

Overview: An Integrated Approach for Process Safety and Loss Management

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Abstract

Process Safety and Loss Management encompasses a wide range of programs dealing with managing changes in people, equipment, and technology for the purpose of minimizing or eliminating unexpected losses. It has its basis in traditional occupational safety management but requires integration of numerous other programs which are normally found in operations, maintenance, engineering, and human resources. The success of a Process Safety and Loss Management program is dependent on success of the programs which directly affect process safety - programs over which the process safety coordinator has no direct control. Auditing and Incident Investigation provide a means for monitoring the success of these programs.

Keywords

process safety management
loss management
management of change
auditing

1. Introduction

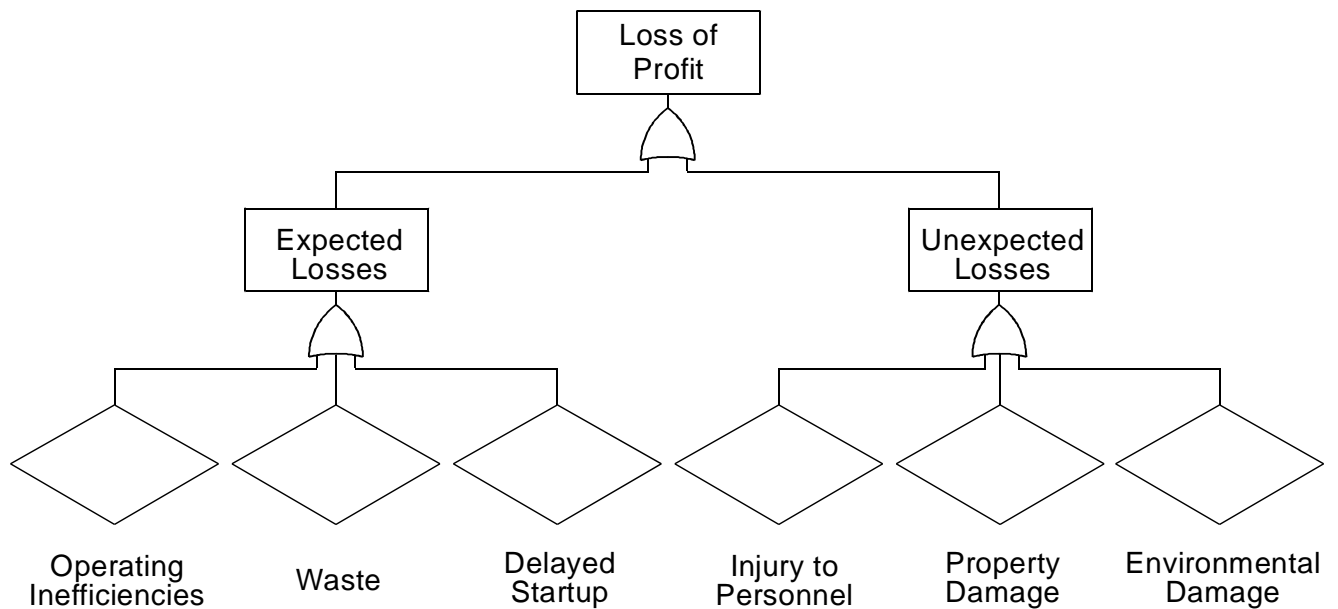
Process Safety was rarely addressed prior to the tragedy at Bhopal in 1984. The subsequent formation of the Centre for Chemical Process Safety of the American Institute of Chemical Engineers was followed by other organizations such as the Chemical Manufacturers Association (CMA, 1985), Union Carbide (Union Carbide, 1987) and the American Petroleum Institute (API, 1990) formulating programs to identify and address various aspects of process safety from a management perspective, giving rise to a new concept - Management of Process Safety.

Process Safety Management is often considered a stand-alone program - a program that if properly managed will result in a safe operation. But such an approach cannot adequately deal with all the challenges to process safety since the challenges often originate outside the bounds of such a program. Process Safety Management requires an integrated approach across a facility or organization to assure that every item which could initiate a process-related incident is adequately addressed.

2. Loss Management

Facilities are operated to generate income and profits for the organization; management of these facilities requires that profit be maximized by minimizing losses. Such losses can be divided into two main categories - expected losses and unexpected losses as illustrated in Figure 1. The expected losses result from operating inefficiencies, excessive waste, delayed startup and various other causes; unexpected losses result from injury to personnel, property damage, or environmental damage due to incidents or accidents. Prevention of these accidents is the focus of Safety and Loss Management Programs.

