U.S. Chemical Safety and Hazard Investigation Board

Chemical Reaction, Hydrogen Release, Explosion, and Fire at AB Specialty Silicones

Waukegan, IL | *Incident Date: May 3, 2019* | **No. 2019-03-I-IL**

Executive Summary From Final Report

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SAFETY ISSUES:

- Mixing of Incompatible Materials
- Hazard Analysis Program
- Storage and Handling of Incompatible Materials
- Batch Equipment and Ventilation System Design
- Gas Detection System
- Emergency Preparedness
- Double Initial Procedure Program
- Process Safety Culture
- Safety Management System that Addresses Process Safety
- Regulatory Coverage of Reactive Hazards

Executive Summary

On May 3, 2019, operators at the AB Specialty Silicones, LLC (AB Specialty) manufacturing facility in Waukegan, Illinois were performing a batch operation that involved manually adding and mixing chemicals in a tank inside the production building. During the operation, an operator pumped an incorrect chemical into the tank, which was incompatible with another chemical that was added to the tank. The incorrect, incompatible chemical was stored in an identical drum to one of the correct chemicals, the only differentiating markings being small labels on the drums, and bung caps. After the incompatible chemicals were mixed, the tank contents underwent a chemical reaction, causing a process upset in which the tank contents foamed and overflowed from the tank's top opening. A fog also formed. The CSB determined that the process upset produced hydrogen gas, which released inside the manufacturing facility's production building.

Soon after the hydrogen gas release started, it ignited, causing a massive explosion and fire. The explosion fatally injured four employees [Byron Biehn, Jeffrey Cummings, Daniel Nicklas, Allen Stevens], destroyed the facility's production building, and forced the company to cease some and relocate other operations until the production building could be rebuilt.

The Waukegan Fire Department and mutual aid from surrounding areas responded to the incident. Other agencies that investigated the incident include the Illinois Environmental Protection Agency (IEPA), the Environmental Protection Agency (EPA), the Occupational Safety and Health Administration (OSHA), and the U.S. Chemical Safety and Hazard Investigation Board (CSB).

Safety Issues

The CSB investigation evaluated the following safety issues:

- **Mixing of Incompatible Materials.** An AB Specialty operator pumped an incorrect chemical into a tank, which was incompatible with another chemical that was added to the tank. The chemicals reacted to produce hydrogen gas, which found an ignition source and ignited to cause the explosion. (Section 3.1)

- **Hazard Analysis Program.** AB Specialty assessed proposed product manufacturing operations through what it called technical service requests (TSRs), which evaluated a mix of business and safety risks. AB Specialty's TSR process did not and was not intended to assess the hazards of performing a process operation or establish safeguards to reduce risk. (Section 3.2)

- **Storage and Handling of Incompatible Materials.** AB Specialty did not have a written procedure requiring employees to segregate incompatible chemical drums in the production building's manufacturing area or remove ingredient containers after use. The incompatible chemicals that were mixed were stored in similar 55-gallon blue plastic drums. The similar appearance of the drums likely contributed to the operator adding the incorrect chemical to the tank. (Section 3.3)

- **Batch Equipment and Ventilation System Design.** As a result of the tanks used in the EM 652 batch process having an open hatch-type lid and no vent pipe to direct gases to a safe location, the hydrogen

gas produced during the incident released directly into the production building, where workers were located. The ventilation system, including an air mover—designed to introduce outside air to the building and which was positioned near the location where the batch operation was being performed—may have helped distribute the hydrogen in the production building and mix it with air, creating a large and explosive gas cloud. (Section 3.4)

- **Gas Detection and Alarm System.** The AB Specialty production building did not have a hydrogen gas or flammable gas detection and alarm system to warn employees of a hazardous atmosphere. The lack of a system to detect hydrogen gas and automatically activate an alarm contributed to personnel remaining inside the production building between the start of the hydrogen release and the time of ignition. (Section 3.5)

- **Emergency Preparedness.** During the incident, workers recognized that a process upset had occurred when the tank contents foamed, overflowed the tank, and a fog formed. However, despite recognizing the process upset, the workers did not recognize the immediate hydrogen hazard created by the upset. Hydrogen is a colorless and odorless gas indistinguishable from air without the use of additional technology, such as gas detectors. Without gas detectors and alarms alerting of the hazardous conditions, or effective training, the workers did not realize the necessity to evacuate. (Section 3.6)

- **Double Initial Procedure Program.** AB Specialty developed a double initial procedure practice in 2014 in an effort to prevent employees from charging the wrong materials to batch processes, which was proceduralized in 2019. The occurrence of the May 3 incident indicates that AB Specialty's double initial procedure program did not prevent a wrong material from being added to the tank. (Section 3.7)

- **Process Safety Culture**. In the years leading up to the incident, AB Specialty exhibited characteristics of a weak process safety culture, including the lack of engineering controls to mitigate employee exposure to known hydrogen gas risks and heavy reliance on procedural controls as primary safeguards, among others. In addition, the company did not require incompatible chemicals to be visibly differentiated or perform a thorough hazard analysis of the EM 652 batch process after a 2014 drum explosion. (Section 3.8)

