U.S. Chemical Safety and Hazard Investigation Board

CSB Public Meeting

September 24, 2021

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

Waukegan, Illinois

May 3, 2019

Executive Director's Introduction

Stephen Klejst, Executive Director of Investigations and Recommendations

Investigation Team

Lauren Grim	Supervisory Chemical Incident Investigator
Vonzella Vincent	Investigator-In-Charge

Steve Cutchen
Chris Lyon
Dan Tillema
Wills Hougland
Tamara Qureshi
Mark Wingard

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Investigation Presentation

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Waukegan, Illinois
May 3, 2019

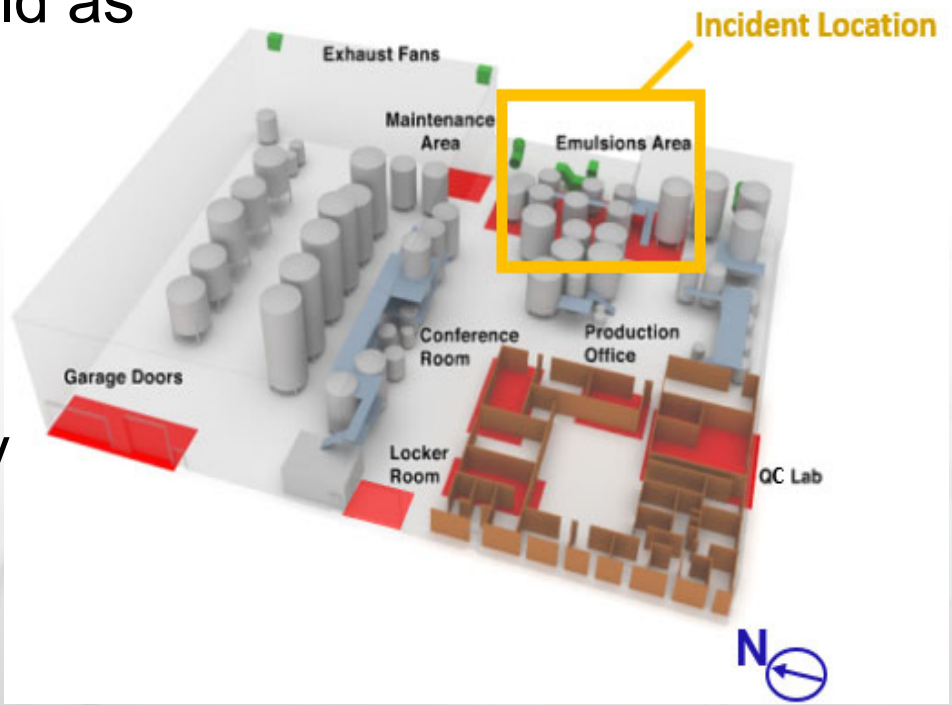
Vonzella Vincent
Investigator-In-Charge

Incident Overview

- On May 2, 2019, operators at the AB Specialty Silicones facility were performing a batch operation inside the production building that involved manually adding and mixing chemicals in a tank
- An operator added an incorrect chemical into the tank containing an incompatible chemical ingredient that reacted
- The chemical reaction produced and released hydrogen gas in the building that ignited, causing an explosion and fire
- Four employees were fatally injured
- The CSB investigation team identified ten safety issues and proposes several recommendations that will be discussed

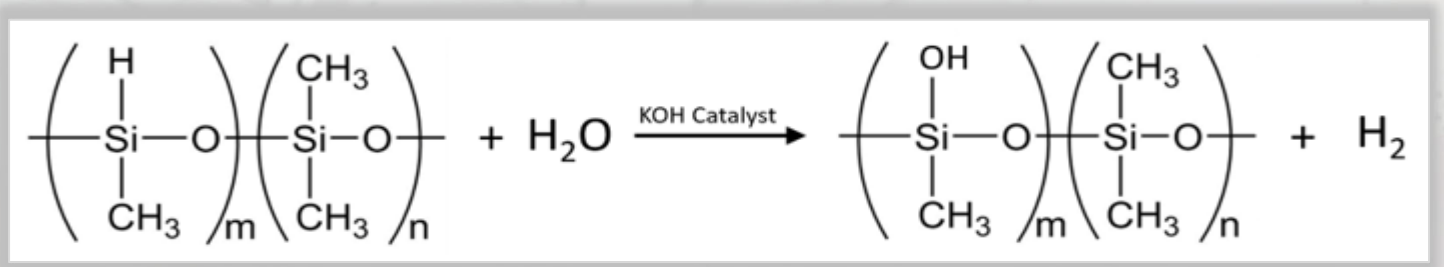
AB Specialty Silicones EM 652 Batch Operation

