

Making the Practical Side of Process Safety Management Work for You

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Process Safety Management audits require time to be spent on the plant / site to verify that the system elements are, in practice, being implemented. There is also the need to interview people working on the plant and in engineering. Inspections of Safety Critical Elements (SCEs) are also required. Plant visits by management are also major opportunities for assessing the state of process safety including the safety culture and spreading important safety messages. There are many references (books and articles) on the procedural side of audits but almost no guidance on extracting maximum value when spending time on the plant with the operating and maintenance staff. Quite often plant visits are undertaken without due thought to the purpose of the visit and with little idea of what to look for.

The author has conducted many Process Safety Management audits using the IChemE course “Fundamentals of Process Safety Management” as the basis for the audits. Much experience has been gained in the practical aspects of conducting such audits. In addition Sasol, a major South African petrochemicals company, has developed guidelines to help its managers interact with plant personnel whilst on process safety related visits.

This paper highlights the need to:

- be clear about objectives for a visit to operating units,
- plan the visit
- look for evidence that hazards and related safeguards are understood, and well managed
- detect common equipment failings
- detect hidden equipment faults
- engage with operating and maintenance staff to assess process safety competence
- execute behaviours and share information to positively influence process safety culture

Many examples including photographs are used to illustrate these points. It is hoped that the contents of the paper will help other plant visitors / auditors to obtain maximum value from their time on site.

KEYWORDS: Auditing, Hazards, Safeguards, human factors, PSM understanding

1. INTRODUCTION

Process Safety Management (PSM) has been formally in place in the USA since 1992 (OSHA PSM Regulations) and in Europe / UK since 1982 (EC Directive on Control of Industrial Major accident Hazards). In the UK the origins of PSM were created in ICI in the sixties. Since these early days PSM has developed as a discipline and today is seen as a vital part of designing and operating hazardous processes or dealing with hazardous materials in general. Many books and articles have been written on the topic. The CCPS, HSE, and IChemE have led the way in books with authors like Trevor Kletz and Andrew Hopkins adding their valued experience. The IChemE series of Hazards Symposia is a leading forum for sharing process safety practices, experience and best practice. A large body of reference material is now available for students and practitioners. In some of these works the importance of Human Factors / Safety Culture is emphasised and the need for line management, in particular, to set the example. This dictates that line management has to be in touch with actual operations and has to visit / audit to know what is happening on the “ground”. In addition, Process Safety Audits are carried out by internal and 3rd parties. There are guides (CCPS) on conducting such audits but there is no clear practical guide to managers, SHE Specialists or PSM auditors on how to interact with Operations staff or what to look for when walking the plant with a “process safety hat” on. This practical aspect of process safety can add enormous value to the drive to improve process safety.

The twin activities of auditing and management / specialist plant visits are aimed at detecting significant deviations from standards, suggesting improvements, coaching and creating a positive PSM culture. For this to be successful the auditor and the “plant visitor” need to be experienced and approach the interaction with the plant and its staff with “calibrated eyes” and a plan of how to get the most out of discussions with staff. They must also be able to detect unacceptable physical deviations on the plant. The author has carried out many PSM audits in South Africa using the IChemE “Fundamentals of Process Safety” training material as the basis. Much experience has been gained on the practical aspects of the audit. In addition, Sasol the major petrochemical company in the region has also developed guidelines for assessing process safety during plant visits. These two inputs have been combined to provide useful guidance and lessons for assessing the practical side of audits and plant visits. The author has collaborated with Sasol on aspects of process safety.

This paper details the experience and useful practices that have evolved from this work. It is hoped that others can learn from this.

2. PLANNING THE PLANT VISIT / AUDIT

There are at least two kinds of visits / audits that may take place.

In the case of the PSM audit, the conventional objective of the plant visit is to obtain the physical evidence that confirm the findings of the procedural audit. This is often done on a sampling basis. This should remain the core reason for the plant visit but the visit can be made into a much more rewarding exercise for both the auditor and the operations staff. The visit can be used to teach people aspects of process safety and show how to inspect plant with critical / objective eyes.

