ENHANCED RISK MANAGEMENT AT THE PASADENA PLASTICS COMPLEX

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ABSTRACT

After the failure of a butadiene tank, Pasadena Plastics Complex personnel decided to evolve the existing risk management program. This evolution required across-the-board commitment from the operators to the plant manager. Risk management was viewed as more than a hazard analysis and compliance process but as a way of doing business.

This paper will present an overview of the enhanced risk management approach and how it has impacted process safety and plant operations at Pasadena Plastics Complex. Finally, this paper will discuss lessons learned during the implementation of the new program at Pasadena Plastics Complex.

INTRODUCTION

The failure of a butadiene tank served as a catalyst for taking a new approach to process safety management (PSM) at the Pasadena Plastics Complex of Chevron Phillips Chemical Company L.P. This incident led Pasadena Plastics Complex personnel to review the existing risk management program and determine what could be done to prevent a chain of events such as those that led to the incident. The examination revealed that a more comprehensive, focused risk management program could be beneficial to the facility.

The new risk management program had a simple goal, "Keep People Safe." Translating this goal into a business reality required direction from management on what measures were to be taken to achieve the goal. Plant management gave the directive that plant efforts were to be focused on preventing loss of containment incidents rather than minimizing the incident consequence. This shifted the risk management strategy farther into the process, necessitating the implementation of additional tools and systems, including improved operating procedures and enhanced instrumented controls.

A significant outcome of shifting from risk management to loss prevention was that plant personnel understood that management was supportive of making the necessary capital and operating investments to make the process unit safer. Preventing "loss of containment" was considered a more conservative approach to managing risk. This drives the plant toward not only safe operation but also better on-stream efficiency. When no losses occur, the plant recovery time from process excursions is faster, and potentially yielding higher production.

OVERALL PROGRAM SCHEDULE AND RESOURCING

Program Scheduling

With loss prevention as the goal, resource scheduling was initiated. The schedule chosen for work execution was aggressive. All risk assessment studies were to be completed during FY 2001. Recommendations associated with potentially high personnel risk were prioritized for implementation. Those that required long-term solutions were assessed to determine the compensating measures that could be instituted immediately to better manage the risk. These compensating measures included additional process monitoring, procedures, or supervision. The identification and implementation of the compensating measures demonstrated conclusively to plant personnel that identified risks were to be managed as a priority.

Compensating measures were scheduled to be fully deployed by the end of FY 2002. Recommendations were to be implemented by the end of FY 2005, so the overall schedule was to complete the facility retrofit within four years, which included seven production units with a nameplate production capacity of approximately 3.3 billion pounds per year of plastic resins in three major business lines.

Resource Management

Based on the schedule, resources were assigned to execute each risk assessment study and follow-up work. The intent of the loss prevention program was to better understand the risk through the deployment of existing tools, such as hazard and operability (HAZOP) studies and human factors analysis, and new tools, such as independent protection layer analysis (also known as layers of protection analysis, or LOPA). These tools were used to identify the existing systems that provided risk reduction and to determine where additional systems were required to minimize the potential for loss of containment events.

Total combined effort to complete the identified studies and reviews was approximately 700 man-weeks. Obviously, with so much work to be accomplished, resource management was critical. Plant management made the commitment to have the most experienced personnel involved in all tasks. This often meant that the senior process engineer and senior instrumentation and control system engineer were not available for day-to-day business activities for months at a time. However, it was understood by everyone that having the best people on the team would result in the highest quality risk assessment.

Each team needed a champion to maintain the focus on the company goal. A senior process engineer was assigned the primary team leadership role, making the senior process engineer responsible for risk assessment quality. As the team champion, the senior process engineer became charged with the responsibility to make sure that recommendations were concrete enough for immediate consideration and action. Additional resources were placed on-call with the requirement that unknowns were to be resolved as soon as possible so that team knowledge was expanded and used as the analysis progressed. This prevented the team from getting bogged down in endless “we don’t know” discussions.

