How major incidents can drive safety, sustainability and profitability: Lessons from the U.S. Chemical Safety Board

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Significant Historical Process Safety Events

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

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

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

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

Clean Air Act Amendments (1990)

Created the Chemical Safety Board

Risk Management Plan rule (RMP)

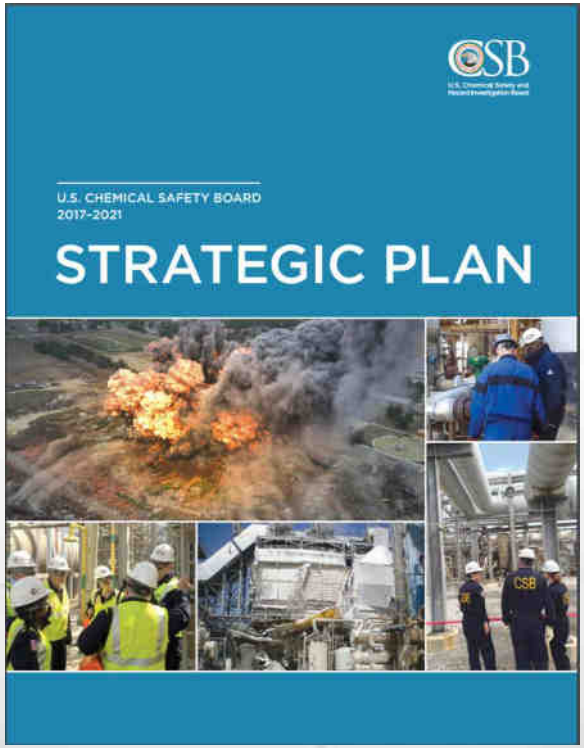
Process Safety Management standard (PSM)

Vision:

A nation safe from chemical disasters.

Mission:

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



About the CSB

- Independent, non-regulatory U.S. Federal agency
- Root cause investigations of chemical incidents
- Primary policy levers are outreach and safety recommendations.

Types of Incidents That We Investigate

Deepwater Horizon
Gulf of Mexico
April 20, 2010

BP America Refinery / Texas City, TX
March 23, 2005

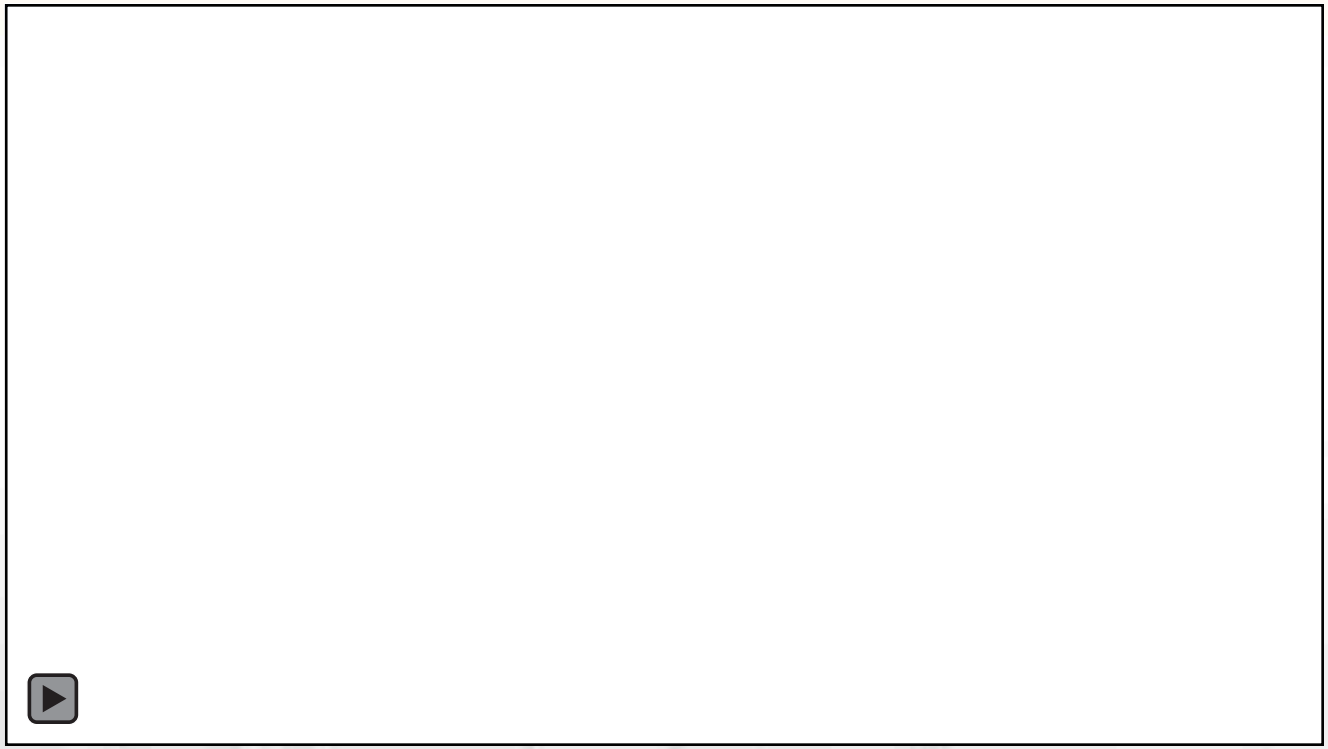
Freedom Industries / Charleston, WV
January 9, 2014

