Guidelines for

Process Hazards Analysis, Hazards Identification & Risk Analysis

PHA

Process Hazards Analysis

CRC

Guidelines for Process Hazards Analysis, Hazards Identification & Risk Analysis

by

Nigel Hyatt

DYADEM

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Over a 24-year period, Mr. Hyatt worked in a leadership role for two major engineering companies, managing and completing projects for significant multinational firms. In 1987, he was Risk Analysis Program Manager for a large tar sands expansion study. He was responsible for the creation, setup and implementation of risk assessment programs that dealt with many leading consulting companies as well as being focused towards meeting the needs of insurance companies.

His experience in the field of risk has been particularly focused on Process Hazards Analysis and facilitation, hazards identification, quantitative risk assessment and risk management. In addition, he also specializes in the field of incident investigation. Moreover, Mr. Hyatt was the originator and key designer of PHA-Pro®, one of the world's best selling hazard identification software tools.

Mr. Hyatt is used to working with, and being responsible for, multi-disciplinary teams of people. He regularly gives courses on process safety and is particularly interested in extending the boundaries and methodologies for hazards evaluation and risk assessment.

Mr. Hyatt is registered as a Professional Engineer in Ontario, is a Chartered Engineer of the U.K. and is also a Member of the Institution of Chemical Engineers. He has 3 children and resides with his wife in Richmond Hill, Ontario.

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Table of Contents

Introduction

Guidelines for Process Hazards Analysis, Hazards Identification & Risk Analysis is a major update to Dyadem's very popular *Process Hazards Analysis Training Manual.* It comes at a time when there is ever increasing awareness of hazardous risks that need to be managed by the industrial community at large.

The guidelines are driven principally by the need to provide practical guidance to both the novice and the seasoned risk professional. The guidelines are also considered to be a useful adjunct to Dyadem's very widely used PHA-Pro® software, Internet reference www.dyadem.com.

Chapters 1 to 4 address Risk Concepts, Regulatory Developments, Risk Terminology and Process Hazards & Risk Management Alternatives. The purpose here is to familiarize the reader with the technical definition of risk, past industrial incidents and their impacts, the legislation for which these incidents have acted as catalysts, the language and terms used in the risk field, types of hazards and simple management strategies.

Chapters 5 to 10 address the different types of structured analytical techniques for conducting Process Hazards Analyses, such as HAZOP, "What if," Checklist, FMEA and so forth. The purpose here is to familiarize readers with the different methods so they understand that different techniques can be used with different applications and for different situations. The user should understand that an older facility, whose drawings are unobtainable or illegible, places different demands on a PHA team than say a new facility, where fully detailed and extensive CAD drawings are available, or a facility that is merely at a conceptual phase only without any drawings. Different situations demand different tools, and this is certainly true in the application of Process Hazards Analysis tools.

Chapters 11 and 12 deal with the subjects of revalidating PHAs and handling Management of Change (MOC) issues, where PHAs may, or may not, be required. With revalidation, it is now understood that there are many issues and concerns with the quality and validity of early PHAs. In addition, new legislation and increasingly stringent demands have to be met to bring these early efforts to an acceptable standard in very many cases. With MOC, companies are continuously updating and modifying their facilities, and the criteria demanding whether or not these changes require PHAs are proposed.

Chapter 13 provides a rapid, order-of-magnitude method of estimating the time required for PHAs. There may, of course, be considerable variance, depending on the experience of the PHA team and the level of detail considered necessary.

Chapter 14 provides guidance in relation to the Management of Hazards associated with the Location of Process Plant Buildings, as well as addressing facility siting issues. When assessing hazards and their impacts on plant personnel and equipment, the overall philosophy of plant layout has changed considerably. It was once considered to be good practice to have equipment located as close as possible, with minimum spacing to minimize pipe runs, etc. and thus minimize plant costs. Incidents, such as Flixborough, 1974, where the control center was located in the heart of the plant and where there were 100% fatalities, have largely changed this approach in favor of safer layouts.

Chapter 15 provides certain important protocols for conducting PHAs and for guidance on safeguarding, especially with respect to Administrative and Engineering Controls, as well as addressing the consequences of failures of such controls.

Chapter 16 addresses human factors. The importance here is not to believe that human error can be totally eliminated, but rather to analyze for factors that can exacerbate and increase the chances of error. Once known, these factors can be addressed in order to minimize the potential for human error.

Chapter 17 deals with Loss of Containment. The different factors to be considered are dealt with qualitatively. Examples of common hazards, e.g., the storage of anhydrous liquid ammonia, LPG, where loss of containment might occur, are presented.

Chapter 18 deals with Managing and Justifying Recommendations that result from PHAs. Since the driving force for risk mitigation and deciding which recommendations should receive priority is somewhat arbitrary, a rationale for applying financial pay-back, based on rate of return applied to the risk, is presented. Different forms of risk matrices are also presented, and their relative merits are discussed.

Chapter 19 looks at PHA Team Leadership issues. It gives direction on the role of the PHA Leader (Facilitator) as well as preparation, setting up, responsibilities, organization and documentation of PHAs. Frequently, the PHA Team-Leader-to-be is thrust into the role where he or she responds "Yes, but what am I supposed to do now?" The object of this chapter is to help such individuals cope and manage what they may regard as an intractable situation.

Chapter 20 provides an overview of the application of Safety Integrity Levels (SILs) in the process industry and the relevant standards ANSI/ISA S84.01 and IEC 61511 developed by the American National Standards Institute / Instrument Society of America, and the International Electrotechnial Commission, respectively.

