U.S. Chemical Safety and Hazard Investigation Board

Years of Driving Chemical Safety Change

1998 2018

U.S. Chemical Safety and Hazard Investigation Board

Driving Chemical Safety Change: The First 20 Years

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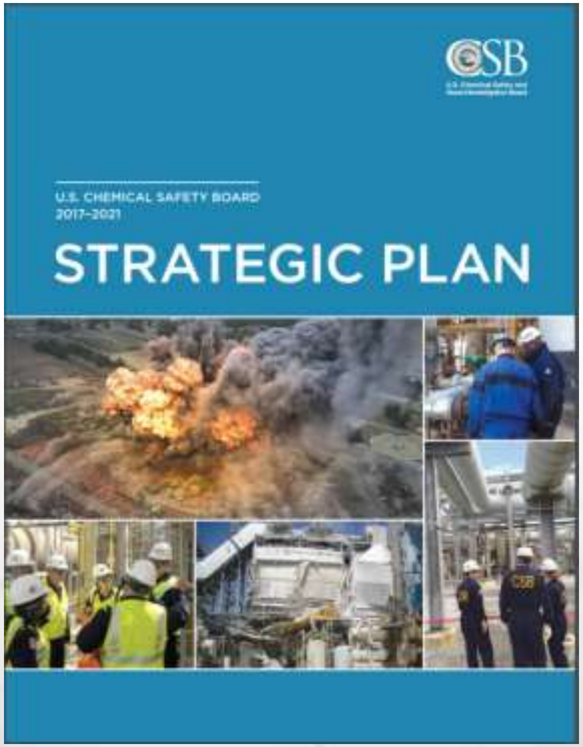
2018 Laboratory Safety Workshop
May 6, 2018

Vision:

A nation safe from chemical disasters.

Mission:

Drive chemical safety change through independent investigations to protect people and the environment.



CSB Quick Facts

- Independent, non-regulatory U.S. Federal agency
  - 40 professional staff; $11 million annual budget
  - Board members are appointed to 5-year terms by the President and confirmed by the Senate.
- Conducts root cause investigations of chemical accidents at fixed industrial facilities.
- Does not issue fines or citations.
- Primary policy levers are outreach and safety recommendations.

Significant Historical Process Safety Events

Union Carbide, Bhopal (1984)
Thousands dead; tens of thousands injured

Phillips 66 (1989)
23 Dead; 314 Injured;
$716 MM in damage

Arco Chemical (1990)
17 Dead; 5 Injured;
$36 MM in damage

AP Photo/Sondeep Shankar
www.healthandsafetyatwork.com
www.gendisasters.com

Clean Air Act Amendments (1990)

Created the Chemical Safety Board

Risk Management Plan rule (RMP)

Process Safety Management standard (PSM)

Types of Incidents That We Investigate

BP America Refinery
Texas City, TX
March 23, 2005

Freedom Industries
Charleston, WV
January 9, 2014

Deepwater Horizon
Gulf of Mexico
April 20, 2010

Jurisdiction: Release of hazardous substance into the ambient air from a fixed facility

