CHAPTER 11

Electrical safety

Introduction

1. This chapter considers the underground electrical system at Pike River. The integrity of parts of that system, and its potential to be a source of ignition for the first explosion, have been the subjects of conflicting evidence.

2. Relevant evidence and submissions have been received from many sources, including the Department of Labour (DOL); Anthony Reczek, an electrical expert engaged by DOL and the New Zealand Police; Rockwell Automation (NZ) Ltd, the supplier of key electrical components called variable speed drives (VSDs); and certain Pike directors, employees and contractors.

3. Because it has not been possible to access the underground parts of the mine in which significant electrical equipment is located, its installation and functioning, and its potential contribution to the explosion, cannot be determined. That is still being investigated by the health and safety regulator. Accordingly, the commission is compelled to limit its analysis.

Electrical systems at Pike River

4. Underground electrical systems are critical to mine safety and production. They must be designed, sited, installed and maintained so that they do not create hazards, including the risks of electric shock and sparking, which may provide an ignition source for flammable gas or material. These systems are complex, and use specialised equipment requiring expertise beyond that of a generalist electrician.

5. Their functions include powering the ventilation system of a mine, the monitoring and communications systems (including those for use in an emergency) and mining equipment. At Pike River that included the ABM, continuous miners and roadheader, the VLI Drilling Pty Ltd drill rig and the water pumps for the hydro monitor and coal transport systems. Although some parts of the electrical system, for example the surface fan, had back-up power supplies, those were often of limited duration.

6. Pike River's underground power supply came from two substations. One, at Logburn, stepped the voltage down 110kV to 33kV. It fed power to another substation near the portal entrance, which stepped that 33kV down to 11kV. From that substation, three 11kV lines delivered power into the mine through the main drift, two to the main electrical distribution board located in pit bottom in stone, identified as SB001 in Figure 11.1. Through that board power was supplied to much of the underground equipment. The third line delivered power to the main ventilation fan distribution board pit bottom south, at location SS601 in Figure 11.1. Pit bottom south extended to the coal reserves of the mine.

7. Those two areas, pit bottom in stone and pit bottom south, contained more substations to further step down the voltage, from 11kV to either 1kV, 690V or 400V, to power underground electrical equipment. Those areas also had the greatest concentration of fixed electrical equipment.

8. Generally, fixed electrical equipment could be controlled and monitored from the surface control room. Some of the equipment had methane sensors and safety cutouts, including in the event of overheating.[1]

9. The red line in Figure 11.1 marks the boundary between two underground zones, the restricted zone, which is to the left of the line and includes the coal workings, and the non-restricted zone to the right. That non-restricted zone includes Spaghetti Junction and much of pit bottom south. The zones are explained below.

