16th STS-AIChE Southwest Process Technology Conference

Chemical Loading and Unloading: *Risks at the Intersection of the Truck Driver and the Facility*

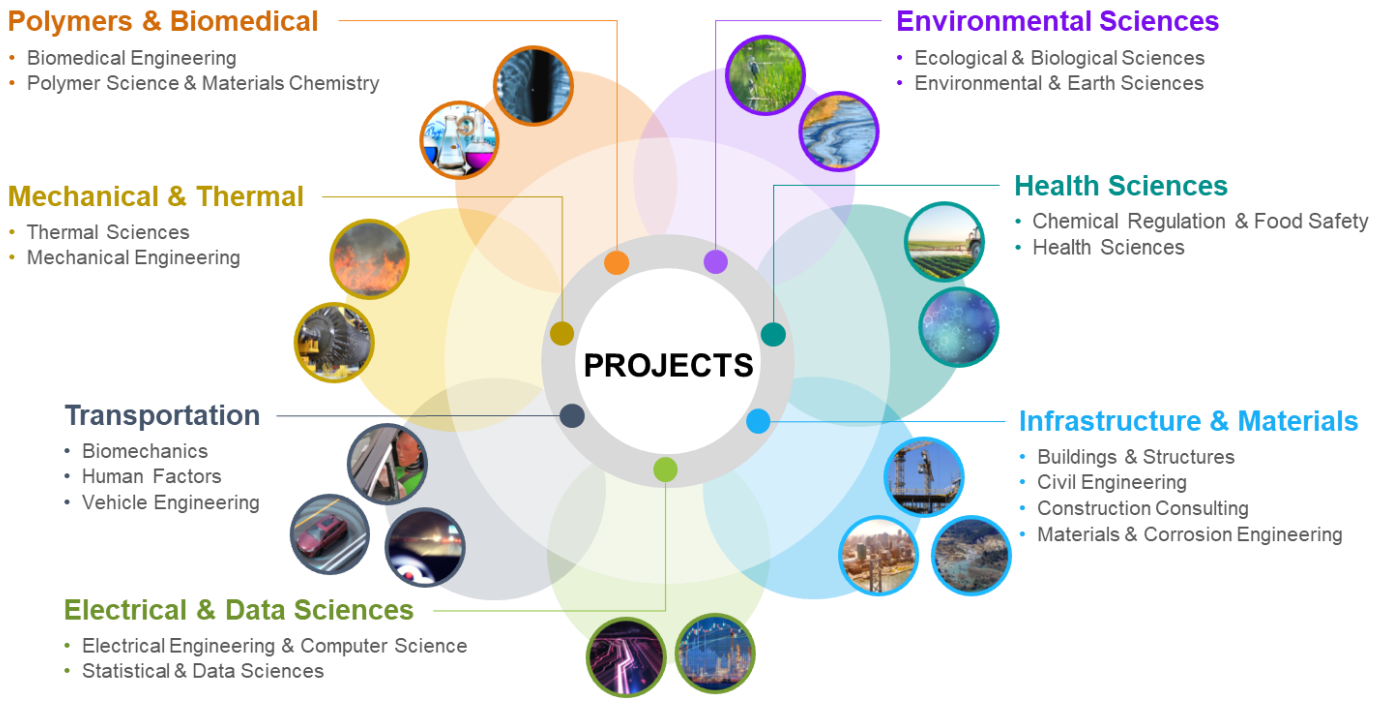
- **Nick Reding, PhD, PE, CFEI**
- **Exponent, Inc.**

Sept 22-23, 2025, University of Houston

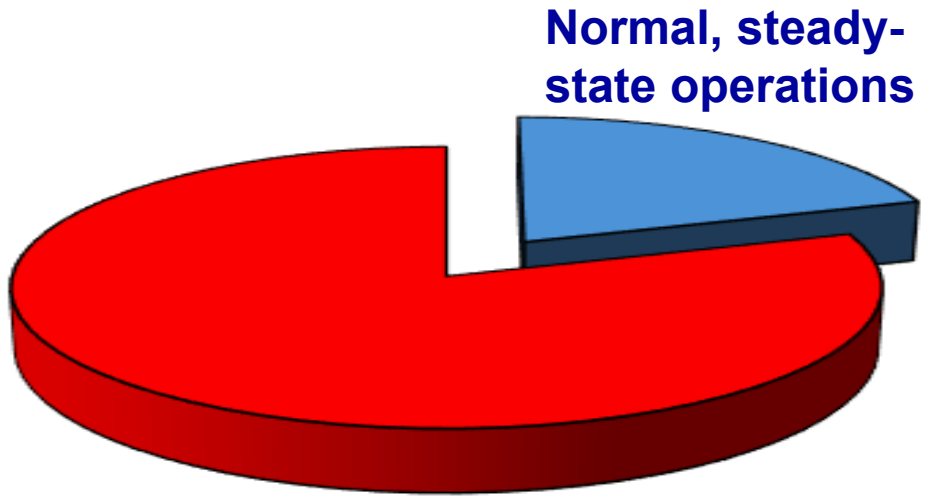
Speaker Bio: Nick Reding, PhD, PE, CFEI

- Managing Engineer in Thermal Sciences Practice
  - Investigate chemical process incidents
    - Chemical releases
    - Fires and explosions
  - Analyses of chemical process failures
    - Failure to meet performance guarantees or technical specifications
    - Construction, cold/hot commissioning, start up, performance testing, handover, turnaround, steady-state, non-routine operations
- AIChE member for >5 years

Engineering and Scientific Consulting at Exponent



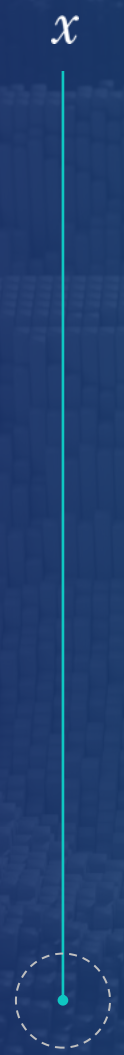
Statistics on Chemical Incidents



- Approximately 80% of chemical safety or near-miss incidents occur during non-routine operations
- Process Hazard Analyses (PHA) of continuous operations may catch a small fraction of hazards associated with non-routine operations
  - AIChE Hazard Analysis book now requires hazard analysis for any non-routine operations
- Motivates continuous learning and process safety management for non-routine operations (i.e., **chemical loading/unloading**)

PHA/HAZOP of Procedures, Short Course, AIChE GCSPS 2025.

