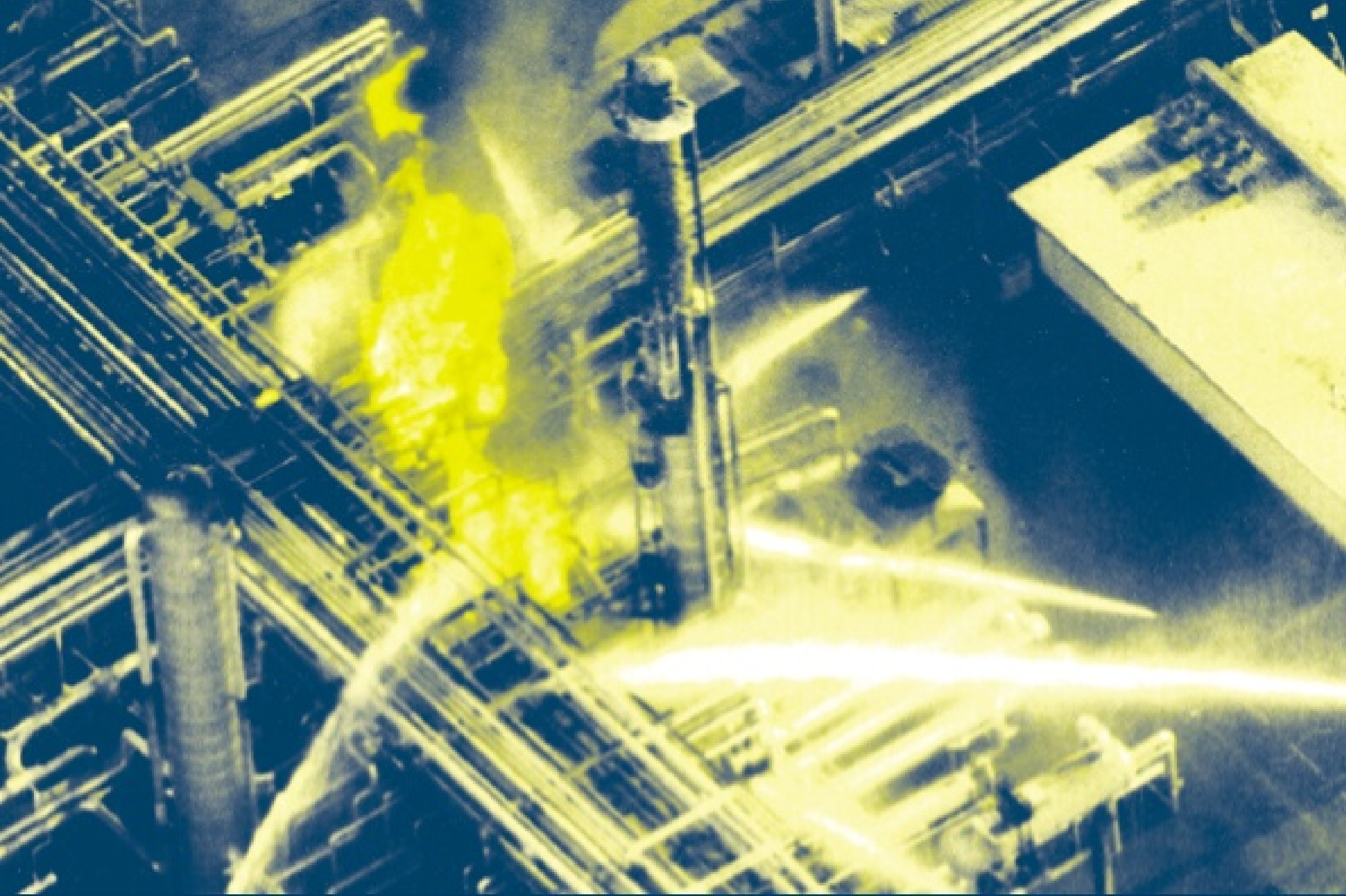


HAVE AUSTRALIA'S MAJOR HAZARD FACILITIES LEARNT FROM THE LONGFORD DISASTER?

AN EVALUATION OF THE IMPACT OF THE 1998 ESSO LONGFORD EXPLOSION ON MAJOR HAZARD FACILITIES IN 2001

BY JAMES NICOL

SPONSORED BY THE PUBLIC POLICY UNIT

OCTOBER 2001

The Institution of Engineers, Australia

HAVE AUSTRALIA'S MAJOR HAZARD FACILITIES LEARNT FROM THE LONGFORD DISASTER?

AN EVALUATION OF THE IMPACT
OF THE 1998 ESSO LONGFORD EXPLOSION
ON MAJOR HAZARD FACILITIES IN 2001

BY JAMES NICOL

SPONSORED BY THE PUBLIC POLICY UNIT

OCTOBER 2001

The
Institution of Engineers,
Australia

Author biography

A Fellow of the Institution of Engineers Australia, James Nicol has spent over twenty years in the chemical and petrochemical industries working at Major Hazard Facilities sites as a maintenance engineering practitioner and manager principally in Australia and the UK. Presently based in Melbourne, recent tasks have included major project advisory roles addressing engineering design and operational practice.

James Nicol's email is janicol@ozemail.com.au

Publication details

Have Australia's Major Hazard Facilities learnt from the Longford Disaster? An evaluation of the impact of the 1998 ESSO Longford explosion on the petrochemical industry in 2001

ISBN 085825 738 6

Author: James Nicol

Project manager: Athol Yates, Senior Policy Analyst, Institution of Engineers, Australia.

Cover photo: Fire at the Longford Gas plant in September 1998. Photographer Ray Kennedy, The Age Photo Sales.

Public Policy Unit
The Institution of Engineers, Australia
11 National Circuit
Barton ACT 2600
Tel 02 6270 6555
Fax 02 6273 2257
Email policy@ieaust.org.au
Www http://www.ieaust.org.au

Table of contents

Foreword 2

Note to the reader 3

Executive Summary 5

1 Introduction 11

2 Study Background 13

2.1 Objectives of the review 13

2.2 Review methodology 13

3 Summary of the Longford Royal Commission Report and OH&S court case against Esso ..15

3.1 Longford Royal Commission Report 15

3.2 OH&S court case against Esso 16

4 Analysis of the formal responses to questions by organisations 17

4.1 Consolidated responses to each question 17

4.2 Summary of responses 21

5 Observations on the management of Major Hazard Facilities 23

5.1 Observations 23

5.2 Additional Questions when undertaking hazard analysis and control work 25

6 Have Australia's Major Hazard Facilities learnt from the Longford Disaster? 27

7 Recommendations 29

8 Conclusion 31

Appendix 1: Abbreviations 33

Appendix 2:Question-Set 35

Appendix 3: The Longford Gas Explosion 37

Appendix 4: The Safety Case 41

Appendix 5: Pressure Vessel Design Standards and Material Selection Requirements Against Low Temperature Duty at the Time of Vessel Construction 43

Appendix 6: Abnormal Situation Management 45

Appendix 7: Lessons from Longford 49

Appendix 8: Victorian Work Cover - Major Hazards Division 51

Appendix 9: Bibliography 53

References 55

Foreword

It has been 3 years since the Esso Longford gas plant exploded in September 1998. This passage of time has allowed Australia's major hazard facilities to review the disaster and implement changes to ensure that such a tragedy does not re-occur.

Unfortunately, according to the author of this report, the industry and the engineering profession have not learnt as much as they might have from the tragedy. Far more could be done to apply the lessons from Longford at facilities around Australia.

Of particular importance is the need for major hazard facilities to have access to technical expertise on-site and on-call - particularly engineering expertise. This has been recommended in both this report and the Longford Royal Commission report.

Coupled with this is the need for the regulators themselves to be technically competent. This means engaging staff who can effectively monitor industry through an understanding of current best practice in operations, maintenance and management.

The best way for government, industry and the community to ensure that those engineers undertaking or overseeing critical functions in major hazard facilities have the competencies they need is to create a regulatory regime for these professionals. Experience has found that the most effective regulatory regime is a co-regulatory one - that is a regime jointly established and run by industry and government. The National Professional Engineers Register is one such regime.[1]

The Institution has recommended to the National Engineering Registration Board that it create a new area of engineering practice on the National Professional Engineering Register for these professionals. It would cover engineers involved in critical risk, safety, maintenance and operations of major hazard facilities. Such an area of engineering practice would complement existing registered areas which have critical health and safety functions such as fire safety engineering and pressure equipment design verification.

The Institution supports all the recommendations of this report and will be working with government and industry to ensure they are implemented.

John Boshier
Chief Executive Officer
Institution of Engineers, Australia
26 October 2001

1 For information on the National Professional Engineers Register, http://www.ieaust.org.au/registers/nper/index.html

Note to the reader

To gain the most from this report, readers should have an understanding of the:

- causes of the Longford disaster;
- safety case approach to risk management; and
- history of material selection for pressure vessels.

To gain an understanding of the Longford disaster and its causes, please review Appendix 3.

To gain an understanding of the safety case approach to risk management, please review Appendix 4. Such an understanding of the safety case is fundamental to understanding the post-Longford MHF management environment.

To gain an understanding of the material selection for pressure vessels, please review Appendix 5. Longford Gas Plant 1 was commissioned in March 1969 and an understanding of prevailing pressure vessel design standards and material selection requirements against low temperature duty (then and now) is relevant to any discussion of the Longford accident.

Executive Summary

Introduction

Nearly three years have passed since the Longford tragedy. On Friday 25 September 1998, an explosion and fire occurred at the Esso Longford facility in South Gippsland, Victoria. As a result of that explosion and fire, two people were killed, a number of people were injured, and all gas supply from the Longford facilities ceased, causing major disruption to Melbourne industry and retail consumers.

The Longford Royal Commission (LRC) appointed to discover the causes of the disaster published its report in June 1999. It contained both findings and recommendations. In Victoria, part of those recommendations has resulted in legislation directed at Major Hazard Facilities (MHF). Elsewhere, different industries and major hazard sites have responded according to their reading of the implications of Longford, and how it has impacted on their culture and procedures.

What was unique about Longford was not the fire and explosion, nor even the tragic loss of life and the injuring of several workers. It was the fact that a royal commission was promptly established to examine what went wrong and why, to identify specific actions to be taken by the operator, and to recommend a way forward for industry as a whole. The LRC had no remit to examine any contributory government responsibility for the accident or for any contribution of privatisation policy to the lack of a secure natural gas supply.

Objectives of the review

The objectives of the review were to:

a) establish what impact Longford has had on Major Hazard Facilities (MHF) operators, and what changes have resulted to their policies, procedures and equipment, particularly from an engineering perspective; and

b) produce recommendations on what industry might do to best respond to the lessons of Longford, particularly the oil and gas and petrochemical industries.

Review methodology

The following methodology was followed:

1. **Examine the findings of the Longford Royal Commission:** This involved examining the LRC's conclusions and identifying any issues that were not examined because of the constraints imposed by the LRC's terms of reference.

2. **Stage 2: Send out a question-set to a number of relevant MHF organisations:** In September 2000, a standard question-set was sent to a number of representative companies operating oil and gas, petrochemical and other MHF, and also to related agencies. Included in the letter were a detailed review remit and some background on the accident. The question-set was sent to Huntsman, Orica, BHP Petroleum, Esso, WMC, Incitec, Santos, Woodside Karratha, BHP Minerals, Shell, Victorian WorkCover, AIG,

APPEA, and the Federal Department of Industry, Science and Resources (Petroleum Industry Branch). The question-set asked recipients to identify the extent and significance of any engineering, operational or cultural changes that have occurred as a result of Longford, and how their organisation's changes reflected the lessons learned. The question-set requested information on:

- HAZOP studies;
- maintenance standards, practice and policies;
- risk management procedures;
- deployment of engineers on-site and off-site;
- engineering supervision of operations, maintenance and design; and
- safety case regimes.

3. **Stage 3: Analysis of the results to the question-set:** Written responses or interviews were received from Orica (who responded on behalf of themselves and Incitec), Huntsman, Incitec, Santos, WMC and Shell. The other organisations stated the following reasons for not responding.

    - Esso, BHP Petroleum and BHP Minerals declined to contribute due to ongoing litigation concerning the Longford tragedy.

    - Woodside (Karratha) did not receive clearance from their legal section to provide a response.

    - The Federal Department of Industry, Science and Resources, APPEA and AIG stated they would look forward to reading the review but did not wish to contribute.

    - The Victorian WorkCover authority had produced a detailed response of their position for this review, but authorisation for its release was not provided.

4. **Stage 4: Informal information collection:** Considerable information was collected from informal sources. This included information from practising engineers and managers. This information was unattributed. This information was only accepted where the author considered that it was sound and reflected reality.

