WASTE ISSUES ASSOCIATED WITH THE SAFE MOVEMENT OF HAZARDOUS CHEMICALS

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ABSTRACT

Moving hazardous chemicals presents the risk of exposure for workers engaged in the activity and others that might be in the immediate area. Adverse affects are specific to the chemicals and can range from minor skin, eye, or mucous membrane irritation, to burns, respiratory distress, nervous system dysfunction, or even death. A case study is presented where in the interest of waste minimization; original shipping packaging was removed from a glass bottle of nitric acid, while moving corrosive liquid through a security protocol into a Radiological Control Area (RCA). During the transfer, the glass bottle broke. The resulting release of nitric acid possibly exposed 12 employees with one employee being admitted overnight at a hospital for observation. This is a clear example of administrative controls to reduce the generation of suspect radioactive waste being implemented at the expense of employee health. As a result of this event, material handling procedures that assure the safe movement of hazardous chemicals through a security protocol into a radiological control area were developed. Specifically, hazardous material must be transferred using original shipping containers and packaging. While this represents the potential to increase the generation of suspect radioactive waste in a radiological controlled area, arguments are presented that justify this change. Security protocols for accidental releases are also discussed. In summary, the 12th rule of "Green Chemistry" (Inherently Safer Chemistry for Accident Prevention) should be followed: the form of a substance used in a chemical process (Movement of Hazardous Chemicals) should be chosen to minimize the potential for chemical accidents, including releases.

INTRODUCTION

Safe Work Practices (SWPs) work-control process is an essential part of the Integrated Safety Management (ISM) and applies to issues of environment, safety, and health.[1] This five-step process consists of the following: defining the work; identifying and evaluating the hazards; developing and implementing controls; performing work safely; and providing feedback and continuous improvement. One of the five core functions of ISM at the activity level is the last step: providing feedback and continuous improvement. In the following, an example of the fifth step is presented. As a result of lessons learned from non-radioactive hazardous material release (referred to as a chemical spill from this point on) in which a security guard was kept overnight in a hospital for observations,[2] changes have been incorporated into procedures associated with hazardous chemicals to improve their safe movement. Adherence to the SWP requirements ensures a formal and consistent approach to hazardous material protection as required by the Department of Energy Order for working in a nuclear research facility.[3]

Moving and/or handling hazardous chemicals presents the risk of exposure to those materials with potential adverse effects for those engaged in the activity and others that might be in the immediate area. Those adverse affects are specific to the chemicals and can range from minor skin, eye, or mucous membrane irritation, to burns, respiratory distress, nervous system dysfunction, or even death. Hazardous chemical exposure can also cause genetic defects and adversely affect fetal development and health.

The control of hazardous materials is an ongoing process that starts during the design phase of a process or facility and continues through the performance of daily job tasks. Hazards involving materials are controlled in a variety of ways; all of these methods fall into one of five categories. These categories, ranked in the order of preference, are elimination, substitution, engineering controls, administrative controls, and Personal Protective Equipment (PPE).[4] For the purposes of this report, the term hazardous chemical shall include any and all substances or materials that present a physical hazard or a health hazard, with the exception of commercially available household products, nuclear materials, and other radiological sources. In the following, a case study of a chemical spill is given, "Lessons Learned" in the form of procedural changes presented, issues generated from implementing these administrative controls addressed, and conclusion from this study drawn.

CASE STUDY

A chemical worker was moving a case of concentrated nitric acid from a warehouse to the nuclear research facility. The case was the factory original; Department of Transportation (DOT) approved shipping container and contained six, 2½ liter bottles of nitric acid. A hand dolly was used to move the case. The original procedure required removing the acid from the original shipping package to a cart at the entrance to nuclear research facility to reduce the generation of suspect radioactive waste. The cart is then used to move the acid within the nuclear research facility, which is a secured Radiological Control Area (RCA) and where access is controlled. Security personnel survey all material brought into nuclear research facility. Part of the survey usually includes passing items through an x-ray machine. This is not the case with hazardous materials such as nitric acid bottles; they are usually moved to a side door for physical inspection by security personnel.

While the chemical worker was transferring the six bottles of nitric acid out of the case and onto the floor of the security portal, one of the bottles broke, see Figure 1. The experienced chemical worker, who was well aware of the corrosive nature of nitric acid, immediately turned the bottle on its side with the hole in the bottle facing up. Nevertheless, approximately 1/2 liter of acid spilled out forming a spill approximately 18 inches in diameter. As this was immediately assessed as a chemical spill, employees nearby were alerted and a spill kit containing an acid neutralizer retrieved.

Fig. 1. Broken Bottle of Nitric Acid.