Outline



Loading & Unloading Procedure

Truck Driver Responsibility

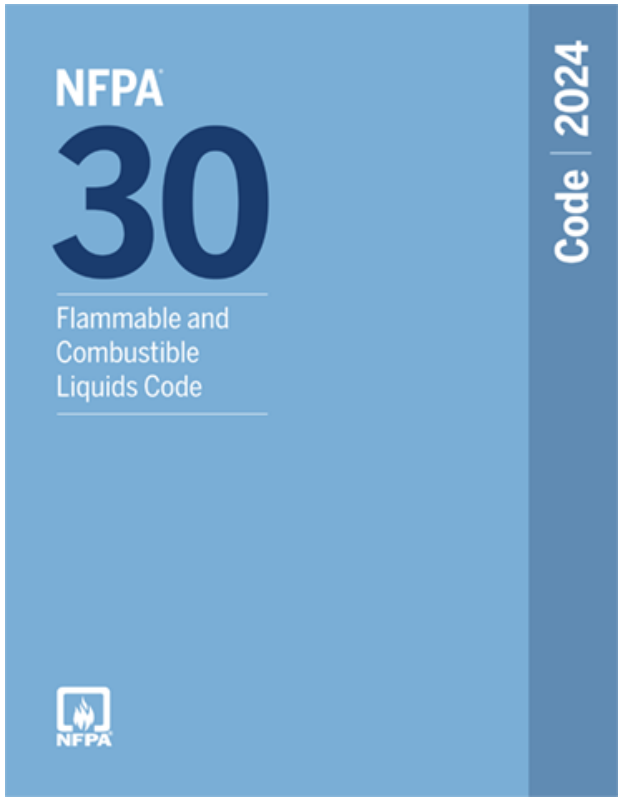
Facility Responsibility

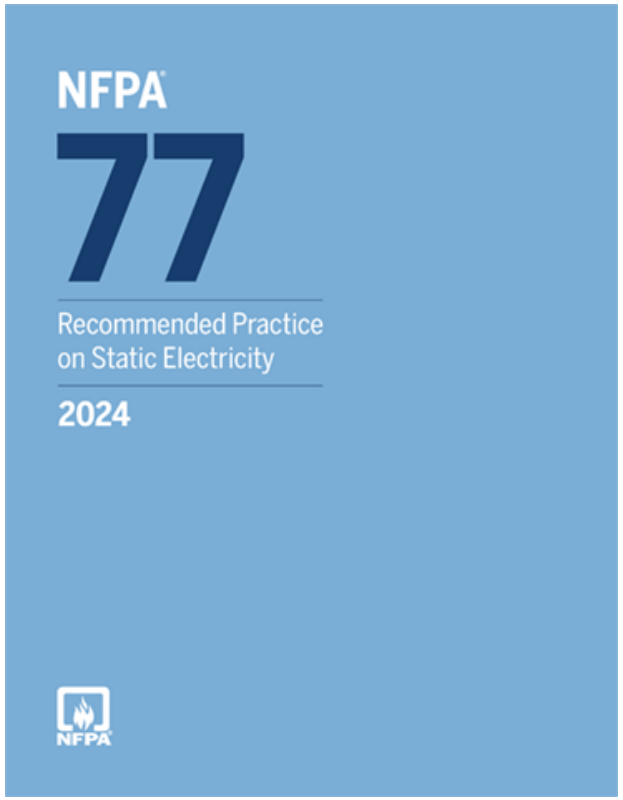
The Intersection

Applicable Codes & Standards

- **NFPA 30: Flammable and Combustible Liquids Code**
  - Ch. 18: Dispensing, Handling, Transfer, and Use of Ignitable (Flammable or Combustible) Liquids
  - Ch. 28: Bulk Loading and Unloading Facilities for Tank Cars and Tank Vehicles

- **NFPA 77: Recommended Practice on Static Electricity**
  - Ch. 12: Static Electricity Hazards of Liquids in Bulk Storage Tanks and in Tank Vehicles





Applicable Codes & Standards

- **NFPA 400: Flammable and Combustible Liquids Code**
  - This code shall apply to the storage, use, and handling of hazardous materials, such as:
    - Ammonium nitrate solids and liquids
    - Corrosive solids and liquids
    - Flammable solids
    - Toxic and highly toxic solids/liquids

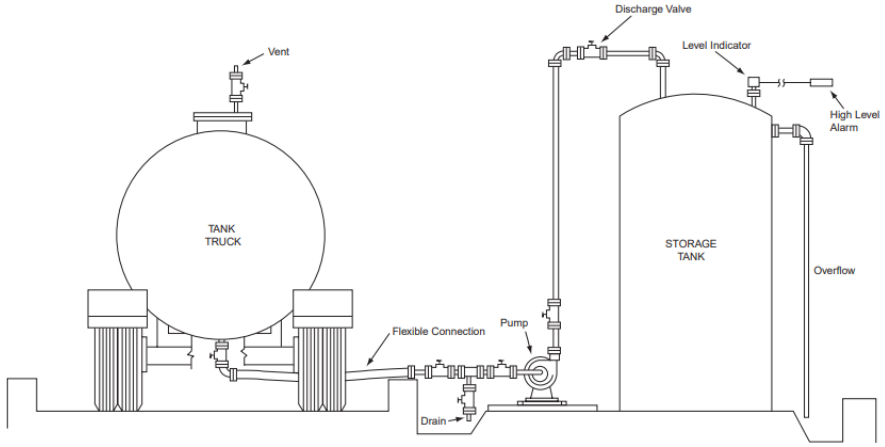
Applicable Codes & Standards

- **OSHA Process Safety Management (PSM) standards**
  - Communication: 29 CFR 1910.1200
  - Highly hazardous chemicals: 29 CFR 1910.119
  - Flammable liquids: 29 CFR 1910.106
  - Control of hazardous energy: 29 CFR 1910.147
  - Loading and unloading guidance: 49 CFR 177.834

- **Department of Transportation (DOT) enforced**
  - Hazardous Materials Regulations (HMR): 49 CFR Parts 171-180

Chemical Loading and Unloading

- The loading and unloading of chemical materials is a critical point in the supply chain where shared responsibility exists between both the truck driver and the facility share responsibility for safety.
- Potential hazards can be magnified if proper procedures and communication are not in place.