Chapter 21 provides an overview of Layer of Protection Analysis (LOPA). An example is used to illustrate the concept of building scenarios in LOPA. This is associated with guidance on constructing and assigning numerical values to individual scenario components, i.e., Consequence, Initiating Event, Enabling Event and Condition, Condition Modifier and Independent Protection Layer. It also provides recommendations on the expertise required to conduct LOPA and a template for documenting LOPA.

Chapter 22 addresses some of the basics of Quantitative Risk Assessment (QRA). It is desirable to understand how hazards, once identified, can be quantified in terms of risk from the consequences, i.e., impacts, as well as determining their frequency of occurrence, as likelihood. Although QRA is considered to belong to a more complex form of risk analysis than PHAs, it is felt that an understanding of the basics of QRA are very important for the risk professional.

Appendix I presents a basic methodology for Deriving Deviations from First Principles. The corollary to this appendix is that it allows the user to apply HAZOP to various types of systems or equipment, such as Compressors, Pumps, etc., where it is currently considered to be ineffectual.

Appendix II presents information on the different forms of HAZOP technique currently being used. Although the Parametric Deviation based method is the most widely used, it is not, for example, necessarily the best method for analyzing batch processes. The alternatives, together with their relative merits and an example of Procedural HAZOP, are presented.

Acknowledgements

I would like to acknowledge the assistance of Dyadem Engineering Corporation (DEC) personnel in the preparation of these guidelines.

In addition, feedback from members of Dyadem International Ltd. (DIL) as well as DEC and DIL clientele, typically through PHA-Pro® software use, PHA Training, PHA Facilitation and QRA Projects, and from advisers that DEC has used from time-to-time, have all proven informative.

Nigel Hyatt
Richmond Hill, Ontario
May 2002

Update: To assist the users of this manual, an index has been added. In addition, to accommodate the duel needs of both SI units and English FPS units, clarification has been provided in Chapter 17 to enable both systems to be used.

March 2004

CHAPTER 1

Risk Concepts

Hazardous Event

The release of a material or energy that has the potential for causing harmful effects to:

- The plant personnel;
- The surrounding community at large;
- The environment.

What is Risk?

Risk relates two important factors:

- How *much* of *what* causes *how much damage* to *whom* (or *whatever* else) from the hazardous event, i.e., the **Consequence**.
- How *often* the hazardous event can be expected to occur, i.e., the **Frequency** or **Likelihood**.

Risk is defined as the product of Consequence and Frequency:

RISK = CONSEQUENCE × FREQUENCY

Typical Incidents that Concern Us

- Toxic gas clouds;
- Asphyxiates;
- Fires (jet fires, pool fires, fireballs);
- Explosions (VCEs, BLEVEs, mechanical/chemical explosions);
- Missile hazards;
- Hazardous liquid spills;
- Combustible dusts;
- Corrosive substances.

Industrial Incidents of Major Significance

The following industrial incidents of major significance are listed below and tabulated:

- Ludwigshafen;
- Flixborough;
- Texas City Disaster;
- Romeoville;
- Pemex;
- Bhopal;
- Ufa;
- Pasadena;
- Chernobyl (worst incident ever);
- The Great Halifax Explosion (worst Canadian incident);
- Piper Alpha;
- Visakhapatham;
- Tosco Refinery;
- Toulouse Fertilizer Complex;
- Seveso, Italy;
- Mississauga, Ontario;
- Sandoz, West Germany.

T E X A S   C I T Y   D I S A S T E R

Location:	Texas City Harbor, French Liberty Ship S.S.Grand Camp.
Date:	April 1947
Hazardous material:	Ammonium Nitrate
Event:	2,300 tons of fertilizer in holds caught fire. Attempts to extinguish fire failed resulting in a huge explosion.
Type of incident:	Condensed phase explosion equivalent to c.700 t of TNT.
Damage:	Massive destruction causing entire ship to disintegrate. Huge damage to surrounding area, at least $1 billion by current standards. Destroyed approx. 1/3 rd of town.
Dead & Missing & Homeless:	576 dead and 178 missing, 2,000 homeless