5. **Stage 5: Study synthesis and report writing:** The formally and informally collected information was analysed. Due to the sensitivity of some elements of the formal responses, these elements have not been attributed. A draft report was written and circulated to the IEAust, its relevant technical societies and units, and several external organisations. Comments from these groups were considered by the author and incorporated if appropriate.

Definitions

A major hazardous facility is a facility where Schedule 1 materials (ie dangerous materials which are regulated) are present or likely to be present in a quantity exceeding their threshold quantity, or a facility determined by the Authority to be a major hazard facility. In lay terms, this will include a site that stores, handles or processes large quantities of dangerous chemicals or products. Typically they include refineries, chemical and gas processing plants, LPG storage and distribution sites, and even types of large warehouses.

A safety case regime is characterised by an acceptance that the direct responsibility for the ongoing management of safety is the responsibility of the operators and not the regulator. The key function of the regulator is to provide guidance as to the safety objectives to be achieved. The operators can achieve those objectives by developing systems and procedures that best suit their needs and agreement with the regulator. This "safety case" then forms the rules by which the operation of the facility is governed.

Findings of the review

Answering the question “Have Australia’s Major Hazard Facilities learnt from the Longford Disaster?” is very difficult. Not least because it is not easy to generalise across the nation and between industries.

However, it is the author's view that industry and the engineering profession have not learnt as much as they might have from the tragedy. In addition, far more could have been done to apply the lessons from Longford at facilities around Australia. This view is based on the level of interest shown by MHF in the Longford disaster, the changes implemented so far at MHF, the regulatory changes to MHF introduced to date, and the indicated future reforms of MHF management, operations and regulation.

As a result of the Longford disaster, there have been a number of positive improvements. These include:

- There has been a renewed focus on HAZOP, particularly at those plants that were built prior to the HAZOP process being universally adopted.

- Greater priority is being given to operating procedures and safety management systems in general, again driven by MHF legislation.

- The recognition of the need for better inter and intra-company communication has now been recognised and reinforced by many operators.

- Technical recruitment strategies are now being reviewed to ensure MHF have the required technical capability and experience. In addition, some MHF sites are now thinking twice before reducing or eliminating their on-site process engineers. Unfortunately, this trend cannot be observed for maintenance, plant and equipment support engineers.

- There is heightened interest in better management and engineering of alarm systems to avoid 'flooding'. A number of operating companies, not all in oil and gas, are allocating significant budgets to this issue. Each alarm is being re-examined individually and discarded or reprioritised as appropriate.

- There is a renewed interest in training for response to abnormal situations. Where simulators are used for training, these are often being upgraded or replaced completely. Many companies are developing paper based or 'desk top' scenario training also.

There are a number of concerns that indicate that the lessons of Longford have not been fully learnt. These include:

- There is a belief by some MHF staff that Longford is only applicable to the oil and gas industry, rather than to all MHF.

- Some sections of senior management at MHF see engineering as a cost centre rather than as a contributor to profit. This decision to reduce engineering on-site capability often occurs with little thought give to the broader consequences of reduced safety, risk and technical resources. This has resulted in a decline of the corporate technical and management memory of may organisations. There is often a long-term cost to an organisation's ability to operate with flexibility and effectiveness, and this is not always recognised.

- Some MHF have been lulled into a false sense of security as their post-Longford reviews of safety and engineering failed to identified any significant new hazards.

- There has been little action to counter the increase of the age profile of engineers staff and to ensure that corporate knowledge is transferred to younger engineers

- There continues to be an over-reliance on a systems approach without making adequate allowance for the fragility of corporate memory during the lifetime of the plant.

Recommendations of the review

Preventing disasters is a priority for all Major Hazard Facilities. Based on analysing the factors that contributed to the Longford disaster and developments at MHF since the explosion, the following recommendations have been made to further reduce the probability of tragedies.

a) *Managers, engineers and operational staff at MHF should familiarise themselves with the Longford disaster and use its lessons to improve their facility's safety and engineering management.*

b) *MHF should never believe that all hazards have been identified and addressed. MHF should deploy a comprehensive HAZOP safety management system supported by an independent people-based risk reduction strategy to manage residual risk.*

c) *MHF must have access to sufficient engineering, operating and maintenance skills on site and at all times coupled with regular and comprehensive surveillance of operating practices and properly kept records.*

d) *MFP need to undertake more sophisticated cost benefit analysis to determine the appropriate level of on-site engineering, off-site engineering and outsourced engineering staff.*

e) *Organisations should have an understanding of the High Reliability Organisation's (HRO) approach to risk.*

f) *A nationally consistent safety case approach should be introduced and the ongoing harmonization of MHF legislation with existing and proposed legislation should be accelerated.*

Conclusions of the review

The Longford disaster highlighted how a combination of ineffective management procedures, staffing oversights, communication problems, inadequate hazard assessment and training shortfalls combined to result in a major plant upset with consequential tragic loss of life.

These elements are not unique to the oil and gas industry. They can be found at virtually all MHF sites. In addition, other factors such as the increasing of age of MHF plants, increased outsourcing of engineering services, the increase in the age profile of the engineering workforce, and the loss of a critical mass of experienced in-house engineering staff and technicians, are also issues which can increase the changes of disasters.

If we look for a common generic answer for the concerns identified by this investigation, it would be *collective mindfulness*, the idea that no system can guarantee safety once and for all.

Industry and its engineering and safety professionals could have learnt a great deal more from the Longford tragedy.

Unless we learn these lessons and apply them professionally and with sensitivity, the possibility of a second Longford will always be with us.

1 Introduction

Nearly three years have passed since the Longford tragedy. The disaster resulted in two people being killed, a number being injured and a two-week interruption to Victoria's natural gas supply.

A Royal Commission was appointed to discover the causes of the disaster. The report of the Longford Royal Commission (LRC) was published in June 1999[1]. The report contained findings and recommendations. In Victoria, part of those recommendations has resulted in legislation directed at Major Hazard Facilities[2] (MHF).

Elsewhere, different industries and major hazard sites have responded according to their reading of the implications of Longford, and how it has impacted on their culture and procedures.

The Institution of Engineers Australia commissioned James Nicol, an engineer with considerable experience in MHF, to undertake this review.

2 Study Background

2.1 Objectives of the review

The objectives of the review were to:

- establish what impact Longford has had on Major Hazard Facilities (MHF) operators, and what changes have resulted to their policies, procedures and equipment, particularly from an engineering perspective; and

- produce recommendations on what industry might do to best respond to the lessons of Longford, particularly the oil and gas and petrochemical industries.

2.2 Review methodology

The following methodology was used:

Stage 1: Examine the findings of the Longford Royal Commission (LRC)

This involved examining the LRC's conclusions and identifying any issues that were not examined because of the constraints imposed by the LRC's terms of reference.

Stage 2: Send out a question-set to a number of relevant MHF organisations

In September 2000, a standard question-set was sent to a number of representative companies operating oil and gas, petrochemical and other MHF, and also to related agencies. Included in the letter were a detailed review remit and some background on the accident. The question-set was sent to Huntsman, Orica, BHP Petroleum, Esso, WMC, Incitec, Santos, Woodside Karratha, BHP Minerals, Shell, Victorian WorkCover, AIG, APPEA, and the Federal Department of Industry, Science and Resources (Petroleum Industry Branch).

The question-set asked recipients to identify the extent and significance of any engineering, operational or cultural changes that have occurred as a result of Longford and how their organisation's changes reflected the lessons learned. The question-set requested information on:

- HAZOP studies;
- maintenance standards, practice and policies;
- risk management procedures;
- deployment of engineers on-site and off-site;
- engineering supervision of operations, maintenance and design; and
- safety case regimes

Additionally, an attempt was made to identify what further actions operators of MHF might do to best respond to the lessons of Longford. The question-set is detailed at Appendix 2.

Stage 3: Analysis of the results to the question-set

Written responses or interviews were received from Orica (who responded on behalf of themselves and Incitec), Huntsman, Incitec, Santos, WMC and Shell. The other organisations stated the following reasons for not responding:

- Esso, BHP Petroleum and BHP Minerals declined to contribute due to ongoing litigation concerning the Longford tragedy;
- Woodside (Karratha) did not receive clearance from their legal section to provide a response;
- the Federal Department of Industry, Science and Resources, APPEA and AIG stated they would look forward to reading the review but did not wish to contribute; and
- the Victorian WorkCover authority had produced a detailed response of their position for this review, but authorisation for its release was not provided.

Stage 4: Informal information collection

Considerable information was collected from informal sources. This included information from practising engineers and managers. This information was unattributed. This information was only accepted where the author considered that it was sound and reflected reality.

Stage 5: Study synthesis and report writing

The formally and informally collected information was analysed. Due to the sensitivity of some elements of the formal responses, these elements have not been attributed. A draft report was written and circulated to the IEAust, its relevant technical societies and units, and several external organisations. Comments from these groups were considered by the author and incorporated if appropriate.

3 Summary of the Longford Royal Commission Report and OH&S court case against Esso

3.1 Longford Royal Commission Report

The report of Longford Royal Commission was issued in June 1999.

The Royal Commission into the accident found that the exchanger failed when hot oil was reintroduced after the exchanger became too cold following loss of lean oil circulation after a major process upset. Metallurgical analysis had concluded that: GP905 failed due to brittle fracture with localised ligament failure. The internal pressure alone was not sufficient to cause the failure of the reboiler, hence an additional source of stress was required. On the balance of probabilities, the additional stress required to cause the failure arose from the temperature differences between the channel and shell. The higher temperature in the shell was due to the introduction of hot lean oil from the restart attempts of the GP1201 pumps. (6.42)

No one who was present was aware of the hazards of loss of lean oil flow, as this was not covered by their training or by current operating procedures. The response to a critical process alarm was therefore inappropriate. The appropriate response had been defined in an early operating procedure,[3] although the resultant hazard due to low temperature had not. As the plant was designed before HAZOP studies were used during design, and a comprehensive HAZOP study had not been carried out subsequently, the specific hazard due to loss of lean oil was unidentified.

The report concluded (in part) that the following factors contributed to the explosion, fire and loss of gas supply.[4]

- Vessels were exposed to cold temperatures for which they had not been designed. (15.6) In the case of GP905 (the failed vessel), the reduction in temperature of that vessel caused the embrittlement of its steel shell. The re-introduction of hot lean oil to a vessel chilled to a temperature of around –48 deg C, resulted in rupture by way of brittle fracture, releasing a volume of hydrocarbon vapour that subsequently ignited, causing an explosion and fire. (15.3)

- The failure to conduct a HAZOP study or to carry out any other adequate procedures for the identification of hazards in Gas Plant 1 (GP1) where GP905 was located. (15.7)

- The lack of operating procedures to deal with the situation experienced by operators at Longford, combined with inadequate training of personnel resulted in an inappropriate response to the situation that arose on 25 September 1998. (15.7)

- The reduction of supervision at Longford, including the transfer of engineers to Melbourne, necessarily meant a reduction in the amount and quality of supervision of operations there. There was a correspondingly greater reliance by Esso on the skill and knowledge of operators. Whilst it is not possible to discern any direct connection between the level of supervision and the accident on 25 September 1998, the Commissioner considers that it was probably a contributing factor. (page 236)

- As a result of Esso's desire to control operating costs (reduction of supervision at Longford, including transfer of engineers to Melbourne and failure to conduct a HAZOP for GP1), asset management practices or policies may have been a contributing factor to the explosion, fire and failure of gas supply. (15.7)

The report recommended (in part) Esso carry out the following actions:

- Design review of critical facility areas to minimise risk of a serious accident, including an isolation philosophy and engineering systems design (ESD) review. (15.15)
- Periodical review of operating standards and practices. (15.16)
- Training of employees in identifiable hazards and procedures to deal with them. (15.17)
- Assurance that access to sufficient engineering, operating and maintenance skills would be available on site at all times coupled with regular and comprehensive surveillance of operating practices and properly kept records. (15.18)
- Safety/risk assessment and responses required to minimise likelihood of accident including fire risk analysis and emergency response plan. (15.20 – 15.23)
- The Commission also recommended that all MHF sites have the safety case extended to them by legislation. (15.26)

In Victoria, part of the Commission's recommendations has resulted in legislation that directs that the safety case will be extended to all MHF operators.

3.2 OH&S court case against Esso

The LRC found that *"the causes of the accident on 25 September 1998 amounted to a failure to provide and maintain so far as was practicable a working environment that was safe and without risks to health. This constituted a breach or breaches of s.21 of the Occupational Health and Safety Act 1985 (Vic.)"*.