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

ITC Fire – March 2019

Intercontinental Terminal Company
Deer Park, TX
March 17, 2019

Case Study: MGP Ingredients



MGPI Processing Plant

- **October 21, 2016 / Atchison, KS**
- **140 people sought medical attention**
- **Shelter-in-place, evacuation of thousands of residents**

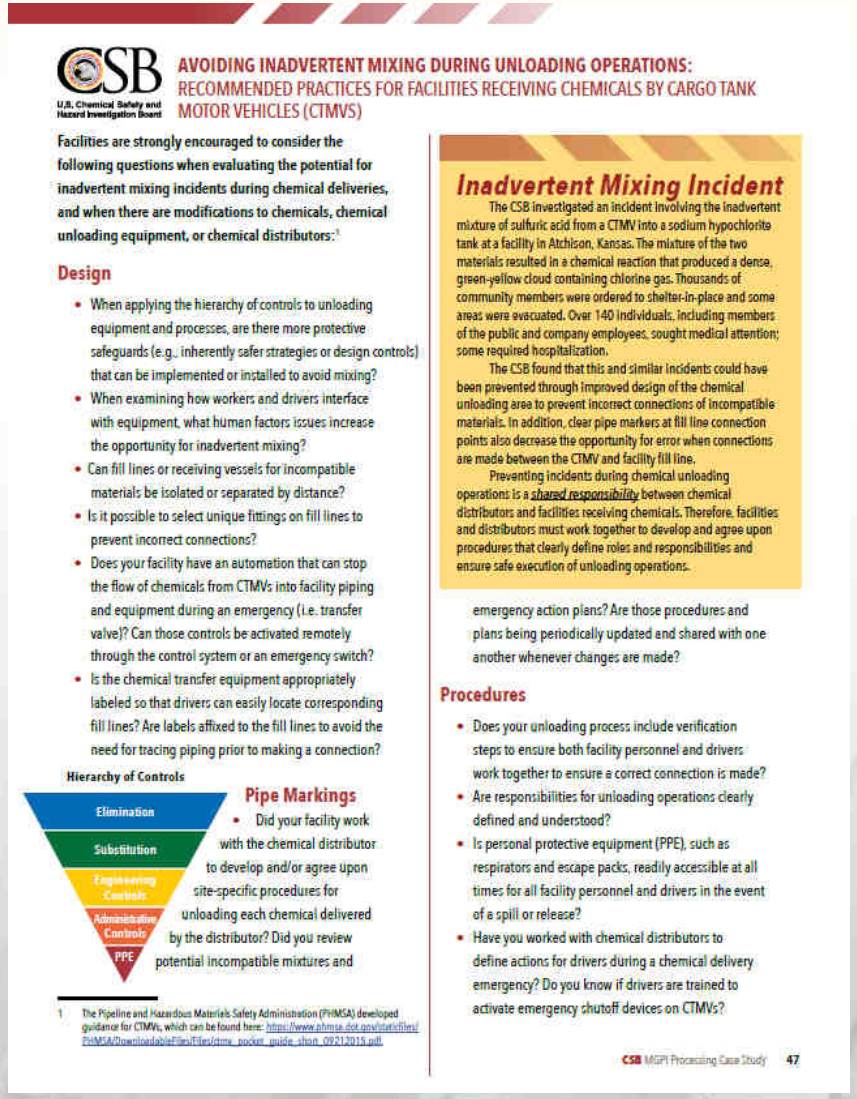
Overview of MGPI Toxic Release

See video

Mixed Connection, Toxic Result

https://www.youtube.com/watch?v=Tflm9mttAAI

Key Lessons from Incident



U.S. Chemical Safety and Hazard Investigation Board

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?

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.

