Process Safety Management

The Experience of Essar Oil

By Gopal Jayaraman

IN BRIEF

- **Process safety management (PSM) focuses on proactively avoiding incidents in oil refineries, and fertilizer, pharmaceutical, explosives and chemical plants that handle hazardous chemicals.**
- **If released, these chemicals could have a major impact on workers, surrounding communities or facilities. The consequences of these incidents have significant life-threatening, environmental, legal and financial implications.**
- **PSM provides a dynamic environment for continual improvement and increases the awareness of the safety impacts of technology, personnel and the management of process hazards.**

Gopal Jayaraman, Ph.D., heads the Health-Safety-Environment-Fire Department for Essar Energy Business at Essar Oil Ltd., Refinery Division, in Jamnagar, Gujarat, India. He holds a Ph.D. in Environment and Ecology with special focus in oil and gas industries. He has more than 40 years' industrial experience in operations, project execution and safety in oil and gas industries and petrochemical plants. He is an international member of ASSE's India Chapter and a standing committee member of the Oil Industry Safety Directorate. During his career, Gopal has conducted safety audits and risk assessments, created emergency preparedness plans and served as a liaison with insurers.

A spate of chemical disasters around the world seems to be the norm these days. Is it the increase in reporting, control or a worsening attitude toward safety? It may be any or all of these and more. Process safety management (PSM) came into the picture in the late 1980s and early 1990s, including OSHA's PSM rule in 1992 (Table 1). A PSM system contains elements for preventing or minimizing the consequences of catastrophic release of toxic, reactive, inflammable or explosive chemicals.

PSM at Essar Oil

In India, PSM is still in its developmental stages. The major players providing guidance include American Petroleum Institute (API), Center for Chemical Process Safety (CCPS), American Institute of Chemical Engineers, DuPont, OSHA and U.K.'s Health and Safety Executive (HSE). In its journey toward world-class refining standards, Essar Oil Ltd. embraced international safety standards. Starting at a highly competitive production of 3 lakh (300,000) barrels per day, management envisioned the importance of PSM and emphasized its implementation at the refinery. Since its inception, PSM has been implemented as a comprehensive management program integrating technology, procedure and management practices.

Essar set up a PSM cell as part of the Health-Safety-Environment-Fire Department and began integrating PSM elements in 2010. Implementation of these elements has been complete in the base units. With the refinery's expanded production nearing 4 lakh (400,000) barrels per day, PSM implementation and monitoring have received a renewed focus. Essar's PSM framework encompasses 13 elements (Figure 1, p. 46):

1) employee participation;
2) process safety information (PSI);
3) process hazard analysis (PHA);
4) operating procedures;

5) training;
6) contractor safety management;
7) prestart-up safety review (PSSR);
8) mechanical integrity;
9) hot work permit;
10) management of change (MOC);
11) incident investigation;
12) emergency planning and response;
13) compliance audits.

The primary intent of PSM implementation in the refinery has been the proactive identification, evaluation and prevention of loss of primary containment of toxic, reactive, flammable or explosive chemicals from a process. PSM provides a systematic approach toward achieving these outcomes, resting on the three pillars of integrity: operational integrity, plant integrity and design integrity. Implementation has occurred in phases, starting with employee participation.

Employee Participation

Employee participation is a vital aspect of implementing any management process. India's Oil Industries Safety Directorate (OISD), OSHA and other regulatory bodies require employers to ensure employee participation in activities such as developing and conducting hazard assessments. At Essar, employees are engaged in various activities providing feedback to management procedures; in creation of standard operating procedures (SOPs); procedural revisions; MOC process; PHA [e.g., hazard and operability (HAZOP) studies, fault tree analyses (FTA), What If, 5 Why]; and PSSR.

In addition, various awareness and training sessions are conducted to enhance employee awareness and share knowledge. These sessions provide insight about actual work/practical issues that help improve systems. Employees are also integral in safety audits and task-based risk assessments/job safety analyses conducted in the field.

Any knowledge gained from internal/external incidents is shared with all employees in a simplified form that explains the probable/root causes and shows incident learnings. Various books, cards and leaflets have been circulated among employees to improve PSM understanding and increase employee participation. Employees report process near-misses regularly, and their valued experience in the field helps strengthen the refinery's systems.

To further develop and sustain PSM, management enlists employees to serve as volunteer PSM coordinators for their respective plants. Currently, the plant safety coordinators act as an interdependent body, highlighting process safety issues while implementing PSM elements in the refinery units.

Process Safety Information

The compilation and continual updating of PSI is key to ensuring the continued safety of any process industry, including a refinery. As required by standards (e.g., factory rules, OISD GDN-206, OSHA), employers must compile written PSI before conducting a PHA as required by several standards. At Essar, compiled PSI is accessible to all employees through an online portal.

The information is managed by technical services personnel and monitored continuously for accurate information on process chemicals, technology and equipment (an OISD requirement). A coordinator streamlines the process and maintains the information.

