneous combustion creates its own explosible gases, such as carbon monoxide, all the way through the ethylenes and the acetylenes and other gases. Spontaneous combustion is a high risk on its own, because it creates potentially an ignition source as well as an explosible mixture.

Obviously a methane-air mixture can be explosible, as we saw in the very first slide. The combination of methane in explosible range and spontaneous combustion is something we've got to avoid, and we will only achieve that by managing both hazards.

This is a discussion of the leakage paths on a longwall goaf. This results from many, many, many measurements of gas concentrations through seals, and at this point here and also at this point here.

The goaf is a very complex animal. We think we understand it, but I don't think we understand it as well as we should. We don't understand the variability in the goaf caused by a changing caving environment, and we can only measure around the periphery. We don't know what's happening in the middle.

We'll talk about the gas fringe in a minute, which is around here. It's really a hypothesis, we don't really know what's happening there, but we have to manage it.

So the thin red line - there's a leakage path around all longwall goafs I've ever measured, which goes around here, which is adjacent to the ribs and along the face, that line here. So there's a relatively low resistance leakage path around the periphery and we'll have a flow around there.

If we measure gas concentrations here, that leakage path will be essentially very close to fresh air, quite high oxygen, low in carbon monoxide.

Q. Where is it coming from? Is it coming from the seals or coming from the maingate?
A. Both, in this case. If this were an exhaust fan, then this leakage here would be gradually - so the maximum leakage in this example with exhaust would be there, and that would be reducing as we go around. In this particular case, the maximum is at that point.

Q. At the tailgate?
A. Yes. That should not be confused with the goaf stream.

Q. I understand.
A. There's a leakage path on longwall faces. The area directly behind the shields is not well consolidated.

Q. Just so the record reflects it, we're now on slide 35. If you would continue, thank you.
A. Yes, so this is showing a leakage path which is directly behind the shields. It's in parallel with the longwall face. It serves a purpose, because it keeps the methane gas fringe further away from the longwall face than it would be if there wasn't a leakage path in that location. It's in parallel. The magnitude of that will depend on the airflow quantity on the face itself and the resistance of the immediate goaf behind here. The pressure differential across the longwall face from maingate to tailgate will dictate longwall airflow quantity across the face and that will also control the magnitude of this leakage path. That is not the goaf stream, either.

Q. Well, what will be the composition of that airflow?
A. If you measure it at this point here, you can feel the air coming out with your hand. That would be high in oxygen, low in CO in normal circumstances.

Q. And you're indicating at the tailgate end of the face?

A. Yes. So really not detectable, not substantially different from the face airflow quantity in terms of composition.

Q. Could we go to slide 36.
A. This had to be a slide because it's a concept or hypothesis. I'll explain the known facts first. So we've got methane gas concentration reducing to the left, so methane is highest in the deep goaf, around here, and it reduces, going in this direction. There's a transitional zone, which is what we call the gas fringe. The gas fringe is not a single line. It is a zone. So there's a transition from high methane, very low oxygen at this point here, through to higher oxygen and lower methane, and somewhere in the middle you can get the circumstances where it's explosible.

The compaction increasing to the right. So the goaf is uncompacted directly behind the shields and compaction builds up usually, and in the GMS most certainly, very quickly, so compaction increases to the right.

Ventilation pressure decreasing right to left. So the pressure here is higher than it is here.

We can argue forever about the shape of this object, which I've depicted as the goaf stream or the gas fringe. CFD modelling will draw something which is more biased, skewed, to the maingate, saying that the airflow goes in and then bends back. This is the reason that we put a brattice screen here, which is to reduce the amount of air which can enter the goaf and therefore become part of all three components - the leakage path there, the leakage path there, and the gas fringe or goaf stream here.

That is probably badly drawn. I would say that that is probably more close to here. The width of it we do not know. We can take measurements with probes and things around here and around here. Occasionally there will be a borehole into the goaf. But without multiple boreholes measuring gas concentrations, you would never get to understand the width of that gas fringe.

Gas fringe is important. There's potentially zones in here - in between this, which is almost fresh air, and in between this, which is high methane and low oxygen, there can be areas which are relatively high in oxygen and relatively low in methane, which means that oxidation can take place.

The best control over spontaneous combustion in this situation is to keep this face moving and moving quickly. That means that any area which oxidises here and gets to elevated temperature gets buried by the goaf as it moves back.

Q. Do I take it from what you've just told us that it's inevitable that at some point in the goaf there will be an explosible mixture of methane?
A. In a gassy mine, yes.

Q. Let's go to the next slide, then, slide 37. Could you tell us what the red rectangles depict?
A. Yes. I'm going to pretend to be a lawyer and go to the caveat first. These are not the only high risk areas. There are others. Along here, you tend to get low resistance, lots of fractured coal, because that's where the longwall face set off so that's also an area, but I'm trying to depict some --

Q. Just slow down.
A. Sorry. I apologise. This area here, we have a leakage path, as we discussed. This area here, we have a leakage path, and in both areas we have high oxygen approaching certainly mid teens in most cases, I would say. So we have a leakage path, we have oxygen, we have broken coal because it's the goaf edge, so this here is solid pillar and this here has been extracted, so there is coal which is in a fractured state in this region, so that would therefore be an area which would have the potential to generate a spontaneous combustion incident.

This area in here, this is the transitional zone I talked about, which is between the deep goaf and the fresh air on the longwall face and just behind it. This is an area which has got plenty of fractured coal in it, it's got oxygen in it, reducing to the right, it's got methane in it, reducing to the left, and we have the fractured coal and a flow path.

When we measure the goaf stream, which is a vital piece of data, we measure it at that point there, and that will be warm to the touch, which means you can find it and you can differentiate it from the cooler fresh air coming down this way, and relatively fresh air coming in this direction. In between those two, there's a warmer zone, and that's the goaf stream.

Now, the importance of the goaf stream is that it has passed these areas of high risk. The reason it's warm is that it's reflecting the oxidation which is taking place in this critical area, so it's at increased temperature, which shows oxidation is taking place, and if not managed or controlled, then that has the potential to become a spontaneous combustion incident.

Q. We understand that the goaf fringe at Grosvenor was customarily sampled twice per shift using a bag sample?
A. Yes, that's fairly normal.

Q. Are there limitations to that process of taking a bag sample?
A. Definitely. I observed conditions at the longwall face here, around here, which would make it inadvisable to try to get too close to the goaf, and it's difficult to get a representative bag sample of the goaf stream unless you are very close to the goaf.

The gases coming out of this goaf stream here are quite condensed, they're rich, because they've not been diluted, so the products of combustion which are generated here in the goaf, reasonably deep, are not subject to substantial amounts of dilution before they get to this point here.

So if you can sample the gas right on the goaf edge and get an undiluted sample, that is the most representative sample of gas monitoring you'll get on the longwall. But that is difficult to achieve. You can use probes, but using the probe you can't find where the goaf stream is because you need your hand to find it.

I think some of the gas samples were taken from C heading, because there obviously the goaf stream at that point there would split. Some would enter the tailgate, some would go in that direction. I don't know which is more representative. I'm unsure about that.

But what we need in this circumstance - and when I say "we", I'm talking industry; this is not really about Grosvenor - we need a reliable and robust method of identifying the goaf sample and taking telemetric readings of it, what people call real-time, which is not actually real-time, but every few seconds or every few - even every few milliseconds, but there's a delay, which is why it's not real-time, but it's much more frequent than twice a day bag samples.

We have tried in the past on numerous occasions to put tubes in the location, but the goaf stream moves. The reason the goaf stream moves is that the shields are advanced, which causes disruptions in the goafing characteristics, which means that the lowest path of resistance is moving on a regular basis.

So the crux of a goaf stream sampling system - and this is researched - the crux of it is a method of identifying where the goaf stream is and then sampling it.

There is technology, which I believe can be either adapted or converted, or whatever it is, to do this. It may be laser gas detection, it may be LiDAR, which is a derivation of laser, by means of which you could have an instrument located somewhere in this vulnerable region, which may require duplication or something of that order, whereby we can identify where the goaf stream is and then sample from that point remotely.

Q. Do devices that are capable of doing that exist?
A. Devices capable of monitoring methane at kilometre distance using LiDAR exist, and they're used for greenhouse gas emission type things on landfills and stuff like that. In coal mining, no, they do not.

Q. Is that because none have been made sufficiently safe for use or adapted for use underground in a coal mine?
A. There would have to be a completely bespoke design made, which would have to be approved for underground use. So that is not going to happen soon.

Q. There are a variety of factors that affect this fringe that you've spoken about.
A. Yes. I'll just go through them.

Q. Could you talk us through them?
A. Sure, ventilation pressure differentials. The pressure differential at Grosvenor was from the perimeter road towards the tailgate. That will affect the position

of the goaf stream. My view, and it is only a view, an opinion, is that that would make the goaf stream or gas fringe, generally speaking, be closer to the longwall face than if the shafts had been on return.

Face airflow quantity and pressure differential will both affect the goaf stream. If the face airflow quantity increases, and that would result from a pressure differential, then the goaf stream will be deeper into the goaf than it would at a lower face airflow quantity.

The back over return will probably split the goaf stream, so some of it would go to that regulator that we showed on the diagram and some would report into the tailgate.

Goaf compaction is a variable. That will move the goaf stream or the gas fringe around, which is why goaf stream sampling is - at the moment I believe it to be a flawed process because you have to identify where it is, and that's very difficult to do without putting yourself in a position that's not safe.

Caving characteristics. Again, if the goaf is hanging up, then the goaf stream will do different things than if the goaf is caving in immediately behind the shields.

Gas make is a factor. If the gas make is higher, and it is a variable, then increased gas make will cause the gas fringe to move towards the longwall face, which could involve an HPI, a gas exceedance.

Post-drainage - the efficiency or efficacy of the post-drainage system will affect the position of the gas fringe.

And the last one, which is the mining engineer's nightmare, is the barometric pressure variation, which happens every day, twice. On a lowering barometric pressure, the gas fringe will be closer to the longwall face than if it's static. On an increasing barometric pressure, the volume of gas in the goaf will reduce, and the gas fringe will move into the goaf away from the face. Again, barometric pressure can be a cause of gas exceedances.

Q. We might come back to this a bit later, but you told

me before that in gassy mines it's almost inevitable that there is going to be an explosible mixture somewhere in the goaf?
A. Not all the time necessarily. Most of the time I would say yes.

Q. You spoke a moment ago about the caving characteristics of the goaf. One thing that can occur is a fall in the goaf as it caves that forces the contents of the goaf or part of those contents on to the face?
A. Yes.

Q. Is that something that we just have to live with? That's an inevitable thing in coal mining, that's going to happen from time to time?
A. With all due respect, I'm not a geotechnical engineer.

Q. Well, is it acceptable that there could be a goaf fall that would push an explosible mixture of methane onto the face?
A. It's not desirable.

Q. Should it be able to be avoided?
A. It would be preferable to avoid it, yes. I don't know how you would do that.

Q. This slide refers to post-drainage and it shows some of the goaf wells.
A. Yes.

Q. What is this diagram designed to show us?
A. These are not the only goaf wells, as I think most people would know. There are older goaf wells around here, other goaf wells along here, but that's not the point of this discussion.

So the gas fringe, which we've spoken about, which will not be that shape, but the general characteristic is of air entering the goaf at this end, sweeping around here and coming back out the tailgate. So it's just a graphical representation of what the goaf fringe may look like.

Q. We've spoken about spontaneous combustion.
A. Could you go back to that one, please?

Q. I beg your pardon, I'm sorry.
A. I pressed the button twice. What I'm trying to show

here is that we've got this back over return thing happening here, which is taking a small quantity of airflow across that triangle piece of goaf there. This is the compromise between spontaneous combustion and gas management. We want to sweep this gas fringe away from this zone here because there are potential ignition sources. We don't want to put air into the goaf, so we compromise. So there's a spontaneous combustion risk compromise here, which is putting air across this area of the goaf. At the same time, we've got goaf wells here which are quite close to this longwall face, and the purpose of those is similar to the goaf fringe management.

So if you look at this situation here, we're drawing goaf atmosphere out through these yellow dots, which are vertical goaf wells, and part of what we're drawing out of there is this back over return here.

So that's a good example, I think, of the compromise between the management of the two systems. We can't a hundred per cent manage gas and ignore spontaneous combustion and vice versa, so there has to be a compromise on spontaneous combustion management which says that we acknowledge that we will pull some air into the goaf by this method, and I think that's probably unavoidable.

Q. That red arrow that we see there, by that arrow, do you mean to indicate that the atmosphere that is immediately behind the shields will be included in that airflow?
A. It will be diluted.

Q. So let's say there is a small amount of spontaneous combustion going on immediately behind the shields.
A. Do you mean physically small or early stages?