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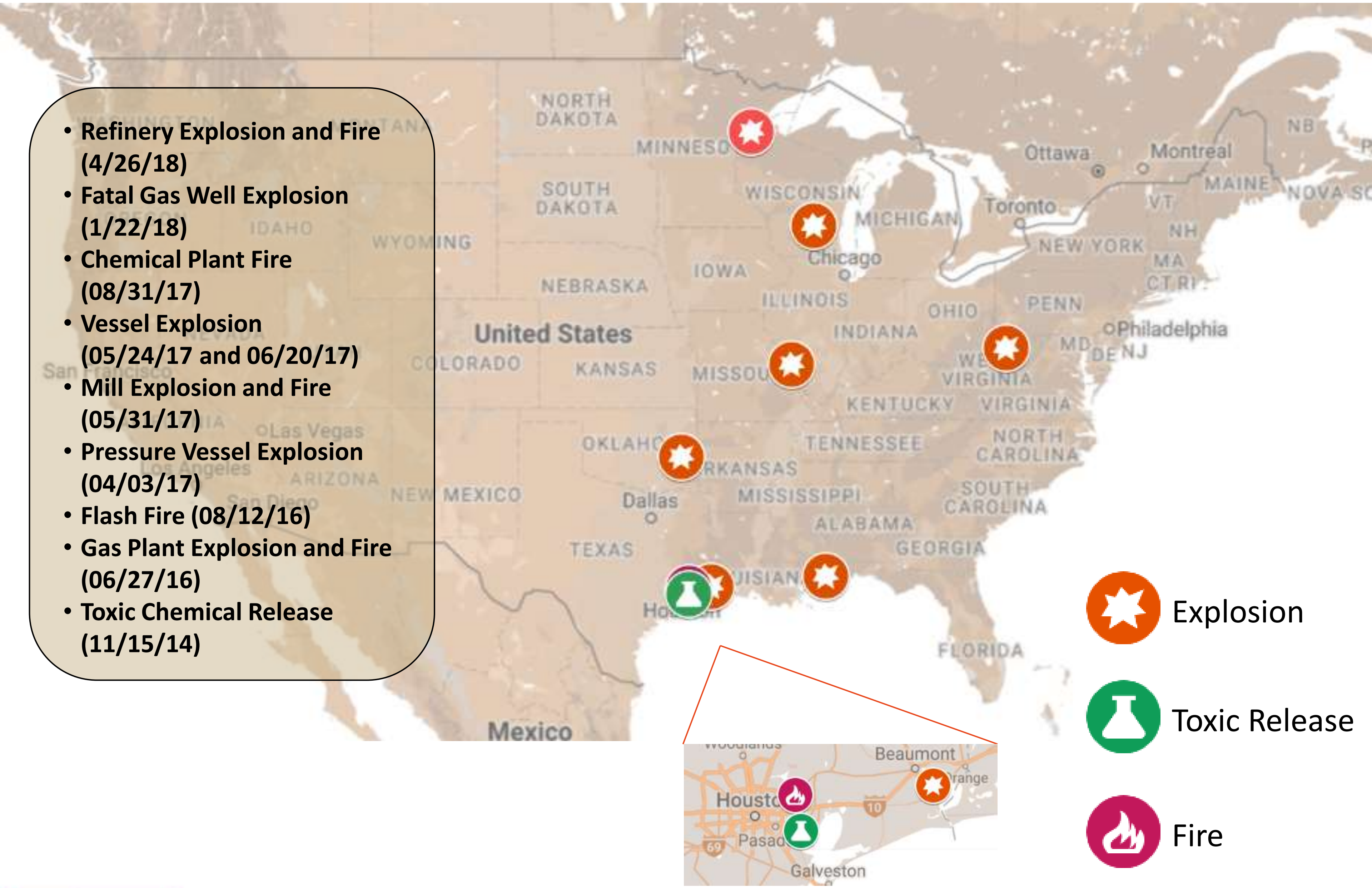
Current Investigations & Deployments

- **Refinery Explosion and Fire (4/26/18)**
- **Fatal Gas Well Explosion (1/22/18)**
- **Chemical Plant Fire (08/31/17)**
- **Vessel Explosion (05/24/17 and 06/20/17)**
- **Mill Explosion and Fire (05/31/17)**
- **Pressure Vessel Explosion (04/03/17)**
- **Flash Fire (08/12/16)**
- **Gas Plant Explosion and Fire (06/27/16)**
- **Toxic Chemical Release (11/15/14)**



20 Years of Driving Chemical Safety Change

January
Overview of CSB's First 20 Years

February
Process Safety Management

March
Safe Hot Work Practices

April
Combustible Dust Safety

May
Extreme Weather

June
Preventive Maintenance

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July

Contractor Safety

August

Laboratory Safety

September

Human Fatigue

October

Emergency Planning & Response

November

Winterization

December

Reactive Hazards

CSB Safety Spotlight: State Advances in Driving Chemical Safety

U.S. Chemical Safety and Hazard Investigation Board

The U.S. Chemical Safety and Hazard Investigation Board (CSB) is highlighting the important role of individual state governments in driving critical chemical safety change. A number of state governments have made significant safety improvements following a chemical disaster within their state. They make them to protect their residents and the environment with the common goal of preventing future similar incidents.

