REFINERIES AND LARGE GASOLINE PLANTS

INTRODUCTION

This PRC Guideline presents guiding principles for loss prevention and control for refineries and large gasoline plants. They are intended as a tool for evaluating the widely diverging protection levels provided at these facilities.

POSITION

Management Programs

Have management program administrators report to top management through the minimum number of steps. Institute an adequate loss prevention inspection and audit program to communicate program effectiveness to top management. Developing management programs which comply with the OSHA PSM standards (OSHA standard 29 CFR-1910.119) is a good start but there are areas within the program that should be further developed. In developing loss prevention management programs, pay particular attention to the following areas:

Process Hazard Analysis (PHA)

The goal of the PHA is to identify potential accident scenarios, determine if the risk is tolerable, and recommend improvements when it is not. The analysis is to be performed by a team. The team should have multiple members but should not be too large or the process can become more complicated than it needs to be. The PHA leader should be someone independent of the process being reviewed. The team members should be experienced staff. At least one member of the team should be fully trained in the methodology to be used. The PHA program should specify the appropriate methodology to be used for each PHA.

The PHA must address the following:

- The hazards of the process
- Past incidents that could have created the potential for a catastrophic situation
- The engineering and administrative controls in place on the process and their adequacy/appropriateness
- Consequences for the failures of these controls
- Facility location and exposure issues (siting study)
- Potential effect on the process due to human factors
- Effect on process personnel due to failure of controls.

The action items that come out of the PHA should be captured in a document to be presented to management. It is then management's responsibility to review the items, evaluate them, and determine what if any action should be taken. Whatever action management decides to take should be fully document including the reasons for their decision. Management must full document what is to be done in a timely manner, develop a schedule for completion, and communicate what was done to the affected employees.

PHAs have to be updated and revalidated at least every 5 years per the OSHA standards. The team chosen to revalidate the PHA should be similar in composition to that of the original team. The team should review the findings and resolutions from the last PHA. The team should review the PSI to determine what process modifications have been made since the PHA was conducted. If the process has been altered extensively then a new PHA should be conducted. If the process changes have been minor the existing PHA should be updated taking the changes into consideration. Good industry practice is to conduct a full PHA at least every third revalidation cycle (every 15 years)

Operator Training and Standard Operating Procedures

Standard operating procedures (SOP) must be developed which provide clear instructions for safely conducting activities involved for each process. The operating procedures must include:

- Steps for each operating mode of the process including: Initial startup, Normal operations, Temporary operations, Emergency shutdown (ESD), Emergency operations, Normal shutdown, Startup following a planned shut down or emergency shutdown
- Technically accurate and easily understood.
- Operating limits of the process including the potential consequences of deviations and the steps required to correct or avoid deviations.
- Process safety systems and their functions.
- Address safety and health considerations including the properties and hazards of chemicals being used, the precautions necessary to prevent exposure such as PPE or administrative controls, control measures to be taken if physical contact or airborne exposure occurs, quality control for raw materials and control of hazardous chemical inventory levels, and any unique or special hazard associated with the process chemicals.
- The operating procedures shall be readily accessible to employees who work in or maintain a process.
- The SOPs shall be reviewed as often as necessary to assure that they reflect current operating practices. The employers must certify the procedures are current and accurate on an annual basis.
- As part of the operating procedures the employer must develop and implement safe working practices. Apply these practices to employees and contractors.

A good training program is important to insure employees working in the process areas have the knowledge, skill & ability to carry out their responsibilities. All personnel should receive general training on topics including general facility safety rules, smoking regulations, personal protective equipment requirements, and emergency procedures such as evacuations, spill reporting, and accident/near miss reporting. Training that is done must be properly documented including the employees name (or other identifier), the date of the training, and how the employer verified the employee taking the training understands the material presented.

Employers should provide more detailed training for all employees of a process. This training should cover all of the SOPs in place for the process area the employee is assigned to work in. Employees moving from one process to another should receive the same training as any new employee for the process they are moving into. Refresher training is also required and must be provided at least every three years per OSHA guidelines. Management in cooperation with the operators could chose to perform the training more often if incidents or other problems result from identified training deficiencies.

Pre-Emergency Planning

The element covers the facility-wide emergency response procedures for handling small and large incidences involving fires, chemical releases or other emergencies requiring evacuation. It should be noted that this element of the PSM standard is designed to cover the internal response to the emergency. It does not require any planning with the local emergency officials such as the fire department. The plan may also address community notification and evacuation. The PSM standard requires covered facilities to comply with OSHA 29 CFR 1910.38 (Emergency Action Plans). In addition the emergency action plan must include procedures for handling small releases.

