CHAPTER 2

Accident analysis – some concepts

Introduction

1. The commission has sought the systemic reasons for the Pike River tragedy. The analysis, therefore, goes beyond the immediate cause to reveal the underlying causes and circumstances that allowed the tragedy to occur. In doing so, the commission has relied on expert evidence and international thinking. This chapter explains some concepts that have helped the commission in its evaluation and in preparing the report.

The 'what/why' distinction

2. Causation can be a vexing issue. In determining the cause of an event, it is possible to focus on the immediate or proximate cause or causes, or to look beyond the immediate to identify not just what happened, but why. The commission has taken the second approach.

3. The 'what/why' distinction can be illustrated by an example. A machine operator in a factory overrides a protective guard and is injured. The immediate and proximate cause is human error (or violation): but for the operator's action the machine could have been operated safely and the accident avoided.

4. Identifying what happened, and the result, has the advantage of simplicity. It allows responsibility to be assigned to an individual and blame to be attributed. And then the quest for explanation can stop.[1]

5. Until comparatively recently, accidents were routinely attributed to frontline operator error, and contributory causes were not considered, including the actions of those at management and governance level. The broader context, or setting, in which the operator acted was essentially ignored.[2]

6. If, by contrast, the question 'why' is asked – why did the operator act as they did? – a whole range of contributory factors may emerge. Perhaps the machine operator's training was deficient, fatigue clouded their judgement, the machine guard inhibited production or overriding guards was commonplace in the factory.

7. The emergence of these factors prompts another level of inquiry. Why was operator training inadequate? Why was worker fatigue an issue? Why was the machinery not fit for purpose? Why was rule violation normalised? These questions invite greater scrutiny. Why were such problems not identified and addressed by management or at a governance level, where resources are allocated and an organisation's direction is set?

8. The explosion and loss of 29 lives at Pike River demands a broad inquiry that extends to all levels of the company. Chapter 3, 'The promise of Pike', which examines the conception, approval and development of the mine, provides the backdrop for the examination of the mine and its systems in subsequent chapters.

9. But, as Dr Callaghan[3] explained, the inquiry must extend further still: 'to interrogate the strengths and weaknesses at all levels of the "system" – the company, the industry, the regulator and the wider government', at least if 'intervention is [likely] to be as efficacious and efficient as it could be'.[4] The commission agrees.

Human factors

10. Dr Callaghan also stressed the need to consider 'human factors' in accident analysis. Human factors are the 'environmental, organisational and job factors, and human and individual characteristics, which influence behaviour at work in a way which can affect health and safety'.[5] The definition identifies three interrelated aspects: the job,

the individual and the organisation, each of which requires consideration. The job is the task to be performed in a specific workplace, including, in particular, the demands posed by that task. The notion of the individual captures the characteristics that influence human behaviour, such as competence, experience, attitude and personality. Some of these are fixed; others are adaptable. The organisation includes such things as resources, leadership and culture – all the company-related factors that influence individual and group behaviour in a workplace.

11. The aim of the human factors discipline is to 'understand and improve competence and safety at work.'[6] It seeks to answer such questions as:

- Why do smart people do unsafe things?
- Why don't people do what they've been told?
- Why are the same mistakes made over and over again?[7]

The questions expose the norm that error is a characteristic of human behaviour and therefore inevitable in any human system. It follows that any system relying on error-free human performance is fundamentally flawed. In any event, accidents are rarely the result of a single action, failure or factor, but rather of a combination of personal, task-related, environmental and organisational factors, some longstanding.[8]

Personal safety and process safety

12. These terms distinguish between two types of accidents widely recognised in the literature. As well as having different characteristics, personal safety and process safety accidents require different approaches to their prevention and investigation.

13. Personal safety accidents may involve one person who is both the cause and the victim. The damage may be significant, but is confined to an individual or a small group of people. Such accidents are relatively frequent because they occur as a result of human errors or violations in relation to hazards that are close at hand (as in the machine operator example). Often they can be described as slips, trips and falls. The defences or protections that guard against them are normally simple and few in number. Typically there is little time between the failure and the accident.