One security guard was relieved because of severe coughing, removed from the area, and placed on nasal cannula oxygen by trained emergency first responders. The same security guard and four other members of the security force, who were potentially exposed, were placed in an ambulance and transported to local hospital for observations. Except for the security guard that exhibited signs & symptoms of exposure, all were examined and released. The remaining security guard was hospitalized overnight for observation and treatment. Later the area of the spill was monitored by an Industrial Hygienist (IH) with an instrument capable of detecting 0.5 parts per million (ppm) of nitric acid. The IH did not detect any acid fumes. The entrance into the secured RCA was returned to normal operations within two hours.

After reviewing the incident, it was estimated that security personnel could have been exposed to nitric acid fumes for up to three minutes. The IH did an analysis of the spill to determine if personnel exposure to nitric acid exceeded Occupational Safety and Health Administration (OSHA) "Permissible Exposure Limits" or American Conference of Government Industrial Hygienist (ACGIH) "Threshold Limit Values for Chemical Substances, Physical Agents and Biological Exposure Indices." Using the Short Term Exposure Limit (STEL) of 4 ppm over a 15-minute period, the estimated vapor concentrations of nitric acid at the estimated exposure time (3 minutes) did not exceed the STEL. This incident was treated with the severity of an off-normal occurrence. In summary, after an incidental chemical spill, twelve employees were evaluated for possible exposure, with one being admitted into a hospital overnight for observation.

LESSONS LEARNED

The direct cause of this chemical spill was the breaking of the acid bottle when it was placed on the floor. While the likelihood of this occurring is infrequent, the severity of the occupational illness makes the risk of this task unacceptable. Clearly, the use of plastic coated bottles and/or secondary containment could have prevented or mitigated this incident. In addition, there were inadequate provisions for response to a hazardous material spill at the security portal. Because there was not an immediate evacuation of the area when the nitric acid was spilled, employees were exposed to acid vapors. The estimates provided by the IH indicated that acid vapors were present for approximately three minutes before the acid was sufficiently neutralized to mitigate exposure hazards. What followings are a series of recommended administrative controls to be added to material handling procedures if applicable. Besides minimizing the handling of hazardous materials, these administrative controls address radioactive contamination control, safeguards/security, and waste minimization.

General

1. Purchase hazardous (corrosive, toxic, flammable, etc.) liquids that are packaged in plastic bottles, when given the option.
2. Transfer hazardous materials using original shipping containers and packaging when possible.
3. When original shipping containers are not available, use sufficient secondary containment (safety carriers for hazardous liquids).
4. For multiple items or those too large to carry safely, use an appropriate 4-wheel cart or hand-truck.

Security Protocols

1. Plan the introduction of hazardous chemicals into security portals to ensure that no delays are encountered when the chemicals are moved from the point of origin to the final destination.
2. Do not introduce hazardous chemicals into security portals during high-traffic periods (e.g., beginning or end of shifts, immediately before or after breaks).
3. Before moving hazardous chemicals to the security portal entry station, inform security personnel of the types of chemicals to be transported, the hazards associated with those materials, and the response to be taken in the event of a spill or other emergency.
4. Do not place hazardous chemicals on or in any security monitoring system (X-Ray device).
5. During required inspections, only qualified individuals should handle hazardous chemicals. Do not allow security personnel to physically touch, handle, or otherwise manipulate hazardous chemicals.

Personal Protective Equipment

1. When moving hazardous chemicals in original shipping containers, don eye protection and a laboratory coat as minimum PPE.
2. When original shipping containers are not used, add appropriate gloves to the PPE requirements.
3. Ensure that security personnel don eye protection as minimum PPE.

Waste Minimization Practices

1. To avoid generating suspect radioactive waste, have a radiological control technician (RCT) immediately survey the shipping materials/packaging when they arrive at their destination and when entering a RCA. Then immediately remove the materials & packaging from the facility.
2. To move multiple items or those too large to carry safely, use an appropriate 4-wheel cart or hand-truck. For items that require the use of a cart, never make transfers from one cart to another as the materials are moved.

   NOTE: The intent is to minimize handling of the material through the use of a single cart that can then be surveyed by an RCT after delivery of the materials and then removed from the RCA.

Security Protocols for Chemical spill

1. Direct security personnel to immediately lock down the entry station and make appropriate notifications to superiors.
2. Establish a perimeter at a safe distance.

DISCUSSION

The controls described in this paper have been established to (1) reduce the potential for hazardous spills, and (2) define appropriate actions to be taken in the event a spill occurs. These recommended administrative controls apply to the movement and/or handling of hazardous chemicals in any areas outside of laboratories in which the materials are used. These areas include: hallways and corridors between warehouses or receiving areas and laboratories, areas in which there is routine access for non-laboratory workers, security portals, and basement or attic areas.