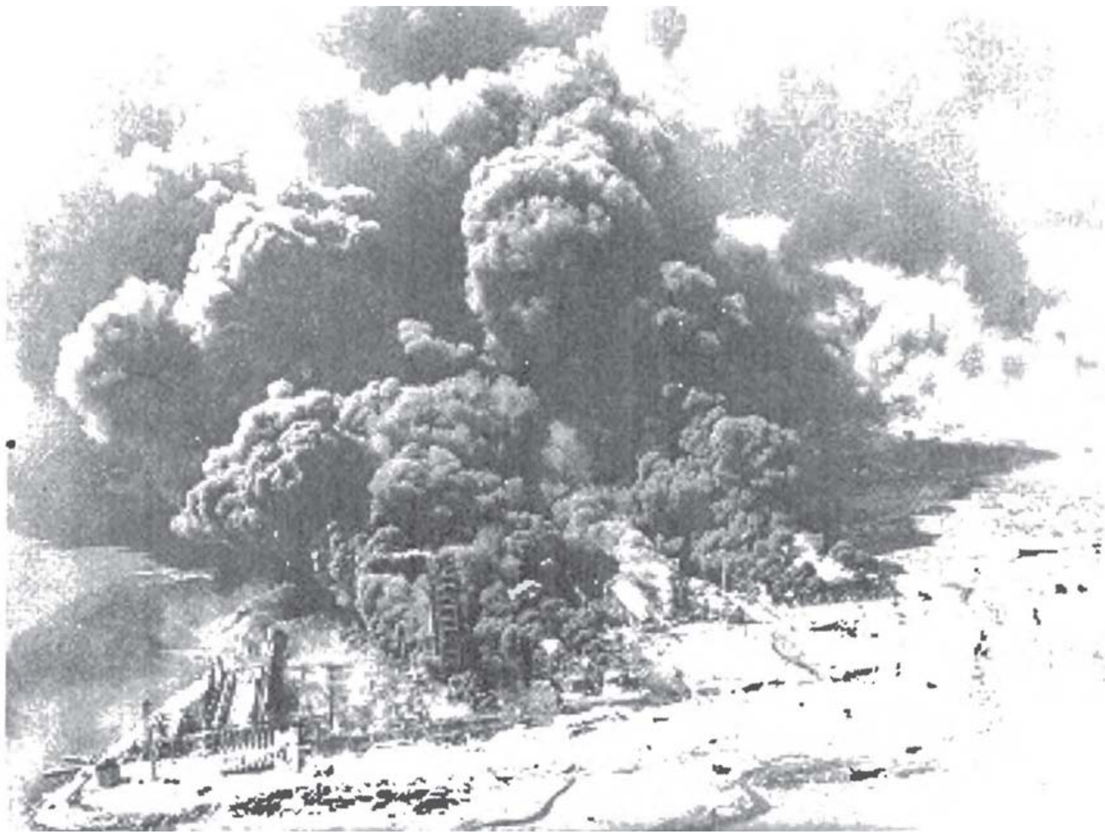

Figure 1-1: Texas City Disaster (Ref: http://www.local1259iaff.org/disaster.html)

L U D W I G S H A F E N

Location:	Chemical facility at Ludwigshafen, Germany.
Date:	July 1948
Hazardous material released:	Dimethyl Ether
Event:	Tank car failure due to overfilling and overheating by the summer sun. The vapor cloud released was ignited 10 to 25seconds later by a welder's torch.
Type of incident:	Vapor cloud explosion equivalent to 20 to 100 t of TNT.
Damage:	Total destruction of a 230 m x 170 m area. Extensive damage over 570 m x 520 m area. $30 millions damage.
Deaths:	207 people killed and 3,818 injured.

F L I X B O R O U G H

Location:	Petrochemical plant, Nypro works, producing 70,000 t/yr. of caprolactam (raw material for nylon) at Flixborough, England.
Date:	June 1974
Hazardous material released:	Cyclohexane
Event:	Massive failure of 20-inch bypass around a cyclohexane reactor, releasing about 40 t of cyclohexane. Approximately 22 t were in the explosive range. Most likely, the ignition source would have been fired heater. Piping most likely failed at the expansion bellows from a temporary dog-leg connection joining two reactors.
Type of incident:	Vapor cloud explosion equivalent to 15 t of TNT.
Damage Onsite:	Total destruction of plant. Destruction of control room, located inside the facility. $48 millions direct damage to plant.
Damage Offsite:	Extended 13 km offsite, including 2,488 houses, shops and factories. Approximately $200 millions offsite damage.
Deaths:	28 people killed (18 in control room) and 36 injured.

ROMEOVILLE

Location:	Union oil refinery at Romeoville, U.S.A.
Date:	July 1984
Hazardous material released:	Hydrocarbons (mainly propane)
Event:	A worker spotted a crack in a circular weld on a 55-ft monoethanolamine (MEA) tower. He attempted to isolate the feeds to the tower but a spark ignited the vapors, causing the 34 t tower to explode. The tower rocketed over 1 km and downed a 130 kV power line. Nearby towers and tanks were ruptured, including an LPG tank that BLEVEd resulting in a second explosion.
Type of incident:	Vapor cloud explosion followed by BLEVE.
Damage:	Severe blast damage within refinery. $500 millions damage.
Deaths:	14 people killed.

P E M E X

Location:	San Ixhuatepec, Mexico, LPG storage distribution center.
Date:	November 1984
Hazardous material released:	LPG
Event:	Explosion during an unloading operation, leading to two 1250 t and four 625 t spheres BLEVEing.
Type of incident:	**B**LEVE (**B**oiling **L**iquid **E**xpanding **V**apor **E**xplosion). 2nd BLEVE worst, causing a 300 to 400 m fireball. 12 explosions in 90 minutes.
Damage Onsite:	Total destruction of facility.
Damage Offsite:	200 homes destroyed and 1800 homes damaged. Homes encroached on area.
Deaths:	542 dead and 4248 injured.

B H O P A L

Location:	Union Carbide's Sevin plant, Bhopal, India.
Date:	December 1984
Hazardous material released:	Methyl isocyanate (MIC)
Event:	2,000 lb. of water entered a storage tank containing MIC. Some MIC boiled off. The vent scrubber was shut down for maintenance so that the vapor could not be neutralized and highly toxic MIC vapor escaped from a 33 m high vent line. The refrigeration system, designed to keep the stored MIC cool, was out of commission. The flare tower was not available since a corroded section of line had not been replaced. The water curtain was not designed for 33 m in height.
Type of incident:	Toxic vapor cloud.
Damage:	No damage to plant itself.
Deaths:	2,000 to 15,000 killed & 200,000 to 300,000 injured due to there being a shanty town surrounding the facility.

U F A

Location:	Ufa, U.S.S.R. NGL transmission pipeline.
Date:	June 1989
Hazardous material released:	Natural Gas Liquids (NGL)
Event:	NGL pipeline was 800 m from railroad and slightly higher. The smell of gas was reported as far as 8 km away from line rupture. Hours after the release, two trains in opposing directions headed into cloud and ignited vapor cloud. The trains derailed and collided into each other.
Type of incident:	Vapor cloud explosion.
Damage:	Trains were destroyed and trees were flattened in 4 km radius.
Deaths:	645 persons killed, many injured.

