Major Common Issues arising from Process Safety Management Audits

RDC Prior, Principal Consultant, SHExellence cc, Dowerglen, South Africa

Synopsis

PROCESS SAFETY MANAGEMENT (PSM) has been applied in South Africa for some 15-20 years. The author has been conducting PSM Audits for 12 years using the structure taught in the IChemE course "Fundamentals of Process Safety" as a guide. Some 40-50 audits have been conducted over this time.

In more recent audits conducted over the past 2-3 years, a number of recurring issues across several companies in different chemical sectors has been noted. Some of these are surprising because they are fundamental in nature and reflect a lack of growth in PSM competence over the last decade.

Ten of these common issues are analysed and solutions for them are proposed. The issues are:

- Lack of proper SIL rated trip systems and confusion about the status of the systems. A lack of knowledge and old systems are two reasons for deficiencies in this area. There is also evidence of suppliers of equipment providing misleading information.
- Failure to accept the philosophy of Inherent Safety and incorporate it in the capital project process. Even people exposed to the four principal methodologies have failed to implement at least the basics of IS in their project systems.
- Inadequate tank bunding. Very surprisingly several companies have not provided proper bunding for tanks containing hazardous liquids.
- Failure to develop Risk Tolerance Criteria for the Company. A reluctance was noted across the board to propose Criteria to Senior Management and have an authorised set of numbers.
- Incomplete PSSR Procedures. Many companies have bits of a PSSR System on different documents but did not recognise the need for a comprehensive review of the hazards before putting the hazardous chemicals into their process.
- No internal PSM Audits. This is linked to the lack of Management System and the effort required to get this going.
- Lack of PSM System / Strategy. Many companies have focused on individual elements of the PSM System and have failed to understand the overall picture or "glue" that a PSM System needs to provide.
- Lack of use of Leading Indicators. Most companies still worry about the well-established lagging indicators having include a few relevant to Process /safety like measuring LOCs. Taking a leap into the future by using predictive indices appears to be difficult.
- Poor chemical storage and incompatibility. Much ignorance and bad practice has been observed consistently in spite of compatibility information being available.
- No developed Asset Strategy / SCEs not identified and used. Quite often this was with companies who has acquired a sophisticated Engineering Maintenance System / Module.

Suggestions will be made to deal with issues for both local and general consideration.

Practical examples will be used to illustrate important points.

Some of the issues are related to local legislation and other domestic factors but the themes and practical considerations should be of interest to many in the Process Safety field.

Keywords : PSM Audits, Common issues

1. INTRODUCTION

The author regularly conducts Process Safety Management (PSM) audits for South African organisations. Over a period of some 12 years, he has conducted about forty audits.

In the more recent audits several themes have emerged with respect to deficiencies seen on audits. These were common across a number of companies. Some of deficiencies reflect very basic failings whilst others show a lack of appreciation of the the more advanced aspects of PSM.

South African legislation on PSM is fragmented. There is no overarching Act or Regulations on PSM. PSM auditing is therefore largely done against the standard of good practice / best practice as seen in countries such as the UK and USA.

The South African Regulator is under-resourced and does not take a proactive role, at this stage, of improving PSM standards.

It is hoped that the observations and suggestions for improvements will assist companies with similar deficiencies

2. AUDIT METHODOLOGY

The audit methodology is derived from the eighteen elements of Process Safety as taught on the IChemE "Fundamentals of Process Safety Management" course. Question sets were developed for each element and have been tested over many years and many audits.

The questions are scored 0, 0.5, 1 for non-conformance, partial conformance, and conformance. The maximum possible score is 377 Companies can plot their improvement over a number of audits. Advice is provided as part of the audit feedback and report.

Elements scored in the PSM Audit are shown in the table below.

ELEMENT	MAXIMUM SCORE
PSM Strategy, plans, resources	14
Inherent safety	12
Process Safety and documentation	17
Design procedures / capital projects	20
PHA / Risk Assessment	17
Emergency planning & response	28
Management of Change	17
Process and equipment integrity	28
Permit to Work	25
Human Factors and safety culture	50
Training and performance	17
Operating/maintenance procedures	30
PSSR	14
Contractors	24
Incident investigation and learning	22
Audits and corrective action	14
Legal, standards and codes	13
Performance measures	15
Total	377

3. MAJOR COMMON ISSUES ARISING FROM PROCESS MANAGEMENT AUDITS

The issues discussed are listed in order of the author's judgement of the importance of the issues.