Figure 1 - Fault Tree for Loss Management



Safety and Loss Management can be divided into two broad categories for controlling incidents - Occupational Safety and Process Safety. An Occupational Incident normally affects one individual - a company or contract employee - and the individual has control of the hazard. These incidents include, for example, slips, falls, and back injuries. A Process Incident can affect several individuals including employees, contractors, and the public; it can result in property damage and environmental damage; and those involved have only limited control over the hazard. These incidents include fire, explosion, and release of toxic fumes, due to causes such as runaway reaction, corrosion, and pump seal failure.

Safety programs aimed at preventing Occupational incidents must have different goals and focus than those directed at Process incidents. Occupational Safety programs attempt to eliminate injuries to personnel while Process Safety programs focus on eliminating process-related accidents which could include explosion/implosion, fire, exposure to hazardous materials, electrical shock, material spills, and exposure to ionizing radiation.

Management of these Safety Programs must also be different if satisfactory results are to be achieved. Occupational Safety Management focuses on the individual while considering interaction with equipment; Process Safety Management focuses on the process material and includes equipment and the individual as part of the system.

3. Process Safety Management

Process Safety Management is a subset of System Safety Management and is based on the concept that the material being processed creates the hazard. Process Safety incidents are caused by changes in the material, either spontaneously or as a result of external operations. These changes could include loss of containment, spontaneous decomposition, increased pressure or temperature, contamination, and various others. If nothing changes, by definition, there cannot be an incident since the status quo will be maintained.

Kepner and Tregoe (Kepner-Tregoe, Inc, 1979) postulated as early as 1970 that problems, i.e. deviations from expected performance, can occur only if something changes or if a deviation existed from the day the system was put into service. In order to determine the cause of a deviation one must analyse changes which occurred in the system prior to the deviation. In the case of a Day 1 Deviation the problem will normally be identified as soon as the system is started; if it is not identified at startup a change in operating conditions will be required to cause the problem to occur.

A recent incident at Novacor's Joffre Alberta plant was caused by a Day 1 deviation. A 16" weldolet was installed on an 18" line and over the course of 15 years the weld weakened to the point that a leak of ethylene occurred. The changing temperatures associated with plant shutdowns and restarts were enough to cause the weld to begin to leak. Similar incidents in the ethylene industry have been caused by improper material installed in low temperature service during original construction. The faulty material performed well until the temperature dropped below the embrittlement point.

In the broadest sense, Process Safety Management is management of changes which can occur in the process, the equipment, and the people. These changes cannot be avoided but must be managed if process-related accidents are to be prevented or the consequences reduced to an acceptable level. Since changes can originate from anywhere within the organization an integrated approach to Process Safety Management is required to assure that all potential challenges have been addressed.

4. Evolution of Process Safety Management

Prior to 1974, the focus of Safety Management was on preventing occupational incidents by dealing directly with the worker. There was some development in the area of system safety using techniques such as The Guideword Approach (Knowlton, R.E. 1992) and Fault Tree Analysis for hazard and cause identification; however, most companies believed that proper training and education of the worker was sufficient to prevent downgrading incidents.

In 1974, the explosion at Flixborough alerted managers and engineers to the off-site damage which could result from process-related accidents. The release of 50 tonnes of cyclohexane was the result of an inadequately designed bypass line. The subsequent explosion was sufficient to destroy the control room and cause the death of 28 workers. The following comments come from 'Myths of the Chemical Industry' (Kletz, T.A. 1984)

"There was no professionally qualified engineer on the plant at the time the temporary pipe was built. The men who designed and built it - design is hardly the word as the only drawing was a full-scale sketch in chalk on the workshop floor - did not know how to design large pipes which are required to operate at high temperatures (150C) and gauge pressures (10 bar), and made no attempt to think through the results of the modification. Very few engineers have the specialized knowledge to design highly-stressed piping but in addition, the engineers at Flixborough did not know that design by experts was necessary or that modifications should be probed systematically. They did not know what they did not know."

This incident provided the impetus for hazard reviews on new or modified equipment and design of new plants began to reflect the need for mitigating the consequences of process-related accidents. Novacor owns five plants which were being designed or constructed at the time of the Flixborough explosion. As a direct result of the incident three of these facilities were provided with a blast resistant control room. The interesting aspect of this is the fact that all these plants were owned by different companies at the time they were being constructed. Flixborough also made it obvious that companies must do a better job in identifying potential hazards associated with engineering designs; therefore, the Process Hazard Review became a key part of the engineering design process.