The plan has to be driven by the audit requirements and there is normally insufficient time to go everywhere. Some ways of deciding on priorities include:

- Go to sections or plant items of highest risk (use risk register / major hazard analysis)
- Go to where incidents have occurred in the past (use incident records)
- Go to where work is taking place (operating, maintenance, projects)
- Go to where most people are working
- Go to control rooms for well automated or instrumented plants
- Go to places where nobody normally works
- Just follow the process flow

The visitor / auditor must be wary of being directed by Operations to places that reflect only good practice or have been “prepared”. The plan needs to include an idea of what questions to ask people and what concepts to discuss / communicate in an appropriate way. The composition of the audit party needs to be thought through.

For a plant visit by a manager or specialist, the objective could be to obtain process safety information, “measure” or influence the process safety culture or communicate process safety relevant information. This visit is fundamentally different to the previous case of an audit. The method here is to interact with as many people as possible and, in particular, the key people on the plant. The plan here would have to include:

- Who should I attempt to meet with and where are they?
- What do I wish to learn from the people or interaction (general and specific)?
- What messages do I wish to pass over?
- What allowance for feedback should I allow?
- Preparation for discussing key process safety issues – what do I need to know and what level is the other party at?
- What parts of the plant do I want to visit and why?
- Who else will be on the plant in addition to operators (maintenance, contractors)?
- What negative messages or behaviours must I avoid (PPE, criticisms only)?
- Who, if anybody, should accompany me?

3. WHO SHOULD ACCOMPANY YOU?

This is often decided upon by management of the site. Minimum requirements are to have a line manager, safety manager / process safety specialist and an engineering representative. Groups in excess of 5 should be discouraged as focus is likely to be lost.

4. WHAT TO LOOK AT?

For auditing purposes the scope is defined to a degree. For a plant visit by a manager, parts of a plant or specific process units could be targeted.

The author has audited plants first and then examined the documentation and vice versa. The later is the more usual approach. The initial observations in the document review could well influence the plant visit.

If possible the plant should be covered following the process flow. Starting at the offloading of raw materials, raw material storage and passing through the process steps to final product storage works well if the plant layout facilitates this. In general, places of maximum process risk and the associated safeguards should be checked. Industry incident experience and facility incident experience can guide the observations.

The visit should test process safety principles like:

- Knowledge of hazards / unrecognised hazards
- Identification of barriers
- Sound condition of barriers
- Sound condition and layout of equipment
- Competence of operators
- Knowledge of incidents and resulting actions

- Are the Safety Critical Elements (SCEs) being managed correctly?

The specific things to look at are a function of the audit needs / auditor's experience. Examples from my auditing experience include:



Figure 1: Storage tank bunding condition (sound construction, joint condition, contents)



Figure 2: Unexplained leak from tank drain valve



Figure 3: Consistency with standards e.g. taping over of flanges



Figure 4: Equipment placed too low in acid tank sump



Figure 5: Hydrogen receivers too close to compressors and transformers – looks wrong!



Figure 6: Offloading of SO₂ cylinders



Figure 7: Ruthenium reactor – only one of the three reactors allowed water addition – inconsistency

OTHER EXAMPLES

- Electrical standards for flammable gases / dusts – how would you know on a visit?
- Standard of lagging – why are some sections missing?
- Under-lagging corrosion – how would you know?
- Venting of hazardous gases to safe places
- Anywhere where incompatible materials may mix i.e. identical tanks with inadequate identification
- Separate pipeline systems with incompatibles – are they connected by design or in error?
- Anywhere where maintenance is taking place
- Where unusual operation are taking place
- Control Rooms – alarms / instruments not working
- Control Rooms – alarms being cancelled without thought for possible issues
- Control Rooms – poor communication with outside operators

5. PSM QUESTIONS FOR OPERATORS/SUPERVISORS/MAINTENANCE

Structured questioning can quickly provide evidence as to whether process safety is under control.