Q. Well, either.
A. Okay.

Q. In terms of what it's emitting by way of spontaneous combustion indicators.
A. Yes.

Q. Is there the risk that rather than reporting to the goaf stream, those spontaneous combustion indicators, or a substantial part of them, will go up the goaf well or through that regulator?

A. Highly likely.

THE CHAIRPERSON: Q. Sorry, what did you say?
A. Highly likely. Those goaf wells will capture whatever there is there in the goaf, and if that happens to be coming off a spontaneous combustion minor event or early event, or whatever, then it will go into the goaf wells, yes.

MR HUNTER: Q. Is there anything further about that slide that you would like to say?
A. No.

Q. Can we move to a discussion of spontaneous combustion and the tension between managing methane levels in the goaf and managing the spontaneous combustion risk.
A. Yes.

Q. Can you tell us, firstly, about what spontaneous combustion is?
A. Yes. I feel the need to dig into this. This is an industry problem. It's not about Grosvenor. It's probably exacerbated in Goonyella Middle seam mines purely because of the thickness of the coal and the coal left behind in the goaf. We need to learn some lessons, I think, on spontaneous combustion management. We've had some major events in the last few years.

Q. Just slow down again, sorry. You've had some major events in the last few years?
A. We've had some major events in the past few years.

For spontaneous combustion to take place, there needs to be an imbalance between the heat generated by oxidation and the heat removed by cooling, and that cooling is normally convective, which is a result of the airflow itself.

In a low flow environment, the rate of convecting cooling may exceed the rate of heat generation. So a piece of coal may oxidise, may increase in temperature. The rate of cooling will increase with the increased temperature and you may reach an equilibrium temperature, most likely at low temperature, and that's where the goaf needs to be.

We will not stop oxidation in the goaf unless we can stop oxygen getting into the goaf, and I don't think that is practical, provided we are ventilating a goaf with high quantities, particularly in a gassy environment.

At higher flow, equilibrium may soon be reached, most likely at higher temperature. That is less stable. In between these two states there's a condition necessary to allow spontaneous combustion to progress. So what I'm saying is we have not got enough cooling to keep the temperature under control, but we have got enough oxygen to sustain the oxidation process. Is that clear, Mr Hunter?

Q. Yes.
A. In some cases that will lead to high temperature equilibrium being established or that equilibrium may be destroyed and the temperature may run away - and people talk about thermal runaway; I'm not entirely sure what they mean by that - up to a temperature at which - there's a temperature in a temperature/time curve beyond which I don't think you recover. I think things have got so far out of control that really whatever you do is not going to get it under control.

Now, where that temperature lies I can't say, but it's not extremely high. I think you can read papers and books that will say if you get to 70 degrees Centigrade, then you're not coming back from that. So we've got to keep down near ambient temperature.

Variables include coal reactivity - that is very much a variable; thermal conductivity, coal is a good insulator; the ambient temperature is a factor; and others. Human intervention is a major factor in spontaneous combustion. I think quite often there may be a fairly minor event happening, and as operators we exacerbate the problem, typically by a ventilation change.

Q. Go to the next slide. I think you might have mentioned the first point already, but can you explain that in some more detail, please?
A. Yes, I did. The temperature rise time curve starts off at low gradient and increases in gradient with temperature, which is because the reactivity of the coal is increasing with temperature.

That means the higher the temperature you're at, the more reactive the coal, so therefore it's less stable. That could be artificially induced, and that will bring us on to the polyurethane resin discussion at some stage.

Beamish's work - we know reactivity increases with temperature. That's a known chemical fact. At higher temperature, the likelihood of it getting away and becoming uncontrollable is higher than at lower temperature. For low temperature equilibrium, we need to be close to ambient, within a few degrees.

If the polyurethane resin did increase the temperature of the coal, then Beamish's work indicates - and I gather this is further work, which I've not seen, but it indicates if you heat the coal up, then it will move up the curve unnaturally and it will continue from that point onwards. So if we're at 40 degrees Centigrade and the coal's heated to 70 degrees Centigrade, then the temperature time curve will resume at the 70 degree mark. It won't come back down. I understand - I haven't really got all the information here, but I understand that somewhere around 100 degrees Centigrade is the definite point of no return.

Assuming that this abnormal oxidation is recognised, ie recognised by gas monitoring, action is often taken when none may be preferable.

Q. Could you explain that?
A. Yes. If you make a change, if we've got a spontaneous combustion event in its early stages and we've identified it, then there are a number of actions you can take. The most positive action is water, because water excludes oxygen and takes away the heat. It's very rarely possible to flood a spontaneous combustion event.

We can introduce inert gases, and there's a caveat to that, which we'll come to later on. Inert gases are capable of excluding oxygen but will not reduce the heat. So if an incident is sitting there, it has oxidised, it's reached a stable temperature, ie it's not increasing, and we inertise, then we may halt that process. But inert gases will not reverse that process. If you introduce water or some other cooling agent, then you can actually reverse the process and bring it back to ambient temperature.

Ventilation changes are extremely high risk when there's a spontaneous combustion event happening. The reason for that is that we don't really understand the changes that will occur within the deep goaf when we make a ventilation change, but what we do know is that a ventilation change has the potential to cause reversals, to cause redistributions. If you have something which is at, say, moderate temperature, if you change the ventilation around, reduce the flow to it, in all good intentions, you want to reduce the flow, to reduce the oxygen getting there, but the truth is that if any oxygen is getting there, then it's not taking away the risk.

So if you reduce the flow getting to that point, the likelihood you're going to reduce the amount of oxygen getting to that point below a point that oxidation will no longer take place is negligible. What the reduction in airflow quantity will do is reduce the cooling.

Ventilation changes have led and continue to lead to explosions. The mechanism is that a reduction in airflow to a spontaneous combustion event by means of, say, putting on seals may led to an increase in temperature coincident with an increase in flammable gas concentration. So the reduction in airflow quantity at the event has two effects - it can increase the temperature and it can increase the concentration of gas at that location. This is where there's a long history in the UK of explosions occurring on an extraction face.

MR HUNTER: I note the time, Mr Martin.

THE CHAIRPERSON: Whatever is convenient, yes. We will adjourn until a quarter to.

SHORT ADJOURNMENT

MR HUNTER: Q. I've just asked that the PowerPoint be taken back to slide 25. In particular, can we have a look at C heading here. The plan is endorsed with that "Danger Irrespirable Atmosphere" marking.
A. Yes.

Q. Is that significant to you, that that roadway or that C heading has been labelled in that way?
A. You would have to ask the question why the atmosphere is irrespirable. If that's accessible, then it should not be.

Q. Would the answer to that be, well, that contains

atmosphere that's coming directly out of the goaf?
A. Yes.

Q. So that's why it's irrespirable?
A. I don't know that. I think so.

Q. If you assume that there was no monitoring for gas in that heading, that it bypassed that 400 metre sensor and then rejoined B heading, what do you say about having a situation where you have this irrespirable atmosphere in C heading that is unmonitored?
A. If you go back to what I said about my preferred design, which had a regulator and intake dilution, that would be a reason that I would do that.

Q. Given that that wasn't done, that there wasn't any dilution, what do you say about having an unmonitored but irrespirable atmosphere in that heading?
A. I wouldn't do it.

Q. Why not?
A. Sorry, why?

Q. Why not?
A. Oh, I wouldn't like an irrespirable atmosphere in a roadway which people could access.

Q. Could we go back, then, to slide 42. I think we'd finished that slide. You were talking, before we adjourned, about ventilation changes potentially bringing an explosible mixture into contact with a spontaneous combustion event.
A. Yes.

Q. Would you go on, please, and tell us?
A. Certainly. A ventilation change - I spoke about it before the break slightly - may bring an explosible mixture into contact with a spontaneous combustion event.

Q. Just slow down, I'm sorry.
A. Already? Sorry.

Q. I know it's difficult, particularly when you're looking at the slide.
A. It's just me.

Q. I'm as guilty of it as you, so just bear it in mind,

please.
A. What I'm saying is that when we make a change, then there will be pressure and quantity changes. We predict those using the ventilation simulation. All mines operate a ventilation model, as it's termed, and we will calibrate that thing periodically, and it needs to be in calibration.

Once we have planned the event using a ventilation model, we know or we have a prediction of the changes that will take place as a result. That will be within probably five, certainly 10, per cent in airways, active airways. That will not be within 10 per cent in goafs, because we don't understand the goaf itself. We don't know what the resistance is across certain sections of the goaf, and it's a variable, it's changing all the time.

This is why I say that a ventilation change when there's a spontaneous combustion event happening is a very serious thing, almost to the point where if you asked me to make a ventilation change, I'll plan it, I'll analyse it, and then I won't do it, because the risk of making that change can be significantly higher than the risk of not making that change.

Q. We know from the accounts of workers who were on the face or nearby at the time of the incident on 6 May that there was a pressure bump or, in some cases the description was there was a reversal of ventilation along the face?
A. Twice, yes.

Q. You've been speaking about planned ventilation changes.
A. Yes.

Q. But does the same concern arise in the case of an unplanned ventilation change such as that caused by a goaf fall?
A. Yes. An unplanned ventilation change we normally relate to where someone's done a change and they should not have. It's usually a human intervention. In that case, a major roof fall, it's changed pressure and flow in the goaf and on the longwall face and all the way out to number 9 shaft, so, yes, that's a ventilation change, albeit not human initiated.

Q. So if in this case what has occurred is that a goaf fall has pushed an explosible mixture across a spontaneous

combustion event, perhaps a small one, is it of concern that there were no obvious signs of spontaneous combustion occurring?
A. I think I say this down the bottom. Major concern, yes. Sorry, let me explain, if you will.

Q. Please.
A. There are two possible mechanisms. If we had a spontaneous combustion event taking place at less than the ignition temperature of methane, that is one circumstance. In that situation, the ventilation change caused by the goaf fall could push oxygen towards that event. I actually doubt that. I think it already had enough - if it was there, it had access to oxygen. In that event, then there could be a change in temperature caused by increased oxidation. I think probably not.

I think the most likely event is that the event was above ignition temperature and the effect of the goaf fall was to push an explosible mixture towards it. So it would be an equilibrium in that the explosible mixture was not at the spontaneous combustion site.

I talked about that critical zone earlier, the higher risk. The likelihood of a spontaneous combustion event is close to the shields. The deeper into the goaf it goes, the less likely it becomes because the lower the oxygen content and higher methane content. It would most likely be close to the shields.

I think the mechanism most likely, in my opinion, is that the methane-air mixture was pushed towards an existing ignition point, and that was the ignition.

Q. You say the absence of any detection by the traditional indicators beforehand is of major concern. Can you elaborate on that, as to why it's a concern?
A. We monitor for spontaneous combustion. We design systems to minimise the risk of spontaneous combustion. We gas monitor. We analyse data. Based on that data, we take actions such as inertisation. If we don't know that a spontaneous combustion event is beginning and even progressing, then we're unable to take action, and one of those actions may be to evacuate people. If we don't know it's there, then we can't take those appropriate actions, whatever they may be.

Q. We've spoken already about the tension between spon com, or spontaneous combustion, management and the management of gas. This next slide addresses that. Can you elaborate on the tension between the two objectives?
A. Yes, I can. We've done some of that so far. Management of gas and spontaneous combustion require contradictory design and operational systems. I'll explain why.

Gas management requires large airflow rates and high differential pressures. The USA practice - I'm generalising - it's common in the USA to put high pressure across goafs, run multiple headings, and the intent is to empty the goaf of methane. I don't think that is possible, but I do think if you apply high flow rates and high differential pressures, then you've got a very high potential to take methane away from the longwall face, which is where most of the ignition potential exists and that's where the people are.

Spontaneous combustion management requires precisely the opposite. We don't want to ventilate the goaf. We don't want any air getting into the goaf. It's complex. I'm not going to try and explain spontaneous combustion and gas management in total right here, but that's the crux of the matter. The crux of the matter is that we need to minimise ventilation into the goaf for spontaneous combustion reasons, we need to maximise flows for gas management reasons.

It's always going to be difficult. The manifestation of one or both of the hazards can be catastrophic.

Q. Let's say you are trying to manage your gas, and one of the things you've told us about managing your gas is that gas management will impact upon your ability to manage spon com?
A. Yes.

Q. So would you expect a mine that was designing a goaf drainage system to include as part of that process a risk assessment for spontaneous combustion associated with that goaf drainage?
A. I think you would need to risk assess gas management and spontaneous combustion management at the same time. I don't think you can treat them as separate issues.

Q. Did you know that at Grosvenor the risk assessment for the goaf drainage system specifically did not address the risk of spontaneous combustion as a result of increased goaf drainage?
A. I'm not aware of that.