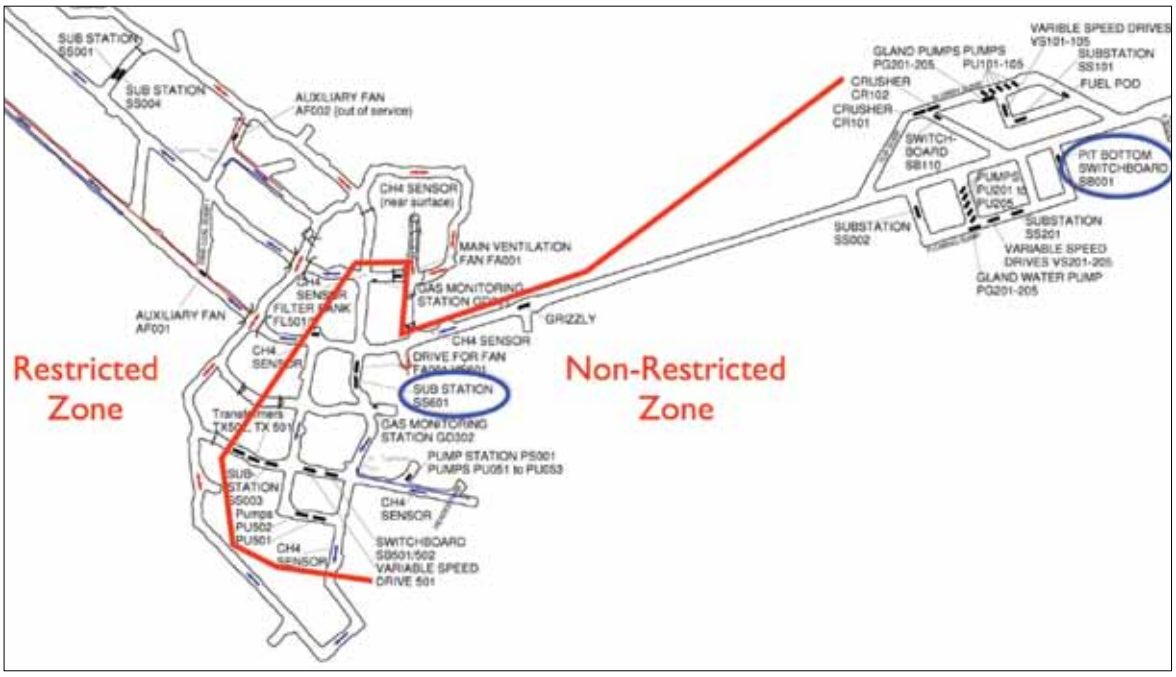

Figure 11.1: Main electrical area and zones underground[2]

The restricted and non-restricted zones

10. Because of the risk of an electrical system being a source of ignition, the Health and Safety in Employment (Mining – Underground) Regulations 1999 provide for restricted and non-restricted zones in gassy coal mines.

11. In gassy mines the restricted zone includes the working faces, the return, any area where flammable gas is likely to be 2% or more in the general body of air and any area containing electrical equipment that has not been shown to be free from flammable gas. Free from flammable gas means there is no more than 0.25% flammable gas in the general body of air.[3]

12. All practicable steps must be taken to ensure electrical equipment used in a restricted zone meets certain safety standards, so that it is not a source of ignition. Essentially, it must be intrinsically safe or flameproof.[4] Intrinsically safe equipment operates at such a low energy level that it is incapable of igniting methane. Flameproof equipment is enclosed in a special housing to ensure any ignition of methane is safely contained inside the enclosure.[5]

13. These requirements were reflected in Pike's detailed ventilation management plan. It contemplated that an 'electrical supervisor' would define any non-restricted zones, following a risk assessment. The zones were to be shown on a plan kept in the surface controller's office.[6] Electrical equipment had to meet legislative standards. Inspections were to occur with a frequency that differed according to the equipment.

14. The restricted and non-restricted zones were defined in August 2010, but the process outlined in the management plan was not followed. There was no risk assessment to define the location of the restricted zone.[7]

15. By then Pike had already installed a large amount of electrical equipment, some of which was neither intrinsically safe nor flameproof, in the pit bottom south and Spaghetti Junction areas of the mine. The motor for the main fan, numerous pumps and VSDs fell within that non-restricted zone as defined.[8]

16. Some electrical equipment was tested on the surface before being installed underground. In addition, before underground electrical equipment in pit bottom south was powered up, gas samples were taken in the vicinity over three days to ensure there was less than 0.25% methane. Methane sensors were placed at various parts of the non-restricted zone.[9]

17. Despite those precautions, the non-restricted zone in pit bottom south extended to the coal measures in the gassy mine and was close to the return. Michael Scott, an underground electrical co-ordinator at Pike, noticed that some of the methane sensors in the non-restricted zone in 'pit bottom south near switchboard SB501 would trip. This was because the tunnel where the header tank is located is a non-free ventilated stub, or dead end, and we did have methane coming out there in small amounts … very low concentrations, maybe 0.3%.'[10] The sensor was moved and ventilation of the area improved. Methane greater than 0.25% in the non-restricted zone was reported though the accident and incident reporting system on at least one occasion.[11]

18. The location of the non-restricted zone did not go without comment at the mine. One deputy said:

> *I asked one of the electrical engineers what [the main fan] motor was doing up there, right next to the main return and fan. He just said it was a non-restricted zone. I can't understand how it could be a non-restricted zone when it was within 10m of a temporary stopping into the main return where all the gas was leaving the mine.*[12]

19. A stopping failure or ventilation fan failure (which may be followed by the reversal of ventilation) could result in methane being introduced into the pit bottom south non-restricted zone.[13] Because some equipment in that zone was not intrinsically safe or flameproof, methane sensors and the associated safety cutouts had to be relied on if methane entered the area.

20. The location of the non-restricted zone concerned Mr Reczek, the electrical expert engaged by DOL and the police. In his view it did not make logical sense and the whole area inbye of the main drift should have been a restricted zone.[14] He stated that 'despite the fact that the presence of methane was possible, there was no explosion protection technology used on the major items of electrical equipment located in the designated "unrestricted" area of the mine's inbye workings at the end of the stone drift entry'.[15]

21. A risk assessment would likely have led to the view that the non-restricted zone, and thus non-flameproof or non-intrinsically safe equipment, ought not to be located within or so near to the coal measures of a gassy mine or, if it was, very good protection would be needed to prevent methane coming into contact with electrical equipment.