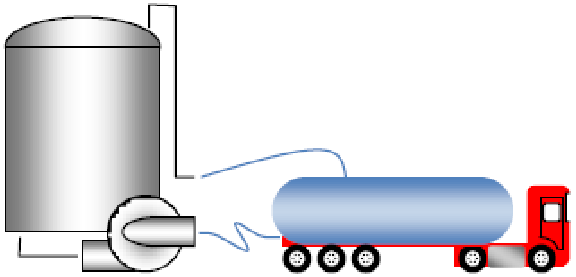


Top Loading vs. Bottom Loading

Caustic Soda Solution Handbook, DOW, August 2010.

The 4 Most Common Scenarios for Truck (Un)loading

1. **Bottom unloading by pump and vapor return**



Advantages:

- In an emergency, power to the pump is cut, immediately stopping pump flow.
- Vapor in the site tank will flow to the truck and not be lost to the atmosphere.

Disadvantages:

- Connecting the vapor return usually requires access to the top of the vehicle, except for ground-operated trucks.

Best Practice Guidelines for Safe (Un)Loading of Road Freight Vehicles Covering Technical, Behavioral and Organizational Aspects. Issue 1, December 2013.

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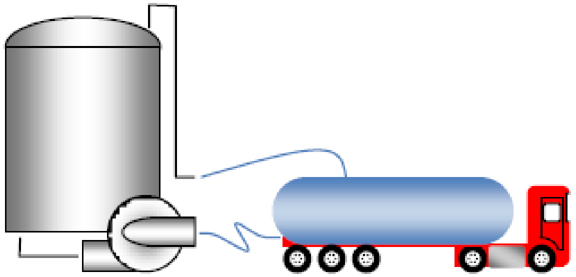

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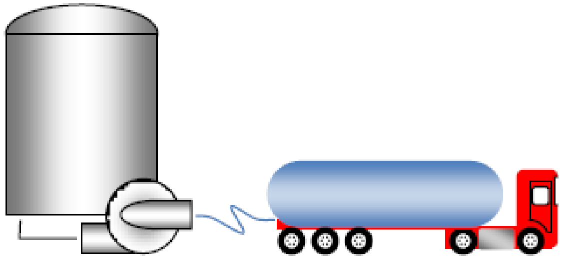
2. Bottom discharge by pump without vapor return



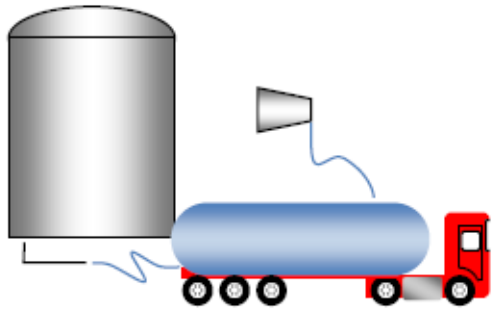
Advantages:
- In an emergency, power to the pump is cut, immediately stopping pump flow.

Disadvantages:
- Opening the vapor valve usually requires access to the top of the site's tank (tank vapor out) and the vehicle (air in), except for ground-operated trucks.
- Vehicle tanks lack proper vacuum protection for discharge and can be damaged if vacuum collapse is not managed.

Best Practice Guidelines for Safe (Un)Loading of Road Freight Vehicles Covering Technical, Behavioral and Organizational Aspects. Issue 1, December 2013.

The 4 Most Common Scenarios for Truck (Un)loading

3. Bottom unloading by compressed air or inert gas



Advantages:

- Without a pump, cleanliness is not a concern, and the compressor does not contact the product, minimizing contamination risk.

Disadvantages:

- Vehicle tanks remain pressurized after discharge; compressor connection usually required top access unless it is a ground-operated truck.

- Site tank vapors must be considered in the process.

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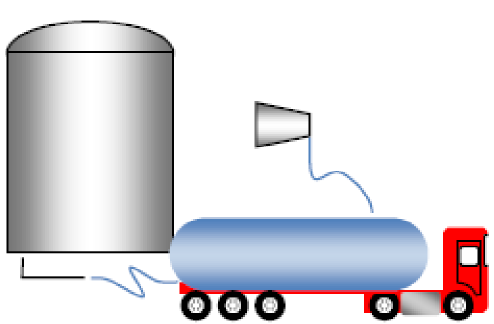

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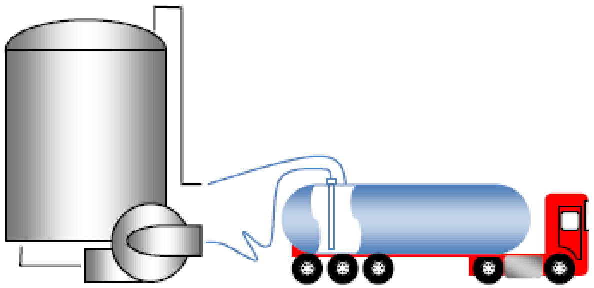
4. Top discharge



Advantages:

- With no openings below the liquid level, the risk of unauthorized access or contamination is greatly reduced.

Disadvantages:

- Access to the top of the vehicle is required.