The information shared includes:
- MSDS for all process chemicals involved;
- design and engineering package;
- block flow diagrams;
- process flow diagrams;
- process and instrumentation diagrams (P&IDs);
- critical operating parameters;
- cause-and-effect diagrams for process, fire and gas systems;
- equipment datasheets;
- alarms and trip settings;

Table 1

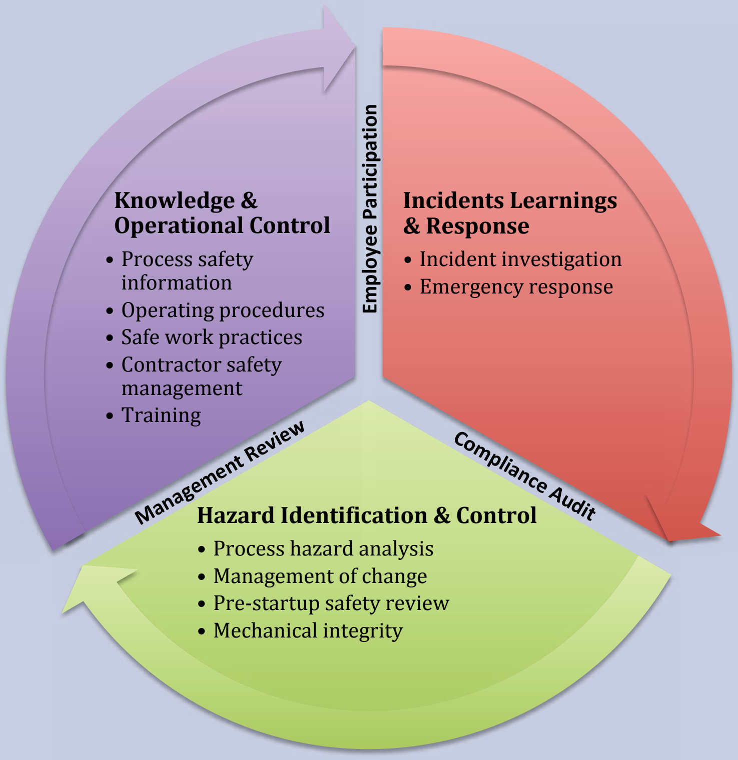
Major Chemical Industry Incidents Leading to PSM Regulations

Year	Location	Event	Result
1970	Agha Jari, Iran	Gas explosion	29 dead, 10 injured
1971	Amsterdam, Netherlands	Butadiene explosion	8 dead, 21 injured
1972	Rio de Janeiro, Brazil	Butane storage vessel BLEVE	37 dead, 53+ injured, U.S. $13.4 million
1973	Potchefstroom, South Africa	Ammonia release from storage vessel	18 dead, 65 injured
1974	Flixborough, U.K.	Cyclohexane VCE at caprolactum plant	28 dead, 104 injured, U.S. $412.2 million
1974	Pitesti, Romania	Ethylene VCE, ethylene plant	~100 dead
1975	Antwerp, Belgium	Ethylene VCE, polyethelene plant	6 dead, 13 injured, U.S. $57.8 million
1976	Seveso, Italy	Tetrachlorodibenzo-p-dioxin (TCDD) toxic release	~20,000 people affected
1977	Pasacabolo, Columbia	Ammonia, etc., toxic release, VCE at fertilizer plant	30 dead, 22 injured
1982	Caracas, Venezuela	Oil froth fire, storage tank	150 dead, 500 injured, U.S. $58.9 million
1984	Bhopal, India	Methyl isocyanate, storage tank	~3,000 dead
1984	Mexico City, Mexico	LPG terminal, VCE-BLEVE	650 dead, 6,400 injured, U.S. $22.5 million
1984	Romeoville, IL, U.S.	Propane absorption column, VCE-BLEVE	15 dead, 22 injured, U.S. $143.5 million
1988	Piper Alpha, North Sea, U.K.	Offshore platform, explosion—gas compression module	167 dead, U.S. $1.7 billion
1989	Pasadena, TX, U.S.	Isobutane VCE, polyethylene plant	23 dead, ~130 injured, > U.S. $500 million

Note. *VCE = vapor cloud explosion; BLEVE = boiling liquid expanding vapor explosion; LPG = liquefied petroleum gas.*

Figure 1

Process Safety Management



Essar's PSM framework encompasses 13 elements.

- electrical hazardous area classification drawings;
- chemical storage locations (e.g., plot plans);
- chemical database;
- data on safety relief devices.

The PSI system is one of the most effective systems implemented at Essar thanks to constant updates and ongoing maintenance. It is accessible to all employees and is available anytime. MSDS and chemical wall charts are displayed in relevant locations in the field as well.

Process Hazard Analysis

Any process industry classified as major accident hazard under the Factories Act (e.g., the refinery) must develop and implement systems to handle emergencies that may arise out of the various hazards it contains. For this to be effective, a site must conduct a PHA on the installation. This is both a requirement of OISD GDN-206 and OSHA's PSM standard.

The Essar Refinery conducted extensive PHA in the form of HAZOPs covering the existing base refinery units in 2008-09, then the expansion units in 2011. Resulting documents are available within the PSI portal. In addition, every change initiated in the refinery follows the MOC procedure that encompasses PHA for ensuring that the change does not introduce new, uncontrollable hazards to the operation.