Q. Have you seen a risk assessment that says just that?
A. I have seen a risk assessment, but the concentration on that was some handwritten notes at the end.

Q. Perhaps if I could ask, Mr Operator, if we could bring up AGM.002.001.0937. This is the risk analysis for goaf drainage. Could we go to page 17 of that document, please, Mr Operator. Do you see endorsed on that document:

> *Increased spontaneous combustion risk due to increased gas drainage has not been assessed in this WRAC.*
>
> *Additional WRAC required to assess and control spon com risk.*

A. Yes.

Q. Does that surprise you, that that approach was taken in terms of the risk assessment for goaf drainage, bearing in mind that production commenced on this longwall prior to 31 May 2020, which was when that WRAC was to be completed?
A. It doesn't say post-drainage.

Q. Sorry?
A. It does not say post-drainage. It says gas drainage. I don't know that it relates to pre-drainage of the seam, which does increase spontaneous combustion risk. I took that to mean that the increased risk of spontaneous combustion is caused by pre-draining the seam, which is true because it drains the seam of coal and it provides access for oxygen to the coal seam.

Q. That, to you, is not a reference to the increased suction on the goaf wells, with the risk of introducing further oxygen into the goaf?
A. The truth is I don't know. I read it as pre-drainage.

Q. If it was about post-drainage, would that be a surprising situation?
A. Yes.

Q. Would you embark upon production on a longwall, if you were operating a mine, without doing a risk assessment for spontaneous combustion associated with gas drainage - that is, post-drainage?
A. No.

Q. Could we go back to the PowerPoint, please, Mr Operator. There's nothing further on this page that we need to discuss, but there are some diagrams that we'll come to. In the first dot point on this page you say that gas monitoring systems and spontaneous combustion indicators are flawed. What do you mean by that?
A. The slide explains that. Gas monitoring takes place at a limited number of locations. We very rarely monitor in the goaf itself. We can monitor goaf wells, but you only have so many gas monitoring points, and things can happen which - they're not normally missed, but things can accelerate and not be identified at an early stage, which is not where we want to be. We need to be identifying problems at an early stage.

It's also TARP driven. When gas monitoring alarms are raised, then that raises a TARP. Are people familiar with the term TARP?

Q. Yes.
A. Which introduces a human element. There have been cases where the person has not used the correct TARP. There may be cases where the person doesn't know what it means or doesn't know how to react or he's very busy and is doing something else because the conveyors have stopped. So as soon as you introduce the human element, you introduce a variability which you can't control.

Gas monitoring systems may be unreliable. Over-reliance on a gas monitoring system in that case is a problem. I've seen gas monitoring systems where as many as 50 per cent of the points weren't working. When we run TARPs we say that if the gas monitoring system is not working, then we replace, for example, a telemetric transducer with a person with an instrument in his hand, so again you've introduced the human element.

This next point is about that. Are people familiar with SIL?

Q. I think you should explain it to us.
A. Yes, safety integrity level is functional safety. It's about putting in management systems which are appropriate to the level of risk quantitatively. A SIL rated system can be tiered. So, for example, we may have a PLC which controls the gas monitoring system, but that may be tiered with two or three others, and the manufacturer produces a PLC, programmable logic controller, to a SIL level, so it's not just something someone bought at the nearest supplier. It's one that's certified as being SIL rated.

Gas monitoring - there's a person who could answer this question better than me at the back there, but not allowed to. Gas monitoring I think is at least a SIL 3, if not a SIL 4, which is up there with railways, lifts, that sort of thing. SIL 3 is potential to kill 10 people. SIL 4 is potential to kill 100 people. So my argument would be SIL 4.

If a SIL 4 rated gas monitoring system was determined to be a necessity, it would almost, in my opinion, require duplication, so we'd have two completely independent systems monitoring gases at various points. Those systems would be independently designed by different people. They would be independently manufactured by different manufacturing processes, and independently installed by different people. So there would be absolutely no common cause of failure between the two systems.

I'm raising the question - and now may not be the right place to do it, but I'm raising the question now: do we need a SIL rated gas monitoring system in an underground coal mine in 2021?

Q. What's your position?
A. Mine?

Q. Yes.
A. Absolutely, yes, we do.

Q. No doubt one of the points that might be made against that is that duplicating the system in the way that you've described would be very expensive?
A. Very expensive to manufacture, install and maintain. I think the maintenance aspect is probably as important as anything else. To maintain it to its specified function.

Q. The next point is perhaps significant when we come to the TARPs.
A. Yes.

Q. You talk about a particular spontaneous combustion indicator reacting earlier than others.
A. Yes.

Q. Can you give us an example and explain what you mean by that?
A. I've seen situations - most spontaneous combustion events, I'm talking about something serious, because I don't get involved in non-serious events, mostly there's one indicator which begins to perform badly before the others do, and it's not always the same one, and some people have a particular pet indicator, and you can't afford to do that. You've got to look at a spectrum of them. Some people look at too many. There's cases of people trying to study 23 different indicators, some of which are just the inverse of others and you confuse yourself.

There are probably five key spon com indicators which have got flaws each but have got different flaws. So the flaws that affect one won't affect the other in the same way, and one may pick up spontaneous combustion in certain circumstances and one may pick up in different ones.

Q. So what are the key indicators, in your view?
A. I would say I still look at Graham's ratio. It's flawed because of pre-oxidation and things like that. Raw CO you can't leave alone. Air free carbon monoxide I believe has a value because the air free aspect dials out dilution by air. CO, carbon monoxide, to carbon dioxide ratio has its problems, like anything else. Where the seamgas is carbon dioxide, to a certain extent it gets corrupted, but it's not affected by inertisation, which is an absolutely vital factor, because the inertisation or dilution dilutes the CO at the same rate as the CO2, so that would probably be my pick.

Q. What do you mean when you say that there can be a tendency to trust the benign indicators and discount adverse ones?
A. This is what I call denial. Operators never want to admit they have a spontaneous combustion event happening.

The reason for that is it will mean that you stop production, you evacuate the mine and you have to report to your boss that you've done that.

I've seen it many, many times. It's a real thing. We get adverse indication on one spontaneous combustion indicator. We don't believe that one. We believe the other four that say things are okay. But they may be saying it's okay for a good reason, and the one that's giving the adverse reading may be doing that for a good reason as well.

I've seen people try and find any excuse for having identified a bad indicator. My approach to it, to manage situations like this, is that if there's an adverse indicator and you believe you have a reason for it which is benign, then you prove it to me.

Q. What about the presence of ethylene? That wasn't one of the four that you listed a moment ago. How significant is the detection of ethylene in gas samples that have come from the goaf?
A. This is a very wide subject, as I think you know. Going back, early stages of my career, if we identified ethylene, we knew we had a major problem and we moved quickly. It was absolutely acknowledged that if ethylene was detected at all, then we had a serious problem.

Modern era, better gas chromatographs, et cetera, we can detect ethylene down to lower concentrations, so the fact that you've detected ethylene is not as probably obvious now as it was in 1980. However, ethylene does not come off at low temperatures. You don't get ethylene, generally speaking, at much less than 100 degrees Centigrade. I said earlier on that at 100 degrees Centigrade, I think it's all over, we've lost this battle, so we're really into damage control.

I think that ethylene may appear occasionally and then go away, and that doesn't mean it was never there in the first place. I also think that when the Simtars, for example, say below 10 ppm ethylene detection threshold, it's qualitative. My take on that is that if it says 3 ppm, it doesn't mean 3, it means something - 2, 4, 5, whatever. It doesn't mean - it's not as precise at less than 10 ppm. So I still believe that if ethylene has been detected, and even if it's 1 ppm, and that means 100 parts per million - let me qualify that as well.

If a gas monitoring point, whether it be a bag sample or a person or whatever, picks up ethylene at 1 ppm, then the ethylene at the source is more than 1, because almost every sample that's taken has been diluted to some extent.

Q. What if, for example, you were detecting very small amounts of ethylene at 3-4 cut-through - so I'm talking about less than 1 ppm?
A. Yes.

Q. That's about 4 kilometres from the face.
A. Yes.

Q. In, what, 70 metres per second of air. What would it tell you if you got, let's say, 1 ppm at 3-4 cut-through about what's going on in the goaf itself?
A. Something very serious, because the dilution rate would have to be at least 70 to 1.

Q. Sorry?
A. If you got 1 ppm at 3-4 cut-through, then the dilution rate would have to be at least 70 to 1.

Q. Can we go to this next slide, then, slide 46. Can you talk us through the points that you make here?
A. Yes. This is a conceptual strategy. I've obviously been thinking a hell of a lot, over my career, really, but more so in light of recent events in Queensland. The objective has to be to remove as much gas as is necessary to allow the longwall to operate at planned production rates and remain compliant with legislation.

That's reasonably obvious. We have to run the goaf drainage as hard as we can to achieve production rates but be compliant. If the simplistic strategy of increasing numbers of vertical goaf wells and increasing suction pressure is applied, oxygen increase to the goaf will result in an unacceptable spontaneous combustion risk if goaf well oxygen concentration is not managed.

So that first bullet point, if we just do that, that would be an example of managing gas but not managing spontaneous combustion, and we can't be in that situation.

If the planned production rates cannot be achieved commensurate with maintenance of less than 5 per cent, I have said - that number is debatable. Less than 2 per cent oxygen, most people would agree - I'm slowing down without being told - that spontaneous combustion activity is unlikely to occur in all coals. Less than 5 per cent, a lot of coals will not spontaneously combust. Some will. Anything over 5 per cent, I think it's fair to say that most coals will spontaneously combust.

My figure is 5 per cent. I would like to say 2 per cent, but I don't think we can adequately manage gas at planned production rates and achieve less than 2 per cent oxygen in the goaf.

Q. We'll come to the TARPs in a moment, but what do you say about a description of a goaf with a maximum of 8 per cent oxygen as being normal?
A. I wouldn't do it.

THE CHAIRPERSON: Q. Sorry, what did you say?
A. I wouldn't do it.

Q. Wouldn't do what?
A. Run a goaf at up to 8 per cent.

MR HUNTER: Q. So if you can't, you say, get that 5 per cent oxygen in the goaf, you talk about these other methods that need to be employed?
A. Yes.

Q. Now, in terms of pre-drainage, it's a bit late if you discover the problem once you've commenced production?
A. Yes, it is.

Q. So what sort of time frame are we talking about in terms of identifying the need to pre-drain and actually doing it?
A. Lead time typically would be at least three months. It could be 12 months. Certain mines do surface to inseam pre-drainage, so the area is degassed before the longwall or even the mine gets there. The lead times there could be two to five years, so it's a very long lead time, and not guaranteed that you will pre-drain all of the area in the prescribed time frame.

Q. Post-drainage of non-worked seams. For example, the P seam here wasn't pre-drained.

A. Yes.

Q. It was, though, potentially possible to post-drain it?
A. You can drill pre-drainage holes which become post-drainage holes, so those holes would be initiated outbye the longwall face and they would penetrate the seams which were intended to be pre-drained. That may be of limited success due to time, permeability, saturation, all sorts of reasons. Those would turn into post-drainage holes. The longwall approaching will fracture and destress other coal seams and the permeability increases as a result can be orders of magnitude, by which I mean 10, 100, 1,000, and they will become post-drainage holes.

I said "combinations of the above" - that's fairly obvious, I think, which is what we are talking about now.

Horizontal goaf wells is another technique which has worked extremely well at some mines and has flopped at others.

Q. What does a horizontal goaf well do that a vertical goaf well doesn't?
A. A horizontal goaf well is close to what I've just described. Holes are drilled - it can be from surface but usually it's from underground nearer to the target, so a series of branched holes, probably, will be drilled up into the strata above the worked coal seam, be drilled to a pre-determined horizon, and they will then dip away towards the longwall face. They might be 800 or 1,000 metres long. The dip of the hole is absolutely vital, because if any what we call undulation swillies - if any undulations are in that borehole, they will almost certainly fill with water and suppress the adsorption.

As I said, my belief is that where they don't work is because they weren't given enough attention and people didn't try hard enough, but that has probably upset people right now.

Q. Can we move to a consideration of the event of 6 May. You've given some consideration to what may have occurred.
A. Yes.

Q. This first graph shows the speed at which the methane concentration at the sensor that's located on the last shield at the tailgate rose?

A. Yes.

Q. And it shows that it was almost instantaneous?
A. Yes.

Q. It stops, though, just under 4.5. Do you think that's a valid reading?
A. I think it's calibration, that the sensor reached its full-scale deflection.

Q. You also looked at the fan pressures.
A. Yes.

Q. The red line at the bottom is the forcing fan located at the rear of the goaf?
A. Yes, it is.

Q. Whereas the blue line is the exhaust fan that's quite some distance away?
A. Yes. Number 6 shaft.

Q. Does that explain the lower amplitude of the change that we see in the blue line?
A. It explains the lower magnitude and it explains the lag.