22. Such a risk assessment is not expressly required by the underground mining regulations. This contrasts with the Queensland legislation in which a risk assessment is required to define three types of zones, those with a negligible explosion risk (methane likely to be less than 0.5%), explosion risk 1 (methane likely to be 0.5 to 2%) and explosion risk 0 (methane likely to be greater than 2%).[16]

Proximity of non-restricted zone and electrical equipment to utility services

23. The inclusion of pit bottom south and Spaghetti Junction in the non-restricted zone led to another hazard. These areas contained roadways and significant utility services – water pipes, compressed air pipes and gas drainage pipes. To those were added 11kV lines. The sheer quantity, and lack of separation, of utility services at Spaghetti Junction is shown in Figure 11.2. The high-voltage cables are red.

24. Of that configuration mining consultant David Reece said:

> *This is quite unusual to have pipes like this, this sort of configuration in a mining situation. The other thing is the high-tension cables that are also interspersed with all these services in that particular area. So this is potentially an area where these could be hit by a diesel vehicle or something of that nature … it's certainly hazardous and the combination of services that you've got there with high-tension cables, and we're talking about 11,000 volts in those cables, if you damaged that at the same time as the pipeline, it is highly likely that you would get an ignition at that point.*[17]

Figure 11.2: Spaghetti Junction[18]

25. Consultant Comlek Electrical Engineering Contracting Ltd had raised the proximity of electrical cabling and equipment to other utility services and the roadways in a 30 October 2009 electrical audit report commissioned by Pike. Its purpose was to assess the compliance of electrical equipment located in a potentially explosive atmosphere with relevant Australian and New Zealand standards and to make corrective recommendations.

26. Comlek was concerned that high-voltage lines 'crossing the mine access road is considered dangerous due to it not specifying clearance heights by signage and not having indication of aerial location' and that standards of electrical equipment and location of storage needed 'major improvement'. An example was an item of electrical equipment (a starter) being located under water pipes, on the floor and without barrier identification.[19]

27. High-voltage cabling and electrical equipment should not be located close to gas, water and compressed air utility services. Where this is unavoidable, protective housing should be used, including protection against vehicle impact.

The variable speed drives

28. Pike used VSDs to allow the fixed speed motors for the main fan and underground pumps to operate at variable speeds. The VSDs do this by varying the frequency of the power supply to the motors.[20] This enables a softer start-up process and also allows the operating speeds of a motor to match its output demand, resulting in cost savings and improved performance.

29. Pike had 12 VSDs underground, at the locations circled in red in Figure 11.3. There were five VSDs in each of the locations to the top right of the plan and one at each of the locations to the bottom left of the plan.

30. There were concerns about the use of VSDs. Mr Reczek was aware of the use of VSDs underground elsewhere, but they were 'explosion protected. They're in flameproof enclosures and they're confined to the body of machinery.'[21]

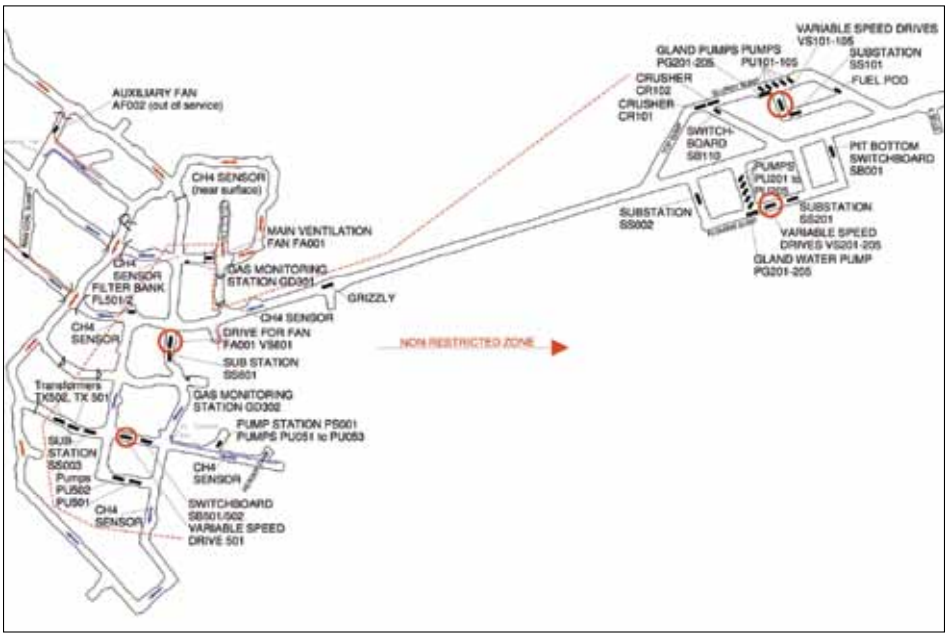

Figure 11.3: Plan showing VSDs underground at Pike River[22]

He had never seen a configuration such as that at Pike River, which was essentially a significant number of fixed VSDs underground.