P A S A D E N A

Location:	Petrochemical plant producing Polyethylene, Pasadena, Texas.
Date:	October 1989
Hazardous material released:	Isobutane, Ethylene and Catalyst carrier
Event:	During routine maintenance of a fluff settling leg on a high-density polyethylene reactor, the entire reactor contents were discharged to the atmosphere. The cloud ignited one minute after release.
Type of incident:	Vapor cloud explosion equivalent to 10 t of TNT.
Damage:	Two complete units were destroyed. Approximately $750 millions damage.
Deaths:	23 killed, 130 injured.

C H E R N O B Y L

Location:	Nuclear power plant, Chernobyl, Ukraine.
Date:	April 1986
Hazardous material released:	Contents of nuclear reactor
Event:	Occurred due to decision by plant management to test ability of turbine generator to power certain cooling water pumps, while generator was freewheeling to a standstill after its steam supply was cut off.
Type of incident:	Local explosion, fire and widespread release of nuclear radiation products.
Damage:	Immense financial and societal impacts, including evacuation of nearby cities.
Deaths:	31 immediate deaths and approximately 75,000 excess cancers in the northern hemisphere. Massive pollution – global impacts. Effects are ongoing.

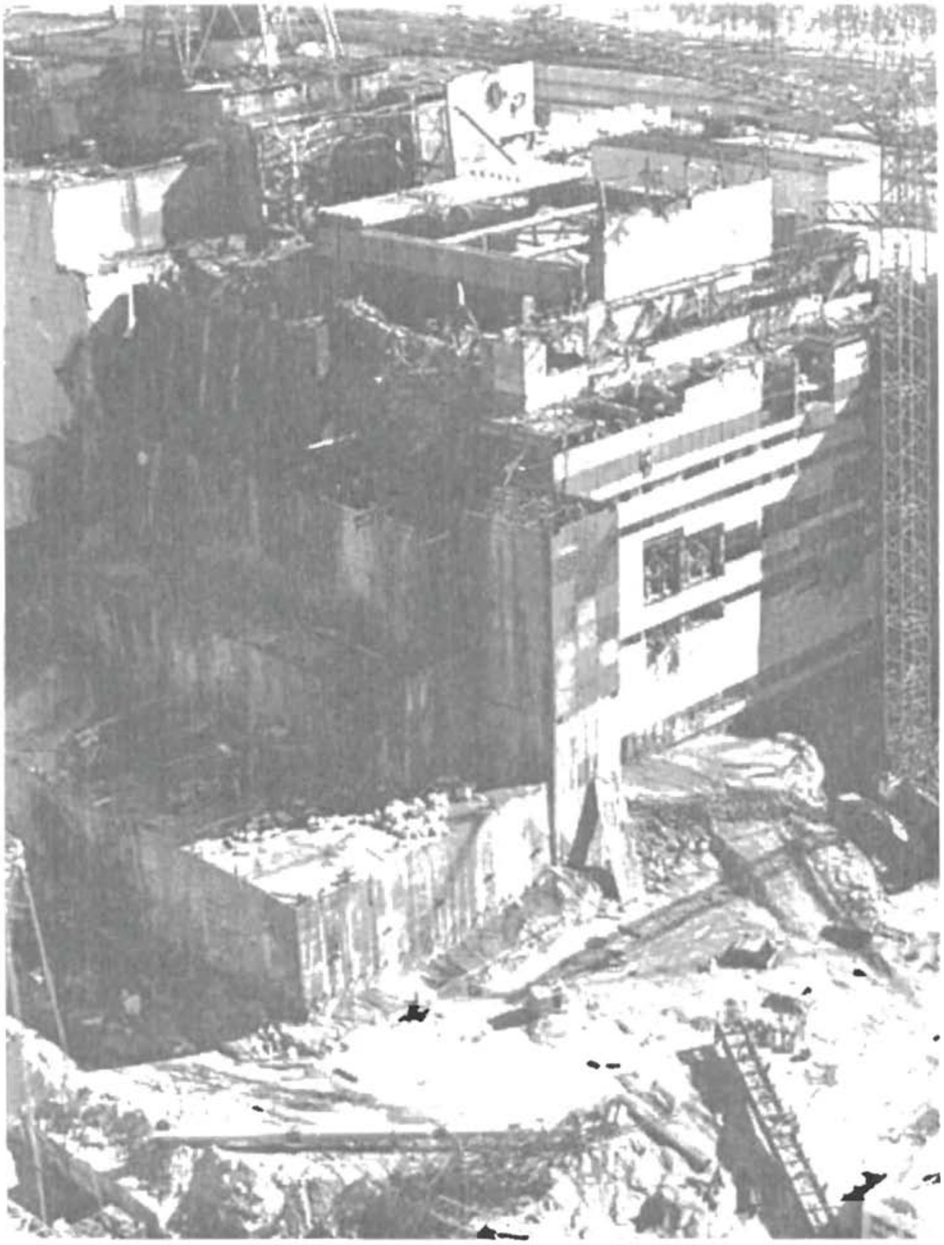

Figure 1-2: Chernobyl Incident (Ref: http://www.ccani.com/chernob.htm)

THE GREAT HALIFAX EXPLOSION

Location:	Halifax harbor (the "narrows"), Nova Scotia.
Date:	December 1917
Event:	The Belgium ship "Imo" collided with the French freighter "Mont Blanc," which was carrying over 2,300 t of picric acid, 200 t of TNT, 35 t of benzole and 10 t of guncotton. There was a fire followed by an explosion, ***creating the world's largest explosion before the atomic bomb dropped on Hiroshima***.
Type of incident:	Massive condensed phase explosion.
Damage:	Large amount of shipping destroyed, 25,000 persons left without shelter, 6,000 lost their homes, 1,600 homes destroyed, 12,000 damaged buildings.
Total cost:	Approximately $15 billion by present-day worth.
Deaths:	1,963 killed. 9,000 injured. 199 blinded.