- Incident occurred while manufacturing an emulsion, commercially sold as Andisil® EM 652
- EM 652 was manufactured using loosely sealed tanks inside the *Emulsions Area*
- The batch operation began by adding multiple XL 10 drums and TD-6/12 Blend
- QC issued pH adjustments for out of specification final product before packaging



Silicon Hydride Reactivity

- XL 10 is a siloxane copolymer containing silicon hydride (SiH) bonds
- Compounds with SiH bonds react readily with aqueous bases, including potassium hydroxide, among other substances
- When 10% KOH, an aqueous base, contacts molecules with SiH bonds, the KOH catalyzes a reaction between the SiH and water, producing flammable hydrogen gas



Incident Description

- May 3, 2019
- AB Specialty Silicones operators packaged the first EM 652 batch
- Partial leftover chemical containers were likely left from the first batch, resulting in up to eleven nearly identical drums containing incompatible chemicals in the immediate process area at the start of the second batch

Incident Description (continued)

- Operator 1 added an incorrect chemical (10% KOH solution) to the tank, while adding first two chemicals for the second batch including, multiple XL 10 drums
- 10% KOH was not included on the batch ticket (instructions) and not intended to be introduced to the batch at this point
- The XL 10, TD 6/12 Blend, and 10% KOH mixture inside the tank reacted, producing hydrogen gas
- The hydrogen gas released inside the production building ignited, causing a massive explosion and fire
- The explosion fatally injured four AB Specialty Silicones employees

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

Mixing of Incompatible Materials

- Partial chemical containers, including XL 10 and 10% KOH, were likely left staged in the Emulsions Area for possible use in the second batch
- AB Specialty Silicones did not require employees to remove partial containers from the area in between back-to-back batches
- One experimental chemical reactivity test generated a large quantity of hydrogen gas and produced foaming similar to witness observations: *the addition of 10% KOH to a mixture of XL 10 and TD 6/12 Blend*

Hazard Analysis Program

- AB Specialty Silicones did not sufficiently analyze the hazards of the EM 652 process:

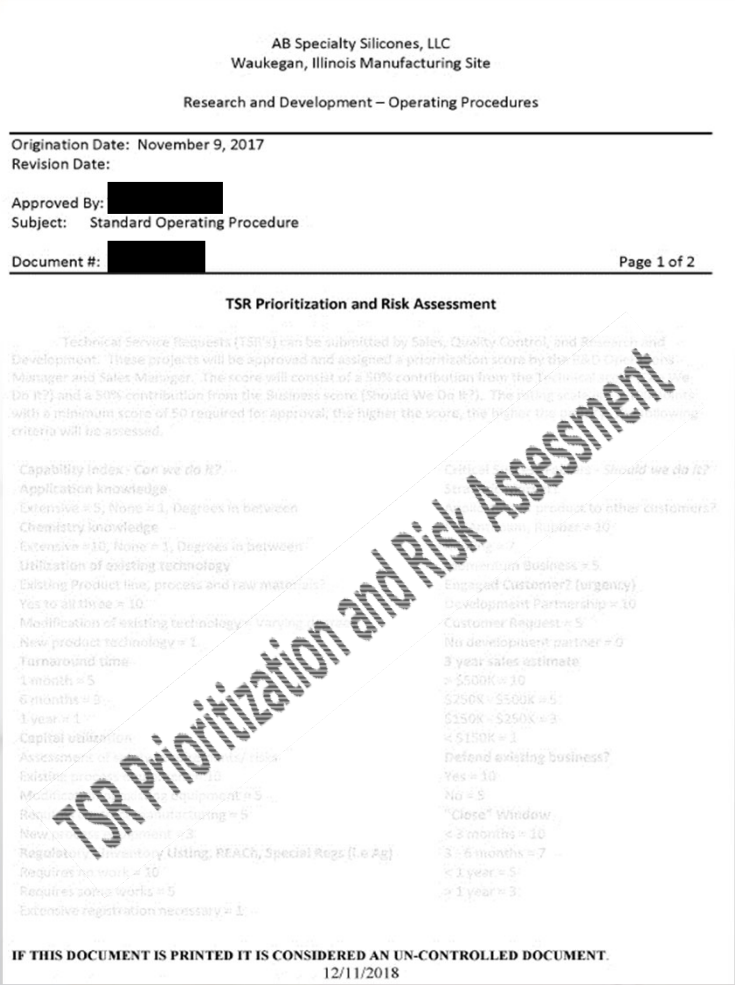
  In 2014, AB Specialty Silicones concluded that "lack of a comprehensive hazard analysis," among other things, contributed to an EM 652 drum explosion