For this process, PHA checklists are used. For a lower-level analysis, the hazard identification (HAZID) checklist is used; for higher-level efforts, HAZOP studies are used. All recommendations of any PHA are immediately reported to the technical services group for implementation and completion. These are tracked through the safety portal for refinery-wide PHA. The refinery is currently revalidating its PHA by conducting new HAZOPs of the refinery units (as required in OISD GDN-206 and OSHA's standard).

In addition, the refinery has conducted a quantitative risk assessment study for the whole refinery (base and expansion). It was determined this would help the site develop emergency mitigation and response plans based on risk scenarios. Study recommendations have been implemented in the refinery, and the entire report is accessible in the PSI portal.

The analyses are performed by multidisciplinary teams consisting of experienced employees. Team members are trained in the various analysis methods used, and they receive a booklet to augment their knowledge.

A safety integrity level study was conducted in 2011-12 to determine the refinery's safety instrumented functions' reliability to operate on demand. The intent was to raise the safety integrity levels for safety instrumentation to a minimum of level 2. To that end, various recommendations were made and are being implemented.

Operating Procedures

As with any industry, processes followed must be uniform and not vary from person to person. Essar has developed and regularly updates/revises various procedures. They are divided into management procedures (applicable to the whole refinery), SOPs (applicable to specific refinery units), and standard maintenance practices. Employees can access procedures through a common portal that contains all departmental SOPs, management targets, records and management procedures. Procedures have been standardized and all employees attend familiarization sessions on every revision or procedure change.

Every critical activity in the field is studied meticulously and SOPs are tailored to fit the respective plant and activity. Training is provided to all field employees, and a competency test (known as Saksham and managed through various web-based portals) is conducted, as are interviews with the respective area managers before deploying officers in the field.

Training

Based on OSHA standards and OISD STD-154, training guidelines have been created for mandatory training. Every person (visitors, employees, contractors) receives a safety induction before entering the refinery complex. Employees complete mandatory OISD STD-154 5-day training consisting of various modules that cover topics such as PSM, incident reporting and investigation, toxic gas awareness, work permits and hazardous area classification.

In addition, a minimum 10% of all plant employees complete a 15-day rotational training program, during which they receive additional information on MOC, mechanical integrity and asset reliability, PHA and PSSR. Employees who have already completed the 5-day program attend a 2-day refresher course.

Since the entire refinery complex is covered under a work permit system, the safety group conducts a separate 1-day training course on this topic to prepare personnel as the issuer/receiver/authorizing party. The health group conducts a 2-day basic first-aid course as well.

Training is a management priority. Much specialized, job-specific and personal development training is conducted throughout the year by the Essar Learning Center. Furthermore, process-related or operational training is delivered to all new employees as well as to their reporting departments prior to deployment. Validation testing is conducted through an online portal.

Contractor Safety Management

Contractor safety management is an essential part of handling various resources, as most work in the refinery is performed by contractors. The contractor safety management procedure is based on OISD GDN-207, which covers items such as tendering, preselection, bidding, selection, evaluation, performance monitoring, penalization and contractor review.

The refinery uses an open tender selection process for annual rate contractors. Contractors are evaluated based on past performance. They are then selected through a competitive bidding process and provided with a personalized-standard contract.

The contract work order includes details on the company HSEF policy, procedures and safety requirements, as well as the job-specific work requirements. Contract employees attend safety induction training before entering the refinery complex. All contractor supervisors and safety officers must attend a 2-day safety training program (OISD-based) and be validated before job deployment. One-time-order contractors receive in-the-field training and job induction to assist in any emergency operations in which they may be involved. All contractors are informed of all hazards existing in the area of their work, and in the refinery in general.

All contractors are continuously monitored. They are briefed on all relevant safe work practices and procedures for implementation. Any violations are penalized based on the procedure for disciplinary action. All work in the refinery starts after the supervisor and engineer in charge deliver a job-related toolbox talk. Each contractor maintains records of these training events.

All contractors are encouraged to report and correct unsafe conditions/actions, and contractors who report near-misses are recognized and awarded. All contractors are also informed of any incidents that occur, with emphasis on applying lessons learned. Contractor workers who are involved in incidents are treated immediately and are involved in the incident investigation. Again, all incident findings/lessons learned are shared with contractors.

Management ensures that all contractors' problems are heard and solved as completely as possible through the relevant engineers in charge. In addition, management holds monthly safety committee meetings with all contractors. Contractors are also encouraged to hold separate safety meetings, and job-specific contractor development training programs are conducted as well.

Each contractor submits monthly safety performance reports to the HSEF Department for continuous monitoring and development. HSEF and reporting staff conduct periodic contactor safety audits as well. As more manpower is used, contractor safety invites more attention and requires more focus. Essar has a constant focus on the contractor workforce and strives to ensure its welfare.

As more manpower is used, contractor safety invites more attention and requires more focus.