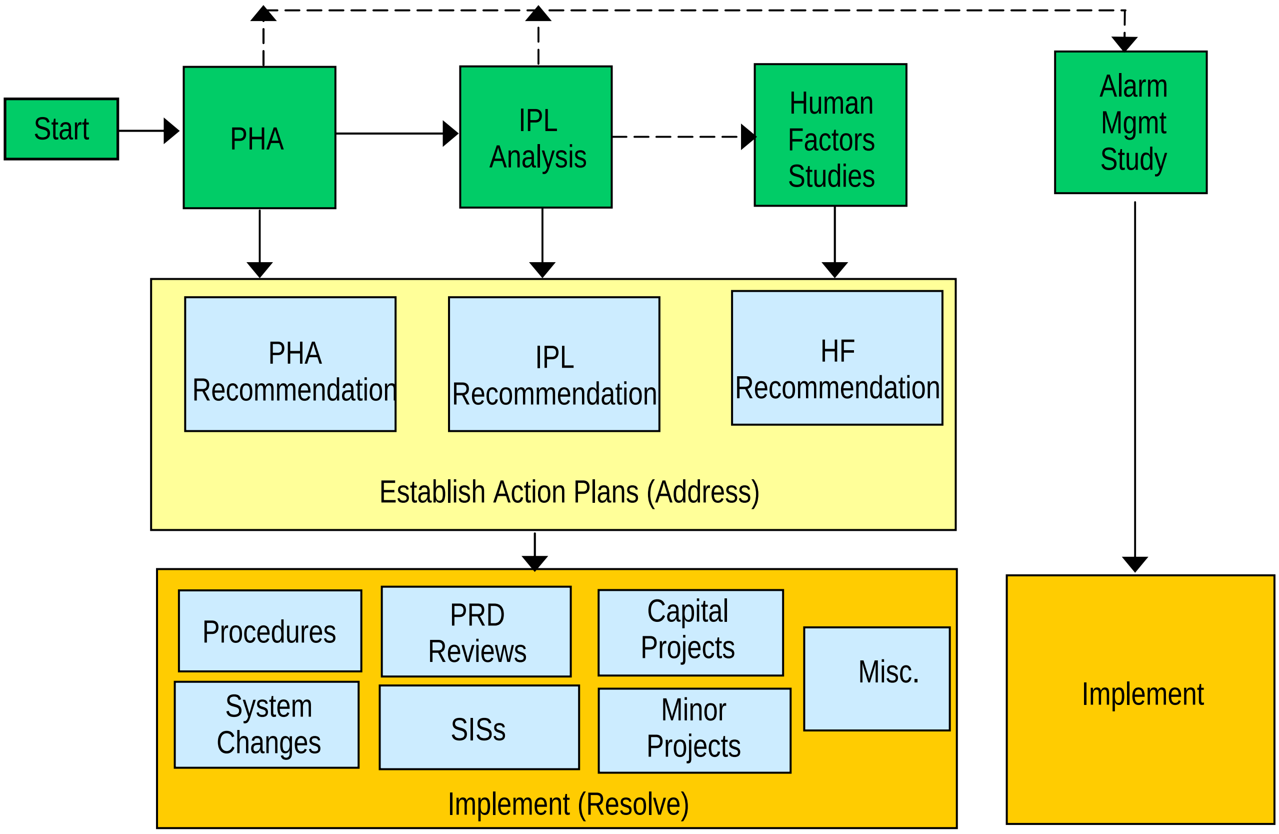
Further, outside resources were contracted to support plant activities. An outside facilitator was used for the risk assessment studies to provide an unbiased view of the process risk and to challenge each team to “think outside of the box.” For implementation of recommendations, outside resources were contracted, as necessary, to obtain skills that complemented those of internal resources and to provide sufficient personnel to meet the aggressive schedule.

TOOLS

Risk Assessment

Tools deployed for risk management ranged from a traditional Hazard and Operability (HAZOP) study, the latest independent protection layer analysis, human factors review and alarm management studies (see Figure 1). Standard HAZOP methodology was used to address operability and safety issues. High personnel risk events identified during the HAZOP were then assessed using IPL Analysis, which provided a more detailed review of the safeguards to ensure that the risk was sufficiently reduced. Critical alarms identified during Independent Protection Layer (IPL) Analysis became critical alarms during the alarm management review. Throughout the risk assessment studies, human factors analysis was used to assess administrative procedures, work procedures and work practices.

