Chemical Transportation

Safety & Security

Introduction

• Chemical transportation
  – Safety risks
  – Security risks

• Chemical transportation risk management

• Resources

Chemical Transportation

• Chemical transportation:
  In-plant, local, in-country, or international transport

• Chemical transportation is an essential element in the chemical supply chain

• Globalization has resulted in:
  – Increased volume
  – Increased speed
  – Strain on transportation infrastructure

Chemical Transportation Safety Risks

• Transporting hazardous chemicals and hazardous waste
  – Risks to people, facilities, communities, and the environment

• Transport vehicle may carry both people and product

• Transport companies may outsource and consolidate hazardous materials
  – Package incompatible materials
  – Insecure packaging & improper labeling
Current Complexity in Chemical Transportation Increases Risk

- Thousands of regulated hazardous materials
- Differences in regulations by country
- Use of different hazard classes
- Different modes of transportation
  - Road, rail, air, marine, pipeline
- Multiple packaging types

Recent Chemical Transportation Safety Accidents in the U.S.

- Road: June 30, 2010 - two men severely burned when fuel tanker explodes on interstate highway.
- Pipeline: November 2007 - 30 centimeter liquid propane pipeline ruptured. 1.7 million liters released. Two deaths, four houses destroyed.
- Air: February 2006 - cargo on a DC-8 destroyed in fire caused by lithium batteries on board.
- Rail: October 2006 - 23 rail tank cars derail releasing denatured ethanol. Fire resulted in evacuation of an entire town for 2 days. Soil and water contamination.
- Rail: August 2002 - railcar unloading hose failed and ~20,000 pounds of chlorine gas released. Town evacuated, no deaths or injuries. In 2005, a similar accident caused 9 deaths.

Chemical Transportation Security Risks

- In-plant threat
  - Sabotage shipments
  - Intentional release
  - Theft
- In-transit threats
  - Hijacking
  - Theft of materials
  - Sabotage
- Attacks on pipelines

[Photo credit: NTSB, Pipeline New Mexico, USA]


Center for Chemical Process Safety (CCPS) Risk Management Publication

- Covers transportation safety, security and risk management
- Provides tools and methods to assist transportation professionals and other stakeholders
- Presents a comprehensive framework for managing transportation risks
- Introduces practical techniques for screening, identifying, and managing higher-level risks
- Emphasizes the need to balance safety with security

The CCPS TRM process includes the following elements:

- Primary Management System
- Identification and prioritization of hazards
- Risk Analysis
- Risk Reduction
- Program Sustainability

Due to the complexity of many supply chains, transportation risk management is a shared responsibility.

Roles and responsibilities may differ for each stakeholder.

Individual activities and actions can impact the risk to the overall chemical supply chain.

A Primary Management System Should Also Include:

- Management Commitment
  - “Risk Reduction Culture”
- Policies, procedures & practices
- Emergency preparedness & response procedures
- Incident reporting system
- Management of change
- Periodic auditing of the system
Transportation Risk Management Model

Transportation risk management follows a general risk management model:

1. **Identify and prioritize** the transportation safety and security hazards for your facility
2. **Risk Analysis**: Estimate the level of risk for each scenario
   \[ \text{Risk} = f(\text{scenario, consequence, likelihood}) \]
3. **Risk Evaluation**: decide on the level of risk reduction
4. **Risk Reduction**: Apply mitigation (controls) to reduce the risk to the appropriate level

Examine the entire chemical supply chain

Transportation Risk Management

Identify Safety Hazards

- Identify the hazardous materials that will be transported
  - What are the physical and chemical properties of the materials?
    - Flammable, toxic, corrosive, reactive?
    - Gas or liquid?
    - Substituted with a less hazardous material?
    - How packaged, contained?

Analyze Potential Safety Risks

External (Accidents)
- Collisions-road, rail
- Cargo shift-road, air
- Derailment-rail
- Crash-air
- External impact-pipeline

Internal Events
- Release or spill that is not due to an external impact
- Example: equipment or containment failure

Analyze Potential Safety Risks

Potential Event Causes
- Human factors
- Equipment defects
- Corrosion
- Overpressure
- Overfilling
- Improper packaging
- Vehicle Impact
- Transportation infrastructure

Photos: U.S. Department of Transportation

Photos: US National Transportation Safety Board

Vancouver Observer.
Transportation Risk Management
Analyze Safety Risk

Risk = f(scenario, consequence, likelihood)

Consequence
• Fatalities/injuries
• Property damage
• Environmental damage
• Business impact/fines
• Negative media
• Distribution system disrupted

Likelihood
• Expected probability and frequency
• CCPS Guidelines gives likelihood estimates for:
  – Pipelines
  – Rail
  – Trucks
  – Barges
  – Ocean-going vessels
  – Intermodal transport

Analyze Safety Risk Qualitative Methodology

<table>
<thead>
<tr>
<th>Chemicals</th>
<th>Hazards</th>
<th>Potential Impacts</th>
<th>Risk Ranking</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chlorine</td>
<td>Toxic gas</td>
<td>Exposure to people along route</td>
<td>High</td>
</tr>
<tr>
<td>Ethylene Oxide</td>
<td>Toxic, flammable gas</td>
<td>Potential toxic exposure, vapor cloud, fire</td>
<td>High</td>
</tr>
<tr>
<td>Mineral Acids</td>
<td>Corrosive</td>
<td>Potential Environmental impact</td>
<td>Medium</td>
</tr>
<tr>
<td>Acrylonitrile</td>
<td>Flammable liquid</td>
<td>Potential explosion and fire</td>
<td>Medium</td>
</tr>
</tbody>
</table>

