

CAN WE STILL USE LEARNINGS FROM PAST MAJOR INCIDENTS IN NON-PROCESS INDUSTRIES?

Frederic Gil[1] and John Atherton[2]
BP Process Safety & Fire Engineering Advisor, Refining Safety & Operations Excellence, Sunbury TW16 7LN UK
Process Safety Consultant, 8 Smolletts, East Grinstead, RH19 1TJ, UK

Major accidents from outside of the process industries, such as Titanic and Columbia, are reviewed against a 21st century process industry integrity management standard. Each such incident is then presented against accidents from the process industries to reinforce the learnings. For example, Titanic can be used to create learnings around the need for pre-start up safety reviews following an emergency shutdown; Columbia on institutional learning. The result is an in-house booklet that has been given wide circulation and subsequently offered to CCPS for publication. The paper will include extracts from non-process incidents and describe how they relate to the process industry.

INTRODUCTION

BP initiated a project in early 2004 to develop a process safety teaching aid in the form of a booklet containing analyses of non-process and process industries accidents against their Integrity Management programme. The first edition was published internally in early 2005, with a second edition containing lessons from BP Texas City March 2005 accident in 2006. BP has offered this booklet to CCPS for wider publication under the title “Incidents that define Process Safety – ISBN 978-0-470-12204-4”.

In discussions with young graduates or even experienced technicians it has become clear that many had not heard of Flixborough, Bhopal or Piper Alpha, and if they had, few of them received enough information to be able to transfer lessons to their current activities. They had, however, heard of Titanic, Chernobyl, the NASA accidents (Challenger and Columbia), Concorde and other aviation accidents through the press and media. The objective of this booklet was to disseminate more widely the main lessons from major incidents from wherever they originated using a simple, user friendly, integrity management tool.

Jesse C. Ducommun was Vice-President, Manufacturing and a Director of American Oil Company in 1961 (joined in 1929) and Vice-President American Petroleum Institute in 1964. While working for Amoco, he conceived, inspired and co-authored the unique series of booklets on process safety in the 1960s that was then updated and complemented after 2002 by BP Refining Process Safety Community of Practices. In the preface, he stated:

> *“It should not be necessary for each generation to rediscover principles of process safety which the generation before discovered. We must learn from the*

experience of others rather than learn the hard way. We must pass on to the next generation a record of what we have learned.”

So why focus on non-process accidents when there is plenty of fertile ground within our own oil and petrochemical industry? There are a number of reasons:

- Oil and petrochemical companies exist in a very similar environment to other commercial ventures, in that:
  - They operate in a highly competitive business environment.
  - They have hierarchal management structures.
  - They employ skilled people who have their own career progression aspirations, which can impact on an individual’s behaviour.
  - They are strictly regulated.
  - They involve similar technologies or practices (for example board operators in a refinery control room and air traffic controllers in a control tower both have to work remotely and can have issues mentally visualising what is going on; replacing critical parts on an aircraft engine or a refinery compressor has to be done with similar rigorous procedures).
- It is very easy for individuals reading accident reports to focus on technical details, whereas the majority of root causes relate to softer, cultural and human behaviour issues. Lessons learned from an incident on a crude oil distillation unit (CDU), for example, may receive a technical review at another refinery which leads to a conclusion that a similar accident could not occur on their CDU as it has a different equipment arrangement or process conditions. In most cases, the root causes are likely to be around human factors and management protocols where meaningful parallels can be drawn. Lessons from non-process accidents do not have a technical equivalence and readers are forced to consider the full range of lessons learned.
- Some industrial sites, or locations, can build up a negative reputation for process safety if there is a history of accidents and incidents, and others may assume that they are better than the site suffering the incident, and that the same thing could not happen to them. Lessons from accidents such as Titanic and the aviation industry can excite the imagination, leading to the learning of valuable lessons that remain in the minds of those who had studied them.

Included in the booklet are a number of major process incidents that have been influential in shaping process safety, such as Flixborough, Bhopal, Phillips Pasadena, and Piper Alpha. These are used to illustrate synergies and because they are important in their own right.