On 30 July 2001 in the Victorian Supreme Court, Esso was convicted of 11 breaches of the Occupational Health and Safety Act. On two of the charges Mr Justice Cummins imposed the maximum fine of $250,000. With four of the fines, including the two maximums, he added additional penalties under the provisions relating to companies with previous convictions. In imposing a record $2 million fine on Esso Australia Pty Ltd, Mr Justice Cummins said, *"prevention is the essence of workplace safety"*. The Judge said the explosion and fire that resulted in two workers being killed was *"no mere accident"* and the responsibility for the tragedy rested solely with the company.[5]

4 Analysis of the formal responses to questions by organisations

4.1 Consolidated responses to each question

Question 1: How have the findings of the Longford Royal Commission impacted on the way the organisation identifies, documents and communicates process hazards?

The general response by all companies was one that confirmed the position that adequate methods and procedures were in place prior to the Longford disaster. The impact had been principally one of revisiting and fine-tuning existing systems though this varied from organisation to organisation. Additionally an improved awareness of the issues and their gravity has been observed of some at executive and board management level, but not all.

Huntsman and others found benefit in the more structured safety case approach to risk and hazard assessment. This has resulted in improved systematic document control and enhanced identification of process hazards. The incident had reinforced a thorough and thoughtful approach to regulations.

For Shell, the Longford disaster findings had been preceded by a Shell International requirement that all sites have an approved HSE (Health, Safety and Environment) case. Their Geelong refinery had already embarked on the production of an HSE case with requirements for Hazard ID, QRA (risk assessment), and hazard reduction to As Low As Practicable (ALAP). Safety in process design is a fundamental for Shell MHF operation and is reflected in their design engineering practices (which share learning from around the world) and the use of 'bottom-up' tools such as HAZOPS, Instrument Protective Function (IPF) Reviews and Technical Safety Reviews. The HSE case drives how Shell identifies, documents and communicates process hazards.

The chemical industry generally has an extensive series of model standards and procedures including specific procedures addressing Safety, Heath and Environment (SH&E) and related engineering issues. These SH&E Management Systems have been developed to manage the interaction between people and the work environment and to ensure sustained compliance with legislative requirements, internal and external standards, and codes of practice. These systems were already in place prior to the Longford disaster. The chemical industry is currently reviewing these and other tools, to ensure that outcomes and processes are consistent, more user friendly and readily accessible to all staff.

Question 2: Has Longford changed the way the quality of the hazard identification process is audited and maintained?

In Victoria, the detailed and prescriptive MHF regulations have resulted in a more structured and transparent approach to the hazard identification process, giving more formality to assessing and responding to safety case requirements. The Longford disaster has reinforced and demonstrated the need for relevance in effective hazard management. Outside of Victoria, national standards (and/or particular State legislative requirements covering the MHF area) have been revisited and reviewed. The general impression gained was that the basic well-established in-house processes and tools have not changed. To date no significant hazards have been identified that were not foreseen and addressed by these existing (pre-Longford disaster) tools and procedures.

The chemical industry particularly stressed ongoing reinforcement of the communication of such systems. Concentration on people and behaviour continue to be expanded and the benefits continue to be shown in improved results. Plant and site procedures are under ongoing review. Enabling systems to allow systematic and streamlined auditing against the three elements of safety (people, plant and procedures) have been put in place to provide the tools for improving the quality and timeliness of hazard identification and audit.

Question 3: Has Longford resulted in an engineering review of the adequacy and limitations of engineering design standards? (e.g. corrosion allowances, temperature and pressure rating margins, relief capacity etc)

The across-the-board response stated that current engineering design standards are sound and are continually under review to reflect current learning, experience and best practice. It was also stated that the safety case approach would reinforce current review practices. No comment was volunteered on the calibre, competency and experience of engineers required to ensure such standards are adhered to.

Question 4: Has Longford resulted in a review of installed equipment, its operating envelope and protective devices such as trips and alarms and relief capacity?

Responses to this question were extremely varied.

Several Victorian based organisations expected that the safety case and related assessments as required by Part 4 of the MHF Regulations[6] would adequately cover such a review of installed equipment. Outside of Victoria, some organisations did not undertake any additional engineering specific detailed review of installed equipment.

The chemical industry carries out ongoing trip and alarm (T&A) model system reviews and upgrades, with alarm flooding recognised as a major issue. Whilst the Longford disaster produced no major impetus to this area, the design assumptions and materials specified for vessels liable to low-temperature exposure and designed before ASME Section VIII (1986), have been revisited.

At Shell, review of their Safeguarding Memoranda had been initiated prior to the Longford disaster findings. These are one of the critical documents underpinning their HSE case. A further initiative exampled at their Geelong Refinery Site is a comprehensive Asset Management System (AMS), which integrates safeguarding, operating envelope, design, inspection and maintenance. Another key requirement is a Management of Change procedure and policy, which ensures that AMS reflects the actual field equipment and conditions. Soon after the Longford incident, the oil and gas industry carried out reviews of plant across their major operational areas and found some items requiring improvement. These items are being systematically attended to.

Question 5: Is the competence, deployment and accessibility of engineering expertise a stated requirement of your company?

A large range of responses was provided to this question. These ranged from organisations that were unaware of any specific company policy addressing this need, to those where site and group management systems specifically spelt out the provision of competent engineering advice and technical resources. Competency registers are often maintained.

The author has found that technical staff at the junior and middle management level is intensely sensitive to this issue and particularly the requirement for adequate people-based supporting competencies and experience. Junior and middle management staff have a perception that the consequences of not retaining a sound mix of in-house and outsourced engineering expertise throughout the full lifecycle of a plant is still not fully understood or appreciated by some executive and board management.

Question 6: Has Longford resulted in a review of the Corporate Technical Memory and how this is to be maintained?

In all cases some system of record was in place to capture technical history and experience. Whilst the adequacy of some of these systems to fully reflect a sound and complete technical corporate memory might be questioned, it appears that the Longford disaster has focused attention at corporate and practitioners' needs in this area, addressing both information systems and retention of personal experience.

A good corporate technical memory was identified to include a system (and personnel) with the ability to retrieve in a timely fashion, not only historical operating, modification, design and maintenance activities; but also the industry and community environment, its executive direction, together with the technical assumptions and budget constraints prevailing at the time. The effectiveness of a sound corporate technical memory can be measured against benchmarked competitor performance, stakeholder satisfaction and good engineering practice.

Shell International has a comprehensive system of corporate technical memory through a combination of their Shell Global Solutions Company (which provides technical and operations advice) and the Shell Design Engineering practices (see above). The Shell Global Solutions corporate technical memory function has been operating for over 50 years. Their Asset Management System (AMS) provides for local site technical memory. Whilst the AMS has historically been driven by a number of factors, the Longford disaster has confirmed to Shell the need for this level of system.

The chemical industry has a codified approach where responsible engineering expertise is reinforced by a learning event database. This database pulls together the model used, requisite manuals and the job management system. Risk and hazard registries are used. Job cycle checks and reviews of procedures are key performance indicators. Over the past two years, safety has gained improved resource allocation priority, with a key objective being the ongoing review and updating of risk and hazard registers.

Throughout MHF ever more complete and comprehensive information systems are being introduced. However it is notable that no respondent volunteered any comment on the measure or value placed on experienced human technical competence and capability, nor the mechanisms for establishing and maintaining an optimum balance between in-house and outsourced resources. The development and mentoring of the specialist technical practitioner and manager was not stressed.

Question 7: Have risk management policies and procedures, particularly for MHF, been impacted by Longford and if so, how? (e.g. are the controls, which prevent accidents such as Longford included within a safety management system).

In all cases the Longford disaster has had an impact. It formalised modification procedures where required, absorbed the safety case mechanisms into existing policies and procedures (where this approach was not already applied) and improved auditing and reporting procedures. Again, the Longford disaster has had an impact on some executive and board level management, but this is not universal.

All respondents have had risk management procedures and safety management systems in place (albeit at varying stages of development and maturity) for many years. The findings from Longford have further reinforced the benefits of the safety case and an asset management approach. A number of companies use a risk assessment matrix to address safety and engineering issues.

Question 8: How has Longford impacted on your company's engineering supervision of operations, modifications, and maintenance in the areas of equipment, system and process design?

Whilst in all cases the response to this question was a resounding no-change, the Longford disaster has resulted in re-emphasising the correct and effective use of existing systems. It was clear that post-Longford, some (but not all) executive and board management have a better understand of the consequences of technical de-manning, maintenance budget reduction and a cut-back of site based engineering expertise.

Question 9: Has Longford resulted in any significant changes to established safety case regimes and training? (e.g. safety case regime covers safety management, including change management, major incidents and hazard identification, safety assessment, emergency planning, and the safety role for employees)

All respondents prior to the Longford disaster operated some of the components that make up the safety case approach or operated under an existing total safety case regime. With the former respondents, the change to a full safety case approach has assisted in the efficient integration of their existing risk minimisation and safety related procedures and initiatives, resulting in improved and formalised operation. Interestingly, the recognition of the need for better inter and intra-company communication has been recognised and accepted by many. The point was made that a consistent safety case approach should be mandatory in all Australian States

4.2 Summary of responses

Below are the main points from the responses:

- To date no MHF operator has apparently identified significant hazards that were not foreseen and addressed by their pre-existing (pre-Longford) tools and procedures.
- The Longford disaster, it seems, has routinely resulted only in re-emphasising the correct and effective use of existing systems.
- The general impression given is that current engineering design standards are sound and are continually under review to reflect current learning, experience and best practice.
- In all responses, some system of record was in place to capture technical history and experience.
- All MHF operators had, prior to the Longford disaster, operated some of the components that make up the safety case approach or operated under an existing total safety case regime.
- Little comment was returned on the question of competence, deployment and accessibility of engineering expertise as a stated requirement of operators, nor how to strike an optimum balance between in-house and outsourced resources. Some organisations stated that they were unaware of any specific company policy addressing this need. However some stated that their management systems specifically spelt out the provision of competent engineering advice and technical resources, and they maintained competency registers.
- No comment was returned on the development and mentoring of specialist technical staff and managers.
- No comment was returned on the supervision of technical change management.
- Soon after the Longford incident, some MHF operators carried out reviews of plant change management across their major operational areas and found some items requiring improvement.
- In all responses from Victoria, the Longford disaster has had an impact on MHF operators' risk policies and procedures. Longford resulted in the modification procedures being formalised, safety case mechanisms being incorporated into existing policies and procedures, and improved auditing and reporting procedures.
- The Longford disaster has had an impact on some executive and board level management, but this is not universal.
- Operators are giving greater priority to operating procedures and safety management systems in general. Some companies operating MHF sites have recognised the Longford disaster as a wakeup call and instituted a review of their specific engineering and safety capability. Others have given all the indications that the Longford accident is unique to the oil and gas industry and therefore of only limited relevance to their industry.
- Training has become a key issue. This includes ensuring that operations staff are completely familiar with the plant process, safeguarding and design envelope, and have problem solving skills to call on during operational upsets. Reflecting this is the need to ensure manuals, procedures and drawings are always kept up to date.

5 Observations on the management of Major Hazard Facilities

5.1 Observations

The following are observations on the management of MHF made during the research for this project.

Little new discussion on the lessons of Longford

It was disappointing that there was so little informed discussion in the media, trade journals, conferences and in public meetings about the lessons of Longford. The vast majority of references to the disaster were based on the LRC report, court cases or the MHF legislation and regulation. The only detailed new work identified has been Andrew Hopkin's book, *Lessons from Longford*. [7] It is of note that more penetrating discussion of Longford was found on overseas web sites rather than Australian ones. Reasons for the lack of Australian discussion may be because of fear of defamation, libel or sub-judice; fear that making comments would jeopardise future promotion or employment; and engineers' reluctance to discuss sensitive issues. Regardless of the reasons, the result is that the courts are the main areas where further discussion occurs. Unfortunately the court cases are focused on allocating blame, and many settlements require parties to not publicly discuss their case's details. These consequences severely restrict practitioners' ability to learn from disasters.

Wide applicability of the lessons of Longford

A Longford-style accident can happen in many industries. It is not particular to just the oil and gas industry. For example, the hazards may be equally present in the chemical, petrochemical, pyrometallurgical, mining and hydrometallurgical industries. Industry needs to be continually reminded to identify and recognise hazards in their operations and to assess and make plans to address those risks with structural changes.

Unfortunately while some companies operating MHF sites have recognised Longford as a wakeup call and instituted a review of their specific engineering and safety capability, others have indicated that the Longford accident is unique to the oil and gas industry and therefore of only limited relevance to their industry.

Some hazards never identified

It is important to realise that even if a plant has been subjected to a comprehensive HAZOP study, some hazards are likely to remain undetected. An effective safety management system must recognise this and include appropriate strategies for the management of unanticipated hazards. Such strategies are particularly important for plants that have not been comprehensively reviewed using HAZOP or similar techniques. Nevertheless, an effective risk reduction strategy should identify as many of the specific hazards as is practicable, and implement explicit techniques to protect against them. This should be complemented by a different people-based risk reduction strategy to manage the residual risk from both undetected hazards and imperfect protection against defined hazards.