Prestart-up Safety Review

PSSR is conducted before any new unit or modified sections of a unit are commissioned. To conduct the review, the refinery has developed a series of robust checklists based on OSHA's PSM standard, HSE guidelines, and OISD GDN-145 and GDN-206. PSSR helps verify that:

- construction and equipment are in accordance with design specifications;
- safety, operating, maintenance and emergency procedures are in place and are adequate;
- where applicable, an MOC procedure has been followed and all HAZOP recommendations have been implemented before start-up;
- employee training has been completed.

To assess these elements, checklists are used after multilevel checks are performed by the construction team. A multidisciplinary team (consisting of experienced personnel) checks and forms a list of items to be cleared before the section/unit is commissioned. These punch points (deviations identified) are prioritized and rectified within an agreed-upon timeframe. An online system is used to track the completion of these issues.

Mechanical Integrity

In every major process incident studied in the past decades, system integrity has been challenged. As noted, the three integrity pillars of PSM are:

- **operation integrity:** training, safe work practices, SOPs;
- **plant integrity:** hardware design, maintenance, construction, reliability;
- **design integrity:** process design, PSI, engineering, material of construction.

OSHA's PSM standard and OISD GDN-206 require a mechanical integrity program to ensure that equipment is designed, installed and operated as intended without chances of failure. To meet this requirement, the refinery implemented a mechanical integrity and asset reliability program. It encompasses the following equipment:

- pressure vessels and storage tanks;
- piping systems (including components);
- relief and vent systems and devices;

•emergency shutdown systems;
•safety instrumentation and controls (including monitoring devices, alarms, interlocks);
•rotary equipment (e.g., pumps, compressors);
•heaters, furnaces, boilers;
•electrical systems;
•fire protection systems.

Given the rising cost of process incidents due to lack of integrity control, focus has turned to preventing catastrophic failure; improving reliability of critical equipment; and avoiding business loss. Based on program requirements, the following activities are key: equipment selection (scope); inspection, testing and preventive maintenance; written procedures; training; equipment deficiency management; quality assurance; and continuous improvement.

The refinery has devised a risk assessment approach to identify critical equipment. This criticality index categorizes equipment as supercritical, critical or noncritical. The index is a function of the criticality and priority scores:

criticality index = criticality score x priority score

The criticality score depends on the effect of the equipment's failure on production (P); quality (Q); safety (S); service level (SL); and redundancy (RF): presence of spares. Thus, the criticality score = [(P + Q + SL) x RF + H)] x S (where H is operational severity, based on design limits).

The priority score is dependent on the failure frequency (FF) and the average downtime (DT): priority score = FF + DT.

Criticality	Score
Supercritical	> 71
Critical	41-70
Semicritical	11-40
Noncritical	0-10

Based on this matrix, all refinery equipment has been categorized for criticality determination. For electrical equipment and instruments, equipment has been categorized based on its type.

Next, inspection, testing and preventive maintenance (ITPM) plans are developed after identifying maintenance tasks needed to ensure the integrity of supercritical equipment. Each piece of equipment has its own plan, which involves these steps:

1) Gather equipment information (e.g., manufacturer data, international standards): a) gask selection: inspection (e.g., corrosion survey); b) testing (e.g., vibration testing); and c) preventive maintenance (e.g., lubrication, tightness checking).
2) Determine frequency for ITPM tasks.
3) Develop SOPs for tasks and recording.
4) Determine responsibility.

Proper training ensures that tasks are performed by only qualified personnel appropriately and consistently. Based on the results of the ITPM plan, deficiencies are noted and subsequent monitoring/relevant maintenance repair/replacement is performed. In addition, administrative procedures have been developed for using a commercial software, maintenance planning, task scheduling and more. Use of this software allows for vendor and quality control, and monitoring of equipment availability and failure patterns.

The root-cause analysis portal created for analyzing and investigating integrity problems in the refinery has been a success with an internally developed FTA module. Inspection frequencies for all critical/super-critical equipment are based on statutory norms (e.g., Gujarat Factory Rules, static and mobile pressure vessels rules, Indian boiler rules) and past experience, incident findings/lessons learned and manufacturer recommendations.

Relief Device Management

Relief device management at Essar addresses the necessity to ensure that:
•pressure relief devices are adequately inspected, tested and maintained;
•isolation is properly managed;
•changes in their setting are critically reviewed and approved;
•basis for their sizing is evaluated and documented.

Relief device isolation is closely monitored in the refinery, and systems are in place to follow the MOC process to facilitate any changes in sizing, service, settings or related areas. Device inspection is based on API 520 and OISD STD-132. Every 6 months, relief devices (e.g., pressure safety valve, pressure vacuum relief valves) are visually inspected using checklists based on the standards.