BP’S INTEGRITY MANAGEMENT STANDARD

The model used to analyse the incidents in the booklet is BP’s Integrity Management (IM) Standard, which sets priorities for process safety improvements in line with the best of industry practices. It sets out the requirements for IM to satisfy BP’s Group Values, particularly

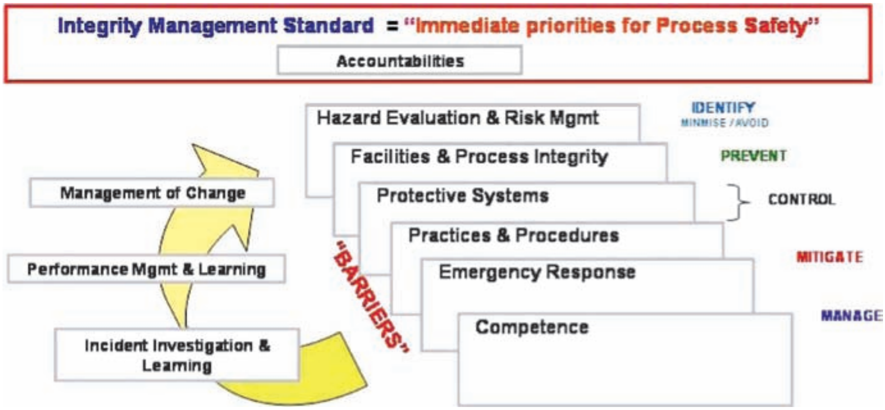

Figure 1. BP's integrity movement standard

those pertaining to Risk, Health and Safety, Environmentally sound operations and the achievement of internal targets as defined in BP's Management Framework. It requires the controlled application of BP's Major Accident Risk (MAR) assessment, process safety and engineering management, combined with internationally recognised industry standards and BP developed engineering and operating procedures. The objective is to sustain BP's license to operate by reducing the probability of uncontrolled release of hydrocarbons and chemicals, including catastrophic and chronic releases to the atmosphere water or ground, and to prevention of equipment failure and hence avoid serious harm to people, the environment and physical assets. Additional benefits are seen in improved operational integrity; enhanced HSE performance; increased life cycle value of assets and greater engineering standardisation and productivity. The IM Standard is shown schematically in Figure 1.

CATEGORISATION OF ACCIDENT SCENARIO'S STUDIED

The scenarios used in the booklet were chosen against a number of topic headings:

- Blind operations
- Design
- External causes
- Inspection & maintenance
- Knowledge and training
- Lack of HAZID (hazard identification)
- Management of Change
- Not learning from near misses
- Operating practices
- Permit to Work

- Emergency Response
- Human Factors

These headings reflect the view of the authors of the major causation of the respective incidents from which the most important lessons can be learned. However, as with all incidents, they are invariably attributable to multiple causes. These are often represented as barriers that have to be breached in order for the chain of events to occur that results in the eventual outcome. For example, with the sinking of the Titanic there are important design, operations and human factors, and emergency response contributors to the eventual tragedy that claimed over 1500 lives. If the original design to complete the vertical bulkheads up to the weather deck had been installed, the progressive filling of the ships' compartments as she went down by the bows would have been prevented; if the ship had been slowed down when ice was forecast, the impact with the iceberg may have been prevented or at least reduced; if the ship had been provide with sufficient lifeboats to enable all members of the crew and passengers to safely abandon it, the loss of life could have been far less.

THE INCIDENTS

The non-process incidents chosen represented a wide range, some of which are well known, e.g. Titanic and the NASA incidents; some less well known, such as the Royal Navy K Class submarines. Not all are recent incidents as, in addition to 1912 Titanic and 1916 K Class submarines, the 1937 Hindenburg, 1930 airship R101 and a 1906 mining incident are included. A significant number were drawn from the marine and aviation industry, such as Betelgeuse, Erika, HMS Glasgow, Concorde and Canada Air Flight 236. Non-oil and petrochemical industry incidents are included: Bhopal and Toulouse, together with nuclear power production incidents at Three Mile Island and Chernobyl. Also included are a number of important oil and petrochemical incidents, including: Feyzin, Phillips Pasadena, Texaco Milford Haven, Esso Longford, Total la Mede, Marathon HF release, Exxon Valdez, Seveso, and Tosco Hydrocracker. Other oil related incidents associated with exploration and production included the sinking of Platform P36 and Piper Alpha. Major BP incidents that are also included are Grangemouth Hydrocracker and Flare Line incidents of 1987, and BP Texas City incident of March 2005.

More details of incidents reviewed are included against each of the sections below.