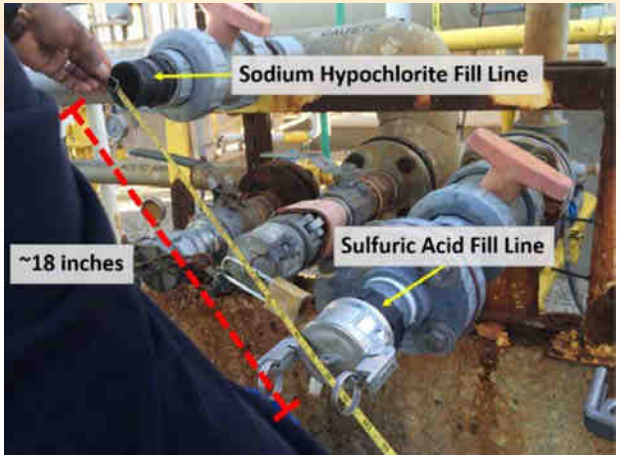
Preventing incidents during chemical unloading operations is a *shared responsibility* between chemical distributors and facilities receiving chemicals. Therefore, facilities and distributors must work together to develop and agree upon procedures that clearly define roles and responsibilities and ensure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

Procedures

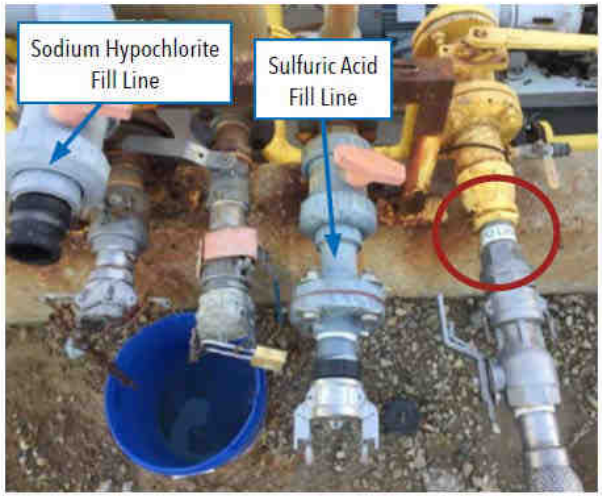
- Does your unloading process include verification steps to ensure both facility personnel and drivers work together to ensure a correct connection is made?
- Are responsibilities for unloading operations clearly defined and understood?
- Is personal protective equipment (PPE), such as respirators and 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?

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.

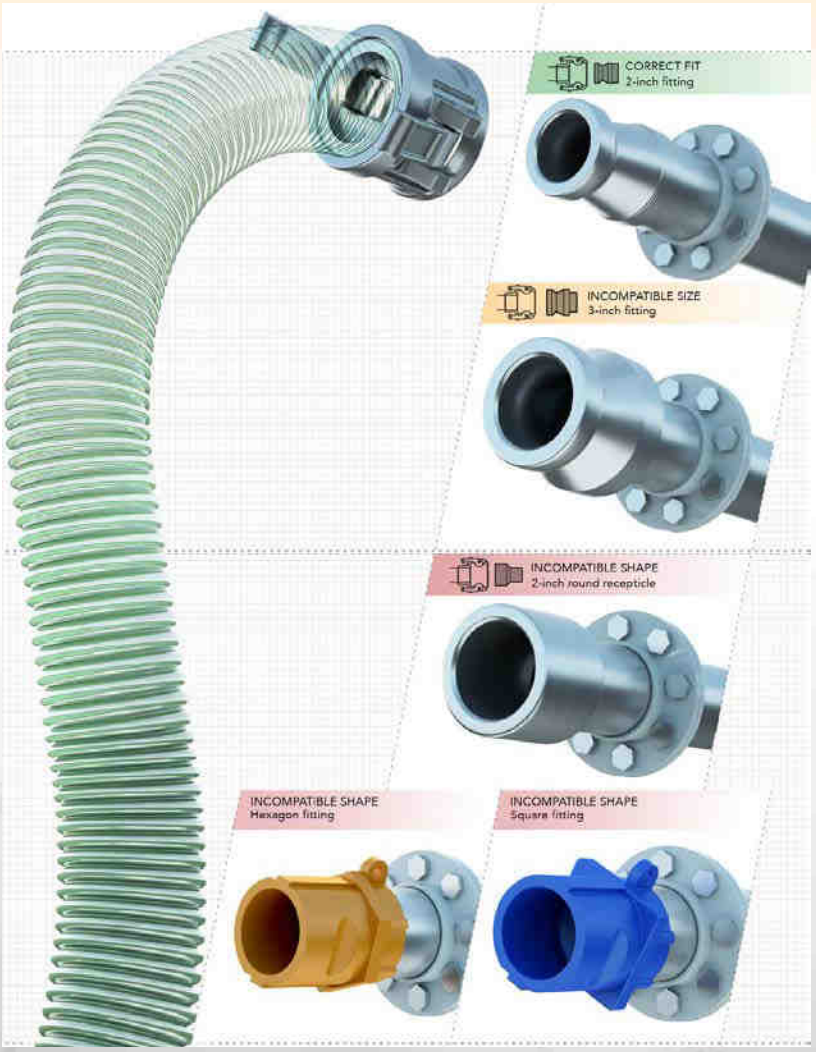
- Design
- Human Factors
- Pipe Markings
- Procedures



Fill line proximity



Pipe markings



Identical 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

Recommendations Issued to MGPI

- Commission an independent engineering evaluation of its building and ventilation system, and implement design changes and controls to protect occupants from a chemical release.
- Conduct an evaluation of the chemical transfer equipment and install appropriate engineering safeguards to prevent and mitigate an unintended reaction, chemical release, or spill during bulk unloading.