In 1984, the tragedy at Bhopal showed the human devastation that could result from a process related accident. It was almost inconceivable that over 2000 people could be killed and thousands more injured due to the release of a material from a chemical manufacturing facility. The immediate response from governments and industry was to ask if the same thing could happen elsewhere. As a direct result of this incident The Centre for Chemical Process Safety (CCPS) was formed by the American Institute of Chemical Engineers. Environment Canada produced the report Bhopal Aftermath: An Assessment of the Canadian Situation with several recommendations which, if implemented, should prevent such an incident from occurring in Canada. One of these recommendations led to the formation of the Major Industrial Accidents Coordinating Committee (MIACC), now called the Major Industrial Accidents Council of Canada, a multi-stakeholder organization whose mission is to reduce the frequency and severity of industrial accidents.

Several publications related to Process Safety Management were developed to assist companies in addressing the subject (CMA, 1985; Union Carbide, 1987; CCPS, 1989; API, 1990; OSHA, 1992). Each publication addresses Process Safety Management and yet there are differences in approach and content. The CCPS publication, in particular, represents Industry consensus and gives some insight into causes of the variation in approaches. The guidelines contain 68 components of Process Safety Management grouped into the following 12 elements:

1. Accountability: Objectives and Goals
2. Process Knowledge and Documentation
3. Capital Project Review and Design Procedures
4. Process Risk Management
5. Management of Change
6. Process and Equipment Integrity
7. Human Factors
8. Training and Performance
9. Incident Investigation
10. Standards, Codes, and Laws
11. Audits and Corrective Actions
12. Enhancement of Process Safety Knowledge

These elements cover a wide area from management to operations to maintenance to engineering and while the list is fairly comprehensive in dealing with hardware, it doesn't deal well with the variety of changes in people which can result in process-related accidents.

5. An Integrated Approach to Process Safety Management

Process Safety Management, as indicated by the previous references, is often considered to be a single program or group of programs monitored by one individual. But Process Safety should be viewed as the end result of properly managing changes - Changes in Technology, Changes in Equipment, and Changes in People. It is not possible for a single person, program, or department to manage these changes effectively; therefore, an integrated approach which crosses departmental bounds must be used to be successful in Process Safety Management.

Supervisors and managers play an important part in this integrated approach since they create the climate that fosters voluntary participation and compliance throughout the company on all activities. The first step in obtaining this commitment is communication of the company policy or vision statement (see attachment A) which makes it clear that all employees, not just managers or supervisors, must be involved in these activities. This is best illustrated by considering the broad range of challenges to process safety in which employees may be involved. The examples identified below are possible methods for dealing with these challenges; however, each facility must identify the challenges which exist at a specific site and develop or adapt programs to suit the site needs.

Changes in Technology are shown in Table 1 along with the type of program which might address the challenge and the department which could be responsible for overseeing it. For example, a new chemical is the type of challenge which could result in an undesired event. Introduction of the chemical should be subjected to a series of reviews which could fall under Management of Change, Experimental Operations, and other site programs. The primary responsibility would probably fall under the Technical Department, but Purchasing, Inspections/Reliability, Operations, and Health, Safety, and Environment would all expect to have input into the decision to purchase and use a new chemical. Without this input there is no guarantee that the chemical would not create an adverse situation.

Table 1 - Changes in Technology

<u>Challenge</u>	<u>Program</u>	<u>Responsibility</u>
New Chemical	Management of Change Experimental Operating Procedures Purchasing Procedures Reactive Chemicals MSDS System	Technical, Operations, Technical, Operations, Purchasing, Risk Control Technical, Lab Industrial Hygiene
New Process	Management of Change Experimental Operating Procedures Critical Operating Parameters	Technical, Operations, Technical, Operations, Technical, Operations,
New Procedures	Experimental Operating Procedures Operating Procedure Review	Technical, Operations, Operations

Changes in Equipment are shown in Table 2. These are the changes most often associated with a Management of Change program. The cause of the incident at Flixborough could be considered as a failure to properly manage a temporary change in a facility. But there are more subtle changes such as wear and corrosion which must also be addressed since they have the potential to result in devastating consequences. The explosion at Mexico City which killed over 500 people was the result of failure of a corroded line. These changes would normally fall under the Preventive Maintenance Program in the Maintenance or Inspections Departments.