Figure 1. Risk Initiatives Overview



HAZOP (PHA). Standard revalidation of existing process hazards analysis was considered an option but not used. The process hazards analysis was started using the structure of the previous HAZOP while scenario development was started from "scratch." The team also had the opportunity to review the previous HAZOP scenarios to ensure that nothing was missed. The team also reviewed all changes (through the management of change program) made to the processes since the last PHA was conducted. The team was told to stay focused and get the job done, but to do the job right. Consequently, no time constraints were placed on the team.

The analysis team was comprised of a plant operator, plant engineer, staff process specialist, research and development personnel, engineer from outside the process under study, and an outside facilitator. The most knowledgeable personnel were placed on the team. The outside facilitator provided needed expertise on process hazards analysis techniques, ensuring that all required regulatory elements were covered. These elements included examining process deviations, engineering and administrative controls, failure of controls, incident and near miss investigations, human factors, facility siting and previous recommendations.

IPL Analysis. Independent Protection Layer (IPL) Analysis is a semi-quantitative methodology that can be used to identify safeguards that meet the IPL criteria established by CCPS[1] in 1993. IPLs must be independent from the initiating cause and other protection layers, must be dependable, must be designed to mitigate the risk, and must be auditable through tests and documentation. IPL Analysis takes the risk information and safeguards from the HAZOP and conducts a more detailed engineering review of the safeguards to ensure that process risk is successfully mitigated. IPL Analysis, also known as Layers Of Protection Analysis (LOPA), is a rational, defensible methodology that allows a reliable, rapid and cost effective means for identifying the IPLs that lower the frequency and/or the consequence of specific hazardous incidents.

While the HAZOP used traditional guidelines for development of the nodes, or process systems, for review, the IPL Analysis examined larger sections of the process. For example, rather than reviewing only a reactor feed line in the HAZOP, the IPL Analysis would examine the entire reactor including feed systems. The examination would examine chains of events that could lead to loss of containment that may not have been identified in the smaller-node systems used in the HAZOP. So, the IPL Analysis included both HAZOP scenarios as well as “brainstormed” scenarios that may not have been considered in the past.

The IPL Analysis relied on many of the same personnel as the process hazards analysis to minimize inconsistency in the evaluation of the process risk between team efforts. Since IPL Analysis was new, an outside expert was used to develop the methodology, software, documentation standard and to facilitate the team meetings. The IPL Analysis was performed as follows:

1. Document the process deviation and hazard scenario under consideration by the team.
2. Identify all of the initiating causes and enabling events for the process deviation and determine the frequency of each initiating cause.
3. Determine the consequence of the hazard scenario.
4. Establish a risk level for the scenario using the frequency and consequence assessment.
5. Using predetermined guidelines, determine whether the unmitigated risk is acceptable. If it is, go to the next scenario.
6. List the IPLs that can completely mitigate all listed initiating causes and determine the probability to fail on demand (PFD) of each IPL. The PFD for each IPL was established in the IPL Analysis procedure, including specific design characteristics that were required for the PFD to be valid for the IPL under consideration.
7. Determine if the residual risk is acceptable. If it is, go to the next scenario.
8. If the residual risk is unacceptable, provide specific implementable recommendations to mitigate the residual risk.

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[1] CCPS/AIChE, Guidelines for Safe Automation of Chemical Processes, 1993, pp. 7-16.

SYSTEMS

Various systems were identified during the risk assessment as being safety critical. All safety critical systems are considered under the mechanical integrity program, which means that the systems now require test documentation at a specific frequency, are under bypass management, and controlled through management of change. These systems included the following:

- Safety critical control loops
- Critical operating procedures
- Safety critical alarms with operator response
- Safety instrumented systems, and
- Pressure relief systems (e.g., rupture disks and pressure safety valves)

Safety Critical Control Loops. The use of safety critical control loops was restricted to hazard scenarios where the initiating cause was not related to the basic process control system. Safety critical loops must be run in automatic mode during normal operation and any changes to the control loop function must be addressed through management of change. Any bypasses of safety critical control loops are managed through a rigorous safe work practice requiring appropriate compensating measures and authorization prior to initiating the bypass.