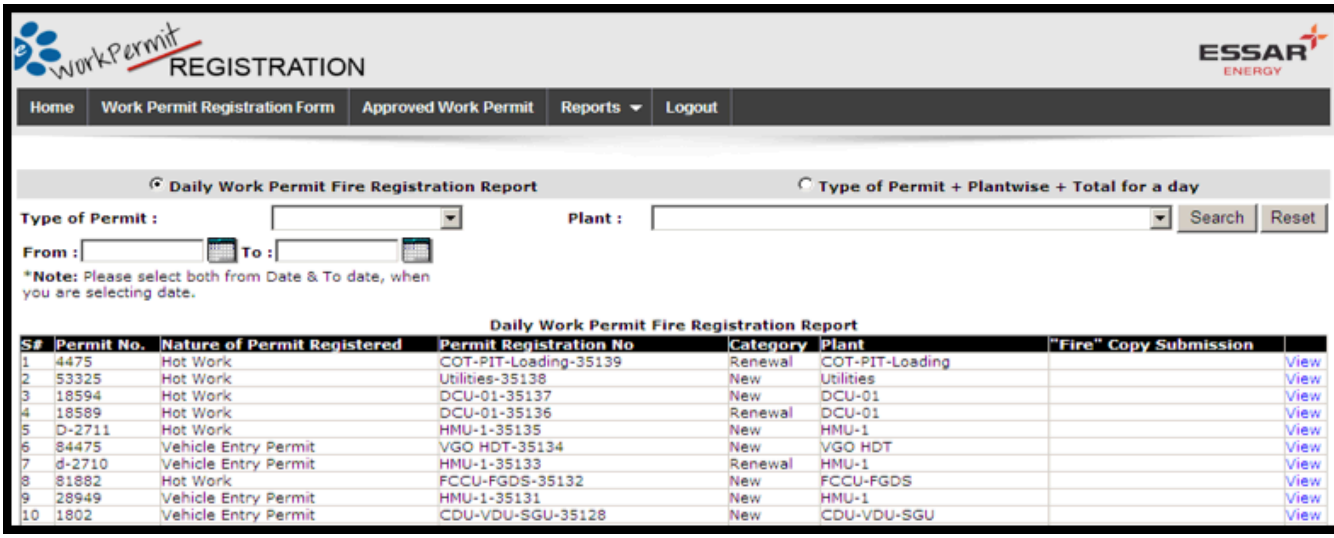
Trip Interlocks & Safety Device Bypass

One critical aspect of PSM is to monitor the bypassing of any safety device in the refinery. Bypassing may be initiated based on various process and operational requirements, such as when process parameters have changed from the initial parameters for which the plant was designed.

The refinery has a safety device and trip interlock bypass procedure in place and monitors the bypassed safety systems weekly. Senior management is informed about any interlocks that have not been taken in-line shortly. This ensures that proper risk assessments are conducted to evaluate the pros and cons of the bypass and to derive suitable solutions.

Hot Work Permits

The refinery's work permit system is based on OISD STD-105 as made mandatory by Rule 171 of the Petroleum Rules (Ministry of Commerce, 2002). Under this system, employees must obtain permits to conduct hot work anywhere inside the refinery complex. Due to the potential for flammable/explosive materials, the primary focus is on ignition control. As per OSHA's PSM rule, hot work permits document fire prevention and protection measures undertaken before a hot-work job begins. Every such job is treated as critical in the refinery and task-based risk assessments with relevant higher-level authorizations are required. All permit records are duly maintained as well. In addition, a hot work permit registration portal is used to monitor jobs in progress.



Work Permit REGISTRATION

ESSAR ENERGY

Home | Work Permit Registration Form | Approved Work Permit | Reports | Logout

Daily Work Permit Fire Registration Report · Type of Permit + Plantwise + Total for a day

Type of Permit : Plant : Search Reset

From : To :

*Note: Please select both from Date & To date, when you are selecting date.

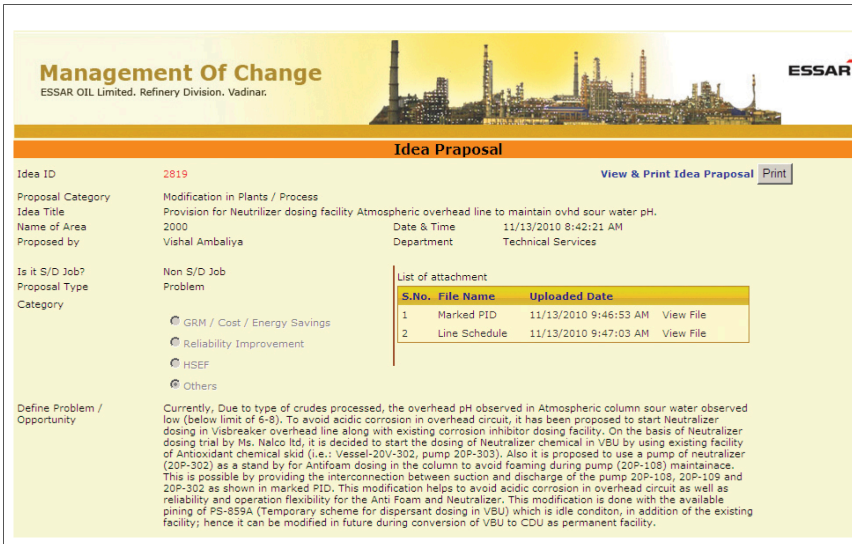
Daily Work Permit Fire Registration Report