Table 2 - Changes in Equipment

<u>Challenge</u>	<u>Program</u>	<u>Responsibility</u>
Replacement in Kind	Maintenance Procedures	Maintenance
New Equipment	Management of Change Capital Project System	Engineering, Operations Engineering
Wear, Corrosion, Erosion	Preventive Maintenance	Maintenance, Inspections Operations
Overpressure	Safety Interlocks Operating Procedures Critical Operating Parameters	Operations, Maintenance Operations Operations, Technical

Table 3 outlines Changes in People. These are generally the most subtle but also have the greatest potential for creating a process-related accident. For example, working under the influence of drugs or alcohol is known to result in process related accidents and yet it is rare that this program ever falls under the Process Safety Management umbrella. It is normally found as part of the Human Resources or Health Services programs. In general, the physical and mental abilities of those doing the work is critical to proper performance and yet the ultimate responsibility for these lies with departments which are not directly associated with the manufacturing process.

Table 3 - Changes in People

<u>Challenge</u>	<u>Program</u>	<u>Responsibility</u>
Organizational Change	Management of Change	Operations, Human Resources Organizational Development
Misuse of Alcohol/Drugs	Drug and Alcohol Abuse Program	Human Resources, Operations Health Services
Aging	Job Evaluation Program Annual Medical	Operations, Maintenance Health Services
Off the Job Injury	Medical Assessment Program	Health Services
New Employees	Selection Interviewing Orientation Training Manuals Job Qualification	All Departments All Departments All Departments Operations, Maintenance
Promotion of Employees	Job Qualification Performance Evaluation	All Departments All Departments

To properly manage Process Safety it is necessary to adopt an integrated approach where all departments and employees have a role. It is not sufficient to put responsibility on Engineering or Operations since the systems necessary to manage critical programs often are the responsibility of other professionals outside the process areas. The key to developing such an approach to Process Safety Management is to identify the challenges - the changes in Technology, Equipment, and People - which can result in process-related accidents and put programs in place to deal with them.

6. Continuous Improvement through Incident Investigations and Audits

Programs associated with Process Safety and Loss Management should not be seen as static but must be part of continuous improvement activities. The results must relate to performance of the company with respect to employees, contractors, and the public. The pace and dedication in the implementation of programs is absolutely essential. Many companies apply extraordinary effort in the initial implementation then when reasonable results are achieved they tend to back off eventually resulting in poorer results. Thus, a sinusoidal pattern sets in with disastrous results on the morale and climate throughout the organization.

In Figure 2 continuous improvement is contrasted with the sinusoidal performance of companies that devote varying resources to Process Safety and Loss Management. The typical sinusoidal curve could represent a company that becomes satisfied with their performance only to see it slip. Response to the slide is relatively quick, but the overall performance tends to be no better than average. The erratic sinusoidal could be a company that devotes large resources to improving safety performance, only to see the performance deteriorate when the next 'hot' item arises.