Q. I was going to come to lag next.
A. Sorry.

Q. But those two smaller dips on the blue line line up, in your view, with the dips on the red line?
A. Correct. This is complicated. I'll try. The red line is the forcing fans at number 9 shaft. You can see there's a dip in fan pressure. That fan is forcing, so that is plus 500 pascals being applied to the mine, so we're forcing air into the mine.

The fan pressure drops down to almost zero, then recovers back to almost normal and then drops down and it goes below zero, which may purely be accuracy, and then it rises back up again. I'll stop at that point.

For that to happen, there has to be a lower than normal pressure at the longwall, because the air is going into the mine without being helped into the mine by the fans, so there's got to be a lower pressure.

We're getting up to geotechnics now, and I've spoken to Rob Thomas at some length about this.

We have to have a situation where the goaf has fallen, created a low pressure zone above it, which has then caused the flow to increase towards the longwall face, which has then recovered, and air has moved into that low pressure place, and then a second event has taken place which has done exactly the same thing again.

After that point, there's an increase in pressure which involves a pressure wave travelling from the longwall face back to number 9 shaft fans, and I think from that point on we're looking at reverberations. It could be argued that that was three or four events. I don't think so. I think it was reverberations. The pressure pulse has reached the top of the shaft and has reverberated around inside the structure.

The blue line is the one that I think is quite confusing. We report fan pressures as a positive number. We say we run at 2,000 pascals pressure. We don't. We run at minus 2,000 pascals pressure, because all underground coal mines in Queensland operate an exhausting system.

So that is not the fan pressure. That is the modulus of the fan pressure. It was actually minus 2,000 pascals. That goes some way to explaining why those blips go downwards and not upwards, because we're going from minus 2,000 to minus 1,900, for example, which is an increase in fan pressure, which is what you would expect from number 6 shaft at that distance from it.

And you can see the second bump there and you will see that where the ignition takes place, there's a lag between number 9 shaft and number 6 shaft, and the reason for that lag is purely distance, but there will be a pressure wave which has travelled against the direction - sorry, with the direction of flow.

Q. So if I put a scenario to you, I'm going to ask you whether what we see there is consistent or inconsistent with it: there is a goaf fall, as described by Mr Thomas, which has pushed an explosible mixture in the vicinity of an ignition source, and there has then been an explosion, a methane explosion. Is that sequence of events explained or depicted by what we see in these traces?

A. I believe so.

Q. If the goaf fall explains the presence of the methane, the second question is the ignition source?
A. The goaf fall doesn't explain the explosible mixture. That would already be there in the goaf. The goaf --

Q. Sorry - I'll let you explain.
A. The goaf fall would move mixtures around. The secondary effect of this is because we've had low pressure in the goaf, which we're saying is caused by the goaf fall - in other words, the material has fallen and created a low pressure zone above it - then that would then, that recovery part, if you look at the upward bump in the middle of all that, at 14:57:40, then that is a recovery, which means that air has gone back into the goaf. So it's indirect, but I think the goaf fall had two effects, and this is my hypothesis. It had two effects, one being that air was moved back into the goaf, creating a larger than normal explosible mixture in the goaf. And the second is it moved that goaf mixture around until it found the ignition source.

Q. Can we move, then, to the ignition source. We've heard evidence that there was no evidence of any electrical issue that might have caused an ignition.
A. Yes.

Q. And that given that the shields themselves weren't moving at the time, there was no movement necessary to generate static electricity?
A. Yes.

Q. Are you content with those two propositions?
A. I think "content" is a bit strong. On the static electricity, I think "content" - in my own mind, I can never rule out electrical. That's not just based on prejudice against electricity. There are many reasons not to trust electrical systems in underground coal mines. I've done work in the past where the - do people understand the flameproof system?

Q. You explain it.
A. A flameproof system is, generally speaking, an enclosure where the electrical components are inside the enclosure. An explosible mixture cannot access the electrical components inside the enclosure. If there was

an ignition inside an enclosure, then it would be contained within that enclosure. A lot of work I do - not a lot - a proportion of the work I do is to do with preventing explosions, and one of the first things in terms of ignition sources that you look at is electrical, because it has been the ignition source in so many cases in history.

The number of occurrences of a breach of flameproofing absolutely shocks me. In my operational career I always believed flameproofing was 100 per cent reliable, and I've discovered in the past 20 years or so that that's not the case. An engineer put it to me and said, "It's an engineering system; it will fail at some time." So I find it really difficult to rule out electrical 100 per cent.

Q. In the cases you've spoken about where flameproofing was found not to have worked, was there in fact evidence that showed where the ignition source had come from?
A. I believe not.

Q. So how was it determined that flameproofing had failed in those cases?
A. In the past where I've found these cases, people have identified it in routine inspections, that kind of thing, but I've seen cases where there's been a flameproof breach. Obviously I'm not going to name any names, but the component was not a flameproof component at all, and yet the thing had been through the manufacturer's compliance testing, had been through the introduction to site, it had been through the introduction to underground, it had been through its codes periodically underground and not been detecting six months, and it horrifies me.

Q. Static electricity. What do you say about it as a potential source?
A. My understanding is the dust guards passed the fire resistant anti-static - FRAS - tests, but in certain circumstances those components can generate an ignitable spark.

Q. Does there need to be movement of them to generate static electricity?
A. Yes.

Q. So does the fact that the shields were not moving and hadn't been moved for some time tend against static electricity in this case?

A. I think it reduces the probability, probably, to negligible.

Q. Number 2 on the list is frictional ignition. What's your view about the likelihood of frictional ignition? Have you seen, for example, the work that's been done about the - I forget the term, but the likelihood of the type of rock that we're talking about here --
A. I've not seen it. I've had it described to me by voice. I'm not going to say much about frictional ignition because it's not my area, so it would be wrong of me to try and pretend to understand it completely.

The GMS goaf, when I've seen it cave, caves fairly slowly. I don't see large amounts of rock high up dropping some distance. We've mined a lot of coal out of the GMS and I'm not aware of any other frictional ignition events in that coal seam. I've not known it elsewhere. But that doesn't mean that it didn't happen. I can't rule that out.

Q. The last point, number 4, is spontaneous combustion. The dot point at the foot of the page that you've included is that that is the source of ignition that requires discussion. Why do you say that?
A. Simply because I think it's most likely.

Q. We know, though, from Mr Watkinson's work that he found no evidence of spontaneous combustion activity accelerating.
A. I think if you ask Martin Watkinson that question today, you would get a different answer, and that would be based on the work that Sean Muller has done, which I think is extremely thorough. It's retrospective and it's hindsight, I understand that, but there are signs in the work that Muller's done that there was evidence of spontaneous combustion.

Q. What in particular about what Mr Muller did --
A. I think the goaf wells carbon monoxide on a methane free basis work was quite compelling.

Q. I won't go to the graphs here, but we're talking about those graphs that show a rise on the morning of 6 May?
A. Yes.

Q. In terms of methane free carbon monoxide?
A. I have to say, those graphs were quite confusing.

Prior to the event, there was increasing carbon monoxide, but at the same time, methane was increasing at a very similar rate and oxygen was decreasing conversely, and it looked very much like a well had been turned down, so the flow rate being reduced, the ingress of oxygen had decreased, so the dilution of carbon monoxide and methane had reduced, causing the increases.

But Sean has done some analysis we don't think coal mines would do routinely, and he has done the analysis on the basis of methane free CO, and he still sees the increase.

Q. So the question that you pose at dot point 2, then, when you say "without detection", do you mean without detection by the conventional methods of analysis?
A. I mean without detection prior to the incident by the mine. We've got repetition here.

Q. I understand that, so please don't, but take us to the points that are new. You talk about CO make being a trusted spontaneous combustion indicator. It has a limitation, though - and that's the one that you've identified?
A. It's a useful indicator, but it's got a flaw.

Q. Which is that you don't know whether it's a small quantity giving off a lot of CO or a large quantity giving off small amounts?
A. Exactly that.

Q. One of the things that the Board has expressed some interest in is the issue of inertisation.
A. Mmm-hmm.

Q. We know that it seems that nitrogen inertisation was being used to some extent at Grosvenor?
A. Yes.

Q. What's the problem with using nitrogen?
A. I'm almost on my own in this. If nitrogen is injected, it can mask a spontaneous combustion event. So if we're injecting nitrogen at point A and monitoring at point B, then point B may only monitor or may mainly monitor the nitrogen, which gives us a nice warm feeling, because we feel that we've inertised the area, but we haven't. We've inertised a very small area.

The other side to this is that the use of nitrogen corrupts gas monitoring data, which I say there. All indicators are corrupted by nitrogen, other than CO/CO2 - back to the dilution thing: nitrogen dilutes both gases at the same rate. So we've masked, potentially, a spontaneous combustion event and we've caused our only tool to detect it to be corrupted.

Q. In the last point on the page you say that for a spon com event to have been the ignition source, it was most likely close to the longwall face in a zone where oxygen was present at sufficient concentration. Why do you say that?
A. Because there's need for oxygen to create the event. The fact that the explosion didn't occur earlier implies that there wasn't methane at that point - or wasn't an explosible mixture, I'm sorry, until the goaf fall took place.

Q. Can we move to the issue of PUR, and you've seen what Mr Watkinson has written on the subject. What's your view about the potential involvement of PUR in, effectively, initiating an accelerated heating?
A. I think it's - I've always thought it was credible. There have been incidents in Queensland where it was suspected but not proven. The work done by Beamish lately I think probably confirms that PUR can accelerate the rate of spontaneous combustion. That's a simplistic way of putting it, but I think the evidence is there.

Q. So what's the solution? If the PUR that was involved here - and we're still waiting for some most recent testing, but the testing that we've seen so far would suggest a curing temperature of anywhere between 110 degrees and 146 degrees Centigrade. You've already told us that, in your view, 100 degrees is the point of no return. What's the solution? Are there products that will do the same job as that product?
A. I've now got no friends in Queensland. I would cease using PUR in underground coal mines with immediate effect. The reason I say that - if it's possible that PUR accelerated spontaneous combustion to the point that an ignition source existed, then we cannot use it. So that's the first answer.

I'm not talking necessarily about a permanent exclusion of use. I'm talking about some risk-based process. I don't believe the controls over - which are in the recognised standard - I don't believe the controls over the use of polyurethane resin are adequate. The 200kg limit per hole, I don't know where that came from. I don't understand why limiting the volume of PUR used won't limit the temperature it reaches. So I don't understand why that is a control strategy.

And I don't understand why we limit the amount of PUR per hole, but we don't limit the spacing between holes. So I think the rules we have for polyurethane resin use at the moment aren't adequate, and I would stop using it at all until we have a new system which was capable of adequately managing that system to as low as reasonably achievable.

Are there other products? There are other products, Fenoflex, which --

Q. Fenoflex?
A. I think it's Fenoflex. Not my area. I don't know if it does as good a job as polyurethane resin. I know that there are two mines, to my knowledge, who have ceased use of polyurethane resin and now use alternative products for strata consolidation.

Q. Do these other products cure at temperatures that are lower than the ones I've described?
A. Yes. The data I've seen indicates 40, 50 degrees Centigrade, type thing.

Q. You've probably addressed the points made here, although you might expand on the last dot point?
A. I can envisage a scene where we had a very small incident taking place, it's at high temperature, it's given off high concentrations of products but it's given off low volumes of products. So those low volumes of products are entering the goaf stream, they are not being detected at the tailgate, are being diluted by the 70 cubic metres per second, or whatever it was, at the tailgate and therefore have been missed.

I don't see that happening with a large event, because the volume of products of combustion will be higher. I think it was a small event.

Q. Is that why a small event may be consistent with the

acceleration of heating being initially provided by the curing of PUR?
A. Yes.

Q. You've mentioned this stream of air that runs immediately behind the shields.
A. Do you mean the fresh air or the goaf stream?

Q. The fresh air.
A. Yes.

Q. One scenario is that the PUR that had been injected into the face and the roof on 3 May had been mined through so that some of it was immediately behind the shields?
A. Yes.

Q. What's the significance or otherwise of that fresh air stream in this scenario?
A. If the event was right in the fresh air stream, I don't believe it would have accelerated, simply because there would be too much cooling, so I think it was probably a little bit further into the goaf where there had been some consolidation, a drastic reduction in the amount of airflow at that point, therefore a large reduction in the amount of cooling, and therefore more potential for the escalation.

Q. So how far back are we talking, then, to be away from this airflow that's immediately behind the shields?
A. I can't really answer that question, but I'm going to say something in the order of a metre.

Q. Could we move, please, to a consideration of the TARPs.

THE CHAIRPERSON: Q. Sorry, Mr Self, when you say a metre, a metre from where?
A. Sorry, horizontally from the base of the shield, directly behind the shield.

