

Managing the risk associated with chlorine facilities

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Process safety management principles can be applied to manage the risk associated with chlorine facilities in the pulp and paper industry.

Introduction

Over the past 1 1/2 years the pulp and paper industry has been developing programs to comply with the Occupational Safety and Health Administration's 29 CFR 1910.119, Process Safety Management of Highly Hazardous Chemicals regulation. One of the highly hazardous chemicals covered by the regulation is chlorine, which has been used by the pulp and paper industry as a bleaching agent since 1798 and is also commonly used to kill bacteria in mill water-treating facilities. Because of this widespread use, chlorine serves to illustrate how process safety management principles can be used to evaluate and manage the risks associated with highly hazardous chemicals found in the pulp and paper industry.

Several major pulp and paper manufacturers have implemented process safety management programs. This article examines the application of Process Safety Management (PSM) principles to manage the risk associated with chlorine facilities. Two federal regulations, OSHA 29 CFR 1910.119, Process Safety Management of Highly Hazardous Chemicals and the 1990 EPA Clean Air Act Amendments Sections 301-4 and 304-c, mandate requirements that are applicable to the pulp and paper industry.

The greatest potential for the occurrence of a major chlorine release exists in the chlorine tank car unloading and vaporizing areas of the mill. Chlorine is received by most mills in 55- to 90-ton tank cars. Depending on pulp bleaching requirements, 2-6 loaded tank cars can be present in the mill. The presence of these large quantities of chlorine represents a potential exposure risk to mill personnel and possibly to the surrounding public.

Hazard description

Tank cars can be classified as a low-level hazard based on regular maintenance performed by owners as required by regulations. Two exceptions are the possibility of fire exposure and mechanical damage. These concerns can be reduced by providing a dedicated chlorine unloading siding located some distance from other mill operations, maintaining the rails and switches in good condition, and following written procedures for spotting and removing tank cars from the siding.

A higher-level hazard is found in the operation and maintenance of the unloading piping and vaporizing equipment and possibly the padding system. Chlorine releases can result from system overpressure, corrosion (internal and external), excessive temperatures, moisture, mechanical damage, and operator error.

Process safety management (PSM) elements

Engineering design

Good engineering practice is a design process that applies appropriate design guidelines and industry codes and standards based on proven technology and regulatory requirements. The Chlorine Institute is one source of industry-specific guidelines that cover basic design criteria applicable to chlorine facilities. Of particular interest are the guidelines covering piping, air padding, and vaporizers. Other guidelines are available from the Chlorine Institute that provide useful, related design information and good engineering practices for chlorine facilities. (See Sidebar, p. 96.)

Compliance with applicable industry codes, standards, and regulations is a mandatory engineering design requirement. Two examples of industry design codes and standards that are applicable to chlorine vaporizers and piping are ASME Section VIII, Division I, Boiler and Pressure Vessel Code and ANSI B31.3, Chemical Plant and Petroleum Refinery Piping.

Past experience is a valuable asset in designing any type of facility. Operating and maintenance input into the design will ensure that the facility can be successfully operated and maintained using the mill's approved procedures. If a design results in operating difficulties, then certain safety features may be disconnected or bypassed. The need for operating and standby spare equipment should be evaluated based on the mill's operating philosophy. The design should provide for safe and efficient maintenance including equipment isolation, system purging, and the testing of critical controls and safety devices.

Process documentation

Documentation of the chlorine unloading and vaporization facili-

ties is an important element of the mill's process safety management program. Compliance with OSHA 29 CFR 1910.119 (d), Process Safety Information requires the mill to compile written process safety information on process chemicals, process technology, and process equipment for all processes covered by the regulation. This information is required before conducting a process hazard analysis of facilities such as chlorine unloading and vaporizer systems. All facilities should maintain and keep up to date certain basic documents: process flow sheets, piping and instrument diagrams (P&IDs), plot plans, safety component test reports, operating procedures, material safety data sheets, incident and accident reports, process hazard analysis reports, and operating logs.

Because deficiencies in the accuracy of this information can result in potential hazards, the completeness and accuracy of the process documents should be verified. Any deficiencies that are found should be corrected and all concerned parties should be notified of the change. Most of this information will be required for the development of operating and maintenance procedures and in performing process hazard analysis reviews.

Process hazard analysis

Adherence to good engineering practice alone is not sufficient to ensure safe design and operation of facilities involving hazardous materials. A process hazard analysis is one essential element of any process safety management program. All chlorine unloading and vaporizing systems, both existing facilities and new designs, should undergo a formal process hazard analysis. (See sample HAZOP worksheet, Table I.) OSHA 29 CFR 1910.119 (e) lists several acceptable process hazard analysis procedures such What-If, Hazard and Operability (HAZOP), Fault Tree, and others. The experience of the review team members will determine the appropriate review procedure to use. Highly experienced teams could produce effective results using a less rigorous procedure such as a combination What-If/Checklist procedure, especially where multiple facilities of similar design are to be reviewed. Teams with limited experience should use a more structured procedure such as a HAZOP study.