A systems solutions is only as good as its corporate culture

A system focus is essential for the safe operation of all MHF. This systems focus may be in the form of a safety case regime as recommended by the Longford inquiry or an in-house management system such as Esso's Operations Integrity Management System (OIMS). However, as seen in the Longford disaster, a system-focus will not prevent tragedies. For a system to work, the appropriate corporate culture is essential. This issue is often overlooked in the discussion about system focus solutions.

Safety versus engineering focus

Safety rather than engineering has dominated the lessons from the disaster. This is reflected in the written literature and in the formal company responses to the questionnaire. The safety focus has resulted in risk management being aimed at reducing high-frequency, low-consequence personal injuries. This is different from an engineering focus that is essential to reducing low-frequency, high-consequence catastrophes. A balance needs to be struck that does not neglect either end of the risk spectrum.

Corporate memory

A sound engineering corporate memory is fundamental to any MHF operator who wishes to maintain and develop their organisation's ability to identify and manage abnormal and emergency modes of operation to a high standard. Executive and board level management seems not to always appreciate this. There is a need for each MHF organisation to retain a critical mass of engineering and technical personnel at all levels as the keepers of that fundamental intangible – sound engineering corporate memory.

Reduction of on-site technical expertise

Over the past decade, the downsizing of on-site personnel with technical expertise and experience in our capital-intensive industries has resulted in a significant loss of corporate engineering memory. As a broad generalisation, the loss of engineering knowledge, continuity and management capability from many organisations continues. (However it is worth noting that this view is not held by many information system managers, human resource consultants, engineering outsourcers and a significant cross section of executive management.)

The on-site engineering downsizing of the 1990s has had a devastating effect on current MHF engineering and operational capability. It has effectively cost a generation of young engineers and technicians the benefit of receiving mentoring and training from in-house engineering staff with a deep local knowledge. These mature practitioners were made up from a very experienced pool of first line engineering supervision and technical middle management. They ensured a human face to the communication of good engineering practice, the sound application of engineering standards and an appreciation of ethical behaviour. As MHF assets age, as does the engineering workforce, the loss of an experienced in-house critical mass of management engineering staff and technicians increases the risk caused by unforseen events.

Given that the young engineers of today will be the senior executive management of tomorrow, it is essential that these engineers gain the experience essential to their organisation's future needs. This includes being responsible not only for sound technical

MHF operation and good engineering practice, but also for creating effective organisational structures, capable communication systems and quality risk management.

Competent specialist review and assessment of the impact of technical manpower ‘downsizing’ on a site’s risk and vulnerability to a major incident is required. The efficacy of outsourcing significant amounts of a company or site’s engineering capability, whether at a management or trade level, should be measured against previous in-house performance to establish the optimum mix for safe, economic and technically sound operations.

Improvements in communication

The recognition of the need for better inter and intra-company communication has now been recognised and reinforced by many operators. For example, this was one of the key lessons that Shell’s Geelong refinery took from Longford. Communication breakdown at all levels occurred at Longford. Shell is concerned to ensure a similar communication breakdown does not occur on their sites. Areas where communication is essential is between management and staff; between engineering and operations; and between shifts.

Trade-off between cost and robustness

There is invariably a financial trade-off between the more expensive and more robust equipment that is designed to be inherently safe and the cheaper but less robust systems that uses protective instrumentation and procedures to provide safety. The criteria for justifying higher expenditure for increased robustness over the life of the plant are ill defined and the systematic risk involved is not amenable to normal quantitative analysis. Better decision making tools are required to enable organisations to make appropriate investment decisions based on robustness of plant operations.

5.2 Additional Questions when undertaking hazard analysis and control work

During the interviewing process, respondents raised a number of important issues that they considered were not addressed adequately by either the question-set or the LRC Report. As a service to those future undertaking hazard analysis and control, the issues have been written as questions and are listed below. These questions should be considered alongside the standard ones when undertaking hazard analysis and control work.

Education

- Do process operators have current knowledge and understanding of the design and operating parameters of an individual piece of equipment, and do they understand the consequences of operating such equipment outside these parameters? (As an example of operator knowledge of individual equipment status; if multiple pumps are installed on a particular duty, can a control room operator readily identify the status of each pump, at all times, particularly when trips and/or local start/stops have occurred?)

- For individual piece of equipment, are there methods in place to identifying particular aspects of its operation, which require operator knowledge reinforcement, and are procedures in place for verifying the completeness and quality of an operator’s knowledge?

Hazard/Accident Investigation

- When investigating abnormal operating conditions, are procedures and systems in place to ensure analysts have unrestricted and timely access to all information?

Backup Power Supplies

- Is backup power supply managed through independent systems?

- Are reliable backup power supply systems in place for DCS and control room systems and instrumentation, ESD systems, key field instruments and critical equipment (eg large machine lube oil systems)?

- Does the architecture of the back-power supply match the architecture of the control and protective systems in diversity, redundancy and independence?

Equipment/Plant Status

- When addressing risk and operational goals, does your site categorise plant states using the convention of normal, abnormal and emergency operating modes?

- Are plant systems that are critical for the management of the full range of plant states adequately identified, detailed, exercised and periodically reviewed?

Design review against embrittlement

- Have vessels designed prior to ASME Section VIII (1986) been reviewed against low temperature limits for both normal and abnormal plant operating conditions? Have the implications of the revised low temperature limits have been adequately addressed?

Alarm Flooding

- What methods are in place to manage excessive numbers of alarms (ie alarm flooding)?

- When multiple alarms occur, is the first-up alarm readily identifiable, and when relevant, is the sequence of related alarms readily identifiable? Can low priority alarms be masked?

6 Have Australia's Major Hazard Facilities learnt from the Longford Disaster?

Answering the question "Have Australia's Major Hazard Facilities learnt from the Longford Disaster?" is very difficult, not least because it is difficult to generalise across the nation and between industries.

However it is the author's view that industry and the engineering profession have not learnt as much as they could have from the tragedy. In addition, far more could have been done to apply the lessons from Longford at facilities around Australia. This view is based on the level of interest shown by MHF in the Longford disaster, the changes implemented so far at MHF, the regulatory changes to MHF introduced to date, and the indicated future reforms of MHF management, operations and regulation.

Below are a list of the major improvements to MHF which occurred or were accelerated as a result of the Longford disaster, and a list of concerns which indicate the lessons of Longford have not been fully learnt.

Improvements

As a result of the Longford disaster, there have been a number of positive improvements. These include:

- There has been a renewed focus on HAZOP, particularly at those plants that were built prior to the HAZOP process being universally adopted.

- Greater priority is being given to operating procedures and safety management systems in general, again driven by MHF legislation.

- The recognition of the need for better inter and intra-company communication has now been recognised and reinforced by many operators.

- Technical recruitment strategies are now being reviewed to ensure MHF have the required technical capability and experience. In addition, some MHF sites are now thinking twice before reducing or eliminating their on-site process engineers. Unfortunately this trend cannot be observed for maintenance, plant and equipment support engineers.

- There is heightened interest in better management and engineering of alarm systems to avoid 'flooding'. A number of operating companies, not all in oil and gas, are allocating significant budgets to this issue. Each alarm is being re-examined individually and discarded or reprioritised as appropriate.

- There is a renewed interest in training for response to abnormal situations. Where simulators are used for training, these are often being upgraded or replaced completely. Many companies are developing paper based or 'desk top' scenario training also.

Concerns

There are a number of concerns, which indicate that the lessons of Longford have not been fully learnt. These include:

- There is a belief by some MHF staff that Longford is only applicable to the oil and gas industry, rather than to all MHF.

- Some sections of senior management at MHF see engineering as a cost centre rather than as a contributor to profit. This means that engineering knowledge, continuity and management capability from many organisations continues to decline. The decision to reduce it often occurs with little thought given to the broad consequences of reducing on-site engineers.

- Some MHF have been lulled into a false sense of security as their post-Longford reviews of safety and engineering failed to identified any significant new hazards.

- There has been little action to counter the increase of the age profile of engineers staff and to ensure that corporate knowledge is transferred to younger engineers

- There continues to be an over-reliance on a systems approach without making adequate allowance for the fragility of corporate memory during the lifetime of the plant.

7 Recommendations

Preventing disasters is a priority for all Major Hazard Facilities. Based on analysing the factors that contributed to the Longford disaster and developments at MHF since the explosion, the following recommendations have been made to further reduce the probability of tragedies.

Wide applicability of the lessons of Longford

A Longford style accident can happen in many industries. It is not particular to just the oil and gas industry. For example, the hazards may be equally present in the chemical, petrochemical, pyrometallurgical, mining and hydrometallurgical industries. Industry needs to be continually reminded to identify and recognise the hazards in their operations and to assess and make plans to address those risks with structural changes. The engineering profession should take the lead in disseminating lessons from disasters. This is in contrast to what happens currently, which is that most discussion of disasters comes from a legal perspective. Unfortunately legal action is focused on allocating blame and many settlements requires parties to not publicly discuss the case's details. The current approach severely restricts the potential for practitioners to learn from disasters. The Institution of Engineers Australia should take a prominent role in disseminating information on disasters from and engineering perspective to the engineering community.

> ***Recommendation:*** *Managers, engineers and operational staff at MHF should familiarise themselves with the Longford disaster and use its lessons to improve their facility's safety and engineering management.*

Some hazards are never identified

Even if a plant has been subjected to a comprehensive HAZOP study, some hazards are likely to remain undetected. An effective safety management system must recognise this and include appropriate strategies for the management of unanticipated hazards. Such strategies are particularly important for plants that have not been comprehensively reviewed using HAZOP or similar techniques, and are therefore likely to contain a number of undetected hazards. An effective risk reduction strategy should identify as many of the specific hazards as is practicable, and implement explicit techniques to protect against these. These should be complemented by an independent people-based risk reduction strategy to manage the residual risk from both undetected hazards and imperfect protection against defined hazards.

> ***Recommendation:*** *MHF should never believe that all hazards have been identified and addressed. MHF should deploy a comprehensive HAZOP safety management system supported by an independent people-based risk reduction strategy to manage residual risk.*

Powerful management systems are only part of the answer

Longford showed that powerful and detailed management systems are only as effective as the human resources charged with ensuring they remain relevant. Quality engineering information management systems will continue to under-perform unless driven and supported by experienced engineering practitioners armed with the appropriate managerial authority. This requires on-site expertise or streamlined access to it when required.

Recommendation: *MHF must have access to sufficient engineering, operating and maintenance skills on site and at all times coupled with regular and comprehensive surveillance of operating practices and properly kept records.*

Trade-off between cost and robustness

There is invariably a financial trade-off between the more expensive and more robust equipment that is designed to be inherently safe and the cheaper but less robust systems that uses protective instrumentation and procedures to provide safety. The criteria for justifying higher expenditure for increased robustness over the life of the plant are ill defined and the systematic risk involved is not amenable to normal quantitative analysis.

Recommendation: *Better decision-making tools are required to enable organisations to make appropriate investment decisions based on robustness of plant operations.*

Reduction of on-site technical expertise

Over the past decade, the downsizing of on-site personnel with technical expertise and experience has resulted in a significant loss of corporate engineering memory. This loss is continuing. This effects the quality of knowledge about operations, maintenance and upgrading of plant and equipment. As seen from the Longford explosion, the lack of on-site engineers contributed to the disaster, as operating staff had no knowledge of the consequences of unforeseen actions. As MHF assets age as does the engineering workforce, the loss of an experienced in-house critical mass of management engineering staff and technicians increases the risk caused by unpredicted events.

Recommendation: *MFP need to undertake more sophisticated cost benefit analysis to determine the appropriate level of on-site engineering, off-site engineering and outsourced engineering staff.*

Harmonisation and standardisation

A consistent safety case approach should be mandatory in all Australian States and Territories. In addition, there needs to be ongoing harmonization of MHF legislation with existing and proposed legislation and regulations.

Recommendation: *A nationally consistent safety case approach should be introduced and the ongoing harmonization of MHF legislation with existing and proposed legislation should be accelerated.*

8 Conclusion

The Longford disaster highlighted how a combination of ineffective management procedures, staffing oversights, communication problems, inadequate hazard assessment and training shortfalls combined to result in a major plant upset with consequential tragic loss of life.

These elements are not unique to the oil and gas industry. They can be found at virtually all MHF sites. In addition, other factors such as the increasing of age of MHF plants, increased outsourcing of engineering services, the increase in the age profile of the engineering workforce and the loss of a critical mass of experienced in-house engineering staff and technicians are also issues which can increase the changes of disasters.