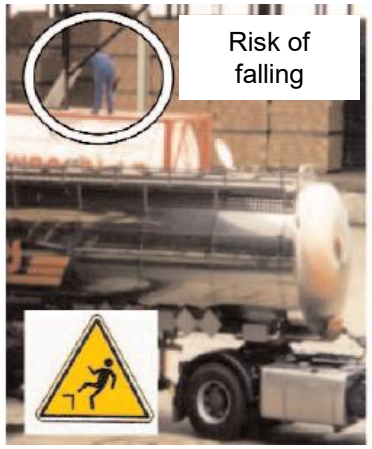
Best Practice Guidelines for Safe (Un)Loading of Road Freight Vehicles Covering Technical, Behavioral and Organizational Aspects. Issue 1, December 2013.

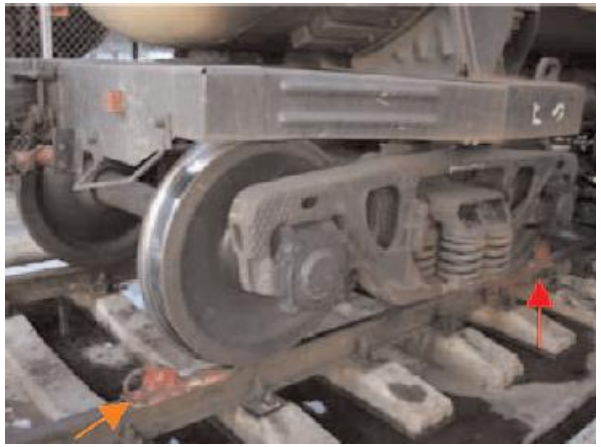
Road Truck vs. Railcar (Un)loading

Considerations	Road Trucks or Tankers	Railcars
Grounding	Requires explicit bonding	Grounded via rail infrastructure
Loading Access	Gantries needed; driver less involved	Specialized arms/platforms; operator-led
Loading Method	Bottom or top loaded; splash risk, additional controls needed	Often bottom loading; strong safety integration
Infrastructure	Simple hoses and valves	Complex systems: EFVs, ESDVs, vapor systems, etc.
Flow & Duration	Shorter, smaller volumes	Larger volumes, longer stays
Operator Role	Driver detached; plant staff in PPE	Trained staff perform the operation

Examples of Inherent Risks for (Un)loading Operations

- Chemical exposure (spills and leaks)
- Overfills
- Equipment failures
- Fires and explosions
- Falls and physical injuries
- Vehicle accidents
- Drive-aways
- Environmental contamination





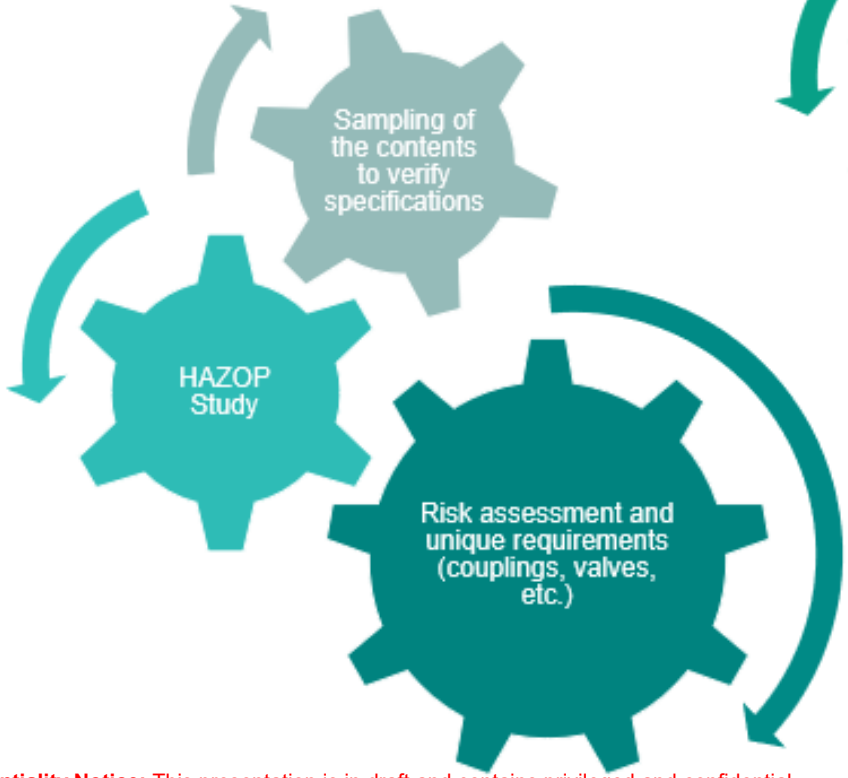
Chocks located beneath wheels of rail truck to prevent drive-away.

Caustic Soda Solution Handbook, DOW, August 2010. Images obtained from BP Process Safety Series: Safe Tank Farms and (Un)loading Operations.

Considerations for Chemical (Un)loading

Clear Communication

An Understanding of Risk



Established Procedure

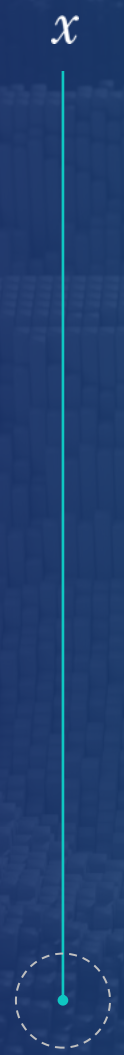
BP Process Safety Series Safe Tank Farms and (Un)loading Operations

Considerations for Chemical (Un)loading

Is division of responsibility clearly defined between chemical transport driver and Facility operations?