S#	Permit No.	Nature of Permit Registered	Permit Registration No	Category	Plant	"Fire" Copy Submission	
1	4475	Hot Work	COT-PIT-Loading-35139	Renewal	COT-PIT-Loading		View
2	53325	Hot Work	Utilities-35138	New	Utilities		View
3	18594	Hot Work	DCU-01-35137	New	DCU-01		View
4	18589	Hot Work	DCU-01-35136	Renewal	DCU-01		View
5	D-2711	Hot Work	HMU-1-35135	New	HMU-1		View
6	84475	Vehicle Entry Permit	VGO HDT-35134	New	VGO HDT		View
7	d-2710	Vehicle Entry Permit	HMU-1-35133	Renewal	HMU-1		View
8	81882	Hot Work	FCCU-FGDS-35132	New	FCCU-FGDS		View
9	28949	Vehicle Entry Permit	HMU-1-35131	New	HMU-1		View
10	1802	Vehicle Entry Permit	CDU-VDU-SGU-35128	New	CDU-VDU-SGU		View

Management of Change

Due to Essar's continuous growth and the need for improvement, various changes are required in the plant's existing design. To ensure that any such changes do not introduce new hazards without control or override existing controls, Essar has created and implemented MOC procedures based on OISD GDN-178, OISD STD-206, OSHA's PSM standard and CCPS guidelines.

At Essar, change management starts with idea conceptualization, which is then posted to the online MOC portal for evaluation. Proposed changes may aim to prevent incidents, improve facility use and optimization, reduce downtime or reduce risk to personnel. The proposal is evaluated, then a process scheme is created, which is then studied in detail for determining any process hazards through checklists, HAZID and HAZOP as required.



Management Of Change

ESSAR OIL Limited. Refinery Division. Vadinar.

ESSAR

Idea Praposal

Idea ID 2819 View & Print Idea Praposal Print

Proposal Category: Modification in Plants / Process

Idea Title: Provision for Neutrilizer dosing facility Atmospheric overhead line to maintain ovhd sour water pH.

Name of Area: 2000 Date & Time: 11/13/2010 8:42:21 AM

Proposed by: Vishal Ambaliya Department: Technical Services

Is it S/D Job?: Non S/D Job

Proposal Type: Problem

Category: GRM / Cost / Energy Savings; Reliability Improvement; HSEF; Others

List of attachment

S.No.	File Name	Uploaded Date	
1	Marked PID	11/13/2010 9:46:53 AM	View File
2	Line Schedule	11/13/2010 9:47:03 AM	View File

Define Problem / Opportunity: Currently, Due to type of crudes processed, the overhead pH observed in Atmospheric column sour water observed low (below limit of 6-8). To avoid acidic corrosion in overhead circuit, it has been proposed to start Neutralizer dosing in Visbreaker overhead line along with existing corrosion inhibitor dosing facility. On the basis of Neutralizer dosing trial by Ms. Nalco ltd, it is decided to start the dosing of Neutralizer chemical in VBU by using existing facility of Antioxidant chemical skid (i.e.: Vessel-20V-302, pump 20P-303). Also it is proposed to use a pump of neutralizer (20P-302) as a stand by for Antifoam dosing in the column to avoid foaming during pump (20P-108) maintainace. This is possible by providing the interconnection between suction and discharge of the pump 20P-108, 20P-109 and 20P-302 as shown in marked PID. This modification helps to avoid acidic corrosion in overhead circuit as well as reliability and operation flexibility for the Anti Foam and Neutralizer. This modification is done with the available pining of PS-859A (Temporary scheme for dispersant dosing in VBU) which is idle conditon, in addition of the existing facility; hence it can be modified in future during conversion of VBU to CDU as permanent facility.

Under the refinery's work permit system, employees must obtain permits (top) to conduct hot work anywhere inside the refinery complex.

To ensure that changes do not introduce new hazards without control or override existing controls, Essar has created and implemented MOC procedures (bottom).

For a proper scheme to result, PSI should be accurate and updated, as it drastically reduces the chances of errors. PHA recommendations are incorporated into the process scheme's design before implementation. In-field implementation may then begin, and the project team monitor for deviations from design.

The MOC process does not end at the implementation stage. It may require that PSI (e.g., P&IDs, cause-and-effect diagrams) be updated or that personnel be retrained. In addition, any changes must be extensively communicated. Once field implementation is complete, the PSSR process is followed. Punch points are resolved as soon as possible before proceeding to commissioning.

All changes are monitored and recorded for knowledge and monitoring. For changes that are not permanent, slightly different approval practices are used, but the process structure remains the same (approval-PHA-design-implementation-PSSR). Typically, temporary changes are valid for 90 days. When necessary to implement a change in an emergency, refinery staff generates a field plant change notification and conducts a PHA before implementation. The MOC process can then be completed within the next week.

Incident Investigation

The incident investigation system is one of the refinery's most robust systems. The incident reporting and investigation system was developed based on various statutory requirements including Gujarat Factory Rules (1963; specifically Rule 68J(4), 103, Chapter IX, Schedule XIX); Indian Factories Act (1948), sections 88, 88A; Indian Petroleum Rules (2002), Chapter XI; workers' compensation laws; and CCPS and HSE guidelines.