The written emergency action plan should include the following as a minimum:

- Procedures for reporting a fire or other emergency.
- Procedure for emergency evacuation, including type of evacuation and exit route assignments. If sheltering in place is desirable in some emergencies it should be addressed in the plan. The plan should cover the designation and training of employees to assist with the evacuation of other employees.
- Procedure to be followed by employees who remain to operate critical plant operations before they evacuate. This should be part of the SOP element as well.
- Procedure to account for all employees after evacuation.
- Procedures to be followed by employees performing rescue or medical duties
- Name and job titles of employees who can be contacted by employees for more information about the plan or an explanation of their duties under the plan.

As part of the plan employers must have and maintain and employee alarm system. Large facilities should have back up systems. The system must have a distinctive signal that can be perceived above the ambient noise and light levels in the process area, a means for reporting emergencies such as manual pull stations, public address systems, radio, or telephone, an established procedure for sounding the emergency alarms, and a program for the installation, restoration, maintenance & testing of the system. Systems should be installed using approved equipment.

The emergency action plan should be reviewed with all employees who work in the process areas. Contractors and visitors who may travel through the site unescorted should also be included in the training. The emergency action plan should be reviewed with personnel when the plan is initially developed, when the employee is initially assigned to a job, when the employee's responsibilities under the plan change, and when the plan is changed

Large plants should have in-house fire brigades and a hazmat team. When these are present the site must have a program to comply with OSHA 1910.120 (Hazardous Waste Operations and Emergency Response (HAZWOPER)).

The facility's emergency response plan should address the following:

- Coordination with outside parties including outside fire departments and mutual aid groups.
- Personnel roles, lines of authority, training and communication
- Emergency recognition and prevention
- Safe distances and places of refuge
- Site security and control
- Evacuation routes and procedures
- Decontamination, emergency medical treatment, & first aid.
- Emergency alerting and response procedures
- Critique of response and follow-up
- PPE and emergency equipment?

Preventive Maintenance and Inspection

A good mechanical integrity program addresses both the maintenance and inspection needs of the site. This can help limit the amount of down time a process experiences and prevent the release of hazardous materials. The mechanical integrity program should cover to all equipment which is critical to the smooth operation of the process or whose failure could lead to a hazardous release. This includes pressure vessels, storage tanks, piping systems including all valves and other system components, relief and venting systems, emergency shut down systems, pumps, and control systems including monitoring devices, sensors, alarms and interlocks.

The program should include:

- Establish written procedures to maintain the integrity of the process equipment and piping.
- Implementation of the written procedures
- Training in proper maintenance procedures.
- Inspection and testing procedures for the covered equipment. The testing must follow recognized and generally accepted good engineering practices.
- Inspection and testing frequencies that follow the manufacturer's recommendations or good engineering practices. If operating experience dictates more frequent testing may be needed.
- Full documentation showing the inspection/test done, the date, who completed the task, the equipment number/name, a description of what was done, and the results of the inspection/test.
- A procedure for insuring any deficiencies identified are corrected in a timely manner.
- A quality assurance program to confirm that all equipment is ordered, fabricated, and installed per the process specifications.
- A program for tracking key performance indicators and "bad actors" to help identify areas in need of improvement.

Management of Change

Each facility must have a management of change process in place to meet the requirements of the OSHA PSM standard. Although it is only necessary to apply this to process areas covered by the OSHA standard good industry practice is to apply the MOC process to all areas of the site. A change is defined as any change in the processes chemicals, technology, equipment, and/or procedures. A process change includes all additions, deletions and modifications to plant, equipment and procedures not considered a replacement in kind. An MOC is also required for any change in another part of the facility that could affect the covered process such as changes in site utilities or staffing levels.

A proper MOC program must include:

- A site developed definition of what is a change and what is a replacement in kind. Typically a replacement in kind is identified as a replacement of raw materials, equipment and/or piping, which satisfies the design specifications.
- A form should be used to facilitate processing of changes. Checklists may be adequate for minor, well-understood changes More complex or significant changes may require hazard evaluation and multidisciplinary approval
- The program should define how to review the potential hazards the change could present.
- The program should provide specific guidelines for Initiating, Reviewing and Approving changes
- The program should outline how to handle Permanent, Temporary and Emergency changes
- The procedure should clearly indicate who is responsible for documentation and recordkeeping including updates to the process safety information.
- The procedure should include the process to be followed for change closure

- The procedure should clearly indicate when a Pre-Startup Safety Review is needed.
- The procedure should clearly define the responsibilities of the employees involved in the MOC program.
- The procedure should include periodic evaluations of the program and its effectiveness.