31. Mr Reczek and Mr Nishioka gave evidence that VSDs need to be placed in a very clean, dust-free environment with a consistent temperature. Mr Reczek thought that 'unless you have a totally enclosed room which is dust free and filtered and separately ventilated, I don't think you could provide a satisfactory environment' underground in a coal mine.[23] Evidence indicates that Pike created, or sought to create, such an environment.[24]

32. VSDs have the potential to cause enough harmonic distortion to generate sparking within the earth system of the power supply. The extent to which harmonics occur depends on many matters, including the type of VSD, the manner in which it is installed and the cabling type, length and connection. The installation and cabling details at Pike River remain unclear.[25] There is conflicting evidence from Mr Reczek and Rockwell, the supplier of VSDs, about the extent and effect of harmonics. This is referred to in more detail in Chapter 14, 'The likely cause of the explosions'.

33. There were other problems associated with the use of VSDs. There was an overvoltage in the power supply to at least one VSD, affecting its performance; this was rectified on about 9 November 2010. Five VSDs failed and were removed. In one case a power structure exploded. On several occasions pre-charge resistors failed. This problem was to be solved by changing the ratings of protective fuses. New fuses had been ordered but not replaced by the time of the explosion.

34. During commissioning of the main underground fan there were intermittent and difficult problems with the associated VSD. On 27 October 2010 the VSD was replaced with an air-cooled model, which was placed within an enclosure to provide protection. It seems this led to overheating. Pike took steps to correct that, including leaving open the doors to the enclosure and installing ducting to direct air into it. On about 9 November 2010 Pike ordered an air conditioner to improve the cooling. It had not arrived by the time of the explosion.[26]

35. In summary, despite Pike's efforts and those of external experts, there was a range of problems associated with the use of VSDs, not all of which had been addressed by the time of the explosion.

Regular electrical inspections

36. Documents filed with the commission show that, as with much other plant, there were frequent inspections of and written reports on electrical plant and equipment. The frequency varied, but some were daily.[27] Despite containing information relevant to health and safety, those reports did not make it as far as the safety and training department.[28]

37. The timing of tests and inspections does not always seem to have been consistent. The October 2009 Comlek audit report shows, at that stage at least, no weekly and monthly tests on certain electrical equipment. A selection of work orders from October 2010 shows that daily electrical checks on some equipment were not always done. The reasons are unclear or not explained.[29]

38. Comlek also pointed out that there was no single line diagram of the underground and above-ground electrical reticulation and that reporting of events and transfer of information at shift handovers needed improvement.[30]

Electrical staffing at Pike River

39. Pike contracted in expert electrical advice,[31] and had its own electrical staff, usually including electrical engineers,[32] within the engineering department. Mr Scott, the underground electrical co-ordinator at the time of the explosion, noted '[w]e had trouble getting good electricians as they needed to be industrial electricians, but the majority of the electricians were up to standard in my view. A couple were beyond the standard.'[33] In October 2009 Comlek identified the lack of procedures for sign-off of electricians at Pike River as having certain certificates of competence.[34]

40. Mr Reczek envisaged an electrical engineer with an overview of the management and operation of electrical equipment and responsibility for the implementation of risk controls as part of an electrical management plan. The relationship with the mine manager would be close.[35]

41. Two early documents of Pike, a draft management plan of September 2008 and a draft electrical engineering management plan of November 2008,[36] contemplated an electrical engineer of some seniority. The final electrical engineering management plan dated 30 April 2010 provided for an electrical co-ordinator.[37] This appears to be a lesser, more maintenance orientated, position than that described by Mr Reczek. It is reflected in the structure of the engineering department before 24 August 2010 (Figure 11.4).