MR HUNTER: Q. What we have here you understand to be the TARPs for spontaneous combustion in the active goaf --
A. Yes.

Q. -- for the longwall return and active goal seal zone?
A. Yes.

Q. Can I ask you, firstly - you'll see in a number of places the TARP triggers involved the use of what I'll call "and" statements.
A. Yes.

Q. What's your attitude to the use of "and" statements in a TARP?
A. I don't favour it. I made the comment earlier that some indicators will show adverse signs when others don't. If we go to the evacuation TARP, which is obviously the most important one, "Ethylene equal or greater than 3 ppm and CO Make equal or greater than 53 litres per second". So if CO make is not over 53, then the ethylene can be any value you wish. I think TARP values have to be stand-alone.

Q. Is it a particular issue when you've got a level 3 trigger, because to get to that point you've already identified that you're at level 2, and so you know there's a problem?
A. I've seen situations where there have been four indications, all with an "and", and three out of the four are showing evacuation and number four doesn't, and so we don't evacuate.

Q. Is there an issue with respect to where the measurements are taken, for example, the longwall return?
A. Absolutely.

Q. We know it's a long distance from the face.
A. Yes.

Q. Is a better place to identify the products of spontaneous combustion the goaf stream?
A. I think it is a better place, in that it's undiluted or relatively undiluted, but that would not stop me monitoring at the 3-4 cut-through point.

Q. I wasn't suggesting that, but there doesn't appear to have been a TARP with respect to the goaf stream?
A. I understand that.

Q. In your view, should there have been?
A. I would have one.

Q. Why?
A. There's no point monitoring if you don't have a TARP,

because the TARP triggers a response to the gas monitoring data, so if you don't have a TARP, there's no mechanism to make you respond.

Q. Tell me if you're not able to answer this, but if you look at the "Normal" TARP for the longwall return and you can see that the specified normal condition is "CO/CO2 less than 0.2" --
A. One thing I will say is I don't understand why CO/CO2 was used at normal and level 1 and then didn't appear at levels 2 and 3, but that's just my - I don't understand why if it was valid at normal and level 1, then it wasn't valid later. CO/CO2 ratio - I looked at the gas evolution curves, and we have to bear in mind that CO2 is a seamgas, so there will be amounts of CO2 which are definitely not caused by spontaneous combustion, and we can't differentiate.

But the evolution curve is actually at source, so every monitoring point that we have is almost certainly diluted. CO/CO2 ratio, in the evolution curves I looked at, was about 100 degrees Centigrade.

Q. So should there be an assumption that CO/CO2 of less than 0.2 is normal?
A. I think so [sic].

Q. It should be?
A. I don't think CO/CO2 ratio of 0.2 is normal.

Q. Can we go to the next slide, if there are no other comments you wish to make about those TARPs?
A. I don't think so, no.

Q. This is a TARP for the goaf or underground to inseam wells. Can I ask you to look at, for example, a level 1 trigger, which includes an "and" statement. Does your view about "and" statements apply to this TARP as well?
A. Yes.

Q. Do you see there it specifies a combination of oxygen at 8 per cent to 11 per cent and methane at 30 per cent to 45 per cent?
A. Yes.

Q. Is it possible to simultaneously have oxygen at 8 per cent and methane at 30 per cent?

A. It depends how much oxygen depletion has taken place. As opposed to oxygen drawn in from some other source raw, it may have been depleted. I'm not sure whether it's possible or not. I don't like the combination of the two together. Again, if methane is at 46 per cent and oxygen is at more than 11 per cent, then that doesn't apply.

Q. You see that the normal state for oxygen is said to be less than 8 per cent, and you've already expressed a view about that being appropriate?
A. Yes.

Q. That aside, are there any other comments you would make about this particular TARP?
A. There's no oxygen trigger on level 3.

Q. Should there be?
A. Hydrogen has appeared all of a sudden. Ethylene is not there.

Q. Would the detection of ethylene in a goaf well be a matter of concern?
A. Yes.

Q. Could it be explained by anything else apart from a heating?
A. Yes.

Q. What else would explain it?
A. There are lots of theories about this. A diesel engine, in theory, running off-tune can create ethylene. This is stretching my imagination, I'm going to say this straight up, but if the diesel vehicle was in the maingate, for example, throwing out ethylene in large concentrations, it's possible that could get into the goaf. It's possible for that to get into a goaf well or into the goaf stream, sampling, and then into the tailgate.

Green timber has been blamed in some circumstances, and it would be very unusual for a longwall goaf to contain timber in any volume, particularly green timber.

Q. Was there an example of timber being used at a mine at Crinum North?
A. Yes. I can go further than that. Timber is used in the generation of ethylene for commercial purposes, so ethylene definitely does come off timber, no doubt about

it. But I said to you earlier, if you think it's green timber that's causing this or you think it's the diesel, then in the case of the diesel, find me the diesel engine, prove to me it was in the maingate at a certain time, take samples off its exhaust and prove that it was generating ethylene. Don't just say, "Oh, there's a diesel there, so that could have been it."

Q. Similarly, if you were going to rule out green timber, you would want to check to see whether any had been used?
A. Yes, absolutely. It's just proof. I won't accept that it could have been X, Y or Z. I want proof of it.

Q. Do you get ethylene, though, under ordinary circumstances out of a goaf where there isn't a heating of coal going on?
A. There are some people believe that it can be in a goaf without being a result of spontaneous combustion, but I've yet to see the evidence.

Q. We talked about the goaf seals.
A. Yes.

Q. This slide, slide 60, shows the location of a number of them where there were monitoring points. Tube bundles 37, 38 and 39?
A. Yes.

Q. I'm going to show you a series of graphs. I won't take terribly long. This is the tube bundle at 40-41 cut-through?
A. Yes.

Q. And it shows oxygen, which is the red, and carbon monoxide, which is the blue?
A. Yes.

Q. Is it correct that you would expect this tube bundle to be monitoring the goaf atmosphere?
A. Given its position, I think it stood a high probability of picking up the atmosphere leaking into the seal, despite the fact there was nitrogen being trickled into that seal at the time.

Q. Do we see here, back in March, but then again later, in May, levels of oxygen that are consistent with fresh air?

A. Yes.

Q. The next slide is from B1 cut-through, which is at the back of the goaf.
A. Could we just go back one, please, Mr Hunter? I can't point to these things, because I've killed the pointer, but --

Q. Is your pointer not working?
A. No. I don't know what I did to it. No, it's dead. I just wanted to point out on that first chart there, we're talking about interpretation of gas monitoring data for the purpose of identifying spontaneous combustion, and if you look at that, the blue line would appear it's gone up to a peak, then it's dipped, then it's peaked again, and then it's dipped, and then it's eventually gone on to an absolute peak, and then it's fallen away and it's come down to a low level.

That's reasonably classic behaviour of a goaf seal. In putting the seal on, we enclose the goaf area, there's oxygen there, it's consumed by the chemical reaction between the coal and the oxygen, and we generate CO. So that's fairly normal behaviour. It increases, we reach a peak, oxygen depletion starts to take place, the CO level drops, and it drops down to a long-term level.

This one didn't do that. Once it reached its trough, it increased again and then it reached a second peak, then it fell away again, and then the data to the right of those vertical red lines I have no confidence in at all.

Q. This is the B1 cut-through seal at the rear of the goaf.
A. Yes.

Q. Again, we have levels of oxygen that are roughly consistent with fresh air?
A. I should point out that the CO is up and down to a large degree, but at low numbers. So small barometric pressure changes, for example, could cause that amount of fluctuation.

Q. Could we go to the next slide. This is the 38 cut-through on the maingate side.
A. Mmm-hmm.

Q. We can see some fairly erratic readings initially, then there's a period of some time where it appears to be consistent with fresh air, but then we have this period of what appear to be once- or twice-daily oscillations. What can you tell us about that?
A. Not very much.

Q. Is that consistent with what you'd expect to see at a goaf seal?
A. No. I would expect a goaf seal to do what I said with regards to carbon monoxide. I would expect oxygen to start decaying immediately and then fluctuate due to barometric changes but essentially drop back to a long-term level, whatever the level might be. That square section, rectangular section in the middle - I don't know, I suspect that that tube was leaking because at that point there's zero CO and there's atmospheric oxygen, so I suggest it was a leaking tube.

Q. We've probably covered most of what appears here.
A. Yes. I think it's important to recognise and acknowledge that we can't a hundred per cent manage spontaneous combustion if we are managing gas. In other words, we can't keep the goaf completely inert. We've got 70 cubic metres running alongside one side of it. We've got penetration to the goaf, which is a known phenomenon, and we can't keep goaf wells down to 2 per cent oxygen, because if we did, then we would not really capture much gas. So I think there has to be a risk taken, but that risk has to be managed and it has to be as small as possible.

Q. So is a 5 per cent target figure realistic, in your view?
A. I believe so.

Q. Perhaps if you can talk us through the points that you make here, commencing with the --
A. I think we've covered most of it. Pre-drainage is generally more effective than post-drainage. In pre-drainage, assuming factors such as permeability and gas saturation, et cetera, et cetera, and holes that stay within seam and aren't water saturated - pre-drainage, the gas comes out of the pre-drainage hole and goes into a reticulation system.

Post-drainage, the gas is in the goaf - it involves two systems competing. The ventilation system operates at low pressure and therefore tends to draw gas out of the goaf, as was shown earlier. The post-drainage system does exactly the same thing. There's a competition between the two. Post-drainage will never a hundred per cent win that argument.

Post-drainage of goaf gas is not as simple as applying the maximum amount of goaf drainage possible. There are a number of reasons behind that statement. Holes compete. If the hole spacing gets too close together, they compete with each other, so you don't capture more gas. There's an absolute limit on the amount of gas you will capture. The more holes we put in, the more suction we apply, the more flow there is and therefore the more flow of oxygen, actually air, into the goaf.

A post-drainage system will inevitably draw air into the goaf or gas will enter the ventilation system. Ideally all the gas would go to the post-drainage system. Then all the air would stay on the longwall face. But it's impractical to achieve that. We can't prevent both of these from happening at times.

Barometric pressure is obviously a factor. There are others, but the barometric pressure is something which happens twice a day. We cannot control it. A barometric pressure change can be of the same magnitude as a fan, so it's extremely powerful as a means of making gas exit the goaf or making air enter it.

Proactive inert gas injection can mitigate against air ingress to the goaf - I absolutely accept that.

However, the masking effect and corruption of spon com indicators make this a flawed strategy, in my opinion.

A robust spontaneous combustion management system - this is a very unpopular thing. A robust spontaneous combustion management system does not need proactive inertisation. That's my view, and that's where we need to be, and then we can use inert gas when we get into trouble.

Q. Can I move on to another topic. We know that there were a number of HPIs on this longwall prior to the explosion that involved methane exceedances in the tailgate.

A. Yes.

Q. Obviously at least there is evidence that suggests that there was a fall in the goaf on 6 May.
A. Yes.

Q. As far as you're concerned, is there any connection between the earlier HPIs and the events of 6 May?
A. Two comments to make. The fact that we're getting HPIs means that the gas make is not being managed as it should, so it's hard to disassociate an outpouring of gas - it's not an outburst. It's probably - you could term it an inrush of gas from the goaf into the ventilation on the longwall face. It's hard to 100 per cent separate those two issues.

But I have to say the mechanism I've seen with the HPIs generally involves something completely different from the goaf fall. So it's things such as excessive production for a period of time or barometric pressure changes or failure of goaf wells, things such as that. I think the event on 6 May in the afternoon was a completely different event from the HPIs in terms of mechanism.

Q. So when you say you can't completely divorce the event of 6 May from the earlier HPIs, what, if any, is the link between them?
A. The reason is that both events, both series of events, are associated with a large volume of gas in the goaf. If you didn't have that large volume of gas close up to the back of the shields, then the HPIs wouldn't happen. That's probably not all that related to the goaf fall, which I think would have pulled gas out of that goaf, come what may.

Q. The last subject is just really to demonstrate what you were saying earlier about nitrogen inertisation, and you have prepared a graph that shows what happens with the introduction of nitrogen into the goaf.
A. Yes, this is a synthetic simulation and it's assuming a certain amount of airflow reaching a certain point, causing a spontaneous combustion event. On the Y axis you've got the carbon monoxide air free. I've used air free. It doesn't matter - as I've said, everything except CO/CO2 is adversely affected by inertisation.

The red line is the air free as calculated. With inertisation at rates ranging from 50 to 1000 litres per second, it shows the effect the inertisation has on the air free carbon monoxide value.