BP Process Safety Series Safe Tank Farms and (Un)loading Operations

Outline



Loading & Unloading Procedure

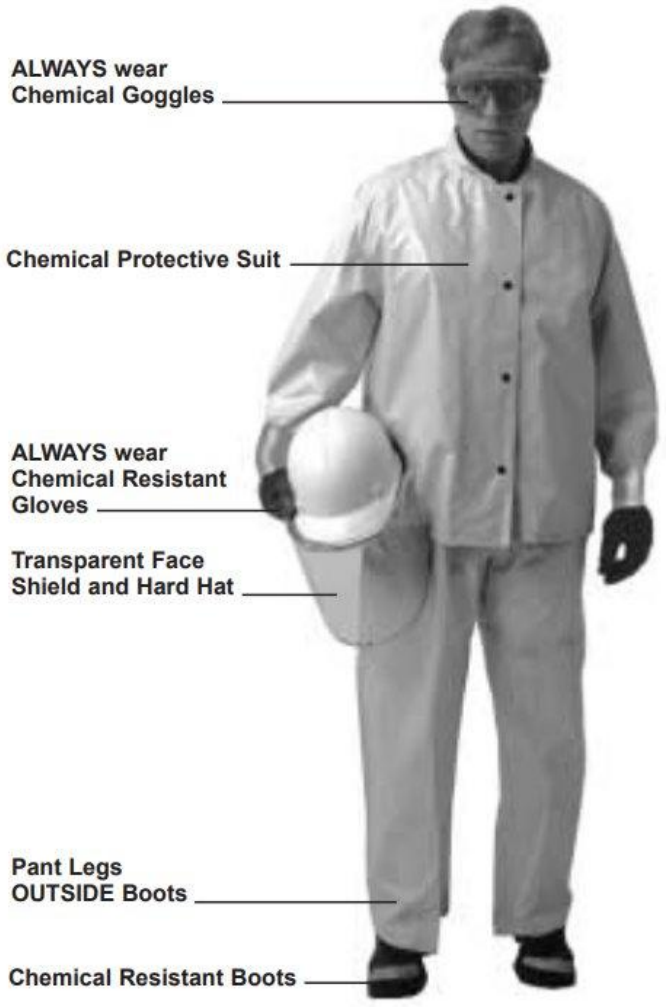
Truck Driver Responsibility

Facility Responsibility

The Intersection

Truck Driver Responsibilities

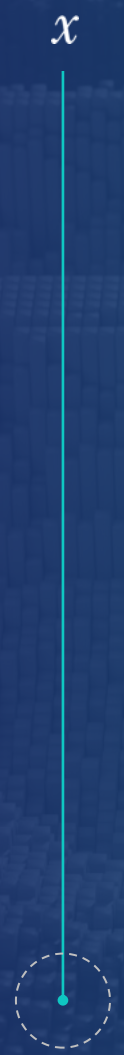
- **Vehicle Inspection**: Conduct pre-trip and post-trip inspections, verifying the tanker's condition, including labels, placards, seals, and gaskets
- **Safety Equipment**: Ensure all required personal protective equipment (PPE) is worn, such as eye protection, gloves, and respiratory protection, depending on the chemical being handled
- **Site Preparation**: Secure the vehicle, chock the wheels, and ensure the area is clear of obstacles or unnecessary personnel



Truck Driver Responsibilities

- **Loading/Unloading Procedures**:
  - Verifying the chemical matches the shipping documents
  - Connecting hoses and grounding/bonding equipment correctly
  - Loading or unloading at a slow, controlled rate
  - Monitoring the process closely for leaks or other issues
  - Ensuring proper ventilation during loading
  - Monitoring volume to prevent overfills
- **Communication**: Communicate effectively with facility personnel regarding safety procedures, potential hazards, and any other issues
- **Emergency Response**: Be prepared to respond to spills or leaks, using appropriate containment and cleanup measures
- **Documentation**: Complete all required paperwork

Outline



Loading & Unloading Procedure

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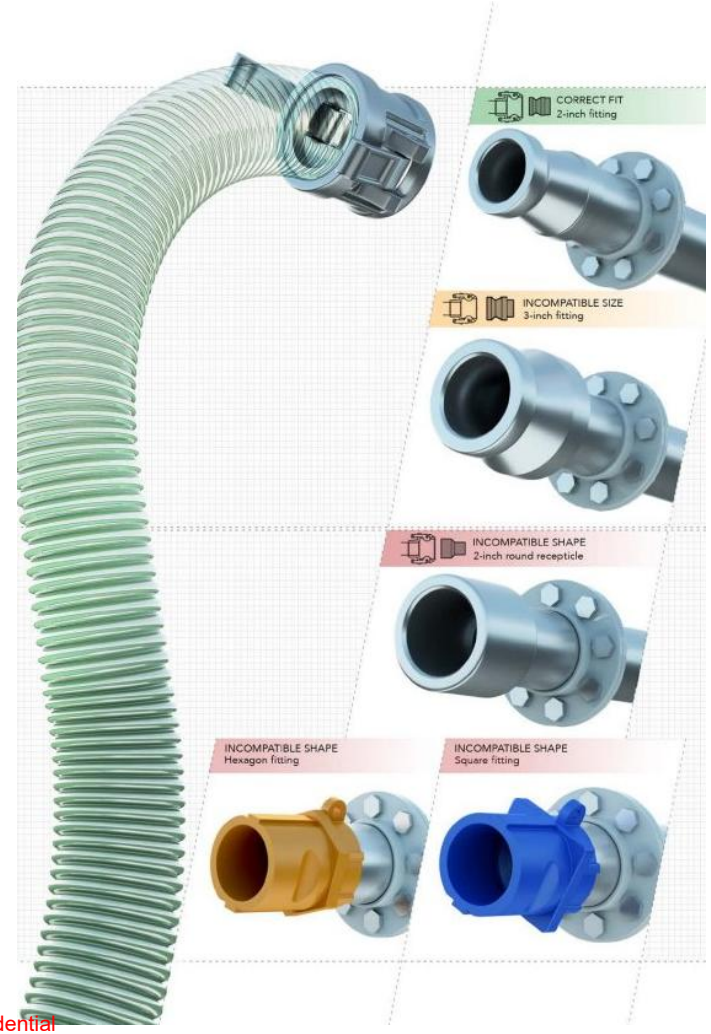
Facility Responsibilities