14. Process safety refers to the prevention of the unintended escape of toxic substances, flammable material or energy from a plant or other workplace. In a mining context the consequence may be an explosion or a fire. Process safety accidents can be catastrophic, causing multiple deaths and large-scale personal and property damage. Typically the organisations that suffer process safety accidents have complex and layered defence systems intended to eliminate workplace hazards. These systems comprise a mixture of hard and soft controls. Hard controls are physical barriers and devices that guard against, monitor or automatically warn of hazards. Soft controls are the organisation's practices and procedures, including operating standards, supervisory oversight and worker training.[9]

15. A layered defence system makes it unlikely that one failure, human or mechanical, will trigger an event. Rather, a combination of failures is required before the multiple defence systems are penetrated, with potentially catastrophic results. Hence the term 'low frequency, high consequence events' is used with reference to process safety accidents. Because these events are often separated by a number of years, or decades, complacency may develop, even to the point where an organisation becomes blind to a known catastrophic risk.

16. The indicators of personal safety and process safety are also different. The occurrence of personal safety accidents has usually been measured by the lost time injury rate of the company. This is a lag indicator, a measure of performance made after the event, actually a measure of failure. Many companies place considerable store on their lost time injury rate figures. They may be used to measure performance and thereby affect a senior manager's bonus payment. They may attract the attention of the regulator, or even of an insurer in fixing a premium.

17. A measure of injury rates is of limited use, however, as an indicator of a looming process safety failure. For this, a mixture of lag and lead indicators is required. Lead indicators, sometimes called positive performance indicators, are

obtained from routinely monitoring selected critical risk controls to ensure their continued effectiveness. The choice of risk controls is important. They must be of a kind to measure process safety performance in relation to the major hazards at the particular workplace.[10]

18. An example relevant to Pike River illustrates the interaction of lag and lead indicators. Methane explosions in mines are prevented by gas management, a key element of which is methane monitoring. This is done partly by using methane sensors, hard controls, strategically located in the mine. The sensors provide a warning of excessive methane levels, or spikes. A high-level spike is a warning sign, while a number or pattern of spikes may be a critical indicator of a potential process safety failure. An associated soft control may be a maintenance programme used to routinely test the calibration and reliability of the sensors. Data confirming that the maintenance programme is carried out on time, and effectively, gives the added assurance that the information supplied by the sensors is accurate. But all indicators are not equal. Failure data, such as a pattern of methane spikes, may demand an immediate response; other indicators may be less critical. What matters most is that there is a range of safety indicators, and that they are analysed and used to drive improvements in safety performance.[11]

19. The explosion at Pike River was a process safety accident. Its occurrence raises many questions. Were the hard and soft controls at the mine adequate? How were the defence layers breached? Were lag indicators gathered and responded to? Were lead indicators used to check the effectiveness of hazard controls? Was there complacency about the existence of an explosion risk? These questions require the commission to look at the whole organisation, and to consider the actions of the regulator and others.

The 'Swiss cheese' model of causation

20. James Reason also devised a causation method, commonly referred to as the 'Swiss cheese' model, which is of particular relevance to process safety accidents.[12]