PIPER ALPHA

Location:	Offshore Production Platform, North Sea, U.K.
Date:	July 1988
Hazardous material released:	Natural gas condensate
Event:	Release and ignition of gas condensate from a section of piping in the gas compression module triggered a chain of fires and explosions, resulting in the almost total destruction of the Piper Alpha Offshore Production Platform. The condensate was released from the former location of a pressure relief valve, which had been removed for maintenance when over pressurizing had occurred. The severity was enhanced by the rupture of oil and gas pipelines connected to the platform, and disabling of most of the emergency systems, as a result of the initial explosion. The control was rendered useless by the explosion.
Type of incident:	Multiple fires and explosions.
Damage:	Total destruction of offshore platform. $1.2 billion.
Deaths:	165 people killed.

VISAKHAPATHAM

Location:	Refinery in India.
Date:	September 1997
Hazardous material released:	Liquefied Petroleum Gas
Event:	A leak developed in a pipeline carrying LPG from a harbor terminal to the refinery. The LPG found a source of ignition that resulted in a large vapor cloud explosion. The resulting fire engulfed 18 storage tanks, destroying 7 tanks containing LPG and crude oil.
Type of incident:	Vapor Cloud Explosion and extensive fire.
Damage:	$23.6 millions.
Deaths:	50 people killed.

TOSCO REFINERY

Location:	Tosco Refinery, Martinez, California.
Date:	February 1999
Hazardous material released:	Hydrocarbons (Naphtha)
Event:	Workers attempted to remove and replace a leaking pipe attached to a fractionating column. Over a 13-day period, repeated attempts had been made to isolate and drain the pipe, but leaking and corroded shut-off valves hampered efforts. While workers were in the process of replacing the pipe section, naphtha was released, causing a fire. At the time, five workers were positioned on scaffolding a hundred feet above the ground and were unable to escape.
Type of incident:	Fire.
Deaths:	4 people killed plus one critically injured.

TOULOUSE FERTILIZER COMPLEX

Location:	Toulouse, France.
Date:	September 2001
Hazardous material released:	Ammonium Nitrate
Event:	Blast was sparked at a site containing 300 tons of ammonium nitrate. Uncertainty as to whether the residue resulting from a leak of sulfuric acid and neutralized by whitewash and caustic soda could have contaminated the store of ammonia nitrate causing a chain reaction starting the explosion.
Type of incident:	Condensed phase explosion.
Damage:	Total destruction of fertilizer plant and significant damage to surrounding community (4,000 homes and 80 schools).
Deaths:	30 dead and 2,000 injured.

SUGGESTED READING (Note: URLs current at date of publication)
"Guidelines for Evaluating the Characteristics of Vapor Cloud Explosions, Flash Fires and BLEVE's" by AIChE, CCPS, 1994 (Chapter 2). www.aiche.org/pubcat/seadtl.asp?Act=C&Category=Sect4&Min=20
"Learning from Accidents" by T.Kletz, pub. by Butterworth-Heinemann, 2001 www.bhusa.com/gulf/us/subindex.asp?maintarget=bookscat%2Fsearch%2Fresults%2Easp&country=United+States&ref=&mscssid=GKTMNF4S2L2C8K5B017248LP4MJXFWVF
"Lessons from Disaster – How Organisations Have No Memory and Accidents Recur" by T.Kletz, pub. by IChemE, 1993 http://harsnet.iqs.url.es/library.htm#books
"What Went Wrong? – Case Histories of Process Plant Disasters" by T.Kletz, pub. by Gulf Publishing, 1998 www.processassociates.com/bookshelf/publisher/gulf_2.htm
Piper Alpha – Spiral to Disaster", AIChE, CCPS (Videotape), 2001 www.aiche.org/pubcat/seadtl.asp?Act=C&Category=Sect4&Min=60
"Loss Prevention in the Process Industries" by F.P.Lees, published by Butterworth-Heinemann, 1996. (Volume 3, Appendices 1 to 6, 16, 19, 21 & 22) www.aiche.org/pubcat/seadtl.asp?Act=C&Category=Sect4&Min=50
"Large Property Damage Losses in the Hydrocarbon-Chemical Industries – A Thirty-year Review", 18th edition, 1998, Risk Control Strategies, J&H Marsh & McLennan www.mmc.com/frameset.php?embed=risk/index.php
"Large Property Damage Losses in the Hydrocarbon-Chemical Industries – A Thirty-year Review", Trends and Analysis, 19th edition, February 2001, Marsh Risk Consulting www.mmc.com/frameset.php?embed=risk/index.php
U.S. Chemical Safety and Hazards Investigation Board – Incidents Report Center (Website) www.chemsafety.gov/circ/
"A $100-million vapor cloud fire" by R.S.Al-Ameeri et al., Hydrocarbon Processing, November 1984, pages 181 to 188 www.hydrocarbonprocessing.com/contents/publications/hp/
"HPI loss-incident case histories" by C.H. Vervalin, Hydrocarbon Processing, February 1978, pages 183 and following www.hydrocarbonprocessing.com/contents/publications/hp/
"Process Safety Analysis, An Introduction" by Bob Skelton, IChemE, 1997 www.icheme.org/framesets/aboutusframeset.htm