If we look for a common generic answer for the concerns identified by this investigation, it would be collective mindfulness. Mindfulness is the strategy adopted by high risk, high reliability organisations(HRO); that is organisations where it is not possible to adopt the strategy of learning from mistakes. Hopkins[8] notes that the essence of the idea of mindfulness is that no system can guarantee safety once and for all. Rather it is necessary for the organisation to cultivate a state of continuous mindfulness; that is an alert wariness of the possibility of disaster. Mindfulness involves interpretive work directed at weak signals. Incident reporting systems are therefore highly developed and people are rewarded for reporting. They act on localised failure and identify the causal path linkages that generated the failure. Such causal linkages often penetrate deeply into the policies and management systems of the organisation.

As a consequence, Hopkins finds that maintenance departments in HROs become central locations for organisational learning. Due to their preoccupation with failure, HROs are willing to countenance redundancy of equipment and personnel to manage abnormal situations when they arise.

Conventional organisations focus on success - they interpret the absence of disaster as evidence of their competence and the skilfulness of their managers. Success is often used as justification for downsizing and outsourcing, for the removal of what is perceived as unnecessary effort and redundancy. The result is that current success makes future success less probable.

Industry and its engineering and safety professionals could have learnt a great deal more from the Longford tragedy.

Unless we learn the lessons and apply the knowledge and experience gained, the possibility of a second Longford will always be with us.

Appendix 1: Abbreviations

AIG	Australian Industry Group
ALAP	As Low As Practicable
AMS	Asset Management System
APPEA	Australian Petroleum Production and Exploration Association
AS	Australian Standard
ASM	Abnormal Situation Management
ASME	American Society of Mechanical Engineers
BS	British Standard
CSP	Crude Oil Stabilisation Plant
ESD	Engineering Systems Design
FSA	Formal Safety Assessment
GP1	Gas Plant 1
HAZOP	Hazard & Operability Study
HSE	Health, Safety and Environment
IPF	Instrument Protective Function
ISR	The Federal Department of Industry, Science and Resources
LRC	Longford Royal Commission
MHF	Major Hazard Facilities
OIMS	Operations Integrity Management System
ROD	Rich Oil Deethaniser
SH&E	Safety, Heath and Environment
SMS	Safety Management System
TEMA	Tubular Exchangers Manufacturers Association
VWA	Victorian WorkCover Authority

Appendix 2:Question-Set

The following questions were sent to a number of representative companies operating oil and gas, petrochemical and other MHF,[9] and also to related agencies.

1. How have the findings of the Longford Royal Commission impacted on the way your organisation identifies documents and communicates process hazards?

2. Has Longford changed the way the quality of the hazard identification process is audited and maintained?

3. Has Longford resulted in an engineering review of the adequacy and limitations of engineering design standards? (e.g. corrosion allowances, temperature and pressure rating margins, relief capacity etc).

4. Has Longford resulted in a review of installed equipment, its operating envelope and protective devices such as trips and alarms and relief capacity?

5. Is the competence, deployment and accessibility of engineering expertise a stated requirement of your company?

6. Has Longford resulted in a review of the Corporate Technical Memory and how this is to be maintained?

7. Have risk management policies and procedures, particularly for MHF, been impacted by Longford and if so, how? (For example are the controls, which prevent accidents such as Longford included within a safety management system).

8. How has Longford impacted on your company's engineering supervision of operations, modifications, and maintenance in the areas of equipment, system and process design?

9. Has Longford resulted in any significant changes to established safety case regimes and training? (Safety case regime covers safety management, including change management, major incidents and hazard identification, safety assessment, emergency planning, and the safety role for employees).

10. Are there further lessons from Longford that industry needs to consider? (Areas, for example, that are not reflected adequately in the summary and questions above).

Appendix 3: The Longford Gas Explosion

The following are extracts and summaries from the Longford Royal Commission Report into the Esso Longford Gas Plant Accident

On Friday 25 September 1998 at 12:25pm, an explosion and fire occurred at the Longford gas production and processing facilities of Esso. As a result of that explosion and fire, two persons were killed, eight persons were injured and all natural gas supply from the Longford facilities to domestic and industrial users in Melbourne and much of Victoria ceased for two weeks.

In response to these events, the Longford Royal Commission into the Esso Longford Gas Plant Accident (LRC) was established with the purpose[10] of finding whether any of the following factors caused or contributed to the occurrence of that explosion, fire and failure of gas supply, namely:

- the design of the Longford facilities including the interdependence of
    - the plants and other components which comprise those facilities; and
    - the Longford facilities and other facilities at, or upstream of, the Esso site at Longford
- operating standards, practices and policies;
- maintenance standards, practices and policies;
- asset management practices and policies;
- risk management procedures and emergency procedures in force at the time of that occurrence;
- any relevant changes in the standards, practices and policies referred to in sub-paragraphs b), c), d) and e) which has taken place before that occurrence;
- the hydrate incident at the Longford facilities which occurred in June 1998, and any previous incidents considered by the Board to be relevant;
- whether there was any breach of, or non-compliance with, the requirements of any relevant statute or regulation by Esso or BHP.

What steps should be taken by Esso or BHP to prevent or lessen the risk of:

- a repetition of the incident which occurred at the Longford facilities on 25 September 1998; or
- further disruptions of gas supply from those facilities?

The LRC commissioners were additionally directed to generate relevant recommendations arising out of the inquiry regarding any legislative or administrative changes considered necessary.

What happened

At Longford near Sale in Victoria, Australia, Esso operates three gas plants to process gas flowing from wells in Bass Strait, and a Crude Oil Stabilisation Plant (CSP) to process oil flowing from other wells in Bass Strait. The gas plants are the predominant source of natural gas for Melbourne. Gas Plant 1 (GP1) at Longford was a refrigerated lean oil absorption plant. In 1969, when Longford was established, there was only the CSP and one gas plant (GP1) on-site. By using low temperatures and high pressures, it employed lean oil to absorb hydrocarbon components from incoming gas. Lean oil is light oil similar to aviation kerosene. It does not contain methane,

ethane, propane or butane. When lean oil has absorbed these hydrocarbons, it becomes rich oil. Using lower pressures and higher temperatures, the rich oil was then distilled to release the methane that was returned to the gas stream, and a mixture of ethane, propane and butane for further processing into different products. After releasing these products the rich oil became lean oil once more and the process began again.

There were two other gas trains at Longford, GP2 (1976) and GP3 (1983). These trains used a cryogenic process to process the gas. This process does not use absorption oil. Instead a series of expansions and liquid separation followed by recompressions are used to remove the ethane and heavier components. Some sections of the cryogenic process are designed to operate at very low temperatures, well below those found in GP1.

At Longford site on the 25 September 1998 at 08:19, the lean oil booster pumps (GP1201) shut down on low flow as a result of a process upset in GP1, causing a loss of lean oil flow to the plant. There was a failure to restart these pumps and they remained inoperative for some hours. The consequence was that a number of vessels were deprived of a flow of lean oil, which, if the plant had been operating normally, would have served to heat them (Figure 1). The purpose of those vessels was to exchange heat with cold rich oil flowing from the absorbers. Whilst the primary role of lean oil was to absorb heavier components from raw gas (as detailed above) used for Melbourne gas sales, it also heated the Rich Oil Deethaniser (ROD) bottoms to around 100 deg C in reboiler GF905, after passing through an adjacent heat exchanger GP922.

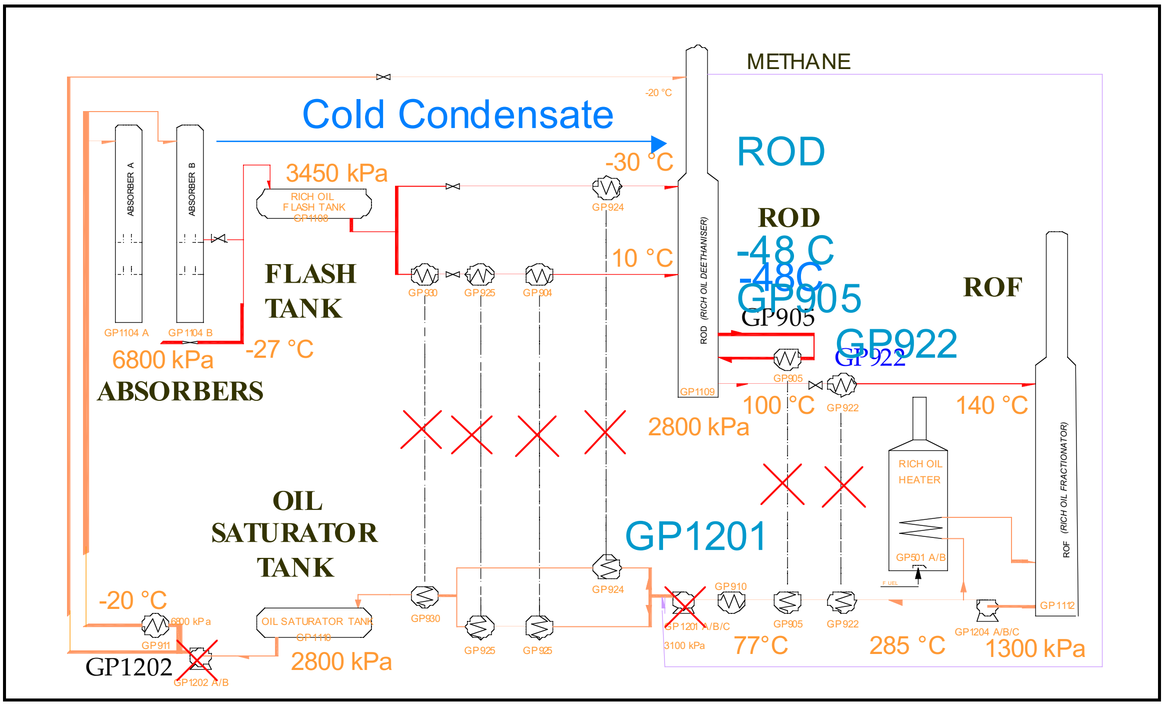


Figure 1. The Lean Oil Circuit[11]

From 08:29 onwards, attempts to restart the booster pumps were unsuccessful. With the loss of process heating supplied by lean oil circulation and exposed to cold condensate from the lean oil absorbers, the plant quickly cooled to around – 48 deg C. The resultant temperature differential induced stresses which caused exchanger GP922 to leak from its body flanges. From 10:30 a.m. the plant was progressively shut down to allow diagnosis of process problems and for maintenance to repair leaks.

Commencing at 12 midday, attempts were made to warm the plant by gradually introducing lean oil. GP905 reboiler was already chilled to a temperature of around – 48 deg C, under the influence of a continuing flow of cold, flashing condensate from the absorbers due to the absence of heating from the lean oil. When one GP1201 pump was eventually started at around 12:17 p.m. the re-introduction of some hot lean oil at around 200 deg C to the shell side of GP905 started to supply heat. As the tubesheet warmed up from its previous low temperature, the stress in the circumferential channel to tubesheet weld increased until at 12.25 p.m. the weld sustained a brittle fracture resulting in the exchanger failing catastrophically, releasing a volume of hydrocarbon vapour estimated at 10t within the first minute. The resulting vapour cloud subsequently ignited from a fired heater 170m away a few minutes later, flashed back to the reboiler and formed a large flash fire.

Two people were killed and another eight were injured; two seriously. All were in the immediate area assisting with repair of GP922, and were caught in the initial explosive release. The fire was progressively fed by a further 12t of inventory from GP1 and impinged upon a major pipebridge. After ten minutes, the first of many pipes in the pipebridge failed, further feeding the fire. Three major releases followed over the next hour and a half, as successive pipes failed, one failure resulting in a fireball 100m high.

Figure 2. The failed heat exchanger GP905 with GP922 in the background[12]

It proved difficult to isolate the plant from all sources of flammables, and the fire was not finally extinguished until two days later. The other two gas plants at Longford could not be restarted until GP1 was effectively isolated, and this took several more days. Gas eventually flowed from Longford nine days after the accident and it took a further five days to safely reconnect all gas consumers. In early November, the state government appointed a Royal Commission to enquire into the cause of the fire and loss of gas supply and to recommend measures to avoid a recurrence. The report of the Commission was issued on the 28th June 1999.

Contributing factors

The report of the Longford Royal Commission issued on 28th June 1999[13] established (in part) that contributing factors to the explosion, fire and loss of gas supply were:

- Vessels were exposed to cold temperatures for which they had not been designed[14]. In the case of heat exchanger GP905 (the failed vessel), the re-introduction of hot lean oil to a vessel chilled to a temperature of around –48 deg C, resulted in rupture by way of brittle fracture, releasing a volume of hydrocarbon vapour which subsequently ignited, causing an explosion and fire[15].

- The failure to conduct a HAZOP study or to carry out any other adequate procedures for the identification of hazards in Gas Plant 1 (GP1) where GP905 was located[16].