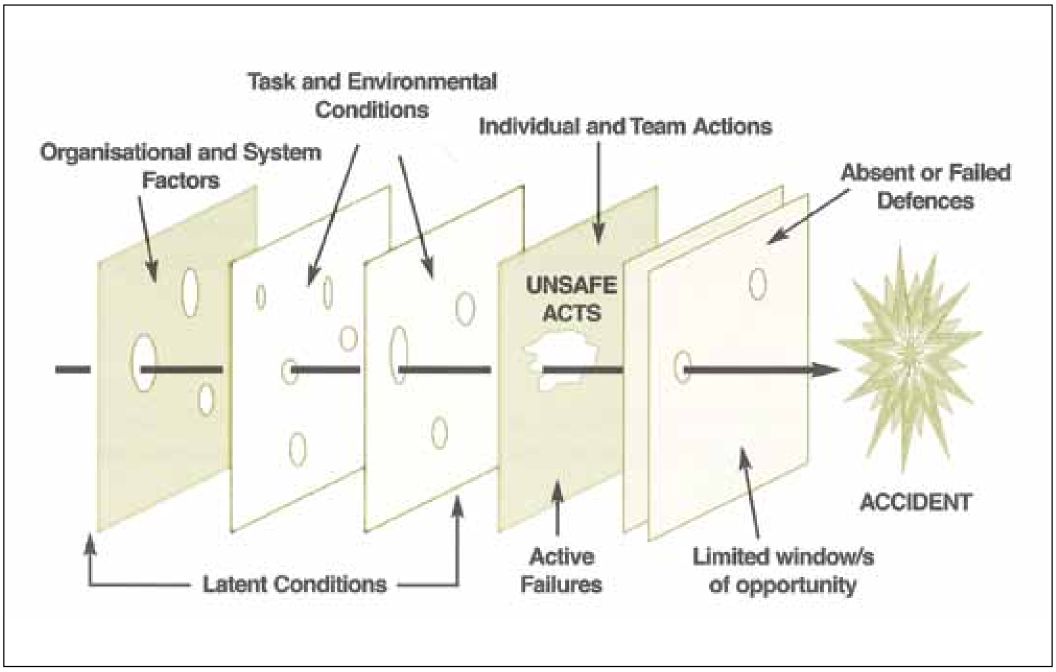

Figure 2.1: 'Swiss cheese' model of causation

Each slice of cheese represents one layer of an organisation's defence system. These are labelled by type (at the top), and also divided into latent conditions and active failures, and windows of opportunity. The holes in each slice represent gaps in the defence system. Some arise from active failures, human errors or violations, which are short-lived. Latent conditions reflect the decisions and actions of the people who design, influence, implement and manage aspects of an organisation's operational systems, such as equipment selection and monitoring, information gathering or safe operation systems. These are latent because they can lie undiscovered and dormant for long periods until a combination of failures triggers a near miss or an actual event.[13]

21. An organisation's defence systems reduce the likelihood of major accidents because an accident occurs only when the holes in the multiple defences align, hence the reference in the model to limited windows of opportunity. Chance plays a part in the occurrence, and timing, of accidents. Defence systems are also difficult to understand and manage. No one person can be expected to oversee the entire system.

22. An organisation-wide safety culture can help to keep holes in the defence systems to a minimum. Active failures, worker errors and violations are likely to diminish in a workplace with a good safety attitude. Latent failures should be more readily discovered if those who design, establish, monitor and review the safety systems are also well motivated. And, most important of all, a safety culture should help to ensure that warning signs are not ignored, but heeded and addressed.[14]

23. The commission has had regard to this model in its analysis.

ENDNOTES

1 Andrew Hopkins, Failure to Learn: The BP Texas City Refinery Disaster, 2008, CCH Australia, p. 10.

2 Ibid.

3 The commission acknowledges the evidence provided by Dr Kathleen Callaghan, the director of the Human Factors Group, Faculty of Medical and Health Sciences, University of Auckland.

4 Kathleen Callaghan, witness statement, 31 October 2011, FAM00042/59, para. 213(f).

5 Health and Safety Executive (UK), Introduction to Human Factors, http://www.hse.gov.uk/humanfactors/introduction.htm

6 Kathleen Callaghan, witness statement, 31 October 2011, FAM00042/6, para. 9.

7 Ibid.

8 James Reason, 'Understanding Adverse Events: Human factors', Quality in Health Care, 1995, Vol. 4, No. 2, p. 85, http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1055294/pdf/qualhc00016-0008.pdf. Reason, who was Professor of Psychology at the University of Manchester 1977–2001, is a prolific writer on many aspects of safety management, including Managing the Risks of Organizational Accidents, Ashgate,1997.

9 BP U.S. Refineries Independent Safety Review Panel, The Report of the BP U.S. Refineries Independent Safety Review Panel, 2007, pp. 21–23, http://www.bp.com/liveassets/bp_internet/globalbp/globalbp_uk_english/SP/STAGING/local_assets/assets/pdfs/Baker_panel_report.pdf

10 Health and Safety Executive (UK), Developing Process Safety Indicators: A Step-by-Step Guide for Chemical and Major Hazard Industries, 2006, http://www.hse.gov.uk/pubns/priced/hsg254.pdf

11 Andrew Hopkins, Thinking About Process Safety Indicators (Working Paper 53), May 2007, National Research Centre for OHS Regulation, Australian National University.

12 Safety Wise Solutions Pty Ltd, 'Analyse Findings', in Incident Investigation Reference Guide, 2010, section 7, p. 2.

13 James Reason, 'Beyond the Organisational Accident: The Need for "Error Wisdom" on the Frontline', Quality and Safety in Health Care, 2004, Vol. 13, Suppl. 2, p. ii29, http://qualitysafety.bmj.com/content/13/suppl_2/ii28.full.pdf+html

14 James Reason, 'Achieving a Safe Culture: Theory and Practice', Work & Stress, 1998, Vol. 12, No. 3, pp. 293–306.