The choice of a process hazard analysis procedure will also depend upon whether the process is a new design or an existing facility. In general, process hazard analyses of existing facilities are more time-consuming and more detailed than those of new designs. In part, this is a result of a history of operation and maintenance experiences. A HAZOP analysis of an existing chlorine facility will take 3–4 days depending on the complexity of the facility and degree of prestudy planning.

For some chlorine facilities, a process safety review or audit that uses checklists and experienced team members may be an acceptable alternate review procedure. In any case, performing a process safety review before a more detailed analysis has two major benefits: early identification of obvious major hazards and indoctrination of

the process hazard analysis study team. The audit should consist of a physical inspection of the facility and a review of supporting documentation such as flow sheets; inspection; and test reports of critical instrumentation such as relief valves and rupture discs. Incident and accident reports should be included in the review. Written operating procedures should be reviewed with operating personnel to determine if the procedures are current and accurately represent the present mode of operation.

A team who will be expected to participate in the more detailed process hazard analysis review should conduct the process safety review. This will ensure that all team members are familiar with the facility and have the same basic understanding of its present level of safety. A process safety review of a chlorine unloading and vaporizing facility should require 1–2 days to perform when used as an introduction to a more detailed review and 2–3 days as a standalone procedure.

Management of change

Management of change, OSHA 29 CFR 1910.119 (l), is one of the most important elements of a PSM program. Modifications to a mill's chlorine facilities can change the existing degree of risk to an unknown or unacceptable level. The purpose of a formal management of change policy is to control and manage all modifications to process equipment, procedures, raw materials, and processing conditions other than "replacement in kind" by identifying and reviewing them before implementing the change. Typical changes made to chlorine unloading and vaporizing facilities and the hazards and operability problems associated with these changes include:

- Relocating tank car unloading rack and forgetting to ensure adequate blowdown facilities are available at the new location
- Increasing the number of tank car unloading connections at the rack and not providing adequate egress to and from the unloading platform area
- Increasing the vaporizing capacity by adding vaporizers and not considering the additional steam design requirements for the system
- Relocating the vaporizers closer to the unloading rack to reduce long, liquid-filled lines and not considering the possibility of liquid condensing in the longer gas lines
- Adding superheaters to long runs of vapor lines to prevent condensation and not considering the possibility of overpressuring the system if isolated
- Installing reserve liquid chlorine storage tanks and not providing means for removing from service such as blowdown and purging
- Bypassing a reserve liquid chlorine storage tank without adequate provisions for expansion in the piping system

training, refresher training, and documentation. A complete, accurate, and up-to-date set of procedures is of little value if operating personnel are not properly trained in their use. All operating areas within the mill have certain inherent hazards and require the implementation of good operating practices. The potential consequences of human error in the chlorine unloading and vaporizing areas can be disastrous. All persons involved in the operation and maintenance of the chlorine facilities should be trained in the hazards associated with their task. The training program should provide for refresher courses and incorporate a means of evaluating the effectiveness of the program.

Personnel protective devices such as goggles, respirators, and protective clothing while conducting routine operations and maintenance are important. If mill personnel properly use protection devices, then they will reduce the chance of injury due to small leaks. Mill personnel also can safely isolate small leaks that could have the potential to develop into a major chlorine release.

Mill personnel should be aware of actions that could lead to unsafe conditions and the resulting consequences. Active participation in a process safety review or process hazard analysis is an excellent method of educating personnel in the inherent hazards associated with the chlorine facilities. Employee participation in process hazard analyses is also a requirement of the OSHA PSM regulation paragraph (c).

The training program should include outside contractors working in or near the chlorine facilities. Although the contractor firm has prime responsibility for training its employees, the mill management is ultimately responsible for contractor safety. The OSHA PSM regulation paragraph (h) addresses requirements for selecting contractors that may perform work in or around processes that involve highly hazardous materials such as chlorine. OSHA requires that the choice of a contractor include an evaluation of the contractor's safety record and experience in performing work on chlorine facilities.

Emergency response and planning

The intent of paragraph (n) of the OSHA PSM regulation is to require employers to address what actions employees are to take when there is an unwanted release of highly hazardous materials. Emergency response and planning is necessary to reduce the consequences of chlorine releases. Planning should not be limited to the immediate area of the chlorine unloading and vaporizing facilities. Because chlorine is highly toxic, releases as small as 100 lb can result in significant exposures. The potential areas affected will depend on the type, size, and location of the chlorine release and the current atmospheric conditions. Large releases have the potential to involve the entire mill and possibly the surrounding public.

Different release scenarios should be developed along with an emergency response plan for each scenario. Dispersion modeling techniques are useful in estimating the size and path of a chlorine vapor cloud. Dispersion modeling will not provide exact results, however, and should only be used as an indication of the potential area affected by a chlorine release.