- Effective controls were not implemented to prevent the mixing of 10% KOH solution and XL 10
- AB Specialty Silicones assesses proposed product manufacturing operations through what it calls technical service request:

  Neither technical service request performed for EM 652 in 2014 and 2018 documented any hazards or safeguards

Hazard Analysis Program (continued)

- The AB Specialty Silicones TSR program assessed potential business and safety risks, primarily aiming to answer:
  - *Can we do it?*
  - *Should we do it?*
  - *Adequacy of existing equipment?*
- The TSR program did not and was not intended to assess process operation hazards or establish safeguards to reduce risk



AB Specialty Silicones, LLC
Waukegan, Illinois Manufacturing Site

Research and Development – Operating Procedures

Origination Date: November 9, 2017
Revision Date:

Approved By: [redacted]
Subject: Standard Operating Procedure

Document #: [redacted] Page 1 of 2

TSR Prioritization and Risk Assessment

TSR Prioritization and Risk Assessment

IF THIS DOCUMENT IS PRINTED IT IS CONSIDERED AN UN-CONTROLLED DOCUMENT.
12/11/2018

Storage and Handling of Incompatible Materials

- At least three EM 652 chemical ingredients were stored in nearly identical 55-gallon blue plastic drums
- XL 10 and 10% KOH solution were stored in an identical drum, differentiated by a small label and bung caps

Storage and Handling of Incompatible Materials (continued)

- AB Specialty Silicones did not have a procedure requiring partial leftover chemical containers to be segregated or removed from the process area after use, contributing to the co-location of incompatible XL 10 and 10% KOH solution
- Industry guidance and strategies are available for reducing the likelihood of mixing incompatible materials

Batch Equipment and Ventilation System Design

- AB Specialty Silicones used tanks containing hatch-type lids that did not seal to manufacture EM 652
- The tanks were not equipped with vent pipes to divert produced gases outside the building, to a process ventilation system, or other safe location
- The AB Specialty Silicones production building's main air mover positioned in the Emulsions Area near tanks used to manufacture EM 652, may have helped distribute the released hydrogen in the area and mix it with air
  - *This manually operated unit was designed to introduce outside air in the building*

Gas Detection System

- The AB Specialty Silicones production building did not have a hydrogen or flammable gas detection system with alarms to warn employees of a hazardous atmosphere
- AB Specialty Silicones gas detection system timeline

Date	AB Specialty Silicones Actions
Around October 2018	Installed two LEL gas detector systems for a trial evaluation – *neither were specifically intended for the EM 652 process*
Around March 2019	Found both detector sensors unresponsive / failed and concluded failure due to silicone exposure
As of May 3, 2019	Had not replaced detector, established a sensor maintenance program, or implemented design changes to address silicone contacting the sensors

Gas Detection System (continued)

- An AB Specialty Silicones manager estimated the sensors life cycle to be about 2 months, while another asserted no hydrogen gas detection system will work in a silicone environment
- Others in industry with similar environments and applications use automatic alarming detectors to warn of hazardous atmospheres
- There are numerous gas detection technologies, each with advantages and disadvantages
- Staff proposes a recommendation to AB Specialty Silicones

Emergency Preparedness

Workers

- Trained on process emergencies
- Recognized the process upset
- Did not recognize immediate hydrogen hazard created by the upset
- Did not evacuate the building

PROCESS EMERGENCY

- Abnormal process situations occurring that could result in excessive equipment pressurization, hazardous material releases, or flammable or toxic vapor releases from the processing area
- If the safety of plant occupants was compromised as a result, a plant wide evacuation must occur and the incident command system activated
- Defensive actions to these situations could include: opening system vent lines, shutting down heating systems, applying cooling, shutting down agitation, shutting down sump drain pumps, opening doors for plant ventilation – these actions should only be taken if safe to do so.