Operators / supervision

- What are the biggest risks in your section? Is this the same as the Risk Register or equivalent/
- What are safeguards that prevent or reduce the consequences of the event?
- How do you know that these safeguards will work when required?
- What safeguards do you monitor and how?
- What are the safety critical elements on the plant?
- What are the safety critical tasks / steps in particular procedures
- What happens when you operate outside the particular flow / temperature etc range
- What was the last LOC event on the plant? Will it happen again? Why not?
- What are the critical trips /interlocks on the plant? What event do they prevent and how?
- Who / how / when are these tested?
- Gas sensors – what level do they detect? Who and how are they tested?
- Do you have enough time to issue Permits to Work correctly?
- What are the key properties of your hazardous materials (Flash Point, Toxicity, Environmental hazard)

Maintenance

- Have you been trained / retrained to accept PTWs? How do I know this?
- Have all the safeguards been put in place for this job? How do you know?
- Could fires, explosions or toxic releases take place on this section / plant?
- What incidents have maintenance been involved in on this plant?
- Where do you have to use special tools anywhere on the plant? Why?

- Are you asked to do modifications on the plant? How do you go about this?
- Can you do small modifications / temporary modifications on the plant? Any paperwork?
- Do you do any planned inspections or replacements? Do breakdowns dominate your work?
- Are you / your workshop on target for doing inspections / replacements?
- Who do you see as “owning” process safety on this plant?
- What section or item scares you the most? Why?
 - Actual trip testing – compared to scheduled frequency and method e.g. Boiler drum low low level trips – 1/month

6. FINDING MORE SUBTLE DEVIATIONS

Whilst many issues are very apparent, some problems require closer examination and questioning for detection and registration for action. “What if” questions can be profitably used Some examples follow:



Figure 8: Erosion / corrosion issues are very difficult to see from the ‘outside’. Question the availability of thickness data for SCEs (Safety Critical Elements) like piping bends and T pieces.

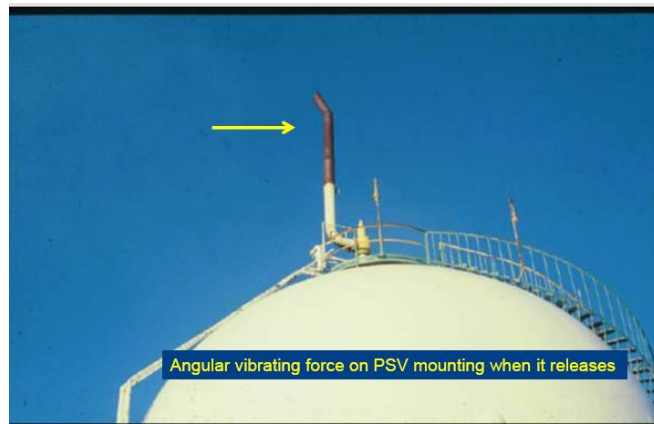


Figure 9: PSV exhaust side piping might create stresses in system. Has this been designed for?



Figure 10: Cold service often produces wet conditions for flange bolts. Corrosion risk for horizontal flanges and bolts



Figure 11: The situation in Figure 10 was much worse when the bolts were removed. The bolts had lost up to 35% of their thickness!



Figure 12: Air intakes may be fine in normal conditions. What can leak in the vicinity when an upset occurs or a LOC is experienced? The same thinking applies to venting at a “safe” distance.

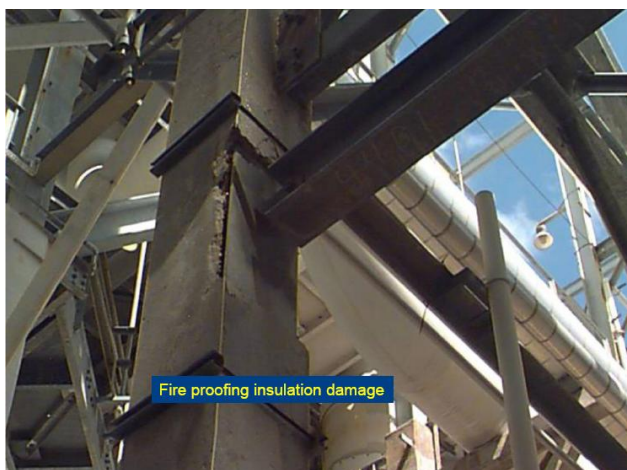


Figure 12: Fire insulation may not be easy to identify on the plant. Damage and degradation may be even more difficult to detect. It will be useful to determine where fire proofing has been applied before the visit.