3.1 SIS WITHOUT A CONFIRMED SIL RATING

A number of companies introduced automatic trip systems 10-15 years ago. At the time the most reliable systems were bought but no SIL rating was requested or confirmed. Knowledge of LOPA / SIL was very limited in South Africa and the recipients of the SIS were in no position to demand a particular reliability for the system.

Discussions with the site and instrument providers provided some evidence that SIS systems were at best SIL 1. The trip testing conducted over 10 years showed failures. The test interval was usually an arbitrary / convenient frequency. In some plants the test was done as part of the shutdown. . As a result, the reliability of these systems is unknown and possibly poor. As these systems are often the last line of prevention of major incidents, a more in-depth knowledge and control of these critical systems is needed.

The other part of the equation that was missing was the required level of reliability given the worst-case scenarios. The sites had no idea what the required SIL levels should be. The sites audited largely produce flammable / explosive / toxic organic chemicals for the coatings industry. The consequences of incidents could be disastrous with asset damage, fatalities and environmental damage being possible. IEC61511 was essentially unknown.

The recommendation that SIL values for reactors and storage SIS systems was accepted and LOPA / SIL studies were conducted subsequently. The information for this work was generated by site teams guided by a consultant. The information missing was often the company's tolerable risk criteria for incidents. There seemed to a reluctance to publish such information. This is, of course, required for LOPA studies.

3.2 INHERENT SAFETY

In PSM audits evidence is sought of the understanding of the concept and application where possible. Some theoretical knowledge of the Inherent Safety approach via the 4 Methodologies (Elimination, substitution, moderation, simplification) was found. This stemmed exclusively from people who had attended the IChemE "Fundamentals of Process Safety Management" course. In the course it is emphasized that the approach should be applied to both new plant and modifications. In one batch organics producer, the stocks of a dangerous flammable / toxic material, acrylonitrile, had been considerably reduced and the material was being substituted by a less toxic material.

The use of inherent safety in modifications was not observed at all.

A company making pesticides for the agricultural market indulged in basic R&D for new products. It had the inherent safety questions in its R&D methodology. This was an exception. In project projects there was no reference to the use of Inherent Safety.

An explosives company used soda ash to replace ammonia in PETN manufacture without realising this was an Inherent Safety change.

One company did not have formal Capital project procedure at all.

There is a systems issue here and resistance to change. Whilst there is an intellectual understanding of the need and methodologies of inhererent safety, the established project procedures and engrained habits of project engineers provide effective barriers to change. Well established change management techniques should be applied here. The use of Inhererent Safety has to be formalised in procedures.

3.3 INADEQUATE BUNDING OF TANKS

A very surprising finding on a number of sites was the lack of bunds for tanks containing highly hazardous chemicals such as sodium hydroxide and sodium hypochlorite. In one case the bund wall was in place except for about two metres of wall which had been removed to provide an entrance to the bunded area. Examples were seen of bund walls which were hopelessly too low to contain a tank overflow. In one case, the ESD valves and piping was situated below the likely level of a tank acid overflow,

The sites were largely old (30-50 years) and it appears that there was no plan from the start of the site to put bund walls around any tanks. When the plants were designed and built there was no legal requirement to bund tanks containing hazardous chemicals. Later on, a requirement to bund tanks containing hydrocarbons was introduced.

No systematic hazard studies were carried out in the early years of these plants which highlighted the need for bunds as preventative or mitigating barriers. The risk of tanks overflowing is completely ignored or underestimated. In general, management seemed relaxed with the lack of protection against overfilling tanks. In some cases, sophisticated trip systems had been put in place to deal with the risk of overfilling.

Practical and financial issues make the rectification of lack of bunding difficult. Some the old plants have no space to retrofit bund walls. They operate in very cramped environments. There also seemed a reluctance by management to spend capital in this area.

3.4 RISK TOLERANCE CRITERIA

Risk tolerance criteria are required for a variety of risk related decision making situations. The most important application is in LOPA Studies where the mitigated risk in a hazardous scenario is required to be compared to a risk tolerance for safety, or environmental or financial consequence.