CHAPTER 2

Regulatory Developments

North America

Bodies and Regulatory Developments in North America

1985:

- The American Institute for Chemical Engineers (AIChE) forms the Center for Chemical Process Safety (CCPS)
- The Chemical Manufacturers Association (CMA) creates the Community Awareness Response Program (CAER) as a result of Bhopal. CAER was initiated by the Canadian Chemical Producers' Association (CCPA)

1990:

- The American Petroleum Institute (API) - Recommended Practice # 750: Management of Process Hazards
- US Environmental Protection Agency (EPA) - The Clean Air Act

1992:

- US Occupational Safety and Health Administration (OSHA) - 29 CFR 1910.119: Process Safety Management of Highly Hazardous Chemicals and Blasting Substances

1996:

- EPA - 40 CFR Part 68: Accidental Release Prevention Requirements: Risk Management Program under CAA, Section 112(r)(7)
- Commonly referred to as the "RMP Rule"

Individual States Legislation in the USA

1985:

- Hazardous Materials Management, California.

1986:

- Toxic Catastrophic Prevention Act, New Jersey.
- Air Control Board Permit Review Program, Texas.

1988:

- Extremely Hazardous Substances Risk Management Act

Occupational Safety and Health Administration (OSHA), Process Management of Highly Hazardous Chemicals and Blasting Substances Regulations – 29 CFR 1910.119

- Process Safety Management of Highly Hazardous Chemicals and Blasting Substances
- Driven by the Pasadena incident in Texas
- Amalgam of API 750, Community Awareness and Emergency Response (CAER) and 3 states legislations; Delaware, California & New Jersey.

Applies to:

- Specific hazardous chemicals (thresholds defined).
  - Flammable liquids and gases exceeding 10,000 lb. inventory

Excludes:

- Many storage-only type facilities.

Key Elements of OSHA 1910.119

- Employee Participation
- Process Safety Information
- Process Hazards Analysis
- Operating Procedures
- Training
- Contractors
- Pre-startup Safety Review
- Mechanical Integrity
- Hot Work Permit
- Management of Change
- Incident Investigations
- Emergency Planning & Response
- Compliance Audits
- Trade Secrets

Employee Participation

Employee Participation requires employers to involve employees at an elemental level of the PSM program. Minimum requirements for an Employee Participation Program for PSM must include a written plan of action for implementing employee consultation on the development of process hazard analyses and other elements of process hazard management contained within 1910.119. The employer must also provide ready access to all the information required to be developed under the standard.

Process Safety Information

With Process Safety Information the intent is to provide complete and accurate information concerning the process which is essential for an effective process safety management program and for conducting process hazard analyses. The employer is required to compile written process safety information on process chemicals, process technology, and process equipment before conducting any process hazard analysis.

Process Hazard Analysis

The intent of performing Process Hazards Analyses is to require the employer to develop a thorough, orderly, systematic approach for identifying, evaluating and controlling processes involving highly hazardous chemicals. Minimum requirements include:

(1) Setting a priority order and conducting analyses according to the required schedule;

(2) Using an appropriate methodology to determine and evaluate the process hazards;

(3) Addressing process hazards, previous incidents with catastrophic potential, engineering and administrative controls applicable to the hazards, consequences of failure of controls, facility siting, human factors, and a qualitative evaluation of possible safety and health effects of failure of controls on employees;

(4) Performing PHA by a team with expertise in engineering and process operations, the process being evaluated, and the PHA methodology used;

(5) Establishing a system to promptly address findings and recommendations, assure recommendations are resolved and documented, document action taken, develop a written schedule for completing actions, and communicate actions to operating,

maintenance and other employees who work in the process or might be affected by actions;

(6) Updating and revalidating PHA's at least every 5 years; and

(7) Retaining PHA's and updates for the life of the process.

Operating Procedures

For Operating Procedures the intent is to provide clear instruction for conducting activities involved in covered processes that are consistent with the process safety information. The operating procedures must address steps for each operating phase, operating limits, safety and health considerations, and safety systems and their functions.

Training

Training helps employees and contractor employees understand the nature and causes of problems arising from process operations, and increases employee awareness with respect to the hazards particular to a process. An effective training program significantly reduces the number and severity of incidents arising from process operations, and can be instrumental in preventing small problems from leading to a catastrophic release. Minimum requirements for an effective training program include: Initial Training, Refresher Training, and Documentation.

Contractors

The intent of addressing Contractors (including Subcontractors) is to require employers who use them to perform work in and around processes that involve highly hazardous chemicals to establish a screening process so that they hire and use contractors who accomplish the desired job tasks without compromising the safety and health of employees at a facility. The contractor must assure that contract employees are trained on performing the job safely, of the hazards related to the job, and applicable provisions of the emergency action plan.

Pre-startup Safety Review

The intent of Pre-Startup Safety Review is to make sure that, for new facilities and for modified facilities, when the modification necessitates a change to process safety information, certain important considerations are addressed before any highly hazardous chemicals are introduced into the process. Minimum requirements include that the pre-startup safety review confirm the following: construction and equipment is in accordance with design specifications; safety, operating, maintenance, and emergency procedures are in place and adequate; for new facilities, a PHA has been performed and recommendations resolved or implemented; modified facilities meet the requirements of management of change; and training of each employee involved in the process has been completed.