Other Management Programs

Incorporate these features into a comprehensive program for loss prevention and control:

- Work permit systems including: Welding, cutting and other “hot work” permits, Line breaking/opening procedures, and lockout/tagout procedures.
- A program to supervise impairments of fire protection equipment using AXA XL Risk Consulting’s “RSVP” program described in *OVERVIEW*.
- Smoking regulations.
- Plant security and surveillance.
- Shift hand over procedures

Plant Layout and Separation

Space separation is the most effective loss control method. Design separation into a plant during the early planning stages of a project. Give consideration to separation of main processing areas, to separation of sections within a processing area, and to separation of equipment within the various sections. Separate storage tank areas from process areas. Minimize exposure of pressure storage vessels to all other plant areas.

Consider the following factors in determining the need or the degree of separation:

- High hazard operations.
- High property values.
- Highly exposed business interruption values.
- Exposure to possible explosion overpressures.
- Adequate access for firefighting and good maintenance.

See PRC.2.5.2 for details.

Process design and controls

Industry best practices call for completely automatic control, using current versions of Distributed Control Systems (DCS) manufactured by reputable experienced companies. The control system should include an operator interface using graphics which mimic the process plant, and which also indicate any trip bypasses put in place. The system should be arranged so only authorized personnel can make changes in alarm or trip settings.

Provide redundant instrumentation for all critical controls. Redundant control loops should include separate signal transmitters, cables and receivers. Install a comparator to notify operators when redundant signals differ significantly.

Key items of rotating equipment should have vibration monitoring and trip devices on them.

There should be Fire & Gas detection systems in all critical areas, such as process units, storage of LPG type materials, API separators and other areas where hydrocarbon can leak into cooling water or other utility systems. Alarms should sound locally and to control room over dedicated lines.

Emergency isolation valves should be provided for large hold-ups, pumps, and compressors. These valves should be operated from the control room or from safe distance outside the affected process area.

The Emergency Shut Down systems should be separate from the process control system.

Relief systems should be designed to international/ national standards for worse case scenario, generally API 521. Relief valves should always be directed to flare systems. There should be the

ability to depressurize high pressure equipment, according to a standard such as API 521. Where liquid could enter relief systems there should be high level trips (SIL rated) to prevent it happening.

Design and specify equipment considering all possible operating conditions, both normal and abnormal. Give particular attention to suitability of the equipment to handle the process materials and to withstand external environmental influences.

Duplicate equipment which is highly susceptible to loss or which is very important in the continuity of operations. Utilize installed spares or at least have readily available spare parts.

The use of long bolt flanges should be discouraged. Any long bolt flanges with bolts 3inches or longer should be protected against fire impingement.

Construction

Fireproof all major load-bearing structural steel supports for outdoor process structures, process equipment, important exposed pipe racks and buildings with materials tested and listed by Underwriters Laboratories utilizing the UL 1709 test procedures. Provide a 2½ h rating by UL 1709 for equipment or structures handling or exposed by liquefied flammable gases, flammable or liquids, or to a lesser extent, by flammable gases. If these structural members are protected by properly designed deluge sprinkler systems, or if located in areas of less severe exposure, fireproofing with a 1½ h protection rating by UL 1709 is acceptable.

Provide fireproofing for important grouped power, control, and instrumentation cables, tubing, or conduit, and fire-sensitive thermal insulation on important equipment. To allow sufficient time for shutdown of the process unit, the fireproofing for this application requires only a 30-min protection rating. See PRC.2.5.1 for details.

Where flammable gases or liquids are handled, select open-sided process structures rather than closed buildings because of inherently good ventilation and explosion relief. Where closed buildings must be used, provide ventilation. Supplement normal ventilation rates with emergency ventilation actuated manually and by diffusion-head-type combustible gas detectors.

Where an explosion hazard exists and closed buildings must be used, provide explosion venting facilities. Design the nonrelieving walls and roof (depending upon where relief is provided) for explosion resistance. See NFPA 68 for details.

Where an explosion hazard exists, do not use load-bearing walls. Carefully consider proper clearance from possible fire exposures and proper classification of hazardous locations for electrical installations. Control rooms, motor control centers, and other essential facilities should be located and constructed to allow operators to safely shut down units under emergency conditions. The control building should preferably be located where it will not be exposed to fires or explosions. If the control room cannot be separated adequately from the hazard area it should be designed withstand explosion overpressure, taking into consideration the possibility of open-air vapor cloud or confined vapor-air explosion exposure. The control room should be pressurized and have gas/smoke detectors in the air intake designed to shut down the system in a release or fire situation.