Critical Operating Procedures. Critical operating procedures are part of the standard operating procedures manual. However, a special symbol is used on the document to flag that the procedure as safety critical. The symbol draws attention to the importance of the procedure when the operators are going through training, simply reviewing the tasks to be performed or accessing the procedure for use. A senior operator or operations engineer wrote critical Operating Procedures with process engineering review and technical writer review. This ensured that the procedure was written from the perspective of the operator and included as much detail as necessary to ensure proper work performance.

Critical Alarms with Operator Response. Alarm management studies were conducted to reduce and prioritize alarms, minimizing the potential for alarm flooding during process excursions. The alarm philosophy was based on the following:

- Every alarm requires an operator action;
- Alarm priority is based on operator response time and process risk;
- No alarm flooding during upset condition;
- Alarms during steady state are minimized;
- No repetitive alarms during normal operating conditions.

Critical alarms identified during the IPL analysis were provided to the alarm management study team. The team rationalized and prioritized the remaining alarms based on operability, production, or product quality issues. Operator responses to critical alarms were documented in a separate standalone alarm management database. Operators are trained how to access this information in the database. Critical alarm responses are indicated by the priority assigned to the alarm in the databsase.

To continuously improve on these reductions, an alarm champion was identified. The alarm champion has the responsibility to monitor alarm reports and to identify the alarm trends that do not meet alarm management philosophy.

Safety Instrumented Functions. For safety instrumented functions (SIFs), management decided to adopt ANSI/ISA 84.01-1996, as its primary design standard. It also chose to implement the emerging international standard, IEC 61511, to the extent possible given its draft status.

SIFs were identified during the IPL Analysis and assigned a risk reduction factor, which was equivalent to the safety integrity level (SIL). Each SIF requires the development of Safety Requirements Specifications (SRS) using an outside contractor that specializes in SIF design. The SRS is available to operations, maintenance, and engineering for review and training purposes. It is considered a control document that must be maintained up-to-date, including any changes to the SIF approved under management of change. In general, the SRS includes the following:

- Full description of how each SIF mitigates the risk,
- SIL required to mitigate the risk,
- SIF architecture,
- Testing frequency,
- Bypass requirements,
- Manual shutdown requirements,
- SIL achieved by the SIF.

In some cases, retrofits were necessary in order for the SIF to meet the target SIL. Each SIF is fully compliant with ISA 84, in terms of design, procedures, and documentation.

Pressure Safety Devices (PSD). The first step in evaluating and better managing the pressure safety devices was to review the design cases for each PSD. The review assures that all potential overpressure cases for each vessel were adequately addressed either through PSD or safety instrumented system implementation. The second step was improvement in the safe work practice used to isolate PSDs. For example, the Pressure Relief Device (PRD) Removal Procedure was renamed the PRD Isolation Procedure to emphasize that the safe work practice applied to any installed PRD, regardless of any perceived in or “out of service” state. This safe work practice requires compensating measures and uses a rigorous authorization protocol prior to the isolation of a PRD.

ADDITIONAL TOOLS

The HAZOP and IPL Analysis were two risk management tools used extensively to identify risks and safeguards to mitigate those risks. However, additional risk management tools were also needed.

Human Factors. Human factors studies were performed throughout the process hazards analysis and IPL analysis. Specific human factors studies were also used to identify where procedures and equipment did not match human expectations and capabilities, using static and dynamic analysis. Static methods analyzed systems supporting human performance, such as administrative and management of change procedures. Dynamic methods were used to focus on specific scenarios and human actions.

Recommendation Tracking. With so many studies being conducted in such a short time period, a new tool was required to manage and track recommendations. Simply tracking open and closed status is insufficient to cost effectively manage this number of recommendations. A recommendation tracking system was necessary to allow the work to be tracked to completion. The inclusion of status update ensured that adequate progress was made and that long-term solutions were adequately planned.