Mechanical Integrity

Mechanical Integrity requirements mean that equipment used to process store, or handle highly hazardous chemicals is designed, constructed, installed, and maintained to minimize the risk of releases of such chemicals. A mechanical integrity program must be in place to assure the continued integrity of process equipment. The elements of a mechanical integrity program include the identification and categorization of equipment and instrumentation, development of written maintenance procedures, training for process maintenance activities, inspection and testing, correction of deficiencies in equipment that are outside acceptable limits defined by the process safety information, and development of a quality assurance program.

Hot Work Permit

The intent of Hot Work Permitting is to ensure that employers control, in a consistent manner, non-routine work conducted in process areas. Specifically, this is concerned with the permitting of hot work operations associated with welding and cutting in process areas.

Minimum requirements include: that the employer issue a hot work permit for hot work operations conducted on or near a covered process and that hot work permits shall document compliance with the fire prevention and protection requirements of 29 CFR 1910.252(a).

Management of Change

Management of Change requires management of all modifications to equipment, procedures, raw materials and processing conditions other than "replacement in kind" by identifying and reviewing them prior to the implementation of the change. Minimum requirements for management of change include: establishing written procedures to manage change; addressing the technical basis, impact on safety and health, modification to operating procedures, necessary time period, and authorizations required; informing and training employees affected; and updating process safety information and operating procedures or practices.

Incident Investigations

The employer is required to investigate each incident which resulted in, or could reasonably have resulted in a catastrophic release of highly hazardous chemical in the workplace. An investigation shall be initiated no later than 48 hours following the incident. An investigation team shall be established and a report prepared which includes: 1) Date of incident 2) Date investigation began 3) Description of incident 4) Factors that contributed to the incident 5) Recommendations from the investigation. The employer is required to establish a system to promptly address the incident report findings and recommendations, documenting all resolutions and corrective actions. Incident reports shall be reviewed with all affected personnel whose job tasks are relevant to the investigation and retained for five years.

Emergency Planning and Response

Emergency Planning and Response requires the employer to address what actions employees are to take when there is an unwanted release of highly hazardous chemicals. The employer must establish and implement an emergency action plan in accordance with the provisions of 29 CFR 1910.38(a) and include procedure for handling small releases. Certain provisions of the hazardous waste and emergency response standard, 29 CFR 1910.120(a) which addresses scope, application, and definitions for the entire standard, while (p), which addresses treatment, storage, and disposal (TSD) facilities under the Resource Conservation and Recovery Act (RCRA) and (q), which addresses requirements for facilities that are not RCRA TSD's, where there is the potential for an emergency incident involving hazardous substances may also apply.

Compliance Audits

Compliance Audits are required so that employers can self-evaluate the effectiveness of their PSM program by identifying deficiencies and assuring corrective actions. Minimum requirements include: audits at least every three years; maintenance of audit reports for at least the last two audits; audits conducted by at least one person knowledgeable in the process; documentation of an appropriate response to each finding; documentation that the deficiencies found have been corrected.

Trade Secrets

The intent with Trade Secrets is to require employers to provide all information necessary to comply with the standard to personnel developing Process Safety Information, Process Hazard Analysis, Operating Procedures, Engineering Planning and Response and Compliance Audits without regard to possible trade secrets. In addition, employees and their designated representatives shall have access to trade secret information contained within documents required to be developed by the standard.

Environmental Protection Agency (EPA), Risk Management Plan (RMP) Rule – 40 CFR Part 68

- Enacted on: June 20, 1996
- Final RMP Submission Deadline: June 21, 1999
- Chemical Safety Information, Site Security and Fuels Regulatory Relief Act, 1999:
  - o Parts of the 'RMP Info' that contain Offsite Consequence Analyses (OCA) information will not be accessible to the public over the Internet as was planned for June 21, 1999.
  - o OCA information is accessible in the form of paper copies of Sections 2 through 5 of Risk Management Plans at the eleven Federal Reading Rooms, open to public as of March 12, 2001.

Applies to:

- Specific hazardous substances with defined threshold
- Covered hazardous substances specified in List Rule of January 31, 1994 (40 CFR Parts 9 and 68)

Compared to OSHA 1910.119:

- Applies to all facilities containing greater than threshold quantity, including storage-type facilities for hazardous substances

  Risk Management Program requirements include implementation of:

  - o Hazard Assessment - Worst Case, Alternative Case Scenarios, 5-Year Accident History
  - o Prevention Programs - Level 1 to 3
    - Level 1 - No impact level
    - Level 2 - Streamlined Mini-OSHA PSM Requirements
    - Level 3 - Requirements very similar to OSHA PSM
  - o Emergency Response Programs

In addition, a Risk Management Plan must be submitted to EPA consisting of:

- o Executive Summary
- o Registration Information
- o Offsite Consequence Analysis
- o Five-year Accident History
- o Prevention Program Information - Level 2 and 3
- o Emergency Response Program Information
- o Certification Statement

List of Hazardous Substances

The list is composed of three categories:

- 77 toxic substances; threshold quantities established from 500 to 20,000 pounds.
  - o 63 flammable substances; threshold quantity is established at 10,000 pounds.
  - o Explosive substances with a mass explosion hazard by Department of Transportation (DOT). Threshold quantity is established at 5,000 pounds.

Amendments to the List Rule

On August 25, 1997

- o Changed the listed concentration of hydrochloric acid.

On January 6, 1998

- o Delisted Division 1.1 explosives (classified by DOT), to clarify certain provisions related to regulated flammable substances and the transportation exemption.