Figure 2 - Program Implementation and Performance

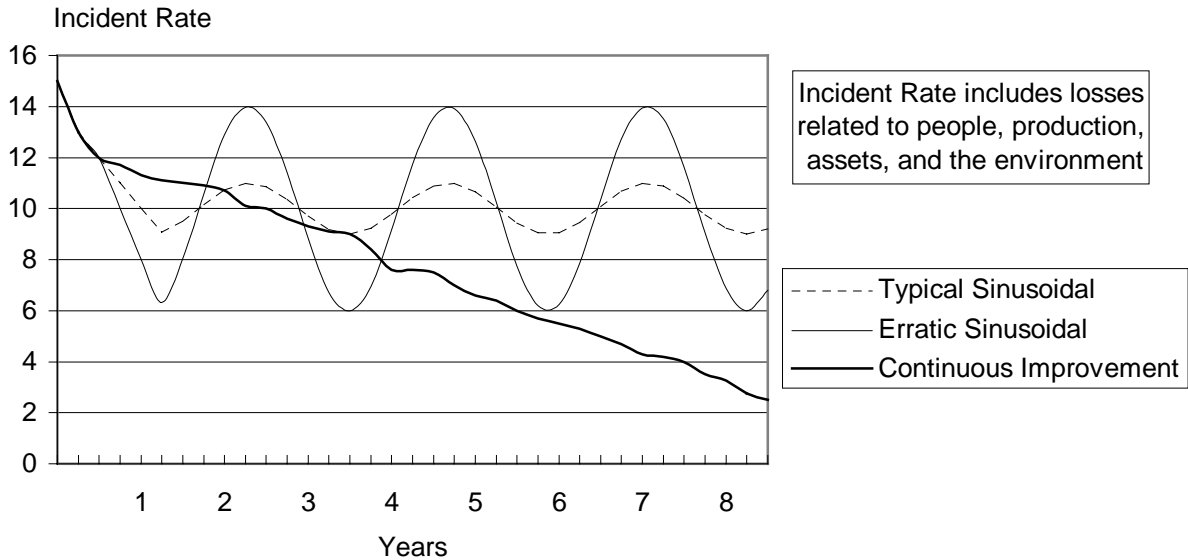
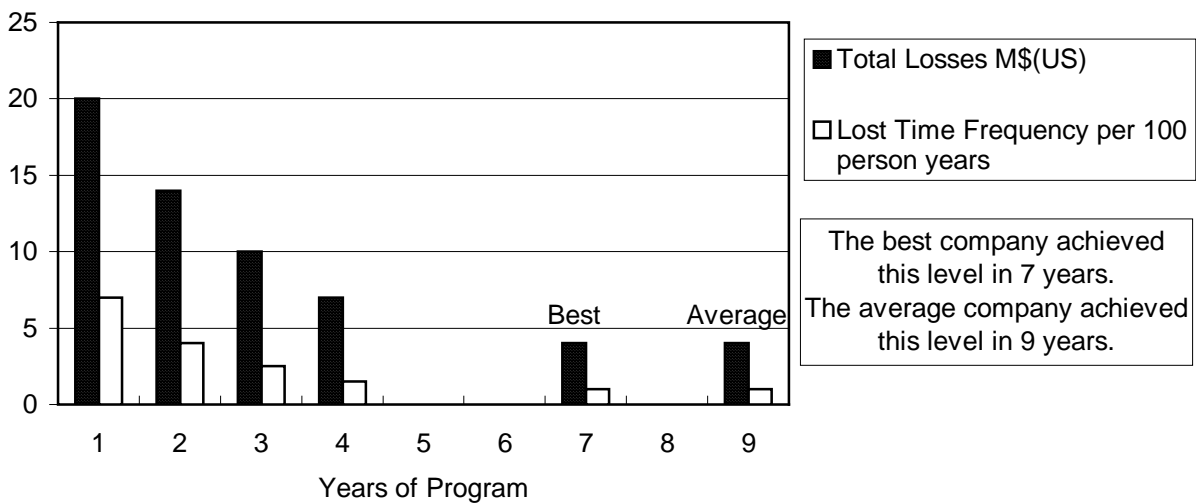


Figure 3 is based on a study by Laird Wilson. Data from six refinery/petrochemical plants in North America, each with approximately 500 employees, were combined to provide an average measure of performance. The data were collected in the mid 1980s for programs implemented in year 1 of the study. The graph shows that satisfactory performance cannot be achieved in a short time but takes several years of concerted effort. Even the company with the best performance required seven years to achieve a level they considered acceptable.

Figure 3 - Typical Large Company Results



Process Safety and Loss Management programs are designed to deal with changes that are known or expected to occur; however, there are also changes which occur unexpectedly. These unplanned or unexpected deviations from normal are classed as incidents and must be addressed and investigated if recurrence is to be prevented. An incident investigation program which is effective in identifying cause is a necessary part of an integrated Loss Management program.

In order to assure continuous improvement there must be some way to monitor program effectiveness. A comprehensive audit program which brings together protocols which will test the effectiveness of the programs and provide feedback on areas that need improvement is one of the most effective ways to accomplish this. But this does not suggest that there needs to be a separate audit program for Process Safety Management (CCPS, 1992). A program which addresses safety and operability in an integrated system provides the most effective use of resources.

7. Closing

Process Safety is the end result of managing changes in Technology, Equipment, and People. Managing these changes requires the coordinated efforts of personnel throughout the site and the company. These efforts must be focused through development of programs which deal with challenges to Process Safety. The programs must be monitored to assure their effectiveness through an overall program of Management System Audits and unexpected changes which are not included in programs must be addressed by an effective Incident Investigation program.

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Attachment A - Typical Policy Statement

Process Safety and Loss Management Policy

Process Safety and Loss Management is an integrated and consistent approach toward the elimination of incidents and the reduction of risks to people, production, facilities and the environment. These activities must be focused on our Company, contractors, and the associated public at large.

The Company is totally committed, on a continuous basis, to the application of our programs on Process Safety and Loss Management in the total operation of our business.

The company will provide safety and healthy working conditions while demonstrating excellence in incident, fire and security protection, and compliance with laws and regulations - both Provincial and Federal.

All employees, contractors and visiting public must comply with the company's rules, regulations and procedures.

The Company recognizes that excellence in Process Safety and Loss Management can only be achieved through the active participation of everyone at all levels, including contractors. All of this must be fully integrated with everyday activities and not treated as a separate issue.

Mary Lou Thatcher
President and Chief Executive Officer
January, 1995