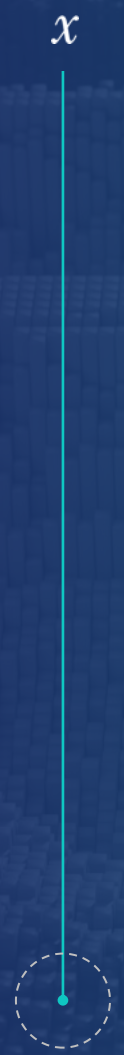
- **Trained Personnel**: Ensure all workers involved in loading and unloading operations are trained in safety procedures, equipment function, and emergency protocols
- **Safety Equipment**: Provide and maintain appropriate PPE, spill containment equipment (e.g., absorbent materials, booms), and fire suppression systems
- **Safe Loading Area**: Ensure the loading/unloading area is secure, well-ventilated, equipped with spill containment, and free of hazards
- **Standard Operating Procedures (SOPs)**: Develop and implement comprehensive SOPs for each chemical handled, outlining safe procedures for loading, unloading, and emergency response

Facility Responsibilities

- **Equipment Maintenance**: Regularly inspect and maintain all loading/unloading equipment (hoses, pumps, valves) to ensure safe and working condition
- **Chemical Compatibility**: Verify the compatibility of the tanker, receiving container, and equipment with the chemical being transferred
- **Supervision and Monitoring**: Ensure a qualified person is present and attentive during the entire loading/unloading process, maintaining an unobstructed view and the ability to stop the operation if needed
- **Security**: Implement measures to prevent unauthorized access to hazardous materials
- **Documentation**: Maintain accurate records of loading/unloading operations and any incidents (or near-misses) that had occurred



Outline



Loading & Unloading Procedure

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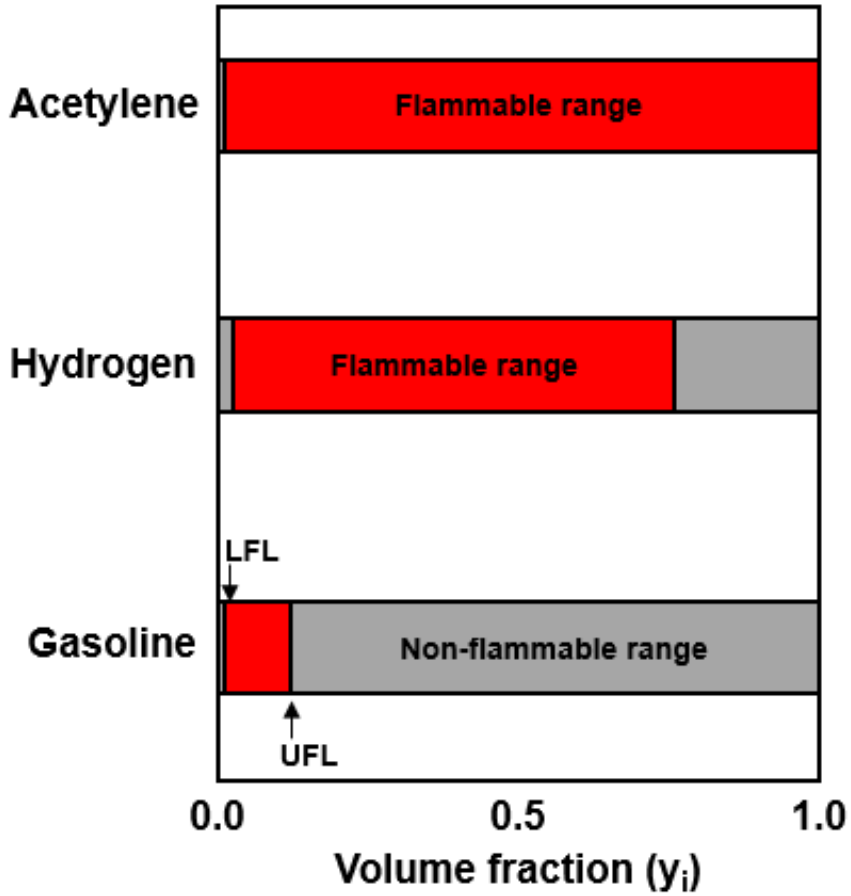
The Intersection

- **Collaboration and Communication**: Communicate openly and frequently to ensure a shared understanding of procedures, potential hazards, and emergency plans
- **Pre-Loading/Unloading Checklist**: Use checklists to confirm all safety procedures have been followed before starting and after completing the operation
- **Training and Education**: Provide regular and ongoing training for both truck drivers and Facility personnel on safe handling procedures, hazard identification, and emergency response
- **Hazard Identification and Risk Assessment**: Thoroughly assess potential hazards associated with each chemical and loading/unloading operation
- **Emergency Preparedness**: Develop and regularly practice emergency response plans and ensure adequate resources are available for spill containment, cleanup, and first aid