THE LESSONS DERIVED FROM A REVIEW OF THESE INCIDENTS

BLIND OPERATIONS

In this section incidents are examined where those operating equipment were unaware of the actual situations they were in. Two of these are from the aircraft industry, and one from the nuclear industry:

- Incomplete information (Pan Am 1736/KLM 4805)

- Unclear information transfer (MD83/Shorts 330)
- Overwhelmed with too much information (Three Mile Island)

The lesson that runs through all of these incidents is that sometimes people create their own blindness or "mind set" either through lack of awareness of what is going on resulting from a lack of training or experience, or through external factors such as stress. It is good practice when faced with a situation that appears to be a bit out of the ordinary, to step back and take a thorough look at all the evidence, or ask a colleague to do that for you.

DESIGN

The five incidents described in this section demonstrate major areas of importance in design:

- Bhopal
- NASA Challenger Space Shuttle
- K Class Submarines (WW1 steam driven submarines built for the Royal Navy)
- TWA flight 800
- Hindenburg airship

These incidents demonstrate a range of important design issues: Bhopal and the steam driven K Class submarines – inherent safety, Challenger – not fully understanding the potential consequences of violating the true limits of a safe operating envelope (solid rocket booster seals), TWA 800 and Hindenburg – compromising a safe operating envelope as deterioration processes kicked in or where subtle changes were made to equipment.

Hazard identification and risk assessment are tools that are required to be used in all major jurisdictions. However, these can only be effective where those conducting these studies can do so knowing that their recommendations will be acted upon in a responsible manner. In more than one of the above incidents, political and commercial pressures either caused the risk assessment process to be shortened or ignored.

The importance of knowing the safe operating envelope and how this can be compromised by external factors or safety critical equipment malfunction is also demonstrated by some of these incidents.

EXTERNAL CAUSES

Two incidents are described:

- Mexico City – Pemex LPG terminal
- Tupras – Turkish Earthquake 1999

Even with the most sudden and extreme events, the use of traditional hazard identification, risk assessment and emergency planning techniques can still provide major benefits. As it is virtually impossible for every potential scenario to be assessed in depth, review team members need to be able to see the wider issues in order to make meaningful recommendations that will make a difference when the major event takes place.

INSPECTION & MAINTENANCE

Seven incidents are included:

- Explosion of the "Betelgeuse" at Bantry Bay
- Sinking of the "Erika" – fuel oil marine tanker in the Bay of Biscay
- Canadian Airways flight TS 236 – ran out of fuel over the Atlantic
- HMS Glasgow – fatalities during construction
- Marathon HF release at Texas City
- Flare line failure at Texaco Refinery, Milford Haven
- FCCU explosion at Total la Mede

The examples given here demonstrate a number of key points, for example the impact of the age of plant and equipment on integrity. Increasing age does not necessarily mean that something is unsafe, but more care needs to be taken to maintain its integrity as deterioration sets in and, for example, corrosion allowances are consumed as occurred in the cases of "Betelgeuse" and "Erika". Exceeding the corrosion allowance was also a major contributor of the Texaco Milford Haven flare line failure. The piping failure that led to Total la Mede also resulted from corrosion that occurred over a long period of time, >30 years. This corrosion mechanism was entirely predicable as it was due to the expected reaction of the process fluids with the materials of construction, but this section of piping had not been regularly inspected, most likely, because it was a bypass.

Failures to follow safe maintenance or construction procedures were a root cause of the remainder of these incidents.

Many major incidents have resulted from maintenance and inspection not being carried out correctly or not at all. Maintenance and inspection are, for the most part, costly and invasive and detract from production if not specified and planned correctly. The role of an Engineering Authority is vital here to ensure that the right risk based arguments on plant integrity are presented to the decision makers with ultimate accountability for safe operations, Directors and Senior Managers, to balance those being put forward by the commercial and production functions. The planning and execution of maintenance and inspection activities is, therefore, critical to ensuring all parts of the safe operation equation are properly balanced.

KNOWLEDGE AND TRAINING

In this section a number of incidents are reviewed where those most involved in the incidents were not aware of the hazards that they were exposed to:

- Feyzin LPG tank farm explosions 1966
- Ammonium nitrate explosions:
  - Oppau, Germany
  - SS Grandcamp, Texas City Port
  - Toulouse, France
- Dust explosion at Courrierres mine, France, 10 March 1906

Feyzin was one of the first post WW2 major process accidents in Europe. It occurred because the operator did not understand the importance of getting the valve sequence right when draining water from LPG storage vessels.