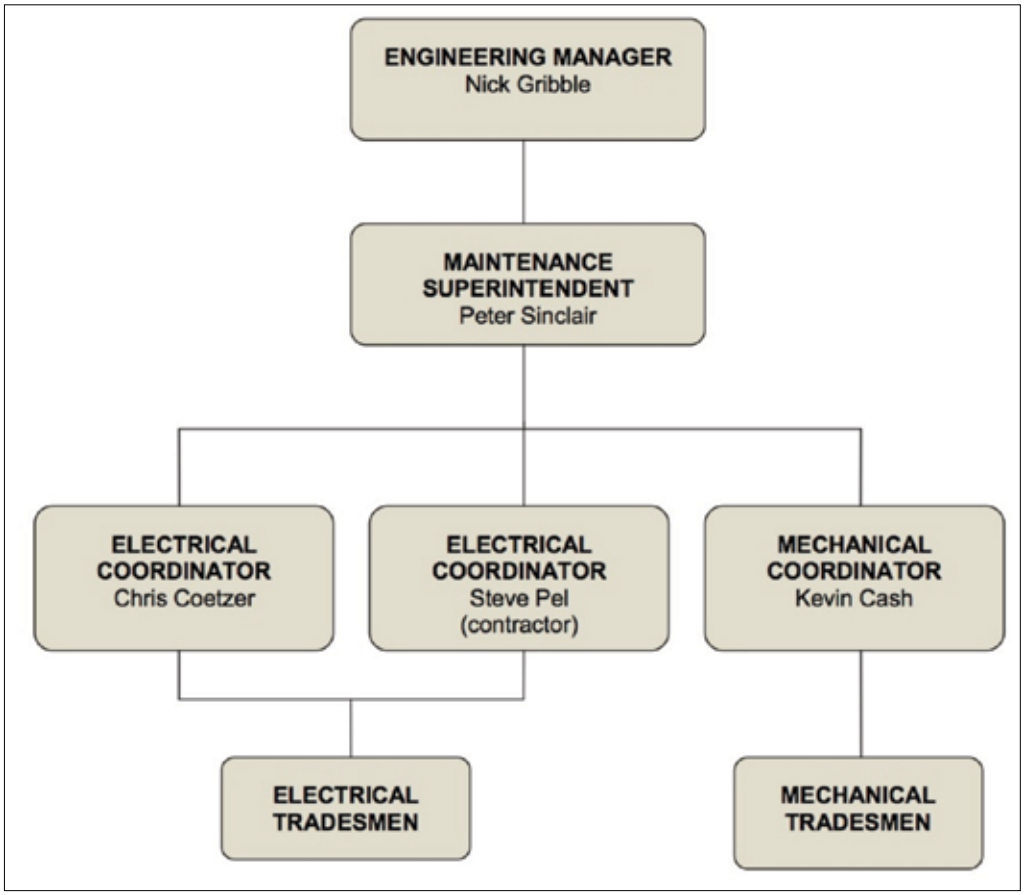

Figure 11.4: Structure of Pike engineering department before 24 August 2010[38]

42. In September 2010 that structure was reviewed by Robb Ridl, the engineering manager for Pike from 24 August 2010 to 30 September 2011.[39] A memorandum from Mr Ridl dated 22 September 2010 records the reasons for the review and resulting recommendations:

> *The current Pike River Engineering Department is currently unable to meet the needs of the business and a new engineering organisational structure has been developed to provide for the maintenance requirements of the business in an operational phase.*
>
> *… The current structure does not have clearly defined areas of responsibility and fixed plant is not being proactively maintained due to lack of supervisory resources.*[40]

43. A new structure with increased staffing was proposed and was approved by Douglas White and Peter Whittall (see Figure 11.5).[41] It included the position of electrical engineer.

44. This was not as senior as the position suggested by Mr Reczek but did include responsibility for many aspects of the electrical system, including risk management, ensuring maintenance in accordance with statutory requirements, electrical inspections and continuous improvement.[42]