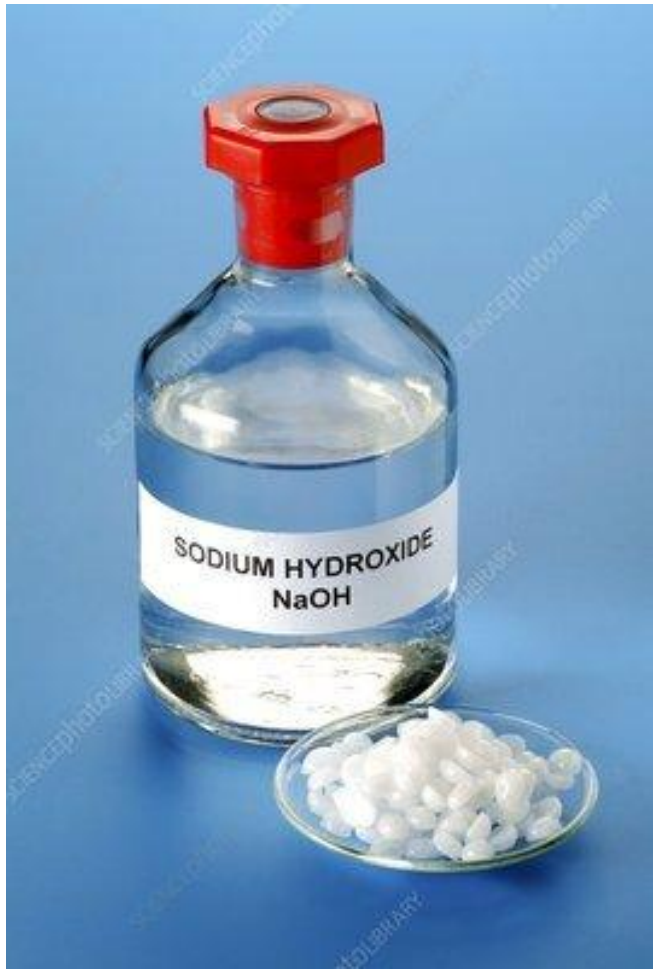
Know the Hazard: *Flammable Liquids*

- **When handling combustible liquids:**
  - Connect a grounding interlock to prevent static discharge from igniting the liquid
  - Avoid overfilling and ensure the tank is properly vented to prevent collapse.
- **Before unloading:**
  - Verify the chemical matches the storage tank to avoid cross-contamination.
  - Open discharge valves slowly and only unload from two compartments at a time.
- **After unloading:**
  - Seal or close all valves and compartments.
  - If highly volatile liquids, consider engaging a vapor recovery system.



Know the Hazard: *Caustic Solutions*

- **When handling caustic solutions:**
  - In addition to minimum PPE, tank truck operators should wear:
    - chemical protective suit
    - hard hat with full face shield
    - chemical resistant boots are required when handling hoses
- **Before unloading:**
  - Unloading operator should verify the location of all fittings before unloading.
  - Have spill containment materials, like track pans, available in the unloading area
- **After unloading:**
  - Water must be available to wash out and dilute any caustic soda remaining in unloading hose.



Caustic Soda Solution Handbook, DOW, August 2010.

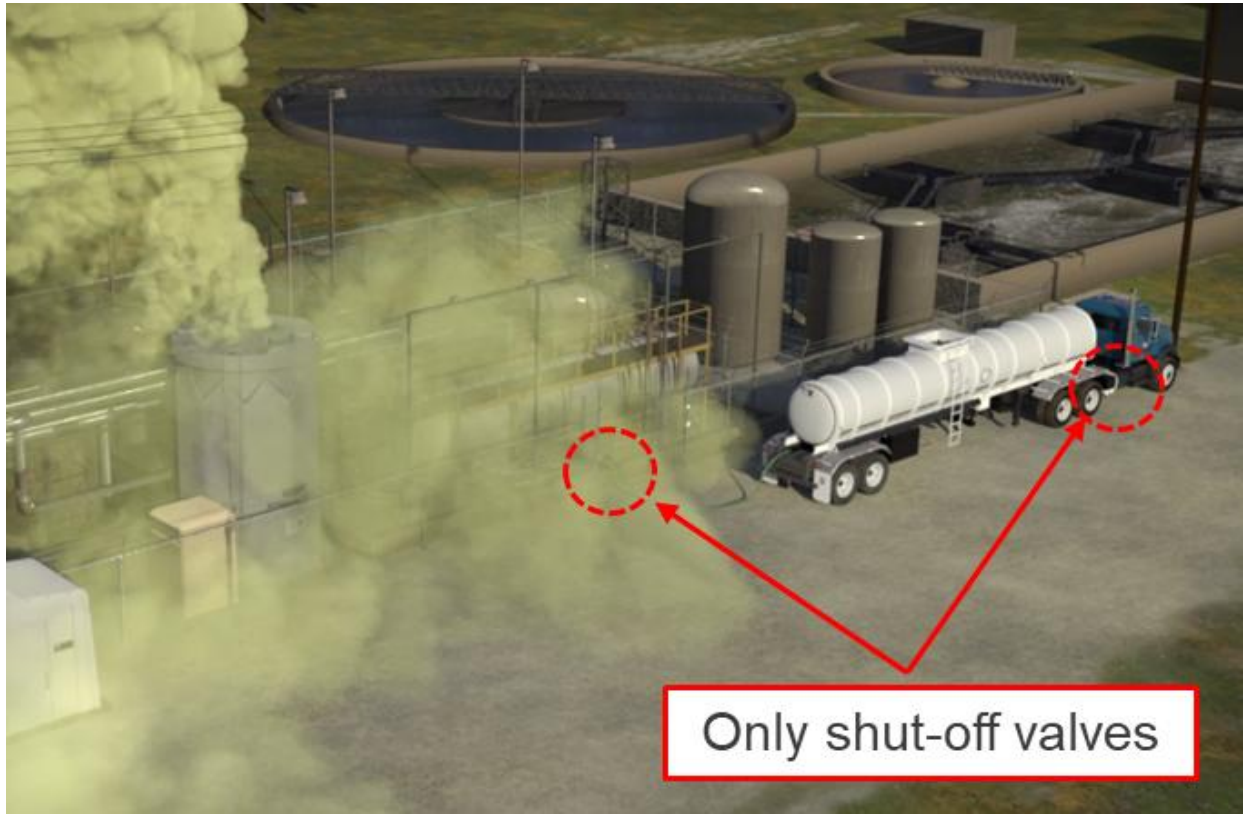
Case Study: *MGP Ingredients Chlorine Release*

October 21, 2016

- 4,000 gallons of 30% **sulfuric acid** was unloaded from tanker truck into a tank containing 5,850 gallons of **sodium hypochlorite**.
- The resulting reaction released approximately 3,490 lbs of chlorine gas - 11,000 people were forced to evacuate the community.

Key Lessons for Preventing Inadvertent Mixing During Chemical Unloading Operations, CSB, 2017-01-I-KS, December 2017.

Incident Timeline



- Driver arrived, operator unlocked the cap on the **sulfuric acid** fill line and identified it to the driver.
- Operator left the area before the driver had connected the hose.
- Driver connected the hose to the unlocked **sodium hypochlorite** line, opened the valve, and returned to cab of the truck during transfer.
- Driver noticed the gas plume form and was unable to access shut-off valves before evacuating.
- Without automatic shutdown, sulfuric acid filled the sodium hypochlorite tank until first responders shut down the transfer.