The lessons of the past are important to everybody, in every walk of life. Sadly, experience shows that the lessons learned many years ago become forgotten over time. The ammonium nitrate accidents are a case in point. The first occurred in 1921, the second in 1947 and the third in 2001. Nothing had changed in the fundamental properties of ammonium nitrate, and in some industries it was used as an explosive. However, those handling this material do not appear to have had an appreciation of its dangerous properties despite the major incidents that had occurred previously. Similar issues are demonstrated in the case of dust explosions, with 3 recent (1997 and two in 2003) incidents explained after the detailed description of the 1906 mining disaster.

LACK OF HAZARD IDENTIFICATION

The six incidents described in this section indicate the consequences of not having put in place some form of formal hazard identification, e.g. HAZID, and risk assessment process. The six cases demonstrate different scenarios:

- Titanic – compromising a safe design
- P-36 FPSO – invalidating a safe design
- Esso Longford not carrying out a formal HAZOP on the original plant design and any modifications
- Reactive chemicals:
  - Road tanker explosion, Teeside Rohm & Haas plant, UK, 3rd January 1976
  - Pesticide explosion during storage, Bartlo Packaging (BPS), Inc, 8 May 1997, where 3 died
  - Napp Technologies, Inc., Lodi, New Jersey 1995, where 5 died

In all cases, the consequences represented a worst-case situation, although the loss of life could certainly have been higher in all of them. The worst case concept has been repeatedly challenged over the years in favour of a more risk-based approach. There is no doubt that the concept of ALARP (as low as reasonably practicable) is valid, provided the risk assessments are based on well founded data. The very fact that a ship/platform floats means that it can sink. A process unit operating with materials that can flash to give very low temperatures means that it will be possible to achieve these temperatures under severe upset conditions. Prevention, control and mitigation measures need to be robust and not vulnerable to a common mode form of failure that renders them all ineffective simultaneously. Consideration of human factors where risk reduction is sought through procedural means must be carefully examined to ensure the right levels of checks and balances.

An unusual aspect of the Titanic incident can be related to Pre-Start Up Safety Reviews. In his book “Last Log of the Titanic” (1), David G. Brown describes how the Titanic was stopped after hitting the iceberg. An assessment of damage was carried out and a decision taken to restart the engines. Up to that point in time the water ingress into the ship was being matched by the pumps that had been rigged to pump out the damaged compartments. It is postulated that the ship could have remained afloat for a far longer time, in all probability enough time for the passengers to be rescued. This would have achieved one if its design intentions to be its own lifeboat. However, once restarted the damage to the hull plating was exacerbated by the forward motion of the ship to a point where the pumps could no longer cope. The parallel in our industry is that following an emergency shutdown a thorough pre-start up safety review needs to be carried out before recommissioning. Process plant will undergo extremes of pressure and temperature excursions in an emergency shutdown situation, demanding such a review. If this is not carried out, perhaps (as in the case of the Titanic) due to pressure from commercial interests to restart quickly, the consequences can be catastrophic and far outweigh any short term gain.

MANAGEMENT OF CHANGE

Two major accidents that have influenced the industry in major ways are described in this section:

- Flixborough explosion.
- Chernobyl radioactive cloud.

Flixborough describes the failure to create a safe design for a critical process modification, and Chernobyl where operations managers and technicians stray outside of a pre-defined safe operating envelope.

Change is inherent in the way in which we live and work. The most important aspect of change is being able to recognise when a change is being proposed or put into action. Even replacement of a machinery spare of apparently identical proportions with that manufactured by another supplier is a change that merits careful review of dimensions and materials of construction of all components to assure that there are no unintended harmful consequences. This applies equally to changes in staffing and organisation (no two human beings are identical), chemicals, feedstocks and all aspects of process plant operation.

Another critical lesson from these incidents is the ability for individuals to “know what they don’t know”. Competition for attractive jobs coupled with personal ambition has led to many cases of individuals being placed into roles with responsibilities they are not fully competent to manage. This in itself may not be problematical provided their limitations are recognised at the outset and those individuals are properly mentored and have no inhibitions in recognising when they need help and asking for it. However, many may see asking for help as running counter to their aspirations for advancement and coupled with the reduced numbers of experienced people available to support them, this may well conspire to major incidents being caused through inexperience and ignorance.

NOT LEARNING FROM NEAR MISSES

Three incidents are selected:

- NASA Columbia Space Shuttle: re-entry fatal incident

- Herald of Free Enterprise: capsized ferry
- Concorde – fatal crash at Paris

It is said that there is nothing new in safety – it has all happened before. These three incidents were all high profile with major loss of life. Had lessons from previous incidents been learned and applied, it is highly likely that they would not have happened.