- The lack of operating procedures to deal with the situation experienced by operators at Longford, combined with inadequate training of personnel resulted in an inappropriate response to the situation that arose on 25 September 1998[17].
- The Commission noted that: *"The reduction of supervision at Longford, including the transfer of engineers to Melbourne, necessarily meant a reduction in the amount and quality of supervision of operations there. There was a correspondingly greater reliance by Esso on the skill and knowledge of operators. Whilst it is not possible to discern any direct connection between the level of supervision and the accident on 25 September 1998, the Commissioner considers that it was probably a contributing factor."*[18]
- As a result of Esso's desire to control operating costs (reduction of supervision at Longford, including transfer of engineers to Melbourne and failure to conduct a HAZOP for GP1), asset management practices or policies may have been a contributing factor to the explosion, fire and failure of gas supply[19].
- The reliance placed by Esso on its Operations Integrity Management System (OIMS) for the safe operation of plant was misplaced.[20] The Commission gained the distinct impression that there was a tendency for the administration of OIMS to take on a life of its own, divorced from operations in the field. Indeed, it seemed that in some respects, concentration upon the development and maintenance of the system diverted attention from what was actually happening in the practical functioning of the plants at Longford.[21]
- The training of its personnel to operate or supervise a potentially hazardous process was the responsibility of Esso and it failed to discharge that responsibility effectively. The lack of operating procedures to deal with the loss of lean oil circulation, low temperatures and the shutdown and start up of GP1 combined with inadequate training of personnel meant that the response to the situation which arose on 25 September 1998 was inappropriate and led to the occurrence of the explosion and fire.[22]
- The formation of Hydrates in the slug catchers in June 1998 was not a cause of, nor did it contribute to, the events which occurred in Gas Plant 1 (GP1) on the 25 September 1998. However, the formation of hydrates has the potential to disrupt gas supply.
- The cold temperature incident that occurred on 28 August 1998 made no direct contribution to the explosion, fire or failure of gas supply on 25 September 1998. However, the failure to report the incident deprived Esso of an opportunity to alert its employees to the effect of loss of lean oil flow and to instruct them in the proper procedures to be adopted in the event of such a loss. Had the incident been reported and appropriate action been taken after the report, the events of 25 September 1998 could have been averted.[23]

As a result of the above findings, The Report of the Longford Royal Commission recommended (in part) that the following actions be carried out:

- a design review of critical facility areas to minimise risk of a serious accident, including an isolation philosophy and ESD system review[24];
- the periodical review of operating standards and practices[25];
- the training of employees in identifiable hazards and the procedures to deal with them[26].
- an assurance that access to sufficient engineering, operating and maintenance skills would be available on-site at all times coupled with regular and comprehensive surveillance of operating practices and properly kept records[27];
- a safety/risk assessment and the responses required to minimise likelihood of accident including fire risk analysis and emergency response plan[28]; and
- the Commission also recommended that all Major Hazard Facilities (MHF) sites have the Safety Case extended to them by legislation[29]. This was really the principal recommendation. If properly executed, the other recommendations should be achieved.

Appendix 4: The Safety Case

The term 'safety case' is used to describe a sophisticated, comprehensive and integrated risk management system. A safety case regime is characterised by an acceptance that the direct responsibility for the ongoing management of safety is the responsibility of the operators and not the regulator, whose key function is to provide guidance as to the safety objectives to be achieved. The operators can achieve those objectives by developing systems and procedures that best suit their needs and agreeing these with the regulator. This 'safety case' then forms the rules by which the operation of the facility is governed.

The safety case includes details of safety management arrangements and risk assessment studies, which, once submitted to and accepted by the regulator, form a co-regulatory guidance document that sets both the standards to be achieved and the mechanism for achieving them.

The safety case also forms the basis for on-going audits of the facility and its operation throughout its life. Key aspects of inspection/auditing by the regulator will be to monitor the effectiveness with which the commitments in the safety case are being implemented, monitor the effectiveness of both the safety management system (SMS) and the operator's audits of them. It should also critically examine the efforts made by management to actively involve the workforce in the safety case process.

The concept was developed in the United Kingdom to minimise major industrial hazards, mainly in the nuclear and chemical industries, and is now used to manage risk in a wide variety of applications. These include the control of risk in British naval operations, the safe operation of the privatised British railway system and the design of computer software programs. The safety case regime is normally based on a 'co-regulatory structure', with an 'operator' preparing and operating the facility for which the safety case is developed and a 'regulator' assessing, accepting and auditing the adequacy of the safety case.

A safety case serves two main purposes:

- to give the 'regulator' (assessor) confidence that the 'operator' has the ability, commitment and resources to properly assess and effectively control risks to the health and safety of staff and the general public; and
- to provide a comprehensive working document against which the 'operator' and the 'regulator' can check that the accepted risk control measures and safety management systems have been properly put into place and continue to operate in the way in which they are intended.

It is intended to be a 'living' document which describes the safety of an operation for the duration of the whole project—from initial concept design to termination of the operation and abandonment of any facilities and drives the continuous improvement of the risk management arrangements.

The safety case concept requires the operator to formally document how risk is to be managed in its operations and across its facilities. It should also demonstrate that the major hazards of the operation have been identified and appropriate controls provided and that adequate provision has been made to ensure the safety of personnel in the event of an emergency. There are three broad categories of information required in a safety case:

- general information about the facility, its activities and operation and its interaction with other facilities or operations (the Facility Description);
- the system by which safety is to be achieved and maintained in design, construction and operation of the facility, (the safety management system — SMS);
- reasoned arguments and judgements about the nature, likelihood and impact of potential major hazards which may impact the facility and the means to prevent realisation of these hazards, or minimise their consequences should they occur (the Formal Safety Assessment—FSA).[30]

Appendix 5: Pressure Vessel Design Standards and Material Selection Requirements Against Low Temperature Duty at the Time of Vessel Construction

The metallurgical evidence concerning the failure of GP905 shows that the heat exchanger would not have failed solely due to reaching a temperature of – 48 deg C. The exchanger GP905 had reached – 48 deg C by 0930 on September 25th 1998, but did not fail until 1225,[31] three hours later. The additional stress required for rupture was introduced by the reinstatement of hot lean oil flow through the exchanger.

Australian Standards (AS)

Prior to 1972, the governing Australian standard for pressure vessels was AS CB1. The Australian standard AS1210 (Unfired Pressure Vessels) replaced AS CBI in 1972. AS CB1 contains no requirements whatever for low temperature steels.

British Standards (BS)

In 1970 the governing British standards for pressure vessels were BS 1500-1958 (replaced by BS 5500 in 1976) and BS 1515 (replaced by BS 5500 in 1976). Both British standards stated that carbon steels were suitable for temperatures down to 0 deg C. Below 0 deg C Charpy tests were required. The Charpy tests requested had to be done at the design minimum temperature and yield values of 15 ft-lb (20 J) averaged over three tests, with none less than 10 ft-lb (13.6 J).

Tubular Exchangers Manufacturers Association (TEMA)

TEMA has no requirements addressing low temperature material selection either in 1970 or now. All such material matters are referred to the ASME Boiler and Pressure Vessel Code

American Society of Mechanical Engineers (ASME)

The ASME standard that specifies low temperature limits of carbon steel was changed in 1986, when it became more consistent with the British and Australian standards. Prior to this time, carbon steel was regarded by the ASME code as being suitable down to -20°F (-29°C) and this limit still persists in the minds of many non-specialist engineers. However, current standards including ASME specify a set of criteria to determine the low temperature limit for carbon steel, which may be significantly higher or lower than -29°C depending on thickness and heat treatment. It would therefore be prudent for managers of plants designed to the old ASME code and potentially subject to low temperatures, to ensure that the implications of the revised low temperature limits have been adequately addressed on their plants[32].

Appendix 6: Abnormal Situation Management

Modern process management practice now differentiates between abnormal and emergency situations. The Longford accident and other major accidents overseas such as that at Texaco's Milford Haven refinery in 1994[33] remind us of the importance of equipping operators to adequately manage developing abnormal situations. Like GP 1 at Longford, many hydrocarbon and chemical plants still operating in Australia were built during the 1960's and 1970's. Managers of such plants face special challenges. The important requirement for managers of such plants designed to the old codes and standards and potentially subject to low temperatures is to ensure that the implications of the revised low temperature limits for material selection have been adequately addressed as has been discussed elsewhere.

Plants built prior to the early 1970's (and some built since) were not reviewed using HAZOP techniques during design. If a retrospective HAZOP has not been performed on such plants, it is likely that a significant number of latent hazards will remain undetected. Management of unidentified hazards places special requirements on operators and the organisations in which they work. Typically, such older plants rely less on automatic trip protection. As a consequence, the integrity of these plants is much more dependent on correct operator response to abnormal situations than would be the case for modern fully-instrumented plants.

Correct operator response to abnormal situations can be aided by:

- Concise and accessible procedures defining the specific response to critical alarms or other clearly defined situations. Such procedures should also identify the reasons for the stated action and the limits of the operators' discretion as applicable, and should be readily available at or via the operator console.
- Training and skills in identifying and managing abnormal situations as they develop.
- Systems such as problem escalation and alarm management that assist the operators to prioritise their responses to developing situations.

Although the correct response to a given situation may have been clearly understood by the designers, as time passes this knowledge and understanding erodes if systems are not in place to prevent this happening. Combinations of changes over time can also erode the integrity of the original systems, even though individual changes may have been reviewed in detail and found to be acceptable. One way to minimise the impact of these changes, is to carry out every 5-10 years periodic HAZOP style reviews that specifically focus on the interactions between equipment, process, and organisational and external changes that occur over time.

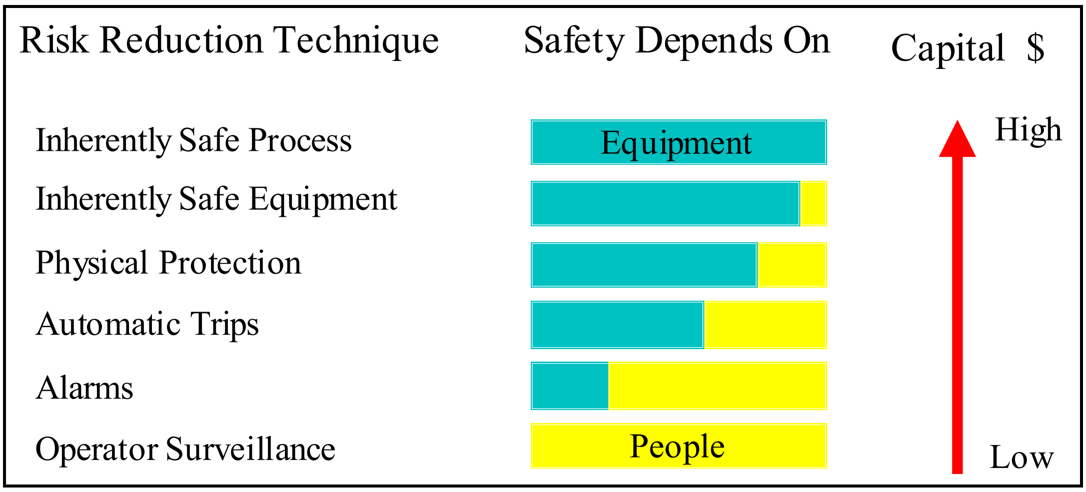


Figure 3. Alternative techniques to reduce risk from a given hazard. Techniques that are less dependent on people for protection are more resilient to loss of corporate memory, but typically have a higher capital cost[34].

Several alternative techniques will generally be available to protect against a given hazard. These are modelled in Figure 3. Maximising inherent safety, for example by minimising inventories or by selecting materials suitable for extreme conditions, is generally only possible during the design of a new plant. Inherently safe design places minimal demands on corporate memory over the life of the plant – "steel never forgets". However, once a plant is in operation, retrofitting inherent protection is generally not practicable. This places particular responsibility on plant designers to ensure that adequate allowance is made for the fragility of corporate memory when selecting the most appropriate protective approach.

At the other end of the scale, an approach that relies solely on operator surveillance is likely to be both less robust in the short term and much more subject to degradation due to loss of corporate memory. It is however, readily adaptable to changing circumstances, at least in principle, and requires minimal capital expenditure.

Selection of the most appropriate risk reduction technique for a particular hazard frequently requires that increased capital cost be justified based on the improved resilience of the plant to degradation during its lifetime. Unfortunately, making this trade-off is not straightforward. The mechanisms of degradation are systematic, not random, and so Quantitative Risk Analysis is not appropriate for this task. It is difficult to quantify the effects of alternative strategies in terms of lifetime cost or other tangible measures that can be clearly related to costs. It is therefore not surprising that capital cost frequently dominates the decision-making process.

It is important to recognise that there will always be some residual risk that cannot be managed explicitly by either procedures or hardware. This residual risk comes from two sources:

- Hazards not previously identified.
- Failure of specific techniques to address identified hazards.