7. The SASOL GUIDELINES FOR MANAGERIAL WALKABOUTS

The major South African petrochemicals company Sasol has issued formal guidelines for managers on a process safety walkabout. The author trains Sasol personnel and consults to various business units. The table below lists the points that managers should have in mind when they visit the plant / control rooms.

FOCUS ON PROCESS SAFETY DURING PLANT AND CONTROL ROOM WALKABOUTS	
<p>During plant walkabouts & associated interaction with people:</p> <ul style="list-style-type: none"> • Look for obvious leaks on process systems or “footprints” of leaks. Was it reported and investigated? • Look for evidence of tank, bund or pit overflows and blocked drains. • Evidence that drains & vents go to safe locations. • Inspect process piping – missing bolts on flanges, missing end blanks, inadequate pipe supports. • Look for temporary modifications linked to process systems and interrogate them. • Inspect emergency equipment, deluge systems, fire fighting equipment and fire proofing. • Check knowledge of the emergency procedure & condition of emergency gathering rooms & assembly rooms. 	<ul style="list-style-type: none"> • Evaluate presence of non-essential persons & vehicles within the area; check that all vehicles have permits to be on site & are safely parked. • Evaluate open work permits & check “Touch and Tag” especially when breaking into live lines • Flexible lines are the weakest point in any piping system. Are they registered, tested and in good shape, especially when carrying hazardous materials? • Visit outlying areas such as battery limits, loading facilities, tank farms and flares. • Interact with people doing tasks on process equipment and ask “What are you busy with? What can go wrong? What will you do if it happens?”
<p>During control room visits and associated interaction with people:</p> <ul style="list-style-type: none"> • Are there any critical activities in progress; such as start-up, shutdown, safe making or commissioning? • Have the critical process safety controls been identified & are they understood & in place? • Does the plant operation appear to be stable? (Process safety risks increase with unstable operations) • Ask the permit issuer about open work permits & verify if associated risks have been identified & controls implemented to prevent them. Ask some “what if” type scenario questions. • Are there specific concerns from control room staff that they want you to be aware of or need your assistance with? 	<ul style="list-style-type: none"> • Ask about the number of nuisance alarms and active alarms. Any management action required? • Look for trips that have been bypassed & verify authorisation documents. • Check & ask about the preparedness for an emergency • Ask about recent process safety incidents & use these as a discussion topic to demonstrate how important PSM is to you as a leader. Ask what could have made the incident worse? What was done correctly? • Ask about recent completed or in-progress modifications & confirm that all required processes were followed.

There are useful additional points which can be used together with the ideas listed in Sections 4&5.

8. WHY OPERATIONS PEOPLE DO NOT SEE THE PROBLEMS?

Familiarity breeds ?

It appears as if the more familiar people are with a plant/area the more likely they are to walk past an obvious problem. The observers are so familiar with a situation so that they only “see” what they want to see. This is analogous to motor car drivers driving on “autopilot”. There is normally sufficient knowledge and skills in the observers to detect problems should they be looking for them. The examples of bund seal failures, grass growing in bunds mentioned above fall into this category. This is similar to the “slip” category of human failure where attention control intervention is needed.

Priorities

With process safety management still being introduced in many places, it is not necessarily the top priority for management. The low frequency of major hazard incidents means that process safety and associated safeguards is not “in people’s faces”. This, of course, changes rapidly in the event of an incident. An effective and positive process safety culture created by senior management can counter this.

Attitudes

The lack of a questioning or inquisitive attitude is prevalent in most sites. This is an aspect of the process safety culture that is very unhelpful. The sense of unease that high performance companies have and where a strong process safety culture exists is uncommon. Again, the low frequency of major incidents might create an expectation that nothing can go wrong.

WHAT CAN BE DONE ABOUT THIS?

A number of approaches can help.

The use of “shock and awe” tactics combined with an analytic appraisal of the risk and associated control methods can be applied. Many professionals are embarrassed to have deviations exposed “on their watch”. Providing this is done in a constructive manner the exposure of deviations can lead to behaviour change.