In the case of Columbia, the time between lessons from Challenger incident being available and the second space shuttle incident was 17 years. This is around half of the career span of the average person, which implies that around 1/2 of the workforce were not around when the first accident happened. The only way they could have benefited from lessons from that far back is for these lessons to be assimilated into the culture of the company so that they remain "evergreen". Even then this is not a guarantee that they will remain in place as senior people evolve and move on, management theory and practices change, and commercial pressures take on different dimensions.

OPERATING PRACTICES

Despite the best design thinking with incorporation of lessons from the past, things can still go badly wrong if the people operating process plants and equipment do not follow proper operating procedures. In this section there are three incidents;

- R101 airship crash
- Tosco Hydrocracker fire
- BP Texas City ISOM explosion

Operating procedures are vital documents and need to be written by competent people. Training in these procedures must be accompanied by some form of testing regime to ensure that knowledge has been taken on board. Changes to procedures need to be reviewed against a robust management of change procedure with operators and others who need to know being properly informed and trained. The Texas City refinery Isomerisation incident on 23rd March 2005 highlights the importance of using operating procedures.

PERMIT TO WORK SYSTEMS

This section describes five major accidents where failure to comply with Permit to Work Procedures resulted in large-scale loss of life and/or property. These are all oil and petrochemical industry incidents, unlike the make up of the preceding sections:

- Motiva tank fire
- Phillips Pasadena process unit fire
- Piper Alpha platform fire
- Port Edouard Herriot tank farm fire
- BP Grangemouth flare line fatalities and fire

Work Permits or Permits to Work are an industry standard to ensuring that work of a non-routine manner can be safely controlled in hazardous areas, and in many jurisdictions are a legal requirement. However, experience has shown that no matter how simple or sophisticated the procedure and work permit forms are, it is by the strict application of the procedures and practices associated with the identification of hazards, assessment of risk and application of Permit to Work conditions that ensures that work can be safely carried out. A Permit to Work system can only be as good as the people implementing it are competent.

EMERGENCY RESPONSE

This section examines incidents where emergency preparedness was overlooked or undersized, communications were mishandled, inadequate tactical choices were made or those designing/operating/authorising installations or responding to the incident were unaware of the actual situations they were in.

Clarity of information is vital to understanding the situations in which we may find ourselves. When designing an installation, risks must be clearly assessed and communicated to all parties involved, so that everyone is clear on the potential consequences and adequate response strategy and resources needed the day things may take a bad turn.

Three types of incident have been selected to illustrate this section:

- The case of Seveso, the authorities did not know until late after the incident that Dioxin was involved.
- Warehouses incidents, such as the Sandoz Bale accident, show the importance of agreeing on tactical response long before an incident, with all parties that will respond (Operator, Local/National Authorities, etc.). The adequate strategy may not be the obvious one, nor the one that media pressure will put forward, and it's sometimes preferable to let a fire burn out than try to fight it to avoid putting firefighters at risk or contaminate huge quantities of water.
- The Tacoa boilover is another example of poor understanding of the risks involved and inadequate management of the incident.

On the face of it, it could be assumed that there was nothing anybody could have done about these major incidents. However, looking closely, there are three important areas that could have prevented or limited the consequences of the events:

- Learning lessons from outside the boundaries of ones own experience. There is a vast amount of information available to the manager, engineer and operator that can help them in times of crisis, but managing such a vast quantity of information is always a challenge.
- Designing installations that are inherently safer and that won't overcome the resources available to emergency responders. The Bhopal incident is a typical case where the hazardous material inventory could have been significantly reduced.
- Writing and exercising realistic major accident scenarios. In this way it is possible to agree and educate on the adequate tactics to respond to different events before they happen, and/or purchase additional equipment if necessary.

Many of the incidents in this book could also have been discussed in this section: from Piper Alpha to Bhopal and the Titanic. Emergency Response has often been perceived as an un-necessary cost centre that was considered disproportionately expensive when set against operational short term gains; why add life boats for all passengers when the ship is supposed to be unsinkable? It is probably part of human nature to think that scenarios like that "can't happen here" and that they are someone else business to deal with. It is the duty of the Managers and the Engineers to overcome these feelings and adopt a transparent and realistic approach to Emergency Preparedness.