Effective management of such risks relies on the correct response to unanticipated events by people within the organisation, predominantly the operators. Training and selection of operating personnel, and development of the systems to support them, must recognise this requirement. This is particularly important for existing plants that have never been subject to HAZOP review, due to the higher proportion of unidentified hazards.

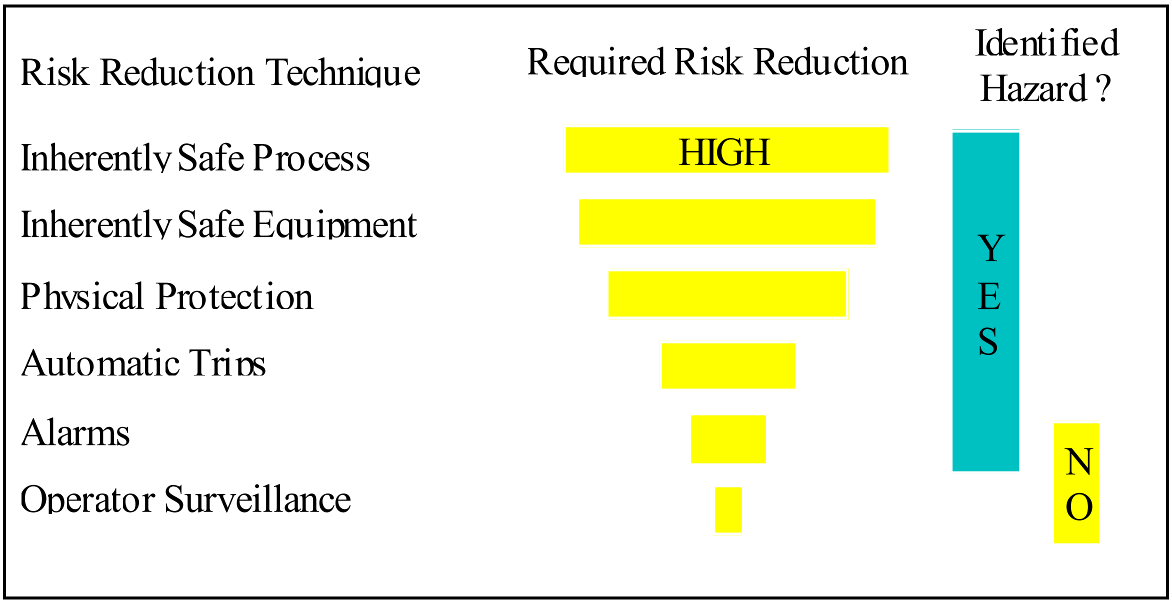


Figure 4. Suitability of different protective techniques based on level of risk and whether hazards have been identified[35].

An effective overall plant risk reduction strategy should result in an appropriate combination of the specific approaches to managing each hazard as shown in Figure 4. The steps required to implement such an overall risk management strategy may be summarised as:

- Identify as many specific hazards as practicable.
- Implement specific strategies to manage each identified hazard using technique(s) appropriate to the level of risk.
- Recognise that not all hazards will be identified explicitly.
- To manage residual risk, develop non-procedural operator skills supported by appropriate systems, both organisation-based and using hardware.

Some of the techniques required to manage this residual risk come under the general term 'Abnormal Situation Management'. Figure 5 shows the different operating regions that a plant can be in.

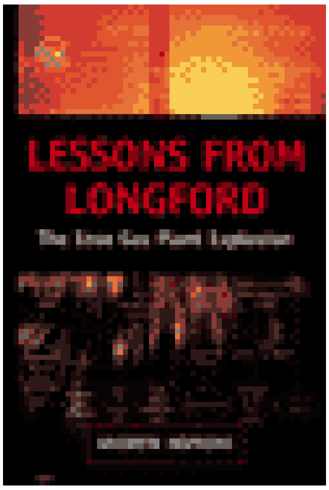
Operational Modes:	Plant States:	Critical Systems:	Operational Goals:	Plant Activities:
Emergency	Disaster	Area Emergency Response System	Minimise Impact	Fire-fighting First Aid Rescue
	Accident	Site Emergency Response System		
Abnormal	Out of Control	Physical and Mechanical Containment Systems Safety Shutdown Protective Systems	Bring to Safe state	Evacuation
	Abnormal	Hardwired Emergency Alarms DCS Alarm System	Return to Normal	Manual Control & Troubleshooting
Normal	Normal	Decision Support System Process Equipment DCS, Automatic Controls Plant Management Systems	Keep Normal	Preventative Monitoring & Testing

Figure 5. Operating regimes, showing the goals of the operator in each (Source: ASM Consortium)[36]

Most sites have well-developed procedures for managing 'Normal' operation and for response to 'Emergencies'. Protective systems as described above are generally intended to avoid entering the Emergency region. The aim of 'abnormal situation management' is to return the plant to 'normal' operation and avoid the operation getting out of control following an initial disturbance. Out-of-control operations place demands on protective systems (mechanical, electronic or procedural) to avoid entering the emergency zone, and if this protection fails, an emergency results.

One key requirement for effective management of abnormal situations is the clear and concise presentation of information to the operators during major upsets. In stark contrast to this requirement, is the more common situation of alarm flooding that occurs on many plants. In order to address this important challenge and related issues, the Abnormal Situation Management Joint Research and Development Consortium (ASM) was formed in the USA in 1994. ASM comprises a number of major oil and chemical operating companies, vendors and consultants, and is developing improved practices and techniques for managing abnormal situations in process plants. ASM is at http://www.iac.honeywell.com/Pub/AbSitMang/.

Appendix 7: Lessons from Longford[37]



The following is a review of the book, Lessons from Longford, by Andrew Hopkins. The review was published by Engineers Australia on 1999, and written by Athol Yates, Senior Policy Analyst, Institution of Engineers Australia

If you think that a disaster of the Esso Longford Gas explosion will not occur at your workplace, then think again. While it may be comforting to think that the explosion and fire which killed two workers was due to poor training or bad luck, the reality is that it there were many contributing factors and most of these are found in even the most safety conscious workplaces. Depressingly many of the factors are outside the ability of workers, managers and even the CEO to eliminate.

This is one of the important messages to be taken away from the disaster exposé book, *Lessons from Longford*. Written by Australian National University's sociologist, Dr Andrew Hopkins, the book examines the organisational reasons for the 1998 disaster that killed two, injured eight others and cut Melbourne's gas supply for two weeks. In doing so, it lays bare the workplace's deficient systems, its lack of hazard identification and uninformed staff.

The book only briefly touches on the technical causes of the explosion at Esso Gas Plant 1 in Longford, Victoria, on 25 September 1998. It happened when 230°C oil entered a frozen pressure vessel as the plant was restarted after a minor problem. The vessel's metal had become brittle and cracked, volatile liquid and gas escaped, and a nearby spark ignited the hydrocarbon cloud. A Royal Commission was appointed to investigate the causes of the disaster and its report mainly focused on the immediate causes of the explosion, such as operator error, lack of training and poor safety systems.

The merit in Hopkins' book is that it climbs further up the chain of causes. This approach takes the reader through the full range of contributing factors, such as management system inadequacies, regulatory failures and even the cost cutting pressure driven by the need to meet shareholder dividend demands. The principle behind this analysis is that if the organisational factors are right, the technical causes of accidents will not come into play.

In doing so, it brings into question much so-called business wisdom such as competency-based training, decentralisation of safety and self-regulation.

Competency-based training (CBT) has been embraced internationally as the best practice approach to vocational education and training. CBT consist of developing training modules that result in someone gaining the knowledge, skills, and abilities required to perform a certain job. Despite the appealing sound of CBT, its application in many workplaces resulted in the atomisation of work functions producing a set of trivial skills, to teach only those tasks defined in competency outcomes, and to provide only the minimum knowledge needed to undertake a task. This problem can be seen at Esso that ran a 'degenerated' form of CBT. Hopkins describes the company's training approach as one, which identified the specific knowledge that operators required to do their job, provided them with this information and tested whether they could present this information back to an assessor. It did not test for understanding. He offers an alternative approach of providing operators with an understanding of the fundamental scientific or engineering principles involved. Such an approach would give operators considerably more knowledge than was required for routine plant operations but would make them better able to analyse and deal with non-routine occurrences.

Another management sacred cow under Hopkins' gaze is the decentralisation of safety. Conventional wisdom is that those closest to the workplace are in the best position to manage their own safety. This may be true for eliminating common hazards such as slippery surfaces and dangerous machines. These are the easy ones to spot. However as the explosion indicated, decentralisation of safety is inadequate to prevent the rare but catastrophic events. These are the ones that require experience to know what to look for and how to spot the warning signs.

Historically a safety section at head office managed these low-frequency, high-consequence risks. These staff would oversee a number of plants and ensure that the lessons learned about rare events were passed around. Esso should have known information on the rare catastrophic brittle failure of pressure vessels, as it was available from their parent company, Exxon. In 1974 and again in 1983, researchers from Exxon Research and Engineering Company published warning articles on these failures. As a direct result, Exxon had inserted into their hazard identification guidelines the requirements that special attention be paid to the possibility of brittle fracture. Unfortunately, Esso's most senor manager in charge of risk assessment was not aware of the two articles nor was Esso's general manager aware of the brittle fracture warning in the guidelines, according to Hopkins. He observes that 'downsizing' of central safety staff and the decentralisation of safety may have gone too far. What is needed is a balance between central oversight and local control.

Industry self-regulation has become another mantra of modern business practice but an examination of the reality — devoid of rhetoric — reveals that in Esso's case; this has not resulted in the expected outcomes. The assumption behind self-regulation of safety is that only employers have the expertise to choose the best strategies for achieving safety in their company. The argument most frequently heard against government imposed regulations is that they hold back innovative ways to improve safety. These views sound reasonable in theory but fall down when workplace reality enters the analysis.

Far from resulting in safety best practice, self-regulation allowed Esso to fall considerably short of best practice, according to the Royal Commission. Best practice hazard identification would have involved carrying out a hazard study of gas plant 1. Esso did not carry it out and defended itself by arguing that it was not required to do so either by law or under Exxon's own guidelines, states Hopkins.

Self-regulation allowed a system to develop where staff used to operate the plant outside specified limits, with warning alarms constantly ringing, as this was the easiest way to maintain the quality of the outgoing gas. It allowed a safety environment to operate where 300 alarms on average went off each day with one incident causing 8500 alarms to trip or 12 every minute over a 12-hour shift. This environment desensitised operators to all alarms.

A major contributing factor to the situation arising at Longford was the failure of government to ensure that Esso provided a safe workplace, states Hopkins. This was because the government gutted the agency that has this function, WorkCover. The government saw that the shift from prescriptive regulation to self-regulation meant that certain work was no longer needed, such as sending inspectors to companies to identify breaches of prescriptive rules and regulations. Consequently staff were shed. But when new functions were identified, such as sending inspectors to sites to ensure employers were providing a safe workplace and issuing prohibition or improvement notices, instead of increasing staff numbers, the tired mantra of doing more with less is trotted out.

The lesson in this is that self-regulation can rapidly degenerate into deregulation if there is no enforcement of the new system.

There are a number of other really big issues raised in Hopkins' book. These include the mistaken belief that someone is actually in charge of many highly automated systems, that failure of bad news to be passed up the management chain and the fact that management often has little understanding of what is happening at the shop-floor level.

The identification of these points is what makes Hopkins' book so useful. It is a tragedy that the cost of discovering them was so high. To ensure that their lives were not lost in vain, companies should invite Hopkins, the Royal Commissioners and others experts to their workplaces to examine the lessons as a first step to preventing the rare but catastrophic disasters.

Appendix 8: Victorian Work Cover - Major Hazards Division

By John O'Meara, B.Eng. (Chem), M.Biomed.Eng

The Victorian WorkCover Authority (VWA) is currently implementing significant changes to the way in which safety at Major Hazard Facilities is regulated. This has entailed the recruitment of permanent staff with considerable technical credentials, providing an excellent example of a government department building up in-house engineering expertise in an era of downsizing, outsourcing, and privatisation.

In February 1999 VWA established a Major Hazards Unit (MHU) in order to address the special needs of safety regulation in Victorian Major Hazard Facilities (MHFs). Before that time, safety at MHFs had been regulated and enforced in much the same way as at all other Victorian workplaces. There was no legislative focus on major hazard issues to distinguish MHFs from other workplaces.

The new regulations - Occupational Health and Safety (Major Hazards Facilities) - came into force at 1 July 2000, and are now being administered by the VWA's Major Hazards Division.

MHFs, in simplistic terms, are sites that contain, or may at times contain, significant quantities of hazardous chemicals. The fear is that an uncontrolled release of such chemicals could lead to catastrophic consequences. Such events are often typified by fires, explosions and the release of toxic compounds, and can cause fatalities and injuries outside the site as well as inside.

