Lessons Learned from a Reactive Chemical Incident

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On May 3, 2019, an explosion and fire killed four employees at the AB Specialty Silicones facility in Waukegan, IL. The facility processed silicone hydride emulsions, which are known to react to form hydrogen when mixed with strong acids and bases. The U.S. Chemical Safety and Hazard Investigation Board (CSB) report concluded that a chemical reaction occurred in a batch reactor when an incompatible chemical was unintentionally charged into the vessel. This unintended chemical reaction produced hydrogen gas in the enclosed production building; the flammable vapor cloud subsequently found an ignition source and ignited.

The CSB's report on the incident called for both the U.S. Occupational Safety and Health Administration (OSHA) and the U.S. Environmental Protection Agency (EPA) to broaden the application of the Process Safety Management (PSM) and Risk Management Plan (RMP) standards to cover reactive hazards resulting from process-specific conditions and combinations of chemicals *(1)*.

The incorporation of reactive chemistry hazards into the OSHA PSM and EPA RMP regulations is likely several years away. In fact, the same recommendation to both EPA and OSHA was previously issued by the CSB in 2001. The report reiterates these recommendations.

Key stakeholders in the process safety community should not wait for the updated regulations to be promulgated. There are several actions you can take now to ensure that the facilities you operate or design appropriately manage the risks of reactive chemicals events.

Screen for reactive chemistry hazards. The identification, assessment, and characterization of intended and, more importantly, unintended exothermic reactions are critical for ensuring the safe operation of chemical processes. Incidents such as the AB Specialty Silicones explosion serve as a grim reminder of the potential consequences of runaway reactions caused by accidental contamination. The ultimate aim of such studies is to specify and document a detailed basis of safety for the protection of the plant and personnel from the consequences of uncontrolled exothermic reactions.

Using free public resources such as the Chemical Reactivity Worksheet *(2)* is one way companies can gather process safety information related to the chemical reactivity hazards of common hazardous chemicals, compatibility of absorbents, and suitability of materials of construction.

Companies may need to conduct additional laboratory screening tests, such as differential scanning calorimetry (DSC), and use this data to identify process hazards and establish safeguards to protect from those hazards. Many useful guidebooks for selecting reactive chemical screening tests are available online at no cost *(3)*.

Adopt a process safety management system framework in your organization, even if chemical quantities do not exceed regulatory thresholds.

Facilities that handle reactive chemicals need to establish a robust process safety management system to identify, evaluate, and control reactive and chemical processing hazards. Many guidance documents and books have been published by the Center for Chemical Process Safety (CCPS) on developing such systems, including *Essential Practices for Managing Chemical Reactivity Hazards*, *Guidelines for Risk-Based Process Safety*, and *Guidelines for Implementing Process Safety Management*.

CCPS also created an internationally recognized approach for developing a process safety management framework called risk-based process safety (RBPS). The RBPS approach recognizes that all hazards and risks in an operation or facility are not equal; consequently, apportioning resources in a manner that focuses effort on greater hazards and higher risks is appropriate. A comprehensive summary of the CCPS RPBS approach is available online *(4)*.

Evaluate human factors. Processing steps and procedures that rely on administrative controls and human actions to control high-consequence scenarios must be well designed and contain adequate layers of protection to ensure that a simple human lapse or error cannot create a catastrophic event. In batch operations that rely on operators to gather and mix chemicals, it is critical that known reactive materials are differentiated through the use of containers of varying colors and sizes, and that design-based solutions (*e.g.,* specialized fittings specific to certain chemicals) are implemented to reduce the risk of operator mistakes.

Companies should evaluate manual operations during hazard analysis and design reviews to ensure that tasks with potential for severe consequences are adequately error-proofed. These types of human-factor studies can be accomplished through systematic evaluation of manual operations, identification of potential opportunities for those operations to be performed incorrectly, and the establishment of safeguards and controls to minimize the potential for error. Designing equipment, operations, and work environments to match human capabilities and limitations is a critical aspect of reactive chemistry management.

Understand and conform to building and fire code requirements. The use and storage of hazardous materials in any structure can introduce process operations to many regulatory and permitting requirements. One of the most overlooked and misunderstood requirements is how hazardous material utilization affects the International Building Code (IBC) and International Fire Code (IFC) occupancy classification of a facility and determines the allowable design and layout features of the structure. Ref. 5 gives a thorough introduction to these important, and often overlooked, building safety requirements.

Fundamentally, when a fire control area within a facility contains more than the exempt quantity of hazardous material, it must be classified and operated as a high-hazard (Group H) occupancy. If classified as a Group H occupancy, additional design and operational requirements apply, including:

- an automatic sprinkler system designed to applicable National Fire Protection Association (NFPA) standards (IBC Section 415.4); based on the operations conducted, additional fire suppression systems may be required.
- specific fire separation distances from other occupancies and facility structures (IBC Section 415.6)
- explosion control for some chemicals that have explosive characteristics, whether or not they are classified as explosives (IBC Table 414.5.1 lists the material categories that pose an explosive hazard)
- ventilation of vapors, dusts, and other emissions to prevent the accumulation of flammable environments (IBC Section 414.3)
- the use of gas and vapor release detection equipment (IFC Section 5001.3.3.8).

A post-incident inspection of the AB Specialty Silicones facility by OSHA identified several Group H occupancy features that were deficient, including the use of non-rated fork trucks in an electrically rated area.

Conclusion. The CSB investigation report for the AB Specialty Silicones explosion provides valuable insight into the hazards of unintentional reactive chemistry in operations. Please take the opportunity to apply the lessons learned from this incident by screening for reactive chemicals hazards, adopting a RBPS management system, evaluating human factors, and understanding and conforming to building and fire codes. These simple actions will significantly reduce reactive chemistry risk in your operations. CEP

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1. **U.S. Chemical Safety Board,** "AB Specialty Silicones, LLC Final Report," CSB, www.csb.gov/ab-specialty-silicones-llc (Sept. 24, 2021).
2. **Center for Chemical Process Safety,** "Chemical Reactivity Worksheet," www.aiche.org/ccps/resources/chemical-reactivity-worksheet (accessed on Nov. 3, 2021).
3. **DEKRA Process Safety,** "A Strategic Guide to Reaction Hazard Assessment," www.dekra.us/en/chemical-reaction-hazards-and-thermally-unstable-substances (accessed on Nov. 3, 2021).
4. **Center for Chemical Process Safety,** "Summary Guidelines for Risk Based Process Safety," www.aiche.org/ccps/resources/publications/summaries/summary-guidelines-risk-based-process-safety (accessed on Nov. 3, 2021).
5. **Snyder, M. D.,** "Demystifying Building Code Occupancy Classification," *Chemical Engineering Progress,* **117** (2), pp. 45–51 (Feb. 2021).