HUMAN FACTORS

Two major accidents are described where failure to look at human factors in training and work organisation strongly contributed to large-scale loss of life and/or damage to the environment.

This Exxon Valdez incident report from the National Transportation Safety Board highlights the following human factors:

- drug & alcohol abuse;
- fatigue;
- excessive workload.

The Flash Airlines crash highlights the following human factors:

- training,
- organisational/hierarchical factors that impede communications.

Human factors are often overlooked, both at the design stage (including in the Management Of Change process: see specific section on MOC) and during investigation of incidents (the Egyptian report of the Flash Airlines crash is a typical example: as the NTSB comments document on this report diplomatically puts it: "the Egyptian Ministry of Civil Aviation's investigation of the operational and human factors related to the accident was minimal"). This may be because human factors seem difficult to grasp or deal with. However, incidents cannot be prevented or fully understood without them.

CONCLUSIONS

There is little doubt that the booklet has been well received. One senior BP manager wrote: "One resource that the Process Safety Specialists have made available for us all is a really great book entitled "Integrity Management - Learning from Past Major Industrial Incidents" (CCPS title "Incidents that define Process Safety"). This contains a large number of case studies both from within our industry and from other events. It is written in a very easy to read style and is a great resource for all of us to use in our facilities to enhance people's awareness of risk and to help us all reduce any sense we have of complacency. All the stories in the book involve people who did not set out to have the accident or incident - that is people just like us!"

Another shared the booklet with several of BP's manufacturing site safety representatives and the one comment that that was heard many times was: "You know, the circumstances that led to the incidents used for the examples could EASILY have existed at our facility".

Other examples of feedback received on the booklet from within BP included:

- The information was seen to be highly relevant to the readers' activities and was received with great interest. Many sites see this as a major additional "lessons learned" training resource that feeds into Knowledge Management.
- Many of those responding requested more additional copies. There were a number of cases where somebody saw a copy sitting on another person's desk and requested their own copy as they saw that the learnings would fit very well with their team's activities. One example was in connection with the supply of drilling and completions safety critical software.
- The professional way in which the case histories were presented was appreciated. The crisp language and detailed information in tabbed format makes it very user-friendly.
- One team intends to convert sections of the booklet into a CBT tool that can be easily shared via their intranet.
- Sections of the booklet have been translated into Dutch and German with PowerPoint presentations being created in other local languages.
- Some have translated the "sharing the experience" booklet and distributed it to operators during toolbox meetings. Others added it to basic operator training.
- One reader found the document excellent background reading for an Open University Post graduate project entitled 'Forensic Engineering'. He was sure his fellow students would benefit from reading the booklet.

REFERENCE

(1) The Last Log of the Titanic, David G. Brown, International Marine - McGraw-Hill, 2001, ISBN 0-07-136447-1

SOME OF THE SELECTED READING USED TO DRAFT THE VARIOUS SECTIONS OF THE BOOKLET

NUCLEAR INDUSTRY:

- Three Mile Island:- US Nuclear Regulatory Commission Fact sheet on the Accident at Three Mile Island, from: http://www.nrc.gov
- "United States President's Commission on the Accident at Three Mile Island." Vol. 9. U.S. Government Printing Office: Washington, D.C., 1979.
- Hodgson, Peter. "Chernobyl After Five Years". Contemporary Review. (July, 1992)
- Lewis, H.W. "The Accident at the Chernobyl Nuclear Power Plant and Its Consequences". Environment. (November, 1986).
- Space and Plane incidents:
- Challenger – NASA web-site: http://history.nasa.gov/sts51l.html: The Challenger Decision to Launch, Diane Vaughan, University of Chicago Press, ISBN: 0-226-85176-1