The CSB has issued 80 safety recommendations to 22 different state governments stemming from 27 CSB investigations. Currently, only six of these investigations still have open recommendations issued to state governments. These CSB recommendations range from identifying risks and increasing safety inspections to developing and adopting significant, state-level chemical safety legislation. Several states have taken significant steps to implement positive safety changes in light of chemical disasters. The following are a few notable examples:

Following a 2007 propane explosion that occurred at a general store in Ghent, West Virginia, killing four people, the CSB issued a recommendation to the Governor and Legislature of the State of West Virginia aimed at improving propane training requirements for propane technicians. West Virginia approved a bill in 2010 requiring the completion of a nationally recognized propane service training program for "persons who install or maintain liquefied petroleum gas systems." This requirement was also implemented into the West Virginia State Fire Code.

On February 7, 2010, Kleen Energy, a natural gas-fueled power plant under construction in Middletown, Connecticut, experienced a catastrophic natural gas explosion that killed

six and injured at least 50 people. The incident occurred while workers were conducting a "gas blow," where natural gas is forced through new piping and released into the atmosphere at a high pressure and volume in order to remove debris. As a part of its investigation, the CSB issued a recommendation to the Governor and Legislature of the State of Connecticut to enact legislation that prohibits gas blows. In September of 2010, the former Governor of Connecticut, M. Jodi Rell,

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Safety Spotlight

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Factual Investigative Update

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Factual Investigative Update

Loy-Lange Box Company Catastrophic Pressure Vessel Failure

Contents

This is a Factual Investigative Update of a CSB investigation into a multi-fatality incident resulting from the catastrophic failure of a pressure vessel.[1] It provides the facts and findings established by the investigation team to date, which is subject to revision and updates as the investigation proceeds. This document identifies a path forward for a number of potential investigative areas of inquiry that may yield lessons for safety improvements.

Incident Overview

At approximately 7:20 a.m. on April 3, 2017, the bottom of a steam condensate (hot water) storage tank catastrophically failed at the Loy-Lange Box Company (LLBC), located at 222 Russell Boulevard in St. Louis, Missouri. The 1952-pound[2], 30-inch diameter by 17-½-feet long steel tank,[3] called a Semi-Closed Receiver (SCR)[4] contained about 510 gallons condensed steam (water at about 330 °F and 100 psig.[5]) Condensate from the vertically-mounted SCR was normally sent to two associated steam generators.[6]

As the pressure in the tank suddenly dropped due to the failure of the tank bottom, a portion of the water in the SCR instantaneously exploded into steam, resulting in an increase in volume of about 75 times the volume of the SCR.[7] A steam explosion of this type is extremely hazardous. The energy released was equivalent to about 350 pounds of TNT.[8] Some of that energy dissipated when the escaping steam condensed to water, but the surveillance video from a nearby custom work truck shop clearly shows the power of the explosion and the effect on the building (Figure 1), as does the damage evident after the event.

Figure 1. Before and after photos for the explosion - Kranz video

The force of the steam explosion exiting the bottom of the SCR destroyed a large portion of the LLBC facility, and launched the storage tank like a rocket through the roof (Figure 2, A). One LLBC employee was fatally injured, and a second was left in critical condition.

Even after pulling loose from all of the piping and floor attachments, and crashing up through the structure of the building and out through the roof, the 1952-pound SCR was still traveling at about 120 mph. It rose to about 425 feet above street level and traveled laterally across about 520 feet. It remained airborne for over 10 seconds.

As it fell, the SCR crashed through the roof of Faultless Healthcare Linen's[9] property at 2030 S. Broadway, fatally injuring three individuals (Figure 2, B).

Various pieces of piping and debris from the explosion also crashed into the surrounding areas. A third building at 400 Russell Boulevard, owned by Pioneer Industrial Group, suffered significant mechanical and water damage when a large piece of pipe from the Loy-Lange site punctured the roof and ruptured a portion of its water sprinkler system (Figure 2, C and Figure 3). No injuries occurred at this third site. An approximately 7 foot long section of about 1.5 inch pipe also speared down through the windshield of a truck parked adjacent to the Faultless property and embedded into the dashboard and floorboard (Figure 2, D and Figure 3).

1 http://www.csb.gov/csb-investigators-deploying-to-explosion-at-the-loy-lange-box-company-in-saint-louis-missouri/

2 The investigation team originally estimated the weight at 3000 pounds.

3 Overall length, including the support skirt, is 20 feet. The investigation team originally estimated the tank at 36 inches in diameter by 20 to 25 feet long.