Drainage

Provide drainage facilities to carry spilled flammables away from buildings, structures, storage tanks, pipe racks and process equipment. Design drainage facilities to effectively and rapidly carry spills, fire protection water and rain water to a safe location without exposing adjacent plant facilities. This may require diversionary curbs, trenches, collection sumps, skimmers, separators and holding ponds or basins. Design general area grading with the anticipation that normal drainage facilities may overflow. See PRC.2.5.3 for details.

Water Supplies

Provide adequate water volumes and water distribution systems to supply the maximum simultaneous demand for hose, monitor nozzle streams and water spray systems for a minimum period of 4 hr. Meet the foregoing criteria with the largest single water supply out of service. Include

the size and congestion of the plant in determining the maximum simultaneous demand. Keep fire protection water storage independent of plant process water storage. Consider cooling tower basins and process water pumps only as alternate emergency supplies.

Drive fire pumps by electric motors, steam turbines or diesel engines. At least 50% of the pumping capacity should be diesel-driven.

Design the distribution system of buried pipe to provide loops and sectional control valves such that with one section of the distribution system out of service, at least 50% of the plant's pumping capacity can be provided in any high-valued area. See PRC.14.1.1.1 for details.

Monitors, Hydrants, and Hose Protection

Locate fixed monitor nozzles around the perimeter of process blocks. Locate nozzles with consideration given to accessibility and desired coverage. All areas of the process blocks should be reached by at least two monitor nozzle streams, so if necessary, install additional nozzles in the interior of process blocks. See PRC.14.5.0.1 for details.

Locate hydrants throughout the plant. Provide an adequate amount of hose, nozzles and other equipment located on motorized apparatus or in accessible hose houses throughout the plant.

Provide portable monitor nozzles.

Foam Protection

Provide fixed or semi-fixed foam equipment, including an adequate supply of foam concentrates to protect all areas where flammable or combustible liquids are stored. Provide adequate application equipment and foam concentrates to extinguish a fire involving the largest storage tank. For small facilities, supply foam equipment and supplies from responding fire departments and/or mutual aid organizations. Make back-up foam supplies available within a 1 h delivery time.

Provide foam injection connections into the water spray systems to protect process areas handling flammable liquids. See PRC.12.2.1.2 for details.

Motorized Apparatus

Use motorized foam/water pumper apparatus to provide foam production and storage capability in facilities. Supplement the fire trucks with dry chemical apparatus where needed. Provide sufficient trained manpower to operate the apparatus. Supply additional manpower from responding fire departments and/or mutual aid organizations. Test pumper apparatus in accordance with NFPA 1901, NFPA 1911 and PRC.12.5.1.

Fixed Water Based Systems

Provide automatic fixed water spray systems for protection of high-hazard or easily damaged equipment, such as high-pressure and high-temperature pumps, air cooled heat exchangers and uninsulated vessels with large liquid hold-up within process units.

Install water spray or deluge sprinkler systems on all storage spheres. Water-weir systems are acceptable.

Install fixed water spray systems on all horizontal or vertical pressure storage vessels.

Equip very large storage tanks or tanks exposed by other tanks or process equipment with water spray systems to protect the exposed segments of the tank shell.

Where practical, cover vessels and equipment **completely** with fireproofing rated for 2½ h per UL 1709, in lieu of water spray.

Provide deluge sprinkler or water spray protection for large important cooling towers per NFPA 214.

See PRC.12.2.1.2 for details.

Protect loading racks with water or foam/water deluge systems. See PRC.9.2.1.1 for details.

DISCUSSION

These recommendations do not contain detailed protection design criteria. Guidance in developing specifics may be found in the following publications:

- American Institute of Chemical Engineers: Center for Chemical Process Safety; Various publications.
- American Institute of Chemical Engineers: “Loss Prevention,” Various volumes.
- American National Standards Institute: Standards (such as ANSI B31.3, “Chemical Plant and Petroleum Refinery Piping”).
- American Petroleum Institute: Various publications.
- American Society of Mechanical Engineers: Standards (such as “Boiler and Pressure Vessel Code”).
- PRC Guidelines: Various sections.
- National Fire Codes.
- Office of Oil and Gas, Department of Interior: “Minimizing Damage to Refineries from Nuclear Attack, Natural and Other Disasters.”