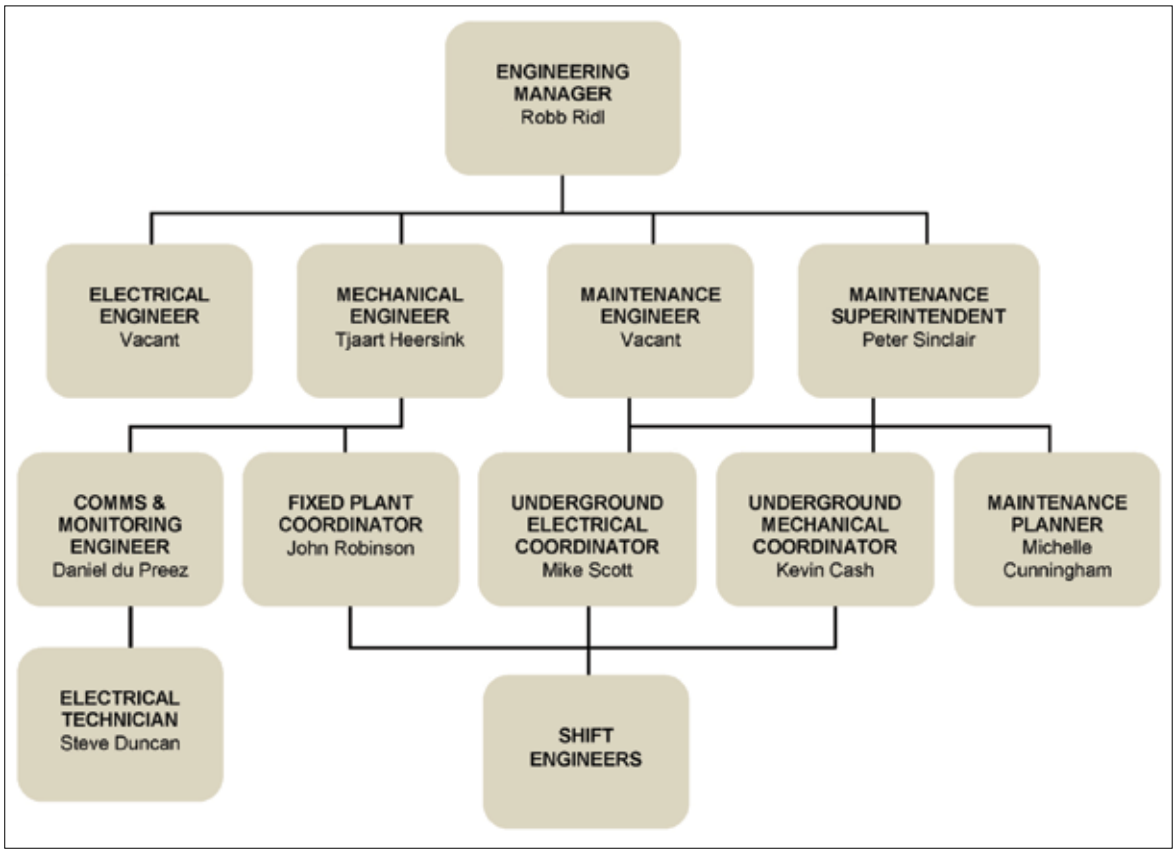

Figure 11.5: New structure for Pike engineering department[43]

45. By 19 November 2010 an electrical engineer, a contractor who had been an electrical co-ordinator, had been appointed but he had not started in the new position.[44]

Overall management of electrical safety at Pike River

46. All of the above issues call into question the extent to which Pike was properly managing electrical issues. The DOL investigation report states:

> *Taken together, it appears that [Pike] was experiencing an excessive number of issues with its electrical system and especially with its VSD operation. Each issue seems to have been explained and dealt with on an*

> *ad hoc basis, as and when it occurred. However, given the high risk environment [Pike] was operating in, and the number of unknown reasons for the electrical failures* ***[Pike] management should arguably have approached the issues first and foremost as a safety matter. From this perspective, it may have been reasonable for [Pike] to have ceased operations and sought further third party expert advice to determine the causes of the electrical issues and the appropriate controls necessary.*** *[Emphasis in original]*[45]

47. The DOL investigation report also states that Pike had:

> *four departures from conventional electrical arrangements for an underground coal mine. These were the placement of the main fan underground, the use of VSDs to drive key infrastructure systems, the long single entry (the Drift) and use of non-hazardous zones and equipment. These four unconventional arrangements individually and together created an increased level of risk because they were largely untested and unusual.*[46]

Given the importance of a safe and efficient electrical system, Pike should have introduced 'compensatory processes to mitigate the higher risk.'[47] Those would include carrying out sufficient research to understand the risks those unconventional arrangements created in a hazardous environment, obtaining independent expert advice on the use and installation of VSDs underground, and a risk assessment.

48. Pike obtained significant advice about the VSDs. Experts were involved in designing and maintaining its electrical system. Assessments were undertaken for certain electrical equipment and there was some above-ground testing before installation. However, problems still occurred.

49. There does not appear to have been a comprehensive assessment of the potential risk of the electrical system. Mr Ridl thought such an assessment necessary but in the short time between his starting employment and the explosion he did not become aware of one.[48] Mr Scott thought the risk assessment process at Pike was more extensive than at other places he had worked, but did not recall an overall risk assessment concerning the use of electrical equipment underground.[49] Mr White was not sure of the extent of electrical risk assessments, and it was outside of his expertise.[50] The Pike board's health, safety and environment committee did not seek confirmation that the underground electrical systems were correctly installed and safe.[51]

50. A comprehensive risk assessment, in mid- to late 2010, would have taken into account the individual and cumulative risks raised by DOL and the problems with important components of the electrical system. The risks should have been considered in the context of Pike's move to hydro mining. This would have indicated the desirability of halting, or at least restricting, hydro-mining operations (because of its introduction of significant accumulated methane in the goaf), until all the electrical problems had been fixed.