In Victoria, as of 1 July 2000, just a few examples of sites that are automatically registered as MHFs would be those containing any of the following.

- 200 tonne of LPG
- 50 tonne of acetylene
- 20 tonne of hydrogen cyanide
- 2000 tonne of oxygen
- 150 kg of methyl isocyanate
- 10 kg of arsine

There have been some well-known catastrophic failures at sites that would today be classified as MHFs.

In 1984, a release of methyl isocyanate gas from a pesticides plant at Bhopal, India caused more than 3000 deaths. In 1974, an explosion at a chemical plant at Flixburgh, UK, caused 28 fatalities. In 1976, a release of dioxins at Seveso, Italy led to widespread and long lasting contamination of the surrounding communities and land.

In Australia, we have avoided such major calamities arising from our chemical plants, but there have been potent reminders of the potential risks.

In 1990, fire and explosions in suburban Sydney destroyed a bulk LPG facility. In 1991, a fire at the Coode Island waste chemical storage complex, not far from the Central Business District of Melbourne, generated severe dangers for emergency workers and clouds of potentially toxic smoke. In 1998, a gas plant at Longford, in Victoria, suffered an explosion and fire, causing two fatalities and a fierce fire that burned for two days.

A major recommendation of the Longford Royal Commission Report (June 1999) was that the government implement a ‘Safety Case’ regulatory regime for MHFs, and that a specialist unit within VWA be established to administer this regime, and to formally review and accept or reject the Safety Case.

The Safety Case philosophy is essentially this - The operator of an MHF must produce a document - the 'Safety Case'. This document should demonstrate to a range of stakeholders (regulatory agencies, employees and the community) that the operator has adequate measures in place to prevent a major incident and to mitigate the consequences of any major incident. The Safety Case must also demonstrate the existence of a comprehensive safety management system.

VWA's consultants had advised that in order for the new unit to be effective, it would have to be made up of highly skilled and experienced individuals, and that it would have to establish credibility with industry. The report further called for the MHU to be staffed by personnel who were skilled in process engineering, software, safety systems, risk analysis, emergency planning and auditing.

VWA's Major Hazard Division undertakes a number of functional roles. A team of field officers/inspectors on MHF sites administers general OH&S and Dangerous Goods legislation. These inspectors work closely with safety case analysts to ensure that the sites are progressing their safety cases in line with the requirements of the MHF Regulations. In addition, the Division has a number of technical specialists who support site activities, and a group of policy and development staff who provide non technical guidance to operational staff.

Engineers are employed in the Division in a range of roles from Safety Analysts to Field Officers/ Inspectors to Policy Officers and Managers.

The Division has provided the following information about its staffing:

> *Major Hazards Division has carried out extensive international recruitment activity over the last 18 months to put together a very skilled team of experienced staff with a high level of technical and operational skills. The staff in the Division have a broad spectrum of skills covering process engineering, general safety, management systems, risk specialists, emergency planning, occupational hygiene, ergonomics, auditing and technical safety.*
>
> *There are 26 technical operational staff in the Division responsible for administering all WorkCover's occupational health and safety and dangerous goods legislation at these sites, as well as the new safety case regime. Twenty-five of these staff have tertiary qualifications and many have multiple tertiary qualifications. Twelve staff have higher degrees above Bachelor degree level.*
>
> *Engineering and science are the most common basic disciplines in the group, and currently twelve of these staff are engineers. Some staff have multiple degrees - for example one senior safety analyst has a BE (Chemical) Hons, MSc (Chemical Engineering and Industrial Chemistry), Grad Dipl Management (Technology Management) and MBA (Technology Management).*
>
> *Eight of the staff also have OHS qualifications like occupational hazard management and occupational hygiene postgraduate studies.*
>
> *The group has a very strong industrial background. Across the group, there is 190 years of industrial experience, predominantly in the petro-chemical and chemical industry. The group also has 70 years of experience in the emergency and health services area, and 17 years in consulting. Staff in the Division have industrial backgrounds ranging from operations managers, production managers, project engineers to process engineers and process workers. In addition, there is considerable experience in the Division of government regulatory roles.*

Appendix 9: Bibliography

AAP, *Esso fine slap on the wrist says union,* The Age 30 July 2001

Barry T.F., 1995. *An Introduction to Quantitative Risk Assessment in Chemical Process Industries*, SPFE Handbook of Fire Protection Engineering, 2nd Edition, 1995

Boult D.M. & Pitblado R.M. & Kennedy G.D., *Lessons Learned from the Explosion and Fire at the Esso Gas Processing Plant at Longford, Australia*, AIChE Spring Meeting 2001 New York http://www.aiche.org/conferences/techprogram/paperdetail.asp?PaperID=192&DSN=spring01

Commission Blames Esso for Longford Disaster, The Oil and Gas Journal, July 05 1999, http://ebiz.netopia.com/process_safety/nss-folder/publicfolder/Catastrophic%20Incident%20 History/Esso%20Longford%20disaster.htm

Dawson, D.M. & Brooks B.J., 1999, *The Esso Longford Gas Plant Accident, Report of the Longford Royal Commission,* Government Printer for the State of Victoria.

Disaster Avoidance - Managing operator cognitive load with agents, http://www.seanational.com.au/emerging-technologies/disaster-avoidance.html

Downs A., *New Laws for Dangerous Sites,* Media Release, 30 June 2000 http://workcover.vic.gov.au

Elias D., *How safe is Longford,* The Age 09 August 2001

The Esso Longford Disaster, Technology Limited, Incident Reports and Transcripts, http://www.iqtechnology.com/incident.htm

Exxon study may have identified Longford hazard, The Oil and Gas Journal, 15 February 1999. http://www.findarticles.com/cf_0/m3112/7_97/53970604/p1/article.jhtml?term=Gas+industry+%2F+Investigations

Hayes J.J. *Esso's approach to safety in plant, design, testing and process equipment modification,* Chemeca `88: Australia's Bicentennial International Conference for the Process Industries (1988: Sydney). - Canberra: Institution of Engineers, Australia, p.382-388

Hopkins A., 2000, *Lessons From Longford,* CCH Australia, Sydney

Hopkins A., 1999, *Managing Major Hazards: The lessons of the Moura Mine Disaster,* Allen & Unwin, Sydney

Intelligent Agent, http://www.cs.mu.oz.au/sea/brochure.pdf

Introduction to the Safety Case Concept, Industry Science and Resources Offshore Petroleum Safety, http://www.dist.gov.au/resources/petr_safety/index.html

Kletz T.A., 1988, *What Went Wrong, Case Histories of Plant Disasters*, Gulf Publishing, Houston

Kletz T.A., 1985, *Cheaper, Safer Plants,* Institution of Chemical Engineers, UK

Kletz T.A., 1986, *Hazop and Hazan – Notes on the Identification and Assessment of Hazards,* Institution of Chemical Engineers, UK

Kletz T.A., 1994, *Learning from Accidents,* Butterworth-Heinemann, Oxford

Lacanna X., *Esso Refuses to apologise for explosion,* The Age 30 July 2001

Lacanna X. & Fitzsimmons H., *Esso fined $2 million for Longford Explosion,* The Age 30 July 2001

The Longford Catastrophe. What Price Safety? The Guardian July 28 1999 http://www.cpa.org.au/garchve1/g964.htm

Larsson T.J. *Shooting at the pianist,* Safety Science Monitor Volume 3, 1999, http://www.ipso.asn.au/vol3/editv3.htm

Major Hazard Facilities, Victorian Workcover Online http://www.workcover.vic.gov.au/vwa/vwa/mha intro and link notes.htm

Major Hazards, Victorian Workcover Online, http://www.workcover.vic.gov.au/vwa/home.nsf/Pages/haz_new#Case

McKay S. *Stricter Rules Needed, report finds,* The Age 29 June 1999

National Standard for the Control of Major Hazard Facilities, NOHSC2014 1996, http://www.nohsc.gov.au/index.htm

National Code of Practice for the Control of Major Hazard Facilities, NOHSC2016 1996, [http://www.nohsc.gov.au/index.htm

Nickols F., *Change Management 101 – A primer*, http://home.att.net/~nickols/articles.htm

Occupational Health and Safety Act 1985 (Vic)

Occupational Health and Safety (Major Hazard Facilities) Regulations 2000 (Vic)

Occupational Health and Safety (Major Hazard Facilities) Regulations 1999 Environmental Impact Statement (Vic)

Perry R.H. & Chilton C.H., 1973, *Chemical Engineers' Handbook - Fifth Edition,* McGraw-Hill Kogakusha, London

Risk Assessment in Process Industries, http://www.r2a.com.au/11RA_process_industries.html#Page11_6

Robinson R.M., 2000, *Risk & Reliability An Introductory Text,* R2A, Melbourne

Role of Fire Safety Studies, Workcover Victoria, http://www.workcover.vic.gov.au/vwa/vwainfo.nsf/all/MajorHazards/$File/GN5-MHFR.pdf

Safety ,Rehabilitation Commission Guidance Material on the Control of Major Hazard Facilities by the Commonwealth, 1999-OHS-BK-21, Commonwealth of Australia 2000

Weick K. 1999 *Why efficiency is the enemy of safety,* http://www.themanager.com.au/index.htm

Wilson S.P., & Kelly T.P. & McDermid J.A., 1999, *Safety Case Development: Current Practice, Future Prospects,* HISE Group, Department of Computer Science, University of York, York England

Yates A., 2000, *Government as an informed buyer, Recognising technical expertise as a crucial factor in the success of engineering contracts,* The Institution of Engineers Australia, Canberra.

Yates A. 2000, *Lessons from accidents: Don't cut down on engineering expertise,* Engineers Australia Magazine Volume 72, No 1, January 2000, http://www.engaust.com.au/magazines/ea/0100coverstory.html

References

[1] The Esso Longford Gas Plant Accident, Report of the Longford Royal Commission, June 1999

[2] Occupational Health and Safety (Major Hazard Facilities) Regulations 2000 – under these statutory regulations a major hazardous facility is a facility where Schedule 1 materials are present or likely to be present in a quantity exceeding their threshold quantity, or a facility, not being a facility to which the above applies, determined by the Authority to be a major hazard facility. In lay terms, this will include a site that stores, handles or processes large quantities of dangerous chemicals or products. Typically they include refineries, chemical and gas processing plants, LPG storage and distribution sites, and even types of large warehouses.

[3] *1975 Operating Instructions for Absorption Oil System* (The Red Book), Esso 1975

[4] All references below refer to Chapter 15.

[5] Victorian Workcover Authority, "Record fine for Esso" website statement, http://www.workcover.vic.gov.au/dir090/vwa/home.nsf/pages/Longford

[6] Occupational Health and Safety (Major Hazard Facilities) Regulations 2000

[7] Hopkins, A. (2000). *Lessons from Longford: The Esso Gas Plant Explosion*. Sydney: CCH Australia

[8] ibid

[9] Companies and agencies invited to contribute were: Huntsman, Orica, BHP Petroleum, Esso, WMC, Incitec, Santos, Woodside Karratha, BHP Minerals, Shell, Victorian WorkCover, AIG, APPEA, Dept of Industry Science and Resources (Petroleum Industry Branch)

[10] The Esso Longford Gas Plant Accident, Report of the Longford Royal Commission, June 1999, (from the appointment statement)

[11] ibid. Fig 2.10 page 23

[12] ibid. Fig 6.4 page 101.

[13] ibid Chapter 15

[14] ibid. paragraph. 15.6

[15] ibid. paragraph. 15.3

[16] ibid. paragraph. 15.7

[17] ibid. paragraph. 15.7

[18] ibid. paragraph. 15.7 page 236

[19] ibid. paragraph. 15.7

[20] ibid. paragraph. 13.42

[21] ibid. paragraph. 13.40

[22] ibid. paragraph. 15.7

[23] ibid. paragraph. 15.7

[24] ibid. paragraph. 15.15

[25] ibid. paragraph. 15.16

[26] ibid. paragraph. 15.17

[27] ibid. paragraph. 15.18

[28] ibid. paragraph. 15.20 – 15.23

[29] ibid. paragraph. 15.26

[30] Dept of Industry Science and Resources (Petroleum Industry Branch) Abstract – The Safety Case Approach to Risk Management

[31] The Esso Longford Gas Plant Accident, Report of the Longford Royal Commission, June 1999, paragraph. 5.61

[32] The writer was unable to sight to sight a 1971 or 1968 edition of ASME VIII.

[33] The Explosion and Fires at the Texaco Refinery, Milford Haven, 24 July 1994 HSE Books, 1997

[34] The Abnormal Situation Management Joint Research and Development Consortium – from their web page at http://www.iac.honeywell.com/Pub/AbSitMang/

[35] ibid.

[36] ibid

[37] Hopkins, A. (2000). *Lessons from Longford: The Esso Gas Plant Explosion*. Sydney: CCH Australia