Recent Developments in North American Railroad Tank Car Safety

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Outline of Presentation

• Review safety trends
• Introduction to tank car safety design
• Recent examples of tank car safety enhancement
• Toxic Inhalation Hazard (TIH) materials
  – Recent release accidents
  – New TIH tank car specifications and concepts
  – Discussion and conclusions
Acknowledgements

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Robert Anderson
US Railroad Accident Rate: 1982-2004

Accidents per Million Train-Miles

Year


44% Reduction
US Railroad Accident-Caused Hazardous Materials
Release Rate: 1982-2004

85% Reduction
Tank Safety Car Design

• Tank cars are usually not the cause of the accident itself

• They may be damaged and release lading in accidents

• However, prevention of accidents is not always possible

• Tank cars are built with varying degrees of damage resistance

• Safety design is commensurate with the hazard of the product they transport

• More hazardous products, more robust tank car design

• But as risk tolerance or perception changes, so may expectations of tank car safety performance
All tank cars are not created equal
Variety of railway tank car configurations

Non-insulated 111A100W1

Insulated 111A100W3

112S340W

112J340W

111A100W2

105A500W
Percentage of tank cars expected to release if derailed in FRA-reportable*, mainline accidents

* FRA-reportable accidents are those that exceed a minimum threshold dollar amount in damage to infrastructure and equipment. This threshold ranged from $6,300 to $6,700 from 1991 to 2005, and increased to $7,700 in 2006.
Railway Supply Institute - Association of American Railroads: Railroad Tank Car Safety Research and Test Project

- Formed in 1970
- Cooperative effort of tank car and railroad industries to improve tank car safety
- Comprehensive database of over 40,000 tank cars and 26,000 accidents they were involved in
- Three categories of data:
  - Accident characteristics
  - Tank car characteristics
  - Damage characteristics and consequences
- Provides a robust basis for quantitative analysis of tank car safety design
Safety Performance of Tank Cars in Accidents: Probabilities of Lading Loss - RA 05-02

• Published January 2006
• Comprehensive statistical analysis of how current tank cars and their safety design elements perform in FRA-reportable accidents
• Series of tables and regression formulae developed to estimate accident performance of each car configuration and components
• Includes statistics on release probability for both mainline and yard accidents, as well as quantity loss amounts and effect of accident speed
Tank Car Sources of Release in Accidents

- Four principal sources of release:
  - Head and Shell
  - Top and Bottom Fittings

- Making tanks thicker and protecting or eliminating fittings improves accident performance
Early applications of RSI-AAR database

- Evaluation of head shields, double-shelf couplers and thermal protection for LPG tank cars
- Analysis of bottom-outlet protection
- Provides quantitative documentation of safety benefit and consequent reduction in risk
- Provides justification for investment
Use of RSI-AAR data and analysis by chemical companies for packaging decisions

- Enhanced-design 111s for Poison Liquid - Packing Group 2 with head shields, jacket and top fittings protection
- Over-packaging of titanium tetrachloride in a 105A500W instead of 105A300W (as allowed by regulation)
Recent applications of RSI-AAR data and statistics

- Developing safety specifications for 286K tank cars
- Risk analysis of Environmentally Sensitive Chemicals (ESCs)
- Risk analysis of Toxic Inhalation Hazard (TIH) chemicals and assessment of alternative tank car designs
Development of specification for enhanced-safety 286K tank cars

- Increase maximum gross rail load (GRL) of hazmat tank cars from 263,000 lbs. to 286,000 lbs.
- Difference equals 23,000 lbs.
- Decision to allocate up to one third to enhanced safety, and the remainder to increased capacity
- Variety of options to improve safety on non-pressure tank cars:
  - Thicker tank
  - Head shields
  - Jacket and insulation
  - Top fittings protection
- What is the most efficient combination of these elements to enhance tank car safety?
RSI-AAR Project database provided detailed understanding on the sources of loss for tank cars in accidents.
Analysis of the most efficient options to enhance the safety design of 286K tank cars

- Solutions indicated by **Blue Dots** provide the greatest improvement in safety per unit of tank car weight increase.

Top fittings protection
Half-height head shield
1/2” TC-128B tank

TFP = top fittings protection
HHP = half head protection
FHP = full head protection
1/2” = 1/2” thickness tank, etc.
for other tank thicknesses

- **Blue Dots** indicate the most efficient options.
- **Red Circles** indicate less efficient options.

**Graph Details:**
- **Y-axis:** Reduction in Release Probability
- **X-axis:** Increase in Weight (lbs)

*Note: The graph shows the trade-off between safety improvement and weight increase for different protection types.*
Three fatal release recent accidents involving Toxic Inhalation Hazard (TIH) materials

Minot, ND - January 2002

Macdona, TX - June 2004

Graniteville, SC - January 2005
Fatalities due to rail transportation releases of ammonia and chlorine: 1989-2005

These accidents changed the perception of TIH risk

- Minot, ND - January 2002
- Macdona, TX - June 2004
- Graniteville, SC - January 2005

Source: USDOT, Pipeline & Hazardous Materials Safety Administration, hazmat.dot.gov/files/hazmat/10year/10yearfrm.htm
# Railroad tank car shipments of TIH

<table>
<thead>
<tr>
<th>Commodity Name</th>
<th>Hazmat Code</th>
<th>TRAINII 2005 Shipments</th>
<th>Total Number of Tank Cars in the Fleet</th>
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<tbody>
<tr>
<td>Chlorine</td>
<td>4920523</td>
<td>36,478</td>
<td>5,877</td>
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<tr>
<td>Ammonia, Anhydrous</td>
<td>4904210</td>
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<td>Sulfur Dioxide</td>
<td>4920508</td>
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<td>Ethylene Oxide</td>
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<td>Hydrogen Chloride, Refrigerated Liquid</td>
<td>4920504</td>
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<td>Hydrogen Fluoride, Anhydrous</td>
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<td>Sulfuric Acid, Fuming</td>
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<tr>
<td>Sulfur Trioxide, Stabilized</td>
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<tr>
<td>Methyl Mercaptan</td>
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<tr>
<td>Acetone Cyanohydrin, Stabilized</td>
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<td>Bromine</td>
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<tr>
<td>Phosphorus Trichloride</td>
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<td>Hydrogen Sulfide</td>
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<td>Hydrogen Cyanide, Stabilized</td>
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<td>Methyl Bromide</td>
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<td>Dimethyl Sulfate</td>
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<td>Chlorosulfonic Acid</td>
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<td>Ethyl Chloroformate</td>
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<td>Allyl Alcohol</td>
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<td>Hexachlorocyclopentadiene</td>
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<td>6</td>
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</table>

**Total** 107,945 15,427
TIH accidents stimulated extensive research on tank car safety

- Statistical analysis of tank car performance and effects of design changes on risk
- Tank car component and full-scale testing
- Failure analysis
- Dynamic modeling of tank car structural response to impacts