Q. So that shows the masking effect, if you like, on the amount of carbon monoxide --
A. I'm calling this "corruption". "Masking" is where the nitrogen gets in between the spontaneous combustion event and the monitoring point. This is where the products of combustion reach the monitoring point, as does the nitrogen. I don't know if that's pedantic.

Q. Either way, the effect is to conceal from the person who's looking at the --
A. One conceals it, and one leads to a false sense of security, and I think they're two different things.

MR HUNTER: I note the time, Mr Martin. I suspect I'm finished, but I wonder if now might be a convenient time.

THE CHAIRPERSON: Yes, we will adjourn until 2.15. Thank you.

LUNCHEON ADJOURNMENT

MR HUNTER: Q. May it please the Board, I'd ask that the witness be taken to RSH.038.002.0001, in particular, the tab of that Excel spreadsheet that is labelled "Vac". Mr Self, you've seen this before, I take it?
A. Yes.

Q. Do you understand that to be a spreadsheet that details the vacuum pressure being applied at the various goaf wells on longwall 104?
A. Yes.

Q. What can you tell us about what we see on the screen there? Are there any matters of significance, as far as you're concerned?
A. There are some numbers that are quite high, up to 28.675 or so. In the right-hand column, that's the average, and the average of the average is just over 14 kPa below atmosphere. That's a little bit above what you'd expect but not dramatically so. It's a post-drainage system which I would assume was being worked quite hard.

Q. I beg your pardon?

A. It's a post-drainage system which I would assume was being worked quite hard.

Q. Were those numbers consistent with it being worked quite hard, to use your words?
A. Not really. 10 to 15 kPa would be fairly typical, I'd say.

Q. What about - you say that there are some numbers that are as high as 28?
A. Yes.

Q. I'm looking at well 7 on 18 April, for example. This number here, for example, just above where I'm holding the cursor now, is that the 28 you were talking about before?
A. Yes.

MR HUNTER: That's all I have. Thank you.

<EXAMINATION BY MR HOLT:

MR HOLT: Q. Good afternoon, Mr Self.
A. Good afternoon.

Q. I want to talk to you first about the modelling, particularly the Moreby modelling, that you spoke about early on in your evidence. That's a topic I'd like to cover early.
A. Yes.

Q. Could I ask, please, that we go to - and, Mr Operator, I apologise, but this was not a document I indicated to you a few minutes ago - Mr Self's addendum report, RSH.022.001.0007. We can see there, this is in your supplementary or your addendum report.
A. Yes.

Q. Where you refer back to your discussion in the first report about the Moreby modelling that had been done in 2010?
A. Yes.

Q. And, in particular, you refer to the statement that you made that:

> *... "Given the variables and unknowns, the 2010 predictive gas emission models are*

within the range of the author's expectations."

A. Yes.

Q. That was because, as you explained - and I hope I don't do the explanation an injustice - when you're modelling in advance of any mining, there is a necessary add expected band of uncertainty or error within the modelling analysis?
A. Yes.

Q. And you indicated that that could be as high as 50 per cent?
A. I've certainly seen that, yes.

Q. And that this modelling that was done in 2010, in terms of how wrong it turned out to be, was in fact within your range of expectations?
A. Yes.

Q. The critical thing with modelling is to understand that it's a useful tool but not an absolute?
A. It doesn't give an answer absolutely, no. Flugge, as I mentioned earlier on, is flawed --

Q. Slow, slow.
A. Flugge is essentially flawed. It doesn't take into account geology, it doesn't take into account residual gas content. There are a number of things which it doesn't do well. The older the modelling is, the less accurate you'd expect it to be, because as time goes on, we gather more data and we can update models. Once longwall extraction begins, then there's an opportunity there to calibrate models based on measured data.

Q. You've paraphrased, perhaps unsurprisingly, what's in the section of your report that's up on screen?
A. I would hope so.

Q. And in the second to last paragraph, as we look at the screen, you've noted:

Following the commencement of longwall extraction, the author would have had the gas emission modelling calibrated against measured data acquired during longwall *extraction. This is considered necessary in order to move the modelling away from the purely theoretical towards a calibrated, practical basis for gas drainage and ventilation system design purposes.*

A. Yes.

Q. You would hold to that, obviously?
A. Yes.

Q. Could we go back to Mr Self's first report, Mr Operator, and could we go to page 11 of that report, which I think is 0011. On that page, you note at the bottom under "Moreby September 2010" that:

Moreby has issued several reports on Grosvenor.

A. On ventilation mainly, but, yes, he has.

Q. You then refer to the 2010 predicted gas emission report?
A. Yes.

Q. Were you provided with updates that Dr Moreby had done after longwall panels on an annualised basis, 2017, 2018 and 2019?
A. No.

Q. I don't know whether you listened to Ray Williams' evidence on Monday?
A. Hardly.

Q. Your expectation, though, would be that after real data was able to be acquired from longwall mining, SGE predictions - any predictions, whatever model was used - would be updated to calibrate them to reality?
A. Yes.

Q. And, in particular, your expectation would be that Dr Moreby would recognise in those updates the limitations of the Flugge model?
A. Yes.

Q. Of the kinds that you've described?

A. Yes.

Q. Specifically recognise that the fact that it originated in Europe limits its applicability to Australian conditions?
A. I agree with that.

Q. And you would expect him then to use other techniques to attempt to make up, in effect, for that deficit or deficiency in the Flugge modelling?
A. I'm not sure. There are other models, probably about 10 empirical models that have been unearthed. I'm not sure that any is superior to the Flugge model, which explains why people are still using it.

Q. But, in any event, what you'd want to see would be actual data from the longwall mining?
A. Yes.

Q. And, in particular, were you aware that one thing that Anglo in particular at Grosvenor were doing at the conclusion of each longwall was taking core samples above the goaf --
A. Yes.

Q. -- in order to identify what the contribution of each of the seams to the gas make had actually been?
A. Yes, yes.

Q. Again, your expectation would be that if Dr Moreby was updating his reports, he would take into account that data?
A. Yes.

Q. In order to, rather than as one might have the impression, stick blindly to the 2010 predictions, to update those predictions on the basis of real data all the time?
A. Yes.

Q. That core sampling above a goaf after the longwall panel has finished, and then the integration of that into future prediction and modelling, is that something you've seen done in many of the operations that you are involved in or you've been involved in?
A. I'd say not.

Q. I think Mr Williams talked about it on Monday as

a good thing to do, a really good data source?
A. Yes.

Q. And we heard on Monday from Mr Williams ultimately that the predictions that Dr Moreby came to in 2019 post longwall 103 and with the use of that core sampling in fact ended up incorporating a range including the Fair Hill seam, which ended up being about what Ray Williams also predicted?
A. Okay.

Q. Thank you. Again, your expectation would be that a company, a business like Anglo, would be using capable consultants to provide them with this kind of updated material?
A. Most definitely.

Q. And indeed with this core sampling, it sounds like being ahead of the game in many ways in terms of data collection?
A. I would agree with that, yes.

Q. Thank you. And you would expect also, obviously enough, as Mr Hunter took you to, Anglo to take on board recommendations or proposals from such consultants?
A. Not always.

Q. That's exactly what I was going to say - but not follow them blindly, right; to make their own decisions about whether they worked in their own setting?
A. It's very easy for a consultant to recommend things. It's less easy to implement those things and there's always an economic angle.

Q. But it's not just the economic angle, is it? It's also in part because of this whole balance of issues that mark the complexity of longwall coal mining, underground coal mining?
A. Absolutely.

Q. That often it's the operator, with their own internal expertise, who has the full range of knowledge about all things in order to make those balancing decisions?
A. I agree.

Q. Yes, thank you. I think I noticed in your evidence when Mr Hunter was asking you questions that you talked

about the Noack pore pressure model?
A. No.

Q. In your report, I think you talk about the Noack pore pressure model?
A. No.

Q. Did you talk about pore pressure?
A. Yes.

Q. In the context of modelling, but not the Noack one?
A. Correct.

Q. It didn't sound like you were positive about the pore pressure modelling?
A. All I've got to say is the pore pressure model relies on a geotechnical model, so you've got a model which is based on another model, both of which are not and cannot be calibrated.

Q. I see.
A. So --

Q. It will rather - sorry.
A. It's another flaw in gas emission modelling.

Q. I think you used the language - I apologise if this is a paraphrase, I hope it's accurate - that gas emission modelling is notoriously difficult?
A. Yes.

Q. And that's why one would never rely on a single model; one would seek to rely on multiple models, but, more importantly, on calibration of those models to real-world data?
A. Yes, I have no confidence whatsoever in uncalibrated models.

Q. Of course, and that's why you would expect and hope that someone like Dr Moreby would recognise that and consistently say you need to be careful about treating models as absolutes. You need to rely as much as possible on real data?
A. Roy Moreby would be very aware of that.

Q. In the course of discussing issues associated with the gas emission prediction and pre-drainage and post-drainage,

you talked about the P seam in particular in this case?
A. Yes.

Q. You note in your report that the P seam is not a seam which, in your experience in the Bowen, is one that is pre-drained by anybody?
A. Yes.

Q. That question was put terribly. You're agreeing with that proposition, I take it?
A. Yes.

Q. Thank you. But are you aware that in fact, of all of the operators, Anglo has been working for about eight years on various strategies to try and pre and post drain the P seam?
A. No.

Q. Again, a competent operator, you would hope, understanding the environment in which it was operating - you would hope they would be trying things?
A. Yes, you would.

Q. And would you agree that one of the issues with the P seam is just a technical, practical one - it's actually a really hard seam to access and to drain?
A. I would.

Q. And again you would hope that a good, competent operator would try different techniques and not give up when the first one failed?
A. Yes.

Q. Indeed, that's part of the process, isn't it, of operating in these kinds of environments?
A. Yes.

Q. Thank you. While we're dealing with the P seam, do you recall - and, please, if you don't, there's no difficulty; there's a lot of documents, but do you recall that one of the goaf wells in longwall 104 was a particularly high-flowing well, 004?
A. No.

Q. Do you recall seeing anything in the material that you reviewed suggesting that what happened with 004 is that it intersected the Dom fault and, as a result, may well have

in fact been extracting gas from the P seam fortuitously?
A. I didn't see that, but it's quite credible.

Q. It's quite credible?
A. Yes.

Q. Thank you. Indeed, a high-flowing well of that kind if it were accessing a gas reservoir like the P seam might well account for at least some of the increased gas make on longwall 104 compared to 103?
A. That's possible.

Q. Thank you. Just, I think, one other topic. I want to talk to you about the ventilation issues that you spent some time talking about this morning. Forgive me, you'll understand - and I don't mean this critically at all - those very helpful diagrams in your PowerPoint were not ones we'd seen until yesterday, so I just have some questions about those.
A. Okay.

Q. First, might we please go to your report at page 33, that is, your first report. Under 8.3, do you recognise this as being - and if you need to look at other parts of your report, please do - the conclusion to your section on ventilation system design?
A. Yes, I do.

Q. And your conclusion was, under the heading "Relevance to the Explosion":

> *The ventilation system design is essentially conventional and of high capacity. The relevance of the ventilation system design to the nature and cause of the incident is considered to be negligible.*

A. I stand by that.

Q. Again, we don't need to go to it unless you want to - we can if you need to. In that section to which that conclusion relates, you had discussed the issue with shaft 9?
A. Yes.

Q. And the ventilation set-up for that?

A. Yes.

Q. And also the C heading roadway?
A. Yes.

Q. In essence, what you've shown the Board with Mr Hunter's questioning today are some issues that you have associated with that ventilation set-up?
A. Ways I would do it differently, yes.

Q. But ultimately falling within that conclusion that was noted there?
A. Yes.

Q. Having said all of that, can I ask you a couple of specific questions about those slides?
A. Certainly.

Q. Might we go, please, Mr Operator, to the PowerPoint, which is SAN.001.002.0001. Could we go, please, firstly, to 0029. I apologise, Mr Martin, there were some different versions of the PowerPoint, so I have a different number. Mr Operator, could I trouble you to work forwards until we come to the first of these diagrams that has the curly red arrow in it. It's about four ahead, I think. There, that one. Thank you so much.

Now, this is obviously, again not meaning this critically at all - you've said so - it's a schematic, a visual representation to help us to understand the environment you're describing the features of?
A. Yes, it is.

Q. Number 9 shaft, I understand that you've operated on the assumption that there was a force fan effectively forcing air --
A. Two.

Q. Two force fans. Would it make any difference to your conclusion if that were in fact not a force fan but a collar, I think is the language that's used?
A. There's an exhaust fan there which has not been commissioned. There's a cooling plant which incorporates two downcasting fans, to the best of my knowledge.

Q. While we're dealing with this diagram, if we consider for a moment that red arrow that we've got there, which is

what I really want to understand --
A. Yes.