All incidents are reported and rigorously investigated in accordance with established procedures. As suggested in OISD STD-206, investigations are reported within 24 hours of the event. Multidisciplinary teams then conduct an investigation within a scheduled timeframe depending on incident severity. The team uses a matrix to categorize the incident based on how it will affect people, environment,

LEARNINGS FROM PROCESS SAFETY INCIDENTS - EXTERNAL	
INCIDENT	NG Explosion at Compressor House
Natural Gas Explosion at Compressor House, Bill Barrett Corp, Fort Mill, Dry Canyon, Carbon County, Nov 20, 2012	
DESCRIPTION	Two men were critically injured in an explosion and fire at the Dry Canyon Natural Gas Operation Station. Smoke filled the air and continuously burning flames were observed at the site due to the catastrophic explosion. A giant hole was found in the ground. Buildings were completely destroyed by the blast, and charred shells of pickup trucks were found near by. The damage to the facility itself was stunning.
CAUSES	[1] A 12-inch, high-pressure gas line had been damaged at some point by a backhoe. Score marks were visible along the top of the pipe where the backhoe (excavator) teeth had contact with pipe. [2] The natural gas pipeline on the property had sustained undetected damage and ruptured when a pressure spike inside the pipeline occurred. [3] When the pipe ruptured, it blew a 30-foot wide by 15-foot deep crater in the ground, and directed a stream of pressurized NG into one the compressor station's buildings. [4] The gas shot into the Compressor Station area, found an ignition source and exploded.
 KEY LEARNINGS	This is the third such incident reported in the last three months. At some points, damage due to crane/ excavator is immediate and noticed/ there is an explosion. [1] In Process Plant, Vehicle movement should be strictly monitored. [2] While excavating near known underground lines, care should be taken against damage. Manual Excavation should be followed. [3] Any damage should be reported immediately and inspected. [4] While using Cranes or Heavy-Lifting equipment near Process Plant Piping/ Vessels, keep safe distance.
PROCESS SAFETY ELEMENTS INVOLVED	[1] Safe Work Practice [2] Mechanical integrity
APPLICABLE AREA	Process Plant Areas
NEWS SOURCE	News Articles
REFERENCE/ LINK	Source Link

All investigation reports are circulated among employees to share knowledge and develop incident learnings.

assets and reputation. Should any containment be lost, a spill release matrix is used to categorize incident severity based on API 754.

A portal provides a systematic platform for conducting investigations; it tracks the actions based on recommendations and documents actions.

Each investigation is performed using a PHA method (e.g., FTA). All investigation reports are circulated among employees to share knowledge and develop incident learnings. Findings are also explained to contractors as part of the safety timeout conducted at the beginning of each month.

All incident reports generated are maintained in a database to provide insights into any patterns that might develop. Each year, overall data are analyzed to identify key focus areas for improvement.

Emergency Planning & Response

The site has implemented an emergency response and disaster management plan. All personnel (visitors, employees, contractors) are instructed in the required responses and warning systems during the safety induction. Separate training is also provided.

The refinery has incorporated many statutory rules and guidelines in these plans, including Factories Act (1948), Schedule 1, Section 41B; Petroleum and Natural Gas Regulatory Board Emergency Response Regulations (2010); OISD GDN-168; Manufacture, Storage and Import of Hazardous Chemicals Rules (1989), Rule 14; and NFPA 1600.

The refinery classifies on-site emergencies into four types for monitoring: 1) spill/leak; 2) fire; 3) injury; and 4) traffic. The event's severity determines the level and action required.

•Level 1: Emergency can be effectively contained within the site or location, and it poses no off-site impact.

•Level 2: The event's impact may spread beyond the site or location and additional resources are required to contain it.

•Level 3: Catastrophic, off-site impact is probable, and external aid is required to contain the situation.

Essar conducts periodic mock drills. To develop these scenarios, the operations department works with the fire department. The mock drills are evaluated by a team of experienced professionals and their recommendations are shared with all in the area following the drill.

Scenarios identified in the quantitative risk assessment study are also included, and resulting actions are tracked in the safety portal. Should an emergency occur, the fire team provides a backup to the area owner. The refinery also has a separate 200-member auxiliary fire squad that activates in the case of a prolonged or critical emergency. The refinery follows OISD STD-116 and 118 for all firefighting/prevention guidelines.

Compliance Audits

Based on OISD, OSHA and similar rules and regulations, the refinery conducts regular compliance audits to monitor implementation and to identify any examples of changes made to existing standards or international best practices. Internal safety audits are usually conducted by refinery personnel or staff from another Essar Group company. External safety audits are performed by reputable third parties. All audit recommendations are tracked in the safety portal.

In addition, gap analyses are performed for every element implemented to verify that the procedures and practices developed under the standards are adequate and being followed.

Trade Secrets

In accordance with industry norms, Essar has a data protection policy that is monitored through a control of documents procedure. This policy ensures the following:

•Latest versions of relevant documents are accessible to concerned personnel for their use.

•Documents are approved for their adequacy before use. They are reviewed periodically and revised if necessary.

•Changes and current revision status of documents are identified.

•Documents originated externally are identified and their distribution is controlled.