Risk The magnitude of a risk involves both the probability (likelihood) and severity of the associated harm. The main goal of implementing these "Lessons Learned" is to decrease the risk to an acceptable level associated with off-normal occurrences from the movement of hazardous materials through the addition of controls, as shown in Figure 2.

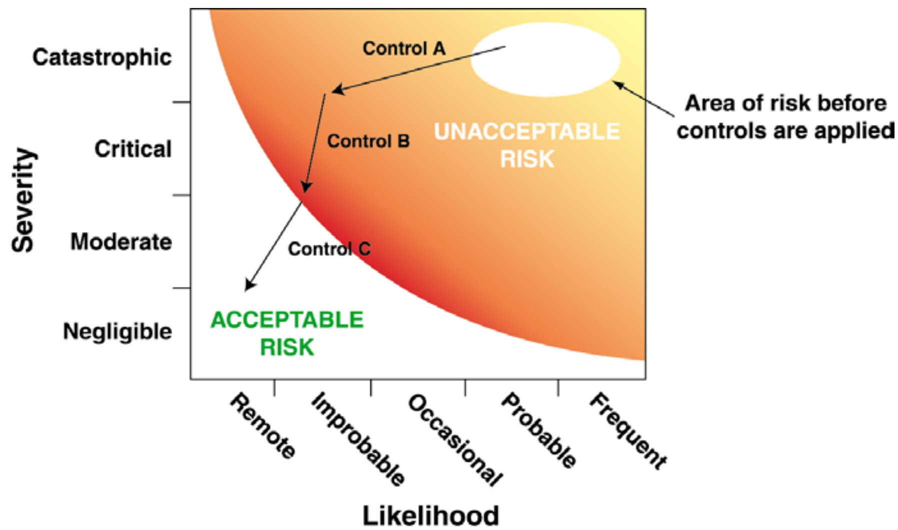

Fig. 2. The Concept of Controlling Risk.

From a business viewpoint, the acceptable level may be achieved when the costs of decreasing a given risk further are greater than the costs realized from the occupational exposure to hazardous chemicals. The procedural changes compiled in the "Lessons Learned" section both prevent and mitigate the hazardous consequence of a chemical spill. The severity of chronic personnel exposure as exemplified by the case study is greater than minor environmental harm from the generation of suspect radioactive waste in a RCA. The risk is reduced further when the materials & packaging are immediately removed from the RCA, since the likelihood of this consequence occurring is now remote.

Chemical spills There have been several documented chemical spill cleanups.[5] Chemical spills required a minimum of one hour of personnel time to clean the affected area of hazardous material contamination. Implementation of these procedural changes eliminates the potential for chemical spills and the associated costs of spill clean up. The time necessary to clean up a chemical spill varies according to how much material was spilled and the types of surfaces that must be cleaned. However, the minimum cost to respond and clean up any type of chemical spill is approximately $150. As a side note, the typical composition of hazardous waste, generated during cleanup activities whenever a chemical spill occurs, consists of the hazardous material, spill kit refuse, and PPE.

Green Chemistry The environmentally benign, linking of the design of chemical products and processes with their impacts on human health and the environment is often referred to as "Green Chemistry."[6] It can be argued that transferring hazardous material in original shipping containers and packaging increases the potential generation of suspect radioactive waste in a RCA, which is a violation of the first rule: *Prevention;* It is better to prevent waste than to treat or clean up waste after it has been created. Upon further analysis, the principles of "Green Chemistry" are maintained because the twelfth rule: *Inherently Safer Chemistry for Accident Prevention;* Substances and the form of a substance used in a chemical process should be chosen to minimize the potential for chemical accidents, including releases, explosions, and fires. In other words, the movement of hazardous chemicals should be chosen to minimize the potential for chemical accidents, including releases.

CONCLUSIONS

Due to the inappropriate use of pollution prevention procedures, a chemical spill occurred during the movement of hazardous chemicals between a receiving area and laboratory through a security portal. Review of this off-normal occurrence resulted in material handling procedures that consider all the rules of "Green Chemistry" by minimize waste generation without compromising the health and safety of the worker. Investigating hazardous material incidents contribute to an organization's scientific and technological excellence by disseminating information aimed at increasing its operational safety.

FOOTNOTES

[1] http://tis.eh.doe.gov/ism.
[2] Occurrence Reporting and Processing System (ORPS) Report TA55-1998-0058, *Employee Kept in Hospital Overnight After Nitric Acid Spill* and references therein.
[3] DOE Order 5480.23.
[4] "Integrated Safety Management Description document," LAUR-98-2837, Los Alamos National Laboratory (1998).
[5] Occurrence Reporting and Processing System (ORPS) Report RFO--KHLL-LIQWASTE-1998-0002, *Alert Declared for Phosphoric Acid Spill* and references therein.
[6] EPA742-F-99-019, Green Chemistry Program Fact Sheet.

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