TRAINING

Hazards analysis identifies existing safeguards and recommendations for new ones. Effective loss prevention goes beyond this identification and extends to the protection of these safeguards. Protection requires more than documented procedures; it requires well-trained people. Consequently, one of the most significant things done in the loss prevention program was employee training. The goal of the training was to make the loss prevention program an “Everybody Program.” Therefore, the training attendees consisted of operators, operations personnel and supervision, maintenance craftsmen, maintenance personnel and supervision, process engineering, control system technicians, and instrument & electrical engineering. One specific training area included the enhanced risk management program. The training course showed personnel how the hazard analyses, including process hazards analysis, IPL analysis, and alarm management studies, were being incorporated into their daily work. The training also discussed how their actions in dealing with the new systems, affected the operation of those systems and therefore, the safety of the plant operation.

Other training areas included the enhanced bypass protocols for the control system, the enhanced bypass protocols for the pressure relief devices, any new safety instrumented systems (including operations and maintenance of the systems) as well as training for any change resulting from implementation of the recommendations of the HAZOP, IPL analysis or alarm management efforts.

LESSONS LEARNED

No effort would be complete without the acknowledgement of lessons learned. The enhanced risk management effort described above is on-going and continuous improvement is being made. The significant lessons learned are as follows:

1. Get value from IT solutions. The investment in database tools may sound expensive up-front, but the cost associated with manually manipulating data later on will be high. PASADENA PLASTICS COMPLEX utilized database systems for the HAZOP, IPL Analysis, Alarm Management, and recommendation tracking. The databases enabled the project team to search for scenarios, device tags, etc., speeding information retrieval. Future improvements will focus on integration of the various database solutions into a more uniform approach.
2. Calibrate the team. Every person has a personal risk perception. This personal perception must be calibrated to ensure that the risk is evaluated according to the corporate risk perception. This reduces team variability, ensuring consistency from one evaluation to the next. Calibration may consist of rules of thumb for the team; such as how to evaluate personnel exposure based on affected occupancy or consequence severity based on release size.
3. Evaluate economic impact. Sometimes there is hesitation about evaluating economic impact when performing risk assessments. The studies are deemed “safety-oriented” and discussions related to economic impact may seem inappropriate. However, this cannot be farther from the truth.

In discussing the hazard scenario, the team has to evaluate how the incident could propagate from the initiating cause to the final incident. When the team understands the propagation, they understand the degree of equipment damage and production loss. These loss estimates are usually easy to make and can demonstrate to plant management the additional benefits of the risk assessment study. For instance, in one case, damage to a compressor resulted in very little safety impact, but caused almost one-month of downtime. Producing a study that stated that no instrumented shutdown was required for safety would have been true, but would have also missed the benefit of identifying a highly critical business loss prevention interlock.

1. Integrate the HAZOP, IPL Analysis, and Alarm Management. Rather than having three separate risk based discussions, have only one. Use the HAZOP guidewords to identify the risks. For low-level risks, use the HAZOP process to list the safeguards. For high-level risks, use IPL Analysis for a more detailed review of the safeguards. Alarms identified in the HAZOP and IPL Analysis should be provided as input information into the Alarm Management study. Alarm management should then focus on the remaining alarms only.
2. Logically group similar processes. Group similar processes and perform the risk assessment on these at the same time. The team will be larger due to inclusion of more operations personnel. However, there are three benefits:
   - The facilitator, process engineer and I&E representative attend one meeting not multiple.
   - Lessons learned in one process are transferred to the personnel associated with the similar unit.
   - Similar recommendations are generated, reducing the downstream engineering costs.

CONCLUSION

Pasadena Plastics Complex has made a substantial commitment to an enhanced loss prevention program. Risk assessment studies, including HAZOP, IPL Analysis, and human factors analysis, have been completed. Alarm management has been used to reduce the alarms to make the operators more effective under normal and abnormal operating conditions. The program provides safety instrumented systems compliant with ISA 84 and IEC 61511.

The new program is not a “bottom up” or “top down” program; it is a “Everybody program.” Everyone is charged with evaluating process risks, determining whether the risk is acceptable, designing systems to reduce the risk, as necessary, and then working hard everyday to make sure that those systems are operational.