- **Safety Management System that Addresses Process Safety.** AB Specialty did not have a safety management system that addressed process safety in place at the time of the incident. Industry best practice publications provide guidance on establishing process safety management systems for facilities with known or potential reactive chemical hazards. (Section 3.9)

- **Regulatory Coverage of Reactive Hazards.** While AB Specialty processed chemicals capable of undergoing a highly hazardous chemical reaction that resulted in a large explosion and four fatalities, the chemicals used at the AB Specialty facility are not listed for coverage in either the Occupational Safety and Health Administration (OSHA) Process Safety Management (PSM) Standard or the Environmental Protection Agency (EPA) Risk Management Plan (RMP) Rule. As such, AB Specialty was not required to implement baseline process safety management system elements to manage the safety of its processes under these regulations. (Section 3.10)

Cause

The CSB determined that the cause of the incident were deficiencies in AB Specialty's operations, policies, and practices including its hazard analysis program, methods used to store and handle incompatible materials, its double initial procedure program, process safety culture weaknesses, and the lack of a safety management system addressing process safety. These deficiencies led to an operator mixing incompatible chemicals, causing a reaction that produced hydrogen gas, which released and ignited in the AB Specialty production building. Contributing to the severity of the incident were AB Specialty's batch equipment and ventilation system design, the lack of a gas detection and alarm system, and ineffective emergency preparedness.

Recommendations

Previously Issued Recommendations Reiterated in This Report

To Occupational Safety and Health Administration (OSHA)

2001-01-H-R1

Amend the Process Safety Management Standard (PSM), 29 CFR 1910.119, to achieve more comprehensive control of reactive hazards that could have catastrophic consequences.

- Broaden the application to cover reactive hazards resulting from process-specific conditions and combinations of chemicals. Additionally, broaden coverage of hazards from self-reactive chemicals. In expanding PSM coverage, use objective criteria. Consider criteria such as the North American Industry Classification System (NAICS), a reactive hazard classification system (e.g., based on heat of reaction or toxic gas evolution), incident history, or catastrophic potential.

- In the compilation of process safety information, require that multiple sources of information be sufficiently consulted to understand and control potential reactive hazards. Useful sources include:
    - Literature surveys (e.g., *Bretherick's Handbook of Reactive Chemical Hazards*, *Sax's Dangerous Properties of Industrial Materials*)
    - Information developed from computerized tools (e.g., ASTM's CHETAH, [CCPS]'s The Chemical Reactivity Worksheet)
    - Chemical reactivity test data produced by employers or obtained from other sources (e.g., differential scanning calorimetry, thermogravimetric analysis, accelerating rate calorimetry)
    - Relevant incident reports from the plant, the corporation, industry, and government
    - Chemical Abstracts Service

- Augment the process hazard analysis (PHA) element to explicitly require an evaluation of reactive hazards. In revising this element, evaluate the need to consider relevant factors, such as:
    - Rate and quantity of heat or gas generated
    - Maximum operating temperature to avoid decomposition
    - Thermal stability of reactants, reaction mixtures, byproducts, waste streams, and products

- Effect of variables such as charging rates, catalyst addition, and possible contaminants
- Understanding the consequences of runaway reactions or toxic gas evolution

To Environmental Protection Agency (EPA)

2001-01-H-R3

Revise the Accidental Release Prevention Requirements, 40 CFR 68, to explicitly cover catastrophic reactive hazards that have the potential to seriously impact the public, including those resulting from self-reactive chemicals and combinations of chemicals and process-specific conditions. Take into account the recommendations of this report to OSHA on reactive hazard coverage. Seek congressional authority if necessary to amend the regulation.

New Recommendations

To AB Specialty Silicones, LLC

Ensure hydrogen gas detection and alarm systems are properly installed, maintained, and configured based on the facility's application and environment, manufacturer specifications, current codes, standards, and industry good practice guidance. The program must address sensor technology selection, installation, calibration, inspection, maintenance, sensor replacement, training, and routine operations.

Establish a safety management system that addresses process safety at the AB Specialty Waukegan, Illinois facility. Include in that system elements recommended in industry guidance publications, for example, Center for Chemical Process Safety (CCPS) publications *Guidelines for Risk Based Process Safety* and *Guidelines for Implementing Process Safety Management*.

Incorporate into operations and activities at AB Specialty the specific elements recommended in CCPS's *Essential Practices for Managing Chemical Reactivity Hazards*, which are:

1. Put into place a system to manage chemical reactivity hazards
2. Collect reactivity hazard information
3. Identify chemical reactivity hazards
4. Test for chemical reactivity
5. Assess chemical reactivity risks
6. Identify and implement process controls and risk management options
7. Document chemical reactivity risks and management decisions
8. Communicate and train on chemical reactivity hazards
9. Investigate chemical reactivity incidents
10. Review, audit, manage change in, and improve hazard management practices and programs