Q. -- as I understood your evidence, but please tell me if I'm wrong, the red arrow is intended to depict the consequence of having what you've identified as a regulator, represented by the R, effectively drawing - changing the pressure such that the air is taken away from the tailgate corner, atmosphere is taken away from the tailgate corner and into that regulator?
A. That is correct, but to a small degree.

Q. And have you been operating on the assumption that the R, what you've described as the regulator, allowing air through is a deliberate part of this ventilation design?
A. I assume so.

Q. Have you had access to the second workings document that described the way in which the ventilation plan was intended to work?
A. The second workings risk assessment, yes. The document, no.

Q. I'll put a document up, and if it's the one you've seen, great. If it's not and you want some time with it, I'm sure we can work that out. Could we go to AGM.002.001.0019 at 0056, Mr Operator. Now, do you recognise this as - is it a document you've seen?
A. I'm not sure if I've seen that particular one, but I've seen a very similar diagram.

Q. If we look at the management of the tailgate roadway from 41 cut-through, can you see that?
A. Yes.

Q. Rather than reading it to you, I'll just ask you to read through it, and again, please, if you need any time, just ask.

Again, Mr Martin, while that's happening, I apologise, but these diagrams and this issue only came in the PowerPoint yesterday, which is why the document wasn't earlier referred to.

THE CHAIRPERSON: Yes, the same thing happened to me. Thank you.

THE WITNESS: Yes.

MR HOLT: Q. If we then go to the next page, please, 0057, we can see the diagrams then effectively showing what happens as the longwall proceeds?
A. That's not inconsistent with what I've said.

Q. Can we come back to the diagram, just so I can understand it. Can we come back to the PowerPoint, to the same page that we were on. What I want to suggest to you - and if there are any limitations in your answer, please say so - in fact, where you've got the R there, that is in fact a closed stopping, not a regulator?
A. Not when I visited, it wasn't.

Q. Were it a closed stopping, which is obviously a matter that can be identified, rather than intended to have air flowing through it, then that would mean the red arrow issue would go away?
A. Yes.

Q. You were asked some questions by Mr Hunter about the identification in a diagram of that as an irrespirable atmosphere. Do you recall that?
A. Yes.

Q. I suggest that in fact the way in which this ventilation system was designed was that as the longwall proceeded, effectively that roadway got blocked off as it went through. Did you see that in --
A. In the documents, it said a barrier. That's not blocked.

Q. Would it make sense - I understand that is general question, but I'm sure you're capable of answering it - then, that as that came through and it got blocked off entirely, effectively it would be treated as an irrespirable atmosphere which no-one would have access to?
A. If it was sealed off, yes.

MR HOLT: Thank you, Mr Martin.

THE CHAIRPERSON: Thank you. Mr Crawshaw?

<EXAMINATION BY MR CRAWSHAW:

MR CRAWSHAW: Q. Can you see me on the screen, Mr Self?

A. Yes, I can. Very small.

Q. That's all right. It's my voice that counts. I want to first ask you some questions about the PowerPoint that Mr Hunter took you to this morning which relate to some of the questions I'm going to ask you. To remind you, could we have on the screen, Mr Operator, document SAN.001.002.0014. Do you remember Mr Hunter asking you about this document, in particular, the parts of it that are surrounded by the red?
A. Yes.

Q. I only want to ask you about (iv). As I understood your answer in relation to that strategy, as I understand the strategy recommended by Palaris, it is that you didn't think it should be qualified in any way by only occurring where the P seam is at virgin gas content and longwall emissions are forecast to be greatest?
A. Yes, the amount of data that we have regarding gas content is obviously limited by the number of holes they put in. So to identify the areas which required pre-drainage and those which didn't I think would be onerous or possibly not practical. So I would just drill it to the extent it needed to be drilled to pre-drain the whole seam.

Q. Could we go back to slide 6 from this slide show, which is the same numbering, 0006. Do you remember Mr Hunter asking you about this document and you particularly wanted to concentrate on the last two columns?
A. Sorry, I don't understand the question.

Q. I'm just trying to take you back to Mr Hunter's questioning.
A. Yes.

Q. Do you remember that? Yes. In particular, in relation to the figure of 14.4 cubic metres per tonne, you gave some evidence - I don't know whether today's transcript could be brought up, but it's at page 879 line 15. Is that possible, Mr Operator, or can someone tell me? If it's not, I'll just read out what it says, what you said about that. It's probably easiest if I do that.

You said to Mr Hunter:

The first thing to note is that 8.2 and

> *14.4 cubic metres per tonne is not especially high as an SGE.*

And then you said:

> *If you wanted to reduce risk considerably, then you would pre-drain the P seam, but you may also think that at 14.4 cubic metres per tonne, we can manage that with conventional pre-drainage, post-drainage and ventilation.*

A. Pre and post and ventilation.

Q. And in relation to your statement there that if you wanted to reduce this considerably, then you would pre-drain the P seam, is this the case, that it would be in the interests of the safety of the workers working in that seam that this should happen?
A. Not necessarily. If the gas can be managed at 14.4 cubic metres per tonne with a conventional pre and post and ventilation system, then it can be done safely.

Q. But would there be any detriment to safety in pre-drainage occurring?
A. I would say not.

Q. So if you wanted to, to use your words, considerably reduce the risk, you would carry out pre-drainage, wouldn't you?
A. I'm not sure I said reduce the risk. I think I said reduce the gas emission.

Q. My note and the transcript said "If you wanted to reduce the risk considerably". Are you departing from that, are you?
A. No, I thought I said "gas emission", but it doesn't really matter.

Q. It would reduce the risk considerably to carry out pre-drainage, wouldn't it?
A. I'm not sure about the risk. If it can be managed at 14.4, then I'm not sure why the risk is higher.

Q. Well, I'm not suggesting the risk can be higher necessarily, but if you want to be sure, it's an extra layer of safety that could be taken, isn't it?

A. It would certainly reduce the likelihood of HPIs, if that's what you mean.

Q. Well, the whole idea in underground coal mining is to reduce the risk as much as possible, isn't it?
A. As low as reasonably achievable.

Q. Well, pre-drainage is reasonably achievable, isn't it?
A. Yes, it is.

Q. This figure of 14.4 cubic metres per tonne, I realise it came from Dr Moreby's original estimates, but it would follow, would it not, that the risk would be considerably reduced if pre-drainage took place at levels of cubic metres per tonne higher than 14.4?
A. All I can say is the lower the SGE, the better.

Q. Yes, so if it's higher than - if you'd do it at 14.4, you'd certainly do it at higher levels?
A. Yes. The higher the SGE with the P seam, the more likely you are to pre-drain it.

Q. Yes, and is there any figure at which you wouldn't pre-drain?
A. No, I don't think there's an accepted number for that.

Q. So if I could now go to your report, the first part I want to go to relates to this topic, it's SAN.001.001.0001 at 0026. Do you see, if you go down three quarters of the way down the page, the second-last paragraph before you deal with post-drainage, you say:

> *It seems to be reasonably clear that effective pre-drainage of the P Seam would have caused a substantial reduction in longwall SGE.*

A. Yes, it would.

Q. You then go on to venture something that you were asked about by my learned friend Mr Holt:

> *However, other mines extracting the GMS do not pre-drain the P seam. Given the lack of precedent it is not surprising that P Seam pre-drainage was not pursued.*

A. I don't understand the question.

Q. I haven't asked a question. I'm just taking you to what you've said.
A. Okay.

Q. Now I'll ask a question. Do you agree that this should no longer be the precedent, that pre-drainage does not occur in the GMS P seam?
A. It's not just the P seam. Ray Williams believes the Fair Hills are a contributor, or may be. I think we've got to reassess what needs to be pre-drained and what doesn't and also reassess what SGE we can cope with with conventional vertical post-drainage and when we need to bring out some other tools to solve that problem.

Q. Thank you. Now if we could move ahead to page 29 of the same document, you'll see in the middle of the page you say:

> *The risk assessment lists inadequate control or dilution of methane gas emissions as a hazard and ranks it on a financial/commercial basis.*

A. Yes.

Q. I just want to ask, first of all, which risk assessment are you talking about here?
A. The ventilation risk assessment.

Q. And your point is that risk assessments shouldn't be ranking hazards having regard to financial, commercial or economic considerations?
A. No, I'm not saying that. I'm saying that particular hazard should be ranked both on commercial and on safety grounds.

Q. Forgive me, because I haven't been able to find it: are you saying the risk assessment didn't do that?
A. Yes.

Q. Can I just deal with this question of ranking it taking into account financial, commercial or economic grounds?
A. Yes.

Q. Why should the risk be ranked on those grounds?
A. Because if you're not managing the methane, controlling the gas emissions, then you will get gas delays whether there are HPIs or self-applied gas delays, so it will have economic impact. But there's also a safety aspect to it as well, of course.

Q. Why should risk assessments have regard to economic impact?
A. Operations rank risks on a number of grounds - business, safety, environmental being examples.

Q. And so I suppose you'd say the same thing, if we go further down the document, if you look at the second-last paragraph, you say:

> *It is considered in the author's opinion that the exceedances may have led to the hazard being viewed differently from an economic consequence had a more recent ventilation risk assessment been conducted.*

A. Yes.

Q. Why do economic consequences come into that consideration?
A. I'm saying they would have been viewed differently from economic consequence had a more recent risk assessment been conducted.

Q. Well, why would the hazard be viewed any differently on the basis of economic consequences?
A. I don't know.

Q. Sorry, when you're talking about "the author", you're not talking about yourself there?
A. No, I am.

Q. There's this concept that risks and hazards should be assessed based on economic, financial or commercial grounds.
A. I realise that.

Q. Shouldn't the process be that you assess the risk and then have regard to how that risk may be reduced, to use your terms this morning?
A. No, risk assessments assess risk based on a number of

different factors. As I said, it could be environmental, it could be safety, it could be business. The group that does risk assessment makes a decision on the basis of that hazard, and then they assess it on that basis. But if something's based on safety risk, it may achieve a different ranking from business, and I am suggesting to you that when they looked at that hazard, they thought it was a higher risk from a business point of view than it was from a safety, but that's guesswork.

Q. Are you saying the risk assessments you've seen in the course of preparing your report were addressed at all those matters rather than pure safety?
A. That risk assessment was definitely covering a range of categories of hazard. Some risk assessments are based on safety only, probably more.

Q. Assessment of risk to safety should first deal with safety matters; correct?
A. Safety overrides all other categories in all circumstances.

Q. If that's the case, why should hazards be ranked at all according to economic consequences or risks?
A. I can't answer that question. I don't know.

Q. You're suggesting they shouldn't be, I would have thought, if you say safety overrides all?
A. I can only say that if I was doing the risk assessment, I would insist it was assessed on safety grounds. But I wasn't there.

Q. No, I'm not suggesting you were. All right, can we move on to page 39. You'll probably have to look at what's on the previous page to remind yourself what the facts are, if we go back to page 38. You're dealing here with conflict between gas and spontaneous combustion management?
A. Yes.

Q. Do you remember essentially what the facts were that you dealt with there? I don't want it to be a memory test. This is just an introduction to my question about page 39.
A. I understand.

Q. Can we go back to page 39, then. You say there:

These facts cast doubts on the often held *belief that proactive inertisation and high capacity goaf drainage systems can be used in combination to mitigate the risk of manifestation of either hazard or both.*

A. Yes.

Q. And:

The task of managing both of these major mining hazards at Grosvenor is onerous. This would require a robust and reliable risk management process which is capable of responding rapidly to changes in the mining environment.

Now, my first question is: such a robust and reliable risk management process didn't take place; is that right?
A. I can't answer that. I know that Anglo have very robust and reliable risk management processes. Whether they were compliant with --

Q. How do you know that?
A. I'm sorry?

Q. How do you know that?
A. Through working with Anglo at some times.

Q. How often have you done that?
A. Occasionally.

Q. You may be reluctant to answer this question, but have you looked at some of the risk management process that occurred in this case?
A. Yes.

Q. And would you describe that as robust and reliable?
A. I think the process is definitely robust.

Q. And reliable?
A. I think the same comment applies.

Q. In saying that, which processes are you relying on?
A. Sorry, is that a question?

Q. Yes. I'm asking you which processes you rely on, which management process do you rely on to say what you've

seen is robust and reliable?
A. I'm talking about Anglo's risk management processes and I believe them to be reliable and robust.

Q. Are you talking about generally?
A. Yes.

Q. From previous experience?
A. Yes.

Q. Not about what happened here?
A. I can't answer that question.

Q. At Grosvenor?
A. I've not prepared myself to answer that.

Q. Yes, okay. Could we go down to page 41. I just want to ask you about what you say about propagation potential in the middle of the page. I think you've given evidence earlier about there appearing to have been a relatively small volume of explosible mixture.
A. Yes.