The use of relevant in-house incidents where they exist is probably the most powerful method. Reference to major events (e.g. Buncefield – bunds) is also useful.

The use of a simple Layers of Protection model is easy to help communicate the basic issue and requirements of process safety management

Senior management will have to communicate and by their own behaviour show that a questioning approach is wanted from all and is rewarded.

The question “What can go wrong here (fire, explosion and toxic release) and who will get hurt?” is a helpful way of focusing the mind.

9. DEALING WITH THE SOFT ANSWER

It is common to be given a “soft answer” when asking PSM questions. Examples could be”

- “the contractor has taken the task risk assessment (required for a Permit to Work) with him and is therefore not available”
- “we always use the XXXX Method to find root causes in an investigation and we are trained in this approach”
- “we have identified the critical items (SCEs) for our plant” (Often based on non-safety related criteria)

Auditors are sometimes fobbed off by responses which are aimed to deflect further questioning and possibly hide weak areas. Auditors have to develop a sixth sense for these situations. There is no other way than to drill down to get the evidence for the verification or rejection of the response. In the examples quoted above it took some hours for the contractor to find the risk assessment and it was in the wrong format. In the case of the investigations query no examples of the XXX Method could be found. The engineering department eventually agreed that they did not identify SCEs but had other critical elements identified for long lead and cost reasons – not safety.

10. WHO SHOULD KNOW WHAT?

This open ended question applies to both the auditor / visitor and the people who are being interviewed.

Auditor / management visitor

Both parties benefit from an in-depth knowledge of process safety management and have experience in the field. The auditor might find this easier than the line manager.

The auditor has to be credible if he or she is to influence the people/plant that is being audited. This is the bigger role described earlier. To achieve credibility knowledge and experience is crucial. Allied to this the ability to communicate this information appropriately is important but the most important ingredient is the passion with which the messages are delivered.

The management visitor is in a slightly different situation. He cannot be as well informed as an auditor but he should be sufficiently knowledgeable to converse usefully with the others. In particular, he should be up to date with the state of process safety on the plant and current achievements / issues. He / she should be able to convey the importance and seriousness of the topic as seen by senior management – “walk the talk”. He needs to be a good listener. Without fail he needs to respond to any promises made on the visit.

People on Plant

The knowledge of people on a plant (operators, maintenance, contractors) is dependent, to a degree, on the organisation structure and job structures. For process safety, knowledge, concepts and tools are required in a much broader, integrated form. The following questions have proved very useful in assessing the state of knowledge on the plant:

- “What are the major hazards on this section?” (What can go wrong here?)
- “What is in place to make sure that this does not happen?”
- “If it happens what is in place to minimize the effects?”
- “How do you know that these safeguards will work when called upon?”
- “Who checks them and how are these safeguards checked?”

The operating staff, in their own way, should be able to answer these questions. Maintenance staff in plants with an excellent process safety culture will also know this. It would be beneficial that contractors have a limited insight into the process safety hazards.

On a recent audit of a rubber plant hazards were discussed with the panel operator. In a reactor shown on the panel an exothermic reaction was taking place. There was a limited understanding of the dangers of runaway reactions. When asked about the safeguards there was reference to alarms. There was a trip on the top of the reactor. The operator was unable to explain the functioning of the trip including the sensors / settings that would initiate it. Further levels of plant management (including the Plant Manager) were interviewed but explained the multiple trip triggers including high-high temperature. This illustrates the narrow thinking of some staff and lack of a questioning attitude. No further information was forthcoming. The plant instrument technician appeared and expertly explained the trip functioning.

Very limited knowledge of trips and SILs is found even among instrument staff and none amongst operating staff. There is a lack of understanding that trip reliability has to be defined and maintained against the risks presented by the process and acceptable risk levels.

11. HOW TO PUT PEOPLE AT EASE

Operators are likely to be suspicious and careful with responses to your questions. It is important to prepare well for any visit and be aware of any issues on the plant such as cost reduction, restructuring etc. The following pointers can assist in getting the other person to relax and provide a true picture of what is going on.