On March 13, 2000

- o In accordance with the *Chemical Safety Information, Site Security and Fuels Regulatory Relief Act,* the list of regulated flammable substances excludes those substances when used as a fuel or held for sale as a fuel at a retail facility.

Amendments to the RMP Rule

On January 6, 1999

- o Added several mandatory and optional RMP data elements

  - Established procedures for protecting confidential business information
  - Adopted a new industry classification system

On May 26, 1999

- o Modified the requirements for conducting Worst Case Release Scenario Analyses for flammable substances and to clarify its interpretation of CAA sections 112(1) and 112(r)(11) as they relate to DOT requirements under the Federal Hazardous Transportation Law.

United Kingdom

Health and Safety at Work Etc. Act (1974)

1974 - Health and Safety Executive (HSE)

Health and Safety Commission (HSC) - Advisory Committees

- Advisory Committee on Dangerous Substances (ACDS)
- Advisory Committee on Toxic Substances (ACTS)
- Chemical Industries Forum

HSE's Safety Policy Directorate

- Control of Major Accident Hazards (COMAH) regulations - 1999

HSE's Health Directorate

- Control of Substances Hazardous to Health (COSHH) regulations - 1999

HSE Guides for COMAH & COSHH

- A Guide to the Control of Major Accident Hazards (COMAH) Regulations, 1999; Guidance on Regulations, HSE
- COMAH Safety Report Assessment Manual, HSE
- Major Accident Prevention Policies for Lower-Tier COMAH Establishments, HSE
- COSHH Essentials: Easy Steps to Control Chemicals: Control of Substances Hazardous to Health Regulations, HSE
- A Step-By-Step Guide to COSHH Assessment, HSE
- Technical Basis for COSHH Essentials; Easy Steps to Control Chemicals, HSE

European Commission (EC)

Seveso I Directive (1982)

- Seveso I Directive (1982) was based on Article 174 of EC Treaty.
- Identification of installation concerned (based on substance and quantities handled).
- Operator provides safety report to authorities.
- Emergency Response Plan (ERP) must be established.
- Community Awareness of Risks and Emergency Response Plan.
- Accident notification procedures.

Seveso II Directive (1999)

- Seveso II Directive was proposed in December 1996 to include an extended scope and introduction of
    - Safety management systems,
    - Emergency planning,
    - Land-use planning,
    - Reinforcement of the provisions on inspections.
- Driven by the incident at Seveso, Italy. Amended twice, after accidents at
    - Bhopal, India (1984), Union Carbide
    - Basel, Switzerland (1986), Sandoz
- Seveso II has fully replaced the original Seveso Directive as of February 1999.

Seveso II Directive (Cont'd)

The Seveso II Directive is implemented in the UK as the COMAH Regulations. These came into force in February 1999 and it improves Seveso I Directive by

- Emphasizing management factors
- Introducing a Major Accident Prevention Plan (MAPP)
- Emphasizing that Safety Reports should
    1. Address potential hazards
    2. Be submitted to credible authorities
    3. Consider management and organizational issues
- Applying provisions to individual installations (plants) as well as whole plants
- Considering effects of an incident on surrounding plants
- Publishing the reports (after removing confidential information)
- Having Emergency plans
    1. With content defined explicitly in Directive
    2. That are tested regularly

Ongoing Revisions to Seveso II Directive

- Currently, revisions to Seveso II Directive are underway following accidents at
    - a mining facility in Baia Mare, Romania (Jan 2000), and
    - *storage* facility of fireworks in Enschede, Netherlands (May 2000).
- These events drive the need for Seveso II Directive to cover hazards from
    - storage and processing activities *in mining,* and
    - storage and manufacturing of *pyrotechnic substances*, specifically.

SUGGESTED READING (URLs current at time of publication)
OSHA Process Management of Highly Hazardous Chemicals & Blasting Substances – 29 CFR 1910.119 (Website) www.osha-slc.gov/FedReg_osha_pdf/FED19990323.pdf
EPA, Risk Management Plan (RMP) Rule – 40 CFR Part 68 (Website) www.access.gpo.gov/nara/cfr/cfrhtml_00/Title_40/40cfr68_00.html
Seveso II Directive Information (Website) www.ipk.ntnu.no/ross/Info/Law/Seveso2.htm
Control of Major Hazards (COMAH) Regulations (Website) www.hse.gov.uk/spd/noframes/spdcomah.htm
Control of Major Hazards (COMAH) Assessment Manual (Website) www.hse.gov.uk/hid/land/comah2/
API (American Petroleum Institute) Recommended Practice (RP) 750 : Management of Process Hazards http://api-ep.api.org/filelibrary/ACF4B.pdf
"Guidance on the Preparation of a Safety Report to Meet the Requirements of Council Directive 96/82/EC (SEVESO II)" by G.A.Papadakis & A.Mendola, published by the Institute for Systems Informatics and Safety (Website) www.ipk.ntnu.no/fag/SIO3043/Notater/Rapporter/safety-report-txt.RTF
"Model Risk Management Plan Guidance for Petroleum Refineries":API 760, 1997, American Petroleum Institute http://api-ep.api.org/filelibrary/ACF4B.pdf
"Model risk management program and plan for ammonia refrigeration", US EPA/CEPPO, 1996 (Website) www.epa.gov/swercepp/rules/ammon.pdf
"COMAH and the Environment – Lessons Learned from Major Accidents 1999 – 2000" by A.Whitfield, Process Safety and Environmental Protection pub. By IChemE, January 2002, pages 40 to 46 www.icheme.org/framesets/aboutusframeset.htm