- MD83/Shorts 330 crash at Paris Charles de Gaulle airport: Bureau Enquêtes-Accidents Report "Accident on 25 May 2000 at Paris Charles de Gaulle (95) to aircraft F-GHED operated by Air Liberté and G-SSWN operated by Streamline Aviation.
- "US summary comments on draft final report of aircraft accident Flash Airlines flight 604, Boeing 737–300, SU-ZCF January 3, 2004, Red Sea near Sharm El-Sheikh, Egypt", National Transportation Safety Board.
- "Factual Report of Investigation of Accident, Flash Airlines flight 604, January 3, 2004, Boeing 737–300, SU-ZCF, Red Sea off Sharm El-Sheikh, Egypt", Egyptian Ministry of Civil Aviation.
- TWA 800 – National Transportation Safety Board Report "In-flight Break up Over The Atlantic Ocean Trans World Airlines Flight 800 Boeing 747–131, N93119 Near East Moriches, New York July 17, 1996" NTSB/AAR-00/03 Adopted August 23, 2000
- Hindenburg – Flight 100 years of Aviation, R.G. Grant, Smithsonian National Air and Space Museum/Duxford Imperial War Museum, ISBN 0-7513037323
- Columbia Accident Investigation Board – Volume 1, Report published by the CAIB on 26 August 2003 and subsequently printed and distributed by NASA and the Government Printing Office, Washington DC. Available on Board web-site: http://www.caib.us/
- Concorde – Bureau Enquêtes-Accidents Preliminary Report "Accident on 25 July 2000 at "La Patte d'Oie"in Gonesse (95), to the Concorde, registered F-BTSC, operated by Air France – English Version"
- R101: The Airship Disaster 1930, 1931, The Stationary Office, London, ISBN: 0 11 702407 4

SHIPPING INCIDENTS

- Disasters at Sea, Capt. Richard A. Cahil, Century, 1990, ISBN: 0-7126-3814
- Bantry Bay - "Disaster at Whiddy Island, Bantry, Co. Cork", Report of the Tribunal of Inquiry, published by the Stationary Office, Dublin
- "Report of the enquiry into the sinking of the "Erika" off the coast of Brittany on 12 December 1999" - Permanent Commission of Enquiry into Accidents at sea (Commission Permanente d'Enquetes sur les Evenements de Mer – CPEM)
- "Grounding of the US tankship Exxon Valdez on Bligh Reef, Prince William Sound near Valdez, Alaska. March 24, 1989" Marine Accident Report PB90-916405 NTSB/MAR-90/04, National Transportation Safety Board.
- "Fire on HMS Glasgow 23 September 1976", Health & Safety Executive/HM Factory Inspectorate, HMSO, 1978, ISBN: 0 11 883075 9
- K-Boats, Steam Powered Submarines in World War 1, Dan Everitt, Airlife Publishing Ltd, ISBN 1-84037-057-2
- MV Herald of Free Enterprise. Report of Court No. 8074 - Formal Investigation (Hon. Mr Justice Sheen - Wreck Commissioner), July 29th 1987. London, Her Majesty's Stationery Office, 1987, ISBN 0 11 550828 7

PETROCHEMICAL INDUSTRY:

- Tosco Hydrocracker explosion & fire - US Environmental Protection Agency Chemical Accident Investigation Report: EPA 550-R-98-009, November 1998
- Mexico City – Lees, F.P., 'Loss Prevention in the Process Industries – Hazard Identification, Assessment and Control', Volume 3, Appendix 4, Butterworth Heinemann, ISBN 0 7506 1547 8, 1996.
- Marsh and McLennan, 'Large Property Damage Losses in the Hydrocarbon-Chemical Industries a thirty-year Review', 16th Edition, Marsh and McLennan Protection Consultants, 1995.
- "Analysis of the LPG Disaster in Mexico City", C.M. Pietersen, TNO, Apeldoorn, Netherlands.
- Tuprus – US Geological Survey Circular 1193, Implications for Earthquake Risk Reduction in the United States from the Kocaeli, Turkey, Earthquake of August 17, 1999
- Bhopal:- "TED Case Studies: Bhopal Disaster," Trade and the Environment Database, 1996. Ashford, N.A.; Gobbell, J.G.; Lachman, J.; Matiesen, M.; Minzner, A.; Stone, R.
- Kalelkar, A.S.; Little, Arthur D., "Investigation of Large-Magnitude Incidents: Bhopal as a case study," Chemical Engineers Conference on Preventing Major Chemical Accidents, London, England, May 1988;
- Marathon HF release – UK Health & Safety Executive Hazardous Installations Directorate "Release of Hydrofluoric Acid from Marathon Petroleum Refinery, Texas, USA. 30th October 1987; website links directly to H&SE's Lifting Procedures guidance. http://www.hse.gov.uk/comah/sragtech/casemarathon87.htm"
- Health and Safety Executive, 'The explosion and fires at the Texaco Refinery', Milford Haven, 24 July 1994: A report of the investigation by the Health and Safety Executive into the explosion and fires on the Pembroke Cracking Company Plant at the Texaco Refinery, Milford Haven on 24 July 1994, ISBN 0 7176 1413 1, 1997.
- Total la Mede – "Etude de l'Accident de la Raffinerie "TOTAL" a la Mede", Dr Ir. P. Michaelis, Risk Manager Total Raffinage Distribution, presented at a meeting of GESIP at Tours on 12 June 1996 (in French).
- Conoco Phillips - Health and Safety Executive Public report of the fire and explosion at the Conoco Philips Humber refinery on 16 April 2001"
- Feyzin – (French) Ministère chargé de l'environnement – DPPR/SEI/BARPI – Inspection des installations classées : Septembre 2005
- P 36 Accident analysis, ANC/DPC Inquiry Commission Report, Agência Nacional do Petróleo/Diretoria de Portos e Costas, July 2001. (Brazilian National Petroleum Agency and Directorate of Port and Coasts joint report).
- Esso Longford – Report of the Royal Commission into the accident at Esso Longford.
- Lessons from Longford, Andrew Hopkins, CCH Australia Ltd., ISBN 1 86468 422 4
- The Fires and Explosion at BP Oil (Grangemouth) Refinery Ltd, a report of the investigations by the Health and Safety Executive into the fire and explosion at Grangemouth