AB Specialty Silicones

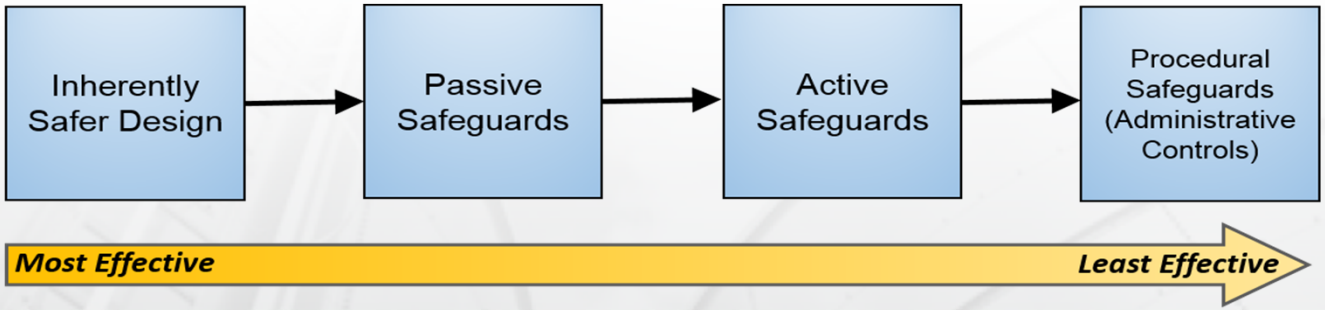
- Did not provide gas detectors and alarms to alert of the hazardous conditions
- Batch ticket warns of XL 10 reactivity and its ability to generate hydrogen

Double Initial Procedure Program

- In 2014 AB Specialty Silicones developed a double initial practice to prevent employees from charging the wrong materials to batch processes and as a part of the FDA's cosmetic good manufacturing practice compliance requirement
- In March 2019, AB Specialty Silicones experienced a near-miss event involving two chemicals stored in similar 55-gallon blue metal drums
- As a result, AB Specialty Silicones proceduralized its double initial practice and retrained all production workers

Double Initial Procedure Program (continued)

- Procedural controls used in industry including the double initial procedure are low on the hierarchy of controls, more likely to fail than are engineering controls and safeguards



- There was insufficient evidence to determine the specific reason for the program failure on May 3, 2019: 1) operator was fatally injured and 2) batch ticket in use, which would have included the employees' initials, was never recovered

Process Safety Culture

- An organization's safety culture is determined by the quality and implementation of safety management programs
- Improving an organization's process safety culture only starts with management; it requires the involvement of all
- Characteristics of a weak process safety culture exhibited at AB Specialty Silicones, specific to EM 652 include:
  - Lack of engineering controls to minimize employee exposure to known hydrogen risk;
  - Not performing a thorough hazard analysis following its 2014 drum explosion; and
  - Heavy reliance on procedural controls as primary safeguards

Safety Management System

- Effective safety management systems, primarily focused on process safety, are critical to prevent reactive chemical incidents
- AB Specialty Silicones did not have a safety management system that addressed process safety to control reactive hazards
- Industry publications including OSHA PSM Standard, the EPA RMP Rule, and the Center for Chemical Process Safety provide guidance on developing process safety management systems to control reactive hazards
- Staff proposes two recommendations to AB Specialty Silicones

Regulatory Coverage of Reactive Hazards

- In 1992, OSHA promulgated the PSM Standard (29 CFR 1910.119) to manage chemical process safety and to help prevent major incidents
- In 1996 the EPA promulgated its RMP Rule (40 CFR 68)
- The AB Specialty Silicones EM 652 operation is not regulated by OSHA's PSM Standard, nor the EPA's RMP Rule because the chemicals used at the facility are not listed for coverage by either regulation

Regulatory Coverage of Reactive Hazards (continued)

- In 2002, the CSB published a *Reactive Hazard Study* that found many reactive chemicals that could contribute to catastrophic incidents are not covered by the OSHA PSM Standard or EPA RMP Rule based on their respective existing selection criteria
- Staff proposes a reiteration of two previous recommendations:
  - OSHA (2001-01-H-R1) and
  - EPA (2001-01-H-R3)

This Concludes the Staff Presentation