- Explain who you are and why you are there
- Ask the other person to explain the job he / she does
- Ask about how long the person has been in the job and the biggest challenges that have been faced.
- Ask what the biggest risks are, in his / her opinion
- Share, if relevant, some of the process safety challenges you have had
- Talk about any process safety training that the person may have received
- Ask about suggestions for improving process safety
- Confirm that no names will be used in the report

12. SHOULD THE AUDITOR / VISITOR BE AN EXPERT ON EVERYTHING?

It is practically impossible for even an experienced PSM auditor and much less so a member of management to know all aspects of the different elements making up the Process Safety Management System. A basic requirement for both functions would be to understand the principles underpinning process safety management, a broad knowledge of the elements, the state of process safety in

the unit and the issues facing the unit. It obviously helps to be able to pass over information relevant to the person / position. An awareness of incidents elsewhere in the company and in the outside world is useful to influence people to understand that a serious incident is often a matter of chance.

13. DEALING WITH MAJOR / THREATENING DEVIATIONS ON THE VISIT

It may happen on a visit / audit that a dangerous situation is experienced on the plant. This has been experienced by the author several times. A recent example occurred in a plant handling ammonium nitrate granules. Ammonium nitrate sweepings from the floor are stored dry in a drum. Figure 13 below illustrates this.



Figure 13: Contaminated ammonium nitrate in drum

The ammonium nitrate was heavily contaminated with grit and organic matter. The only missing element in the disaster scenario was an ignition source. The staff was unaware of the risk they were running. The matter was immediately brought to the attention of supervision. Within the hour all such drums were filled with water and the solution used to fertilise the nearby lawn.

Each dangerous situation uncovered requires treatment on its own merits. If the danger is imminent and serious then immediate action would be called for. The action of the auditor / management visitor depends on the response of the Operating Staff. Should it be effective and swift then no intervention is needed. If not then the auditor / management visitor should inform higher management of the situation. As a backstop the incident and its handling should be included in feedback sessions to management and in the audit report itself.

14. LINKAGE TO THE DOCUMENTATION ASPECTS OF THE AUDIT.

In carrying out a Process Safety Audit the practical side of the audit involves looking for a) physical evidence that the documented standards are in place and b) that equipment / materials are being stored or used correctly and c) evidence that people are competent and are contributing to a good process safety culture. Depending on the structure of the audit, evidence for compliance for the audit element (18 elements in the audit system used by the author) might be fully collected on the plant visit or only a small part on other elements. The pre-prepared audit questions will guide the questioning on the plant. This is the narrow view of a typical audit. It happens that preliminary views of compliance which are established during the documentation review are changed when actual compliance is tested on the plant.

It is possible to take a broader view of audits. Quite often the author has found that it is value –adding to share background and principles when explaining to plant staff why hazards have not been recognised or safeguards are not in place. Often, examples of disasters in other plants where similar conditions have prevailed have educational value. This aspect is a personal characteristic of the author's approach and may not work everywhere. Time and a receptive audience are requirements.

15. CONCLUSIONS

It is possible to extract maximum value when visiting or auditing a process plant if the following points are considered:

15.1 The visit is planned with respect to desired outcomes, priority areas or activities to be observed, SCEs to be checked and people to be interviewed.

- 15.2 Prepare well by understanding the process, history of incidents and state of implementation of PSM.
- 15.3 Relevant evidence for verification of the audit documentation findings is sought.
- 15.4 Equipment deviations are sought particularly where these could lead to loss of containment or, as a safeguard, fail on demand. Pressure vessel failure and bund failure are examples. Use the lists and examples as prompts for your situation.
- 15.5 Look out for more subtle deviations where the issue is not obvious. Examples are provided.
- 15.6 Get an understanding of why operating staff have not detected the problem and addressed the issue.
- 15.7 Probe past the glib answers to unearth the real state of affairs.
- 15.8 Test operators and supervision for competency by asking for information on major hazards and their control.
- 15.9 Spend time in the control room and observe reactions to alarms and upsets.
- 15.10 Strengthen the process safety culture by recognising positive behaviours or good standards.
- 15.11 Ask “What if” questions at all suitable opportunities.