4 It was called a Semi-Closed Receiver (SCR) because it received condensed steam (hot, high pressure water) from the LLBC steam system. "Semi-closed" refers to an open vent from the tank that vents any air in the system (and a small amount of steam from the hot water) to the atmosphere.

5 psig: pounds per square inch gauge.

6 A steam generator is a device similar to a steam boiler that turns water into steam. At Loy-Lange, the steam heated equipment that was used to make corrugated cardboard.

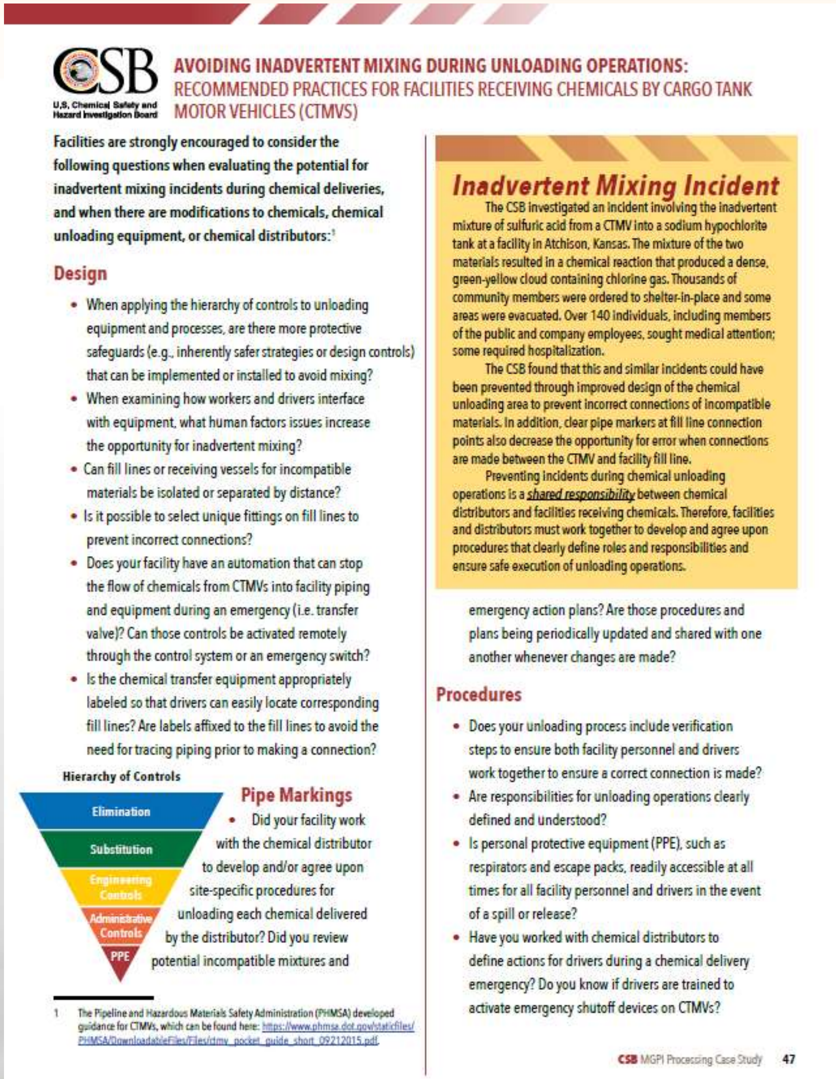
7 Investigation team calculation.

8 Investigation team calculation. Energy difference between 510 gal of water in the tank and water at ambient conditions is about 700,000 BTU. 1 pound of TNT releases about 1800 BTU.