Q. Could I just ask you this: what factors would have made the propagation potential greater on the particular day --
A. If there had been a larger volume of methane-air mixture in the explosible range or if the ignition had propagated into a coal dust explosion.

Q. Would it also be dependent on the amount of production that was taking place at the time?
A. Well, that would lead to the larger volume of methane-air, so yes.

Q. So any of those factors were potentially present at this time when the explosion took place?
A. I don't think the risk of coal dust explosion was high. That tailgate was stone-dusted to a standard which is higher than I've seen.

Q. I just finally want to take you to page 46. Under the heading "Spontaneous combustion", you say:

The GMS has a history of spontaneous combustion at other longwall mines in Queensland ...

A. Yes.

Q. You may not be able to answer this, given your previous answer about risk assessment, but was this history dealt with in any risk assessments that you saw?
A. Sorry, say that again, please?

Q. Was this history of spontaneous combustion dealt with in any risk assessments that you saw?
A. I don't know.

MR CRAWSHAW: Yes, thank you, Mr Self.

MR HOLT: Mr Martin, I apologise, could I correct one matter that I put? When I referred to the high-flowing well, I referred to it as ending in 004. In fact, it ends in 002. I just wanted to correct the record, but I'm sure it won't make a difference to Mr Self's evidence.

THE CHAIRPERSON: Thank you. Ms Grant?

MS GRANT: No questions, thank you, Mr Martin.

THE CHAIRPERSON: Mr Trost?

MR TROST: No questions, Mr Martin.

THE CHAIRPERSON: Mr O'Brien?

MR O'BRIEN: No, thank you.

<EXAMINATION BY MS HOLLIDAY:

MS HOLLIDAY: Q. Mr Operator, if we can bring up the PowerPoint at slide 31. You may recall that Mr Holt asked you some questions in relation to this slide?
A. Yes, I do.

Q. You indicated that it wasn't sealed off when you were there?
A. The document doesn't talk about sealing off. We can go back to it, if you wish. It talks about - I think it said "barricade", I'm not sure. It did not say "seal". There's a big difference between a barricade and a seal. A barricade will prevent access by people but not any effect on the gas transfer, whereas a seal will hold almost

entirely, not quite, gases either side of it and prevent people accessing. So there is a difference.

Q. Based on the information that has been available to you, including what was put to you by Mr Holt, you maintain your view as per that schematic as to what should have been the ventilation arrangement, in your opinion?
A. That's the - not that one, the one with the blue line at the top is the one I would implement.

Q. Yes. I'm interested, though, when you said when you were there - you visited the mine after the serious accident; that's correct?
A. Yes.

Q. So that's the point in time that you were mentioning that you inspected the underground as per its conditions and the arrangements that were in place at that time?
A. Yes.

Q. At that time, what were the arrangements in relation to C heading?
A. It was something like I've drawn there.

Q. Mr Operator, if we can go to the first report of Mr Self, at page 22, and if we can focus in on the graph and also the sentence underneath the graph. You were asked some questions by Mr Hunter in relation to that graph as it appeared on the PowerPoint slide.
A. Yes.

Q. More particularly, he asked you whether or not the 93.5 per cent post-drainage capture efficiency was achievable.
A. Yes.

Q. Your answer was that as a peak, it was achievable.
A. Grosvenor has achieved that sort of number as a peak, but it hasn't averaged it.

Q. That was going to be my question. As an average, you make the point in your report that it was generally in the 80 per cent range?
A. Yes, I made my statement in evidence that it was around about 83 per cent average.

Q. So you were confining your comment to it being

achievable, that 93.5 per cent, as a peak?
A. As a maximum.

Q. As a maximum rather than the average?
A. Yes.

Q. Indeed, you make the comment underneath figure 5 that:

These figures are high by industry standards and Grosvenor was taking on an onerous task.

A. I stand by that.

Q. And is that because of the level of post-drainage capture efficiency requirement that they needed to meet?
A. Yes, it is.

Q. If I can take you to page 50 of that same report, and if we can focus in on dot point number 4, on this page you make a number of points in relation to TARPs?
A. Yes.

Q. I just want to take you to this one in relation to ethylene. Does it remain your position that any evidence of ethylene should be taken as elevated temperature?
A. It should be taken as elevated temperature. It should be taken seriously.

Q. The point that you made to Mr Hunter in relation to other possibilities, such as green timber and old diesel engines, is that that doesn't mean that the presence of ethylene should not be taken seriously, but, in fact, that it should always be taken seriously and that then investigations should occur as to if there are any other possibilities to explain it?
A. That is my stance, yes.

Q. And, of course, if there was a sustained presence of ethylene in a number of monitoring points over an extended period of time, that would be relevant to assessing, on an investigation, if there was any other possible cause of ethylene?
A. It does, I agree, but the rate of change and the location of points is important.

MS HOLLIDAY: Those are the only questions that I have, thank you, Mr Martin.

THE CHAIRPERSON: Yes, thank you. Mr Hunter?

<EXAMINATION BY MR HUNTER:

MR HUNTER: Q. There's just one matter I should clarify. Could we go, please, to slide 25 in the PowerPoint, Mr Operator. You made the point earlier today that the C heading was marked on this ventilation plan as being an irrespirable area?
A. Yes.

Q. I should in fairness show you the most recent ventilation plan prior to 6 May, because this plan represents the situation as at 22 June.
A. Yes.

Q. Could the witness please see RSH.002.385.0001. It might take a moment or two to download. It's quite a large document. Mr Operator, if we could please zoom in on the area that would be longwall 104, which would be this area here (indicating). Perhaps I can approach it this way. On this plan, which was prepared when the mine was still in operation --
A. Yes.

Q. -- that area is not marked as an irrespirable atmosphere?
A. I acknowledge that.

Q. Does the plan tell you anything about the types of seals that exist or existed at the time between the B heading and C heading?
A. It's normally annotated on the VCD.

Q. So when you say there was a regulator when you were there --
A. It was an open door, yes.

Q. Do we see any such device on that plan?
A. I can't see. It needs to be expanded a bit.

Q. Perhaps if we could zoom in a little bit closer, and again, please.
A. I can't actually read that text. There's obviously a VCD shown there.

Q. If what you can't read in that diagram in fact reads "14 kPa", what would that tell you it was?
A. That would be a 2psi stopping.

Q. So would that be a regulator?
A. It would be a stopping with a door in it. A regulator is normally controllable, so there are louvred types which can adjust the orifice from zero to fully open. That wasn't a regulator of that type; it was just purely a door that was open.

Q. And that's what you saw?
A. Yes.

MR HUNTER: Those are the only questions I have.

THE CHAIRPERSON: Yes, Mr Clough.

MR CLOUGH: Q. Mr Self, I just want to run through some maths I did off some of your tables and ask you to check my logic.
A. Okay.

Q. If we could go to slide number 8, which is table 3.4, "Longwall Ventilation and Goaf Drainage Requirements", please. Mr Self, I had a look at the capture efficiency column --
A. Sorry to interrupt you. Can I point out, that's not my table. That's Roy Moreby's.

Q. That's okay, but if you could check the logic?
A. It's the logic you want. Yes.

Q. So based on the table and applying some maths to back-calculate what the goaf drainage CH4 is in litres per second, I came up with a goaf capture efficiency at 90 per cent of 6300 litres. Now, how I did that, I said basically 700 litres per second is going down the return.
A. Yes.

Q. So 700 litres per second is 10 per cent of the total. The other 90 per cent has to go up the wells.
A. No, you need to start at the beginning. The peak methane litres per second is in that column there, so that's the total amount of methane that's being released by the mining process. If you take off the 700 from that,

which is the maximum carrying capacity of the tailgate return, then what remains is what needs to be goaf drained. And then if you divide the goaf drainage number by the total, the peak, that's the post-drainage capture efficiency.

Q. I think we come up with the same number. I still think at 90 per cent, the peak is still 6,300?
A. Okay, would you like to check that maths later and get back to you?

Q. Yes, sure. So if I then actually turn to your table - I've got here SAN.001.002.0017 - if we're looking at the peak of, say, 6,300 off that table --
A. Yes.

Q. -- that equates to about 15,000 tonnes per day?
A. Yes, bearing in mind this one is at 25 cubic metres per tonne. The previous table, Moreby's, at 14.4.

Q. Does it actually make a difference?
A. Yes.

Q. I thought basically we're restricted by what you can pull up the goaf wells?
A. If you want to run those calculations at 14.4, both those lines would move 40 per cent-ish downwards. So the 6000 litres per second you mentioned would equate to a higher number of tonnes.

Q. So if we just go off this table, then, for 25 cubic metres per second at 6300 litres per second, what does that equate to in terms of goaf capture efficiency?
A. I can't give you a figure from that chart.

Q. That might be something we have to come back to, because I was driving at what's the cap on the production rate for the mine annually based on the capacity of goaf drainage systems?
A. I can certainly give you an answer to that, but not now.

Q. Okay. That's my first question. The second question: in terms of detecting spontaneous combustion and the reliance on TARPs, from a lot of the conversation I've heard so far, I'm almost left with the impression there's an underlying assumption that TARPs are right.

A. I agree.

Q. So I think at slide 44 you stated that lack of detection is a major concern.
A. Yes. Just back on TARPs for a second, if you don't mind - very subjective, very little scientific process goes into a TARP. I think we over-rely on TARPs, and as you just said, we assume that they are correct.

Q. Which leads me on to the next two questions. I know one of the approaches is to use historical performance of previous longwalls to give information on what's considered normal for the emissions from the goaf.
A. That is slightly flawed, yes.

Q. The question I ask is: does that give you any feeling for a factor of safety between what's normal and what could be a heating?
A. No, and that's a problem.

Q. One aspect is relying on history.
A. Yes.

Q. The second question is relying on laboratory results: is there a potential that the laboratory results can understate particularly the propensity for spontaneous combustion?
A. Absolutely. There is a big difference between a laboratory experiment and a coal mine, as you well know.

Q. So this highlights two potential issues in setting TARPs?
A. Agree.

Q. And you could underestimate --
A. Agree.

Q. -- your TARP's level of intensity of the heating?
A. Yes.

MR CLOUGH: No more questions, thank you.

THE CHAIRPERSON: Thank you. Mr Hunter, might Mr Self be excused?

MR HUNTER: With thanks.

THE CHAIRPERSON: Yes. Mr Self, thank you for your attendance today. You are excused.

<THE WITNESS WITHDREW

THE CHAIRPERSON: Just before we adjourn - as I understand it, Mr Self was listed for two days?

MR HUNTER: He was.

THE CHAIRPERSON: On Friday, we have Mr Beamish; is that correct?

MR HUNTER: Yes.

THE CHAIRPERSON: Mr Hunter, could you just indicate the witnesses after Friday as well, if they're settled?

MR HUNTER: I understand that a Mr Munday is scheduled for Monday afternoon; Mr Ren on Monday morning; and on Tuesday or Wednesday - I think it's more likely to be Wednesday - we hope to hear from one of the workers on the face, who was injured, Mr Sellars.

THE CHAIRPERSON: All right. For the benefit of the parties, that's the current update.

Was there also mention of further investigations in respect of PUR?

MR HUNTER: We are still awaiting a report from Simtars concerning testing that's being done on the particular brand of PUR that was being used to consolidate the face at longwall 104. My learned friend Ms Holliday might be able to assist as to when we expect a report concerning that?

THE CHAIRPERSON: Ms Holliday, do you have any update on that?

MS HOLLIDAY: My latest instructions are that the report will be finalised by Friday of this week.

THE CHAIRPERSON: Friday of this week?

MS HOLLIDAY: Yes.

THE CHAIRPERSON: Thank you. Presumably that's a potential further witness?

MR HUNTER: Yes.

THE CHAIRPERSON: All right. That, it seems, Mr Hunter, is likely to be the whole of the evidence in this tranche?

MR HUNTER: Yes.

THE CHAIRPERSON: Assuming that's so, I would just like to indicate to the parties that the Board will be seeking written submissions to be provided to the Board by the end of Friday, 9 April. I was particularly keen to let you know, Mr Holt, and you, Ms Holliday, as soon as possible what the plan is at this stage.

MR HOLT: Thank you, Mr Martin.

MS HOLLIDAY: Thank you, Mr Martin.

THE CHAIRPERSON: If you would both work towards that, I would greatly appreciate it.

Of course, as was the case in the first tranche, a document will go out itemising issues, but I suspect you are well advanced, in any event.

Is there anything else before we adjourn?

MR HUNTER: No.

THE CHAIRPERSON: So 10 o'clock on Friday?

MR HUNTER: Yes.

THE CHAIRPERSON: Yes, thank you. Adjourned until 10 o'clock Friday.

AT 3.20PM THE BOARD OF INQUIRY WAS ADJOURNED TO FRIDAY, 26 MARCH 2021 AT 10AM

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