Electrical inspections

51. Mr Reczek considered that the underground Pike electrical system warranted 'a significant amount of attention' from a regulator, because of its location in a hazardous area and its unconventional nature. The focus would be on the measures undertaken to assure safety.[52]

52. However, regulator oversight was limited. On 13 February 2007 Richard Davenport, from the Electrical Safety Service of the Ministry of Economic Development (MED), and Michael Firmin of DOL, inspected the electrical system. They approved the then installation, but at that stage the drift was still being developed and the underground electrical cabling and system had not been installed.[53]

53. On 26 November 2008 Mr Davenport, with Kevin Poynter of DOL, conducted another electrical inspection.[54] This concluded that all electrical installations were compliant.[55] At that stage the underground electrical equipment had not been installed.

54. From January 2009 MED no longer conducted electrical inspections in underground coal mines and DOL did not have the expertise to carry them out.[56] As a result, key underground electrical systems installed in 2010 were not scrutinised by an electrical expert from or on behalf of DOL.

Conclusions

55. The underground electrical system at Pike was unconventional in a number of ways:

- the main fan was underground;
- the non-restricted zone, which contained some non-flameproof and non-intrinsically safe electrical equipment, extended to the coal measures in this gassy mine;
- there was significant use of VSDs underground to drive key infrastructure and a range of problems was associated with their use; and
- high-voltage cables and utility services were intermeshed at Spaghetti Junction.

56. Individually, and in combination, these unconventional arrangements introduced significant risks to the underground environment. The location of the non-restricted zone, and the overall electrical system, ought to have been subject to comprehensive risk assessment, followed by any necessary actions. Within the overall context of the mine's development and operation in mid- to late 2010, that may have led to a halting or restriction of hydro-mining operations while electrical problems were being corrected.

57. A risk assessment conducted before creating the non-restricted zone at pit bottom south would likely have led to the view it ought not to be located in or near the coal measures in this gassy mine.

58. Pike had both external and internal electrical expertise, but did not have a sufficiently senior electrical engineer with responsibility for the whole electrical system.

59. There was inadequate regulatory oversight of the electrical system from 2009 onwards, owing to a lack of expertise within the DOL mines inspectorate.

60. The commission has significant concern about the electrical system and whether it played a role in the explosion.

ENDNOTES

[1] For example the VSD for the main ventilation fan: Robb Ridl, witness statement, 14 March 2012, DAO.041.00009/28, para. 116. See also: Pike River Coal Ltd, Incident/Accident Form, 12 October 2010, DAO.001.00359/3–5.
[2] Pike River Coal Ltd, Plant Location and Ventilation Plan: Rescue 101119_181, 22 March 2011, DAO.010.13140/1. (Extract of the plan modified by the commission)
[3] Health and Safety in Employment (Mining – Underground) Regulations 1999, reg 2.
[4] Ibid., reg 55.
[5] Anthony Reczek, witness statement, 7 February 2012, DOL3000160001/5, para. 16.
[6] Pike River Coal Ltd, Ventilation Management Plan, 2008, DAO.003.07114/72, para. 242.
[7] Douglas White, transcript, p. 4971.
[8] Michael Scott states the electrical equipment for the hydro monitor was installed between June and August 2010: Michael Scott, witness statement, 30 May 2012, SCO7770010001/17, paras 64–66.
[9] Michael Scott, witness statement, 30 May 2012, SCO7770010001/18, paras 68–69; Douglas White, transcript, pp. 4968–70.
[10] Michael Scott, witness statement, 30 May 2012, SCO7770010001/36–37, para. 150.
[11] Pike River Coal Ltd, Incident/Accident Form, 12 October 2010, DAO.001.00359/3–5; Douglas White, transcript, p. 4972.
[12] Dene Murphy, witness statement, 2 December 2011, FAM00057/12, para. 60.
[13] Michael Scott, witness statement, 30 May 2012, SCO7770010001/37, para. 151 (stopping failure); Dene Murphy, witness statement, 2 December 2011, FAM00057/11, para. 58 (ventilation fan failure).
[14] Anthony Reczek, transcript, pp. 4774–75.
[15] Anthony Reczek, witness statement, 7 February 2012, DOL3000160001/28, para. 108.
[16] Coal Mining Safety and Health Regulation 2001, cls 286–91.
[17] David Reece, transcript, p. 4485.
[18] DR12 – Photo of Spaghetti Junction, DOL3000150019/1.
[19] Comlek Electrical Engineering Contracting Ltd, Audit Report of Electrical Management Systems at Pike River Coal NZ, 30 October 2009, DAO.025.26626/6–7, paras 1.14–1.15.
[20] Anthony Reczek, witness statement, 7 February 2012, DOL3000160001/16, para. 55.
[21] Pike River Coal Ltd, Plant Location and Ventilation Plan, DAO.010.13140/1 (extract of the plan modified by the commission).
[22] Anthony Reczek, transcript p. 4760. In a memorandum, Mr White referred to a VSD unit that he said was 'the only one of it's kind on site, and, we are lead to believe, the only one of it's kind in the Southern Hemisphere [sic]': Memorandum, Douglas White to Peter Whittall, 22 March 2010, DOL3000160011/1.
[23] Anthony Reczek, transcript pp. 4760–61; Masaoki Nishioka, transcript, p. 3494.
[24] Gregory Borichevsky, Police/DOL interview, 7 June 2011, INV.03.20410/30.
[25] Department of Labour, Report on Electrical System Evidence, 8 June 2012, DOL7770050017.
[26] Michael Scott, witness statement, 30 May 2012, SCO7770010001/26–28.
[27] Karyn Basher, witness statement, 10 November 2011, CAC0117/3.
[28] Neville Rockhouse, transcript, p. 4234.
[29] Pike River Coal Ltd, Work Order No 17075, 26 October 2010,