Very few of the smaller / middle sized companies audited had risk tolerance criteria. Again, those with some process safety training understood the role that such numbers could play. Most had some form of risk matrix where, depending on the sophistication of the matrix, it was possible to estimate some kind of tolerance for risk. However, none of the companies had done so or saw the opportunity to do so. These was also no understanding of the rationale of the structure of the risk matrix so any derived figures would be questionable. Many of the risk matrices were inherited from earlier generations of managers or previous company owners.

With no risk tolerance figures, the risk calculations were not done.

There is a general reluctance for senior management to debate and agree risk tolerance figures. This appears to come from the need to agree the risk of fatalities which is a contradiction of the “ZERO HARM” target. Some larger companies like Sasol have agreed risk tolerance figures.

The UK risk tolerance figures were in general use by the AIAs (Approved Inspection Authorities). The AIAs are the only approved bodies in South Africa who are permitted to conduct QRAs for the Major Hazard Installations. The UK numbers have been accepted by the South African authorities for about 15 years but have not appeared in any local legislation. It may require a court case to establish the validity of these figures.

3.5 INCOMPLETE PSSR SYSTEMS

Few of the companies audited recently had formal Pre-Start Up Safety Review (PSSR) systems. One exception was an explosives plant where PSSR is applied to new equipment and modifications. Plant standing a long time at the Site gets cannibalised so it is essential to check the status of the plant before start-up.

Some companies have a few PSSR questions in other documents like the Start-Up Procedure and Return to Operations Form. With some modification an acceptable PSSR checklist could be created.

The following additional PSSR related checks could be done:

- Construction and equipment are to specification

- All types of procedures in place
- HAZOP has been performed and actions completed
- Training complete.
- Equipment checked
- Correct safety equipment available and in good condition

These additional questions may require a higher-level team for execution but should still include operators and artisans. Some companies need to understand the difference between a PSSR and Start-Up Checklist. There is also a need for PSSRs specific to different plants and not use a generic PSSR checklist.
Virtually all audited plants need a written PSSR Procedure to ensure uniform application of the technique.

3.6 INTERNAL PROCESS SAFETY AUDITS

Most small / medium sized companies did not have a system of internal process safety audits. Together with not having leading KPIs, these companies had no real idea of the standard of Process Safety Management, priority issues or required actions to improve the situation. For these companies there is a total reliance on a third-party audit such as the one the author carries out. This audit is usually conducted every three years or so, with the result that the status of PSM at the companies is not well monitored.
A number of issues hinder the implementation of internal PSM audits. Audit protocols such as the one I use are too complicated and lengthy for use internally. Many of the audit questions are high level involving PS strategy, various systems and culture. For internal PSM audits these questions would not be easy to get answers to.

Companies have requested "targeted" audits which process engineers can lead for their specific plants. They need to be limited in scope and focus on a few key PSM elements. Some auditing training would be needed.

Many companies do not understand the difference between audit and inspections.
Most companies have close-out systems where audit actions can be monitored and closed out.

3.7 LACK OF PSM SYSTEM / STRATEGY

Many companies do not have a single document that can be called a PSM System. These companies have usually implemented PSM in a piecemeal manner. Elements such as Permits to Work, Incident Investigations, Risk Assessment, HAZOP have usually been acquired from Occupational Safety or imported from other companies. Of the twenty elements in a typical PSM System, the company might have the majority of them in place over some years. However, there is no overall picture of what PSM is aimed at and no "glue" to hold the elements together.
All systems are composed of several parts which are related to each other. A PSM System is no different. For instance, Risk Assessments cannot be done if proper Hazard Identification has not been performed.

The PSM definition : "A *systematic framework for managing the integrity of hazardous processes and which uses a blend of engineering and management skills focused on preventing major accidents, particularly explosions, fires and toxic releases"*. states the systematic nature of the concept.

The System should follow the HSE model of Plan – Do – Check – Act.

Without a PSM System a proper PSM Audit is difficult to conduct. Auditing a System is different to auditing a number of System elements.
Most companies I have audited do not have a PSM implementation strategy. At best there will be a12 month plan. A five-year window is desirable for fully implementing a PSM System.