Other PSM elements

Other elements necessary for a complete process safety management program to be effective include pre-startup safety reviews,

mechanical integrity, hot work permits, incident investigations, and compliance safety audits.*

Identified hazards

The number of potential hazards associated with chlorine tank car unloading and vaporizing facilities to some extent are limited. This becomes evident to process hazard analysis teams that frequently perform detailed, hazard identification studies such as HAZOPs on these facilities. The following list of items was identified during detailed hazard analyses of chlorine unloading and vaporizing facilities. Although the list is not comprehensive, these items can be used as a starting point in developing a checklist for conducting preliminary reviews of existing chlorine facilities:

- Inadequate number or location of expansion chambers
- No routine inspection reports of rupture disc integrity on expansion chambers
- No pressure detection on expansion chambers
- Nonfunctional temperature control valve on vaporizer steam line
- No records of relief valve tests
- Inadequate isolation of padding gas supply
- Long, liquid-filled chlorine lines
- Inadequate vaporizer isolation provisions
- Inadequate instrumentation and alarms
- Excessive structural support corrosion
- Excessive equipment and piping corrosion
- Incomplete and outdated procedures
- Inadequate area access warning signs
- Physical location of vaporizers.

Risk management

It is obvious that the only way to eliminate all risks associated with chlorine is to use an alternate bleaching process. In certain cases, this may be the only method to reduce the risks to an acceptable level. A mill located near a densely populated area should carefully consider converting to an alternate bleaching process. However, this may not be the best solution for risk reduction in a mill located in a rural area. For these mills, the risk associated with hazards found in chlorine facilities can be managed by:

1. Reducing the consequence
2. Reducing the likelihood of occurrence
3. Eliminating the hazard.

*For a more general discussion of the application of process safety management programs to the pulp and paper industry, see Brown, C. A. and Buettner, C. A., *Tappi J.* 75(8): 59(1992).

Selected annotated references pertinent to managing the risk associated with chlorine facilities

The following references, suggested by Carl A. Brown and Chris A. Buettner of Brown & Root Engineering, Inc., may be useful when implementing a process safety management program to manage the risk associated with chlorine facilities.

1. American Institute of Chemical Engineers (AIChE) Center for Chemical Process Safety (CCPS), Guidelines for Technical Management of Chemical Process Safety, New York, 1989.
2. American Institute of Chemical Engineers (AIChE) Center for Chemical Process Safety (CCPS), Plant Guidelines for Technical Management of Chemical Process Safety, New York, 1992.
3. American Petroleum Institute (API), Recommended Practice (RP) 750, Management of Process Hazards, Washington, 1990.
4. Chemical Manufacturers Association (CMA), Responsible CARE Process Safety Code of Management Practices, Washington, 1990.

5. U.S. Environmental Protection Agency (EPA), Clean Air Act Amendments of 1990, Title III, Air Toxics, Washington, 1990.
6. OSHA 29 CFR 1910.119, Process Safety Management of Highly Hazardous Chemicals, Washington, 1992.
7. OSHA future publication, "Process Safety Management—Audit Guidelines," in press.
8. Organization Resources Counselors, Inc., Recommendations for Process Hazards Management of Substances with Catastrophic Potential, 1988.
9. Brown, C. A. and Buettner C. A., Process safety management in the pulp and paper industry, *Tappi J.* 75(8): 59(1992).

The following selected references are publications of the Chlorine Institute that are related to the design and operation of chlorine systems found in pulp and paper mills. Copies of these and other publications may be obtained from the Chlorine Institute, 2001 L St. NW, Washington, DC 20036.

- Pamphlet 1, Chlorine Manual
- Pamphlet 5, Non-refrigerated Liquid Chlorine Storage
- Pamphlet 6, Piping Systems for Dry Chlorine
- Pamphlet 9, Operation of Chlorine Vaporizing Equipment
- Pamphlet 64, Emergency Control Planning Checklist for Chlorine Facilities
- Pamphlet 66, Chlorine Tank Car Loading, Unloading, Air Padding, Hydrostatic Testing
- Pamphlet 74, Calculating the Area Affected by Chlorine Releases.

For example, the consequence of exposing operating personnel to small chlorine leaks can be reduced by use of personnel protective devices and clothing. The likelihood of moisture accumulating in the chlorine piping system can be reduced by ensuring the air-padding system dryers are always functional and by requiring routing testing of dew point analyzers and interlock systems. The hazard associated with moisture in the air-padding system can be eliminated by using dry nitrogen for the padding gas.

Conclusion

The risks associated with chlorine facilities in pulp and paper mills can be successfully managed by applying process safety management principles. For some facilities, the application of these principles could indicate that an alternate bleaching process is the only solution that would reduce the risk to an acceptable level. For other facilities, however, an acceptable level of risk may be ob-

tained by implementing a comprehensive process safety management program. The success of the program will require regular audits to ensure all elements are in place and functioning as intended. When deficiencies are noted, changes should be made and the program updated to reflect the changes. ■

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