•Obsolete documents are stored for version history, and those required for legal or other purpose are identified and preserved.

These documents are maintained through the Essar Refinery Integrated Management System, and all relevant copies are stored on company servers. Since this is a web-based system, the documents can only be accessed by authorized personnel. When access to a soft copy is not practically possible, any printouts or copies issued to users for official use are treated as controlled copy. Furthermore, access restrictions do not allow for external electronic transfer of the documents.

Management Review

All management programs are effective only with regular, periodic management review of existing practices. Senior managers receive weekly updates on any critical process safety issues (e.g., safety devices/interlocks bypassed). The top management team, consisting of all area managers, department heads and the refinery director, meets the first week of every month. In addition, process safety key performance indicators have been drafted in accordance with API 754 and CCPS's leading and lagging metrics for monitoring the refinery's PSM performance. This information is presented in monthly meetings and is incorporated into the management performance report.

Any incident reported is considered to be a process safety event and is categorized as Tier 1 or Tier 2 based on event characteristics:

1) Threshold quantity. The amount of material released should exceed this stated amount for the concerned chemical. Manufacturing, Storage and Import of Hazardous Chemicals rules also have a set threshold limit for most chemicals. API and CCPS guidelines cover these and are more stringent.

2) Acute release. The release within 1 hour should be above threshold quantity. For example, if a hazardous release exceeds threshold quantities but over a period of many days, instead of 1 hour, it will not be considered a process safety event.

Conclusion

Essar has come a long way in PSM implementation in recent years. In keeping with its goals for continual improvement, management has sustained and developed the PSM system. As of Oct. 1, 2013, the refinery has recorded 2,008 lost-time-incident-free days and 1,593 major fire-free days. Incident prevention depends on the actions of people, applying lessons learned from incidents and periodical review of systems and procedures. All involved must agree that it is critical to produce chemicals safely without harming human life or environment. Investment in safety should be treated as an opportunity cost. PSM is the fulcrum of the safety integrity of any process plant; if practiced with sincerity, many major incidents can be prevented or minimized. **PS**

References

American Petroleum Institute (API). (2010). Process safety performance indicators for the refining and petrochemical industries (API RP-754). Washington, DC: Author.

API. (2000). Sizing, selection and installation of pressure-relieving devices in refineries: Part 1—Sizing and selection; Part 2—Installation (API 520). Washington, DC: Author.

Center for Chemical Process Safety (CCPS). (2008). *Guidelines for management of change for process safety.* New York, NY: Author.

CCPS. (2011). Process safety leading and lagging metrics. New York, NY: Author.

International Association of Oil & Gas Producers. (2011). Process safety: Recommended practice on key performance indicators (Report No. 456). Retrieved from **www.ogp.org.uk/pubs/456.pdf**

Labour & Employment Department. (1948). Indian factories act. Retrieved from **www.labourandemployment.gov.in/lc/factory/statutesa.htm**

Labour & Employment Department. (1963). Gujarat factories rules. Retrieved from **www.labourandemployment.gov.in/lc/factory/rules_chapter_index.htm**

Ministry of Commerce & Industry. (2002). Petroleum rules. Retrieved from **http://peso.gov.in/Petroleum_rule.aspx**

Ministry of Environment & Forests. (1989). Manufacture, storage and import of hazardous chemicals rules. New Delhi, India: Author.

NFPA. (2007). Standard on disaster/emergency management and business continuity programs (NFPA 1600). Quincy, MA: Author.

Oil Industry Safety Directorate (OISD). Contractor safety (OISD GDN-207). Noida, Uttar Pradesh, India: Author.

OISD. Emergency preparedness plan for marketing locations of oil industry (OISD GDN-168). Noida, Uttar Pradesh, India: Author.

OISD. Fire protection facilities for petroleum refineries and oil/gas processing plants (OISD STD-116). Noida, Uttar Pradesh, India: Author.

OISD. Guidelines in safety management system in the petroleum industry (OISD GDN-206). Noida, Uttar Pradesh, India: Author.

OISD. Guidelines on internal safety audits (procedures and checklist) (OISD GDN-145). Noida, Uttar Pradesh, India: Author.

OISD. Guidelines on management of change (GDN-178). Noida, Uttar Pradesh, India: Author.

OISD. Inspection of pressure relieving devices (OISD STD-132). Noida, Uttar Pradesh, India: Author.

OISD. Layouts for oil and gas installations (OISD STD-118). Noida, Uttar Pradesh, India: Author.

OISD. Pressure relief and disposal system (OISD STD-106). Noida, Uttar Pradesh, India: Author.

OISD. Safety aspects in functional training (OISD STD-154). Noida, Uttar Pradesh, India: Author.

OISD. Work permit system (OISD STD-105). Noida, Uttar Pradesh, India: Author.

OSHA. (1992). Process safety management (29 CFR 1910.119). Washington, DC: U.S. Department of Labor, Author.

Petroleum & Natural Gas Regulatory Board. (2010). Emergency response regulations. New Delhi, India: Author.

PS EXTRA

To view a sample of the spill release matrix and other screen shots from systems used at Essar, visit www.asse.org/psextra.