Post-Incident Changes

- Labeling of fill lines
- Chemical unloading procedures
- New couplings on sulfuric acid fill line
- Secure cages with card-reader access control
- Engineering system interlocks
- 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)

Post-Incident Changes (cont.)

- Dedicated locks with separate keys
- New key fob lockout system
- Color-coded tags
- New shutoff valves

New key fob lockout system (photo courtesy of MGPI)

New shutoff valve (photo courtesy of MGPI)

Top-to-bottom Review of Operation

Established local requirements for inspection, testing and standards for pressure vessels, piping, storage tanks, pressure-relief devices, pumps and control systems.

Process Hazard Analyses → Enhanced Safety

PHAs done on other chemicals at the transfer station:

- **Propylene oxide**
  (extremely flammable, probable carcinogen, RMP)

- **Phosphorous oxychloride**
  (water-reactive, PSM, RMP)

- **Acetic anhydride**
  (Class II combustible, irritant, water-reactive)

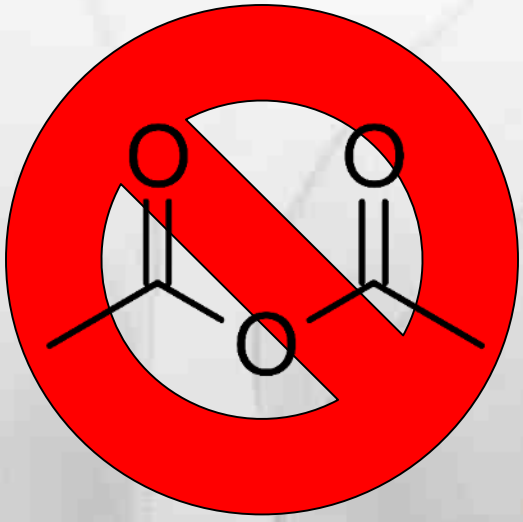
Identified potentially hazardous process deviations such as misdirected flow, high or low temperature, high or low-level indication, high or low pressure, and outside external elements.

The propylene oxide day tank and all instruments and conduit in the propylene oxide containment were replaced.

Bulk Flammable Chemical Removed

Process involving acetic anhydride was removed entirely and the tank decommissioned.

Number of liquid bulk chemicals: 5 → 4
Number of bulk flammable chemicals: 2 → 1



Additional Facts

Hired a full-time process safety engineer.

Achieved cost savings from streamlined, safer, more sustainable processes.

CSB Safety Spotlight: Innovation, a 'Key' Factor in Driving Chemical Safety

U.S. Chemical Safety and Hazard Investigation Board

The U.S. Chemical Safety and Hazard Investigation Board (CSB) spotlights the actions of a single plant for its response to our investigation. The MGPI Processing, Inc. (MGPI) facility's thorough, thoughtful, innovative thinking and immediate implementation of safety improvements serve as an example of how companies can drive chemical safety change following an incident.

Summary of Incident and Key Findings

On October 21, 2016, a chemical released occurred at the MGPI facility when the driver of a chemical company's delivery vehicle (owned and operated by another company) inadvertently connected its sulfuric acid hose to a tank containing sodium hypochlorite, better known in its less concentrated form as bleach. This mixture of two incompatible chemicals formed a solution, and the uncontrolled chemical reaction quickly formed a toxic vapor cloud. There was no way to stop the continued mixing of the chemicals other than closing manual valves or triggering one of the truck's emergency shut-offs, neither of which could be accomplished due to the vapor cloud. The CSB found that the close proximity of the sulfuric acid and sodium hypochlorite fill lines increased the likelihood that workers would make an incorrect connection during chemical unloading. The two fill lines looked and functioned identically, and used the same type of connections, which were not clearly labeled or properly secured.

Thoughtful, Safety-Minded Planning

As the CSB conducted its investigation, MGPI facility managers were also examining their own processes and equipment to identify opportunities to reduce risk and prevent reoccurrence. Prior to the discussion of potential recommendations, the company presented the CSB with a list of processes and equipment that they were looking to modify.

BEFORE: *Old unloading portals (photo courtesy of CSB)*

AFTER: *New unloading portals with magnetic key fob access (photo courtesy of MGPI)*

As a result of MGPI's initiative to address potential safety issues, the CSB only issued two recommendations to the facility. The first required MGPI to commission an independent

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