DAO.004.05509/1; Pike River Coal Ltd, Work Order No 16856, 19 October 2010, DAO.001.07114/1; Pike River Coal Ltd, Work Order No 15936, 27 September 2010, DAO.001.07211/1; Kevin Poynter, transcript, pp. 3018–28.

[30] Comlek Electrical Engineering Contracting Ltd, Audit Report, DAO.025.26626/5, paras 1.7–1.9.

[31] Anthony Reczek, transcript pp. 4823–29.

[32] Douglas White, transcript, p. 4965.

[33] Michael Scott, witness statement, 30 May 2012, SCO7770010001/7, para. 20.

[34] Comlek Electrical Engineering Contracting Ltd, Audit Report, DAO.025.26626/4, para. 1.1.

[35] Anthony Reczek, transcript, pp. 4771–73.

[36] Pike River Coal Ltd, Roles and Responsibilities: Management Plan (Draft Document), 9 September 2008, DAO.002.00960/67; Pike River Coal Ltd, Electrical Engineering Management Plan: Management Plan (Draft Document), 2 November 2008, DAO.002.00662.

[37] Pike River Coal Ltd, Electrical Engineering Management Plan, 30 April 2010, DAO.003.07228/9.

[38] RJR1: Engineering Structure Before 24 August 2010, DAO.041.00006/1.

[39] Robb Ridl, witness statement, 14 March 2012, DAO.041.00009/3, para. 2. Mr Ridl had also been a mechanical co-ordinator at Pike from August 2006 to May 2007.

[40] Memorandum, Robb Ridl to Douglas White, 22 September 2010, DAO.043.00004/1.

[41] Robb Ridl, witness statement, 14 May 2012, DAO.043.00050/12.

[42] Pike River Coal Ltd, Engineering Department Areas of Responsibility, DAO.043.00001.

[43] Pike River Coal Limited Organisation Chart as at 19 November 2010, PW23a/1. (Extract with 'Note 2' removed from beside Robb Ridl's name by the commission)

[44] Pike River Coal Ltd, Manager's Promotion Recommendation, 4 November 2010, DAO.043.00049/1; Douglas White, transcript, pp. 4965–68.

[45] Department of Labour, Pike River Mine Tragedy 19 November, 2010: Investigation Report, [2011], DOL3000130010/161, para. 3.37.10.9.

[46] Department of Labour, Investigation Report, DOL3000130010/151, para. 3.37.4.6.

[47] Ibid., DOL3000130010/151, para. 3.37.4.7.

[48] Robb Ridl, witness statement, 14 May 2012, DAO.043.00050/9–10, paras 50–51.

[49] Michael Scott, witness statement, 30 May 2012, SCO7770010001/41, paras 169–170.

[50] Douglas White, transcript, p. 4967.

[51] John Dow, transcript, p. 4033.

[52] Anthony Reczek, transcript, p. 4770.

[53] Richard Davenport, Inspection Audit Report, 13 February 2007, DAO.025.42883/2–3.

[54] Kevin Poynter, witness statement, 19 October 2011, DOL7770040003/17, paras 84–86.

[55] Ministry of Economic Development, Energy Safety, ES Audit Report, 4 December 2008, MED3000010002/2–4.

[56] Michael Firmin, transcript, pp. 602–04, 684.