9 http://www.faultlessliner.com

Overview of MGPI Toxic Release

Key Lessons from Incident



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AVOIDING INADVERTENT MIXING DURING UNLOADING OPERATIONS: RECOMMENDED PRACTICES FOR FACILITIES RECEIVING CHEMICALS BY CARGO TANK MOTOR VEHICLES (CTMVS)

Facilities are strongly encouraged to consider the following questions when evaluating the potential for inadvertent mixing incidents during chemical deliveries, and when there are modifications to chemicals, chemical unloading equipment, or chemical distributors:[1]

Design

- When applying the hierarchy of controls to unloading equipment and processes, are there more protective safeguards (e.g., inherently safer strategies or design controls) that can be implemented or installed to avoid mixing?
- When examining how workers and drivers interface with equipment, what human factors issues increase the opportunity for inadvertent mixing?
- Can fill lines or receiving vessels for incompatible materials be isolated or separated by distance?
- Is it possible to select unique fittings on fill lines to prevent incorrect connections?
- Does your facility have an automation that can stop the flow of chemicals from CTMVs into facility piping and equipment during an emergency (i.e. transfer valve)? Can those controls be activated remotely through the control system or an emergency switch?
- Is the chemical transfer equipment appropriately labeled so that drivers can easily locate corresponding fill lines? Are labels affixed to the fill lines to avoid the need for tracing piping prior to making a connection?

Hierarchy of Controls

Pipe Markings

- Did your facility work with the chemical distributor to develop and/or agree upon site-specific procedures for unloading each chemical delivered by the distributor? Did you review potential incompatible mixtures and emergency action plans? Are those procedures and plans being periodically updated and shared with one another whenever changes are made?

1 The Pipeline and Hazardous Materials Safety Administration (PHMSA) developed guidance for CTMVs, which can be found here: https://www.phmsa.dot.gov/staticfiles/PHMSA/DownloadableFiles/Files/ctmv_pocket_guide_short_09212015.pdf.

Inadvertent Mixing Incident

The CSB investigated an incident involving the inadvertent mixture of sulfuric acid from a CTMV into a sodium hypochlorite tank at a facility in Atchison, Kansas. The mixture of the two materials resulted in a chemical reaction that produced a dense, green-yellow cloud containing chlorine gas. Thousands of community members were ordered to shelter-in-place and some areas were evacuated. Over 140 individuals, including members of the public and company employees, sought medical attention; some required hospitalization.

The CSB found that this and similar incidents could have been prevented through improved design of the chemical unloading area to prevent incorrect connections of incompatible materials. In addition, clear pipe markers at fill line connection points also decrease the opportunity for error when connections are made between the CTMV and facility fill line.

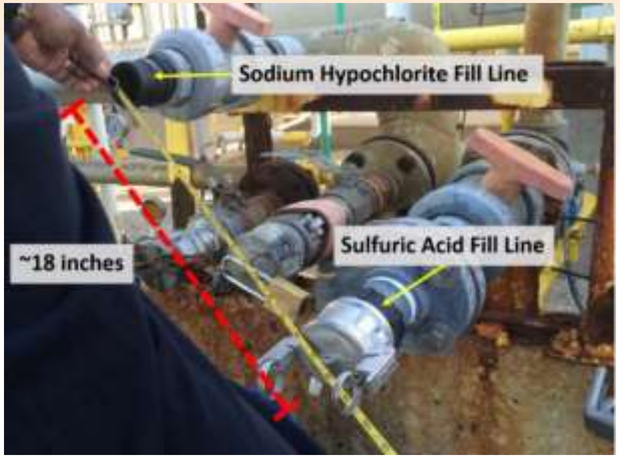
Preventing incidents during chemical unloading operations is a *shared responsibility* between chemical distributors and facilities receiving chemicals. Therefore, facilities and distributors must work together to develop and agree upon procedures that clearly define roles and responsibilities and ensure safe execution of unloading operations.

Procedures

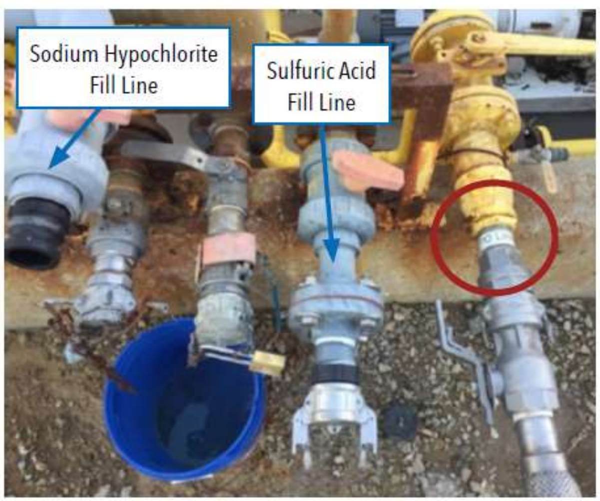
- Does your unloading process include verification steps to ensure both facility personnel and drivers work together to ensure a correct connection is made?
- Are responsibilities for unloading operations clearly defined and understood?
- Is personal protective equipment (PPE), such as respirators and escape packs, readily accessible at all times for all facility personnel and drivers in the event of a spill or release?
- Have you worked with chemical distributors to define actions for drivers during a chemical delivery emergency? Do you know if drivers are trained to activate emergency shutoff devices on CTMVs?