3.8 LACK OF LEADING KPIs

Audits revealed that many companies did not have practical leading Key Performance for Process Safety. As with Occupational Safety measurements companies have found it easier to measure historical events in the form of lagging indicators. The reasons for this appear to be that this is not seen as a priority activity and there is a lack of a planned approach to implementing leading KPIs.
Some companies have learnt the hard way by putting in numerous leading KPIs and finding out that some were meaningless after some months.
One company handling hazardous chemicals in a port area demonstrated a good approach by showing critical tank levels and protection devices in "traffic light" mode in the main offices.
Assistance has been given to some of the companies by suggesting a few KPIs to start with, focussing on measurements that show the health of the critical preventative barriers and introducing them to the HSE and CCPS Guides on the topic. Typical initial measurements have been:

- Adherence to scheduled maintenance targets
- Trip and alarm testing performance
- Tank bund status
- Planned Task Observations (PTOs) that are 100% correct

In one case one company had too many KPIs including leading KPIs for PSM. This leads to an inability to focus on the really important measurements.

3.9 POOR CHEMICAL STORAGE AND COMPATIBILITY (Drums and bags)

A number of examples of poor chemical storage situations have been observed. This has been surprising as some of sites have been in operation for many years and assistance in the form of MSDSs/SDSs has been available for a long time. Some poor examples of storage included:

- Flammable liquids in general stores
- Unidentified materials in drums and bags
- Non-flammable substances like 25% ammonia solution stored in flammable stores. A fire affecting the solution could be very serious
- Wooden pallets in general use in flammable stores
- Collapsing stacks
- Hazardous chemicals like sulphamic acid, sodium sulphite, potassium dichromate stored between sodium carbonate and sulphonic acid without any consideration of incompatibility
- Ammonium nitrate sweepings stored in general fertiliser bags
- Combustible packaging stored with flammable solids (hexamine)

Some of the reasons for poor storage are:

- Handling of chemicals not main business – major pulp and paper mill
- Chemical stores out of sight / out of mind
- Control systems look satisfactory on paper – two different worlds
- No audits
- Lack of knowledge of compatibility and properties of materials

Some very good storage practices were also observed. A site using a variety of and large quantities of peroxides stored these in a separate bunker away from other storage. This bunker presented the largest explosion risk on the site.

On audits ,advice is given on the principles of sound storage, segregation rules (HSE booklet) and urgent interventions urged for particularly dangerous situations.

3.10 POOR ASSET STRATEGY / LACK OF SCEs

Virtually all companies had well established Scheduled Maintenance Systems. Schedules were established over years and revised from time to time. A few Preventative Maintenance Systems were observed. These were usually non-destructive thickness testing and oil lubricant analysis. Approaches like RBI (Risk Based Inspection) were very rarely seen.
Many companies had sophisticated Maintenance Systems like SAP but were under-utilizing them.
The acquisition of capital items was usually done on an ad hoc basis.
No companies possessed an overall asset strategy which covered all aspects of asset acquisition and maintenance. There was little evidence of planning ahead to ensure that assets remained "fit for purpose" for say at least 5 years.

Safety Critical Elements (SCEs) presented a mixed picture. One company, an oil refinery, had a very well-developed set of SCEs and the procedures for giving them the priority they needed to ensure high levels of reliability. This was well established practice. Most companies have backed off from identifying SCEs and installing the systems to maintaining them properly. The task appears daunting and not a high priority in improving PSM performance. On audits advice was given on taking a simple approach to identifying SCEs. An initial approach would be to refer to the Major Hazard Reports and extract the preventative barriers for the major risks and critical items of equipment which are likely to be involved in causing major incidents. A few have taken up this challenge.

4. CONCLUSIONS

A number of common themes illustrating PSM deficiencies and failings have been seen in the process of doing Process Safety Audits as a third-party auditor to many South African companies. The companies have covered a wide spectrum of industries including batch organic manufacturing, explosives plants, pulp and paper mills, oil refineries and many others. The audits were conducted within the framework of South African legislation which does not place many requirements on companies with specific reference to Process Safety. The PSM audits, based on the IChemE PSM elements, used international PSM best practice standards as a reference.
The common issues ranged from basic deficiencies such as failure to store incompatible chemicals separately to the difficulties experienced in establishing a reliability (SIL value) for a legacy trip system. What was surprising was the failure to apply many of fundamental principles of process safety to common situations. Information is available on many of these points but there appears to be a lot of inertia in making improvements. Many of the improvements which should be made are not seen as high priority.
In the process of performing PSM audits it was normally possible to offer advice to the companies on how to advance their standards. This advice was taken more seriously than that offered by their own process safety professionals.
By quoting many examples from several industries, it is hoped that others can benefit from these experiencies.

RDC PRIOR

17.08.2022