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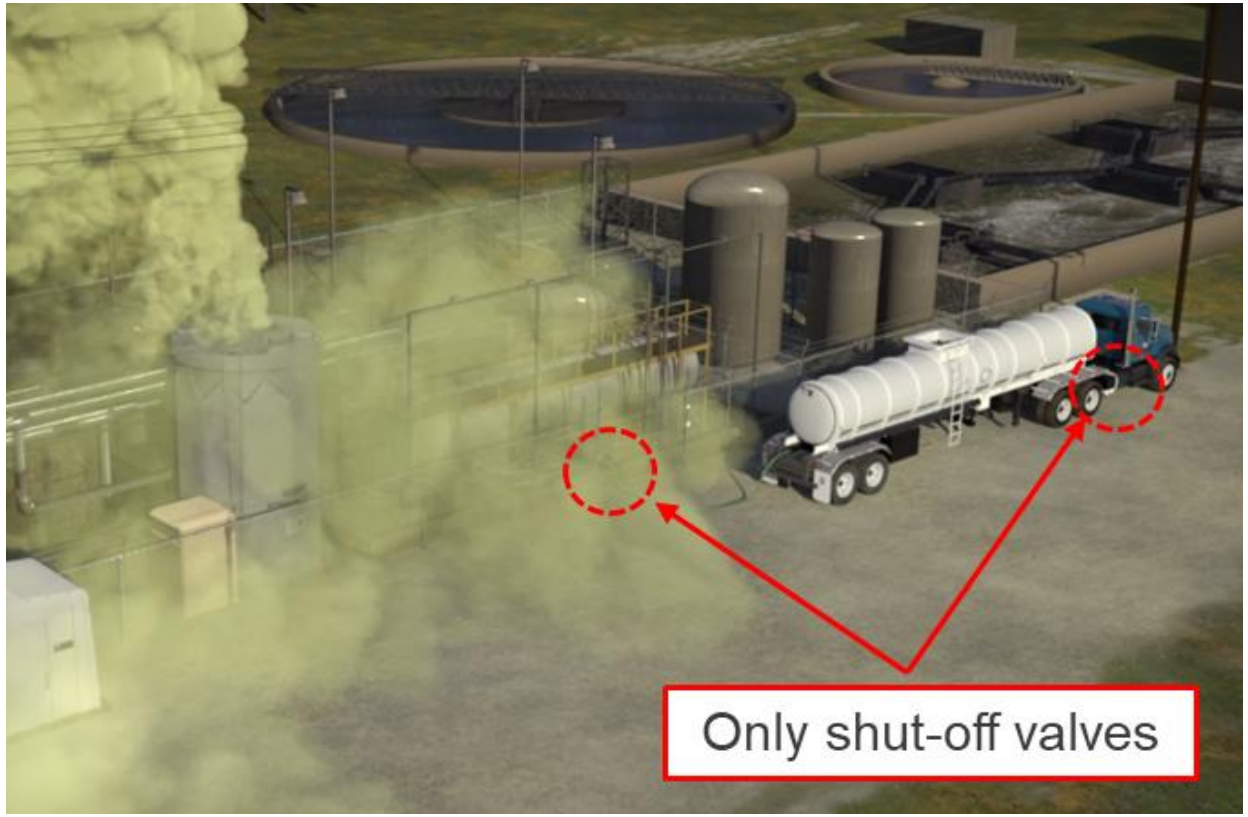
What Went Wrong…



Operating procedures and work practices were not aligned

Operator did not verify the correct connection had been made and open the fill line valve

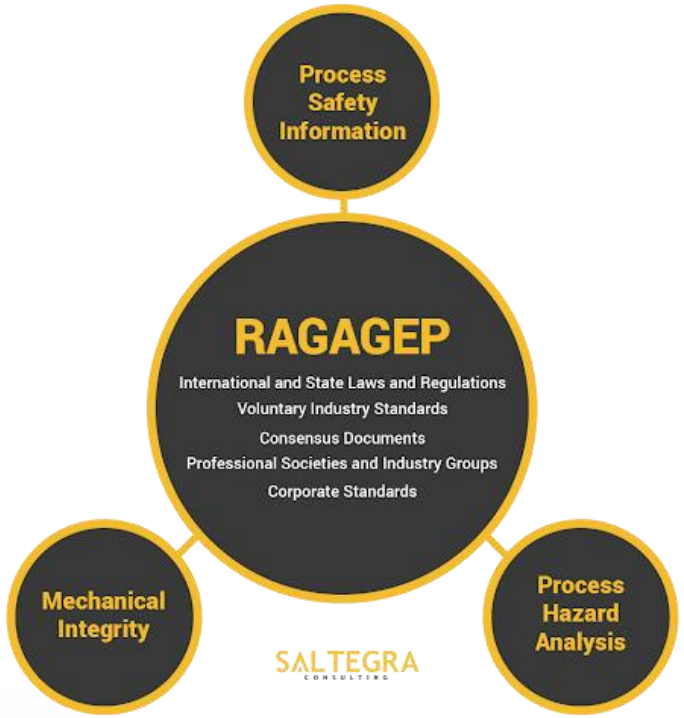
Driver did not carefully check that the connection was made to the correct vessel and continuously monitor the transfer

Key Lessons for Preventing Inadvertent Mixing During Chemical Unloading Operations, CSB, 2017-01-I-KS, December 2017.

Process Safety Takeaways?

Process Safety Learnings with Chemical Transfers

- Approach chemical transfers (non-steady-state) as you would steady-state operations
  - Know the hazards
  - Consider **RAGAGEP**s/industry practices
  - Design the process to minimize the risk
- Chemical transfers are heavily dependent on human operators
  - Understand the human factors involved and ways to reduce the possibility of error
- Where is the intersection between truck driver and the Facility?
  - **Regular PHAs and audits on risk**



https://saltegra.com/industry-news-and-trends/ragagep-in-psm-past-present-and-future/

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Thank You – Questions?

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