and Dalmeny, Scotland, 13 March, 22 March and 11 June 1987, HSE Books 1989, ISBN: 0 1188 5493 3

- The Flixborough Disaster, Report of the Court of Inquiry, HMSO, 1975, ISBN 011 361075 0
- BP Texas City – web site http://www.bp.com/genericarticle.do?categoryId=9005029&contentId=7015905
- CSB Investigation Report No. 2005-04-I-TX, March 2007 "Refinery Explosion And Fire, Bp Texas City, Texas March 23, 2005" from http://www.csb.gov
- Motiva - US Chemical Safety and Hazard Investigation Report – Refinery Incident - Motiva Enterprises LLC, Delaware City Refinery, Delaware City, Delaware, July 17 2001; issue date October 2002.
- Phillips 66 Company Houston Chemical Complex Explosion and Fire, Implications for Safety and Health in the Petrochemical Industry, A Report to the President by US Department of Labor Occupational Safety and Health Administration, April 1990.
- Public Inquiry into the Piper Alpha Disaster, Volumes 1 & 2, November 1990, HMSO Publications Centre ISBN 0-10-113102-X
- Skikda: "The Incident at the Skikda Plant: Description and Preliminary Conclusions," LNG14, Session 1, March 21, 2004, DOHA-Qatar, Sonatrach.

AMMONIUM NITRATE

- Accident on the 21st of September 2001 at a factory belonging to the Grande Paroisse Company in Toulouse, Report Of The General Inspectorate For The Environment Ministry For Regional Development And The Environment (France), 24 October 2001
- Damages of the Toulouse Disaster 21st September 2001, Nicolas Dechy and Yvon Mouilleau, 11th International Symposium Loss Prevention 2004, Prague.

DUST EXPLOSIONS:

- "Courrières 10 mars 1906 : la terrible catastrophe'' by Bruno Vouters (2006). Lille: Editions La Voix du Nord. ISBN 2-84393-100-2
- US Chemical Safety Board report 2003-07-I-NC Sept. 2004 (West plant)
- US Chemical Safety Board report 2003-09-I-KY February 2005 (CTA Acoustics plant)
- INERIS report "Explosion d'un silo de céréales, Blaye (33)", July 1998
- "Agricultural Dust Explosions in 1997 in the USA", February 27, 1998, University of Kansas State, Department of Grain.

REACTIVE CHEMICALS:

- "BPS Inc., West Helena Arkansas" EPA/OSHA chemical accident investigation report, EPA 550-R99-003, April 1999.

- "Napp Technologies Inc., Lodi New Jersey" EPA/OSHA chemical accident investigation report, EPA 550-R97-002, October 1997.
- "Morton International Inc.", Chemical Safety Board investigation report 1998-06-I-NJ.
- "The explosion at Concept Sciences: hazards of Hydroxilamine", Chemical Safety Board case study 1999-13-C-PA, March 2002.

WAREHOUSES:
- "Sherwin-Williams Paint Warehouse Fire, Dayton, Ohio (May 27, 1987) – With Supplement on Sandoz Chemical Plant Fire, Basel, Switzerland," United States Fire Administration, Federal Emergency Management Agency, Technical Report Series, 1987.
- "Flammable Liquid Warehouse Fire, Dayton, Ohio, May 27, 1987," NFPA Fire Investigations Report.