Transportation Risk Management
Risk Reduction

• Address highest priority safety hazards first
  – Written procedures
  – Personnel training
  – Hazard communication
  – Packaging
  – Spill containment
  – Equipment inspection
  – Personnel protection (PPE)
  – Emergency response and reporting

Hazard Communication
  – Safety data sheets
  – Shipping papers
  – Labeling
  – Placarding
Transportation Risk Management

Risk Reduction

Emergency Response Guidebook (ERG)
- Interactive internet version:
- Developed jointly by:
  - US DOT, Transport Canada, Secretariat of Communications and Transportation Mexico
  - For first responders to transportation incident
  - Guide to quickly identify material classification
  - Protect initial responders and public

Transportation Security Vulnerability Analysis

List Chemicals and Hazards
Review Modes and Quantities Shipped
List Chemicals and Hazards
Identify Sensitive Areas Along the Route
Security Risk (C, V, T)
- C = consequence
- V = vulnerability
- T = threat

Security Risk = f(C, V, T)

Security Risk = (C, V, T)

Transportation Security Risk Management

**Risk Reduction**

**Plant Security**
- Include *internal transfers* in plant security plan
- Limit access to facilities and shipping information
- Secure transportation equipment
- Keep an inventory of hazardous materials
  - Use tamper resistant seals
- Personnel Security
  - Background checks
  - Identification cards or badges

*Photo: U. S. Transportation Security Administration*

**Highway Security Sensitive Materials**
- Depends on quantity and packaging
  - > 3000 liters in single container
- Explosives
- Flammable Gases
- Anhydrous Ammonia
- Toxic Gases
- Flammable Liquids & Solids
- Oxidizers
- Water reactive
- Corrosives
- Radioactive, infectious substances

*Credit: US TSA Highway Security Sensitive Materials*

**In transit security threats**
- Vehicle travels on unprotected public roads, rail or sea
- Surroundings are constantly changing
- Sabotage or theft is not detected until in progress
- One person responsible for transport
- Typically there are no security personnel accompanying shipment

*Photo: U. S. Transportation Security Administration*

**High risk shipments require high-level controls:**
- Increase possibility of detecting an attack
  - Provide for additional security personnel
  - Alarm the shipment
  - Use communication systems

*Photo: http://www.securityguardcompanies.us/*
Transportation Security Risk Management
Risk Reduction

• Increase the possibility of delaying an attack
  ▪ Cargo secured to vehicle
  ▪ Immobilize vehicle
  ▪ Hazardous material in vault
  ▪ Locks, barriers, entanglements

Drum Cage
Photo credit: DOE NNSA Presentation, October 17-November 5, 2010

Transportation Security Risk Management
Risk Reduction

Metal Grating

Container Tie Down
Photo credit: DOE NNSA Presentation, October 17-November 5, 2010

Selection of Transportation Contractor
– Evaluation of accident history and transportation safety plans
– Safety training of personnel
– Certifications/licensing
– Condition of equipment
– Confirm the following:
  • Secure packaging
  • Shipping documentation/bill of lading
  • Labelling/placarding
  • Safety data sheets
  • Appropriate PPE for spill response
  • Spill containment kits on board
  • Emergency Contact Information on board

Photos: TSA User’s Guide on Security Seals for Domestic Cargo

Smoke Obscurant

Chemical Identification
Photo credit: DOE NNSA Presentation, October 17-November 5, 2010
The US FMCSA regulates:

- Driver qualifications
- Years of service
- Equipment standards
- Driving and parking rules
- Alcohol and controlled substances
- Financial responsibility
- Operational requirements

HAZMAT training required for:

- Personnel who prepare, load/unload, or transport hazardous materials.

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**Balancing Transportation Security with Safety**

<table>
<thead>
<tr>
<th>Issue</th>
<th>Safety</th>
<th>Security</th>
</tr>
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<tbody>
<tr>
<td>Disaster</td>
<td>Contingency information related to emergency responses to meet responsibility to react and mitigate any impact.</td>
<td>Combined with a decision making process by teams to ensure safety's outcomes.</td>
</tr>
<tr>
<td>Accounting</td>
<td>May result in loss of public trust if there are small failures at the infrastructure doing maintenance on critical transportation components.</td>
<td>Breaching a boundary on a specific target area could lead to major disruptions and new risks that are community to another.</td>
</tr>
<tr>
<td>Working with supply chains (integrating security countermeasures)</td>
<td>The logistics of the entire process of goods moving in a supply chain. Must be possible in a secure manner and maintaining time-sensitive chemical transport.</td>
<td>The transportation is secure because it does not allow for the diversion of chemical transport to another location.</td>
</tr>
<tr>
<td>Risk Analysis Methods</td>
<td>Rational and structured analysis to evaluate risks.</td>
<td>Participation and engagement by individuals with different perspectives, roles, and background/skill sets for safety, security, and transportation.</td>
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<td>- Participation and engagement by individuals with different perspectives, roles, and background/skill sets for safety, security, and transportation.</td>
<td>Root cause analysis (guidelines)</td>
<td>- Low decision conflicts (guidelines).</td>
</tr>
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Always expect the unexpected