CSB MGPI Processing Case Study 47

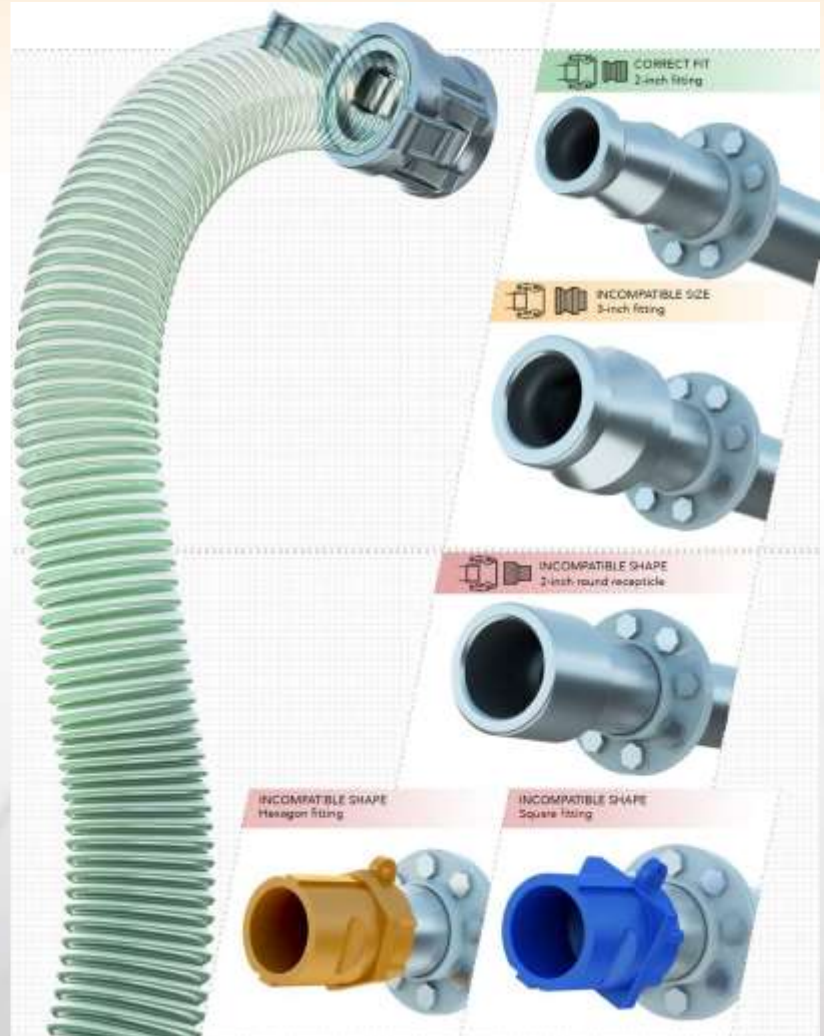
- Design
- Human Factors
- Pipe Markings
- Procedures



Fill line proximity



Pipe markings



Nonidentical connections and locks

- Alarms and interlocks on process control system
- Automated shutdown procedures
- Building design and ventilation system

- **Practices aligned with procedures**
- **Access to respirators**
- **Defined responsibilities during an emergency**

Post-Incident Changes

- Fill lines
- Chemical unloading procedures
- New couplings on sulfuric acid fill line
- Secure cages with card-reader access control
- Engineering system interlocks
- Monitoring and shutdown devices
- Design changes to control room
- Greater accessibility of respirators

New coupling on the sulfuric acid fill line (Source: MGPI)

Separation of unloading connections with secure cages around connection points (Source: MGPI)

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