Tank Car Accident Safety Research for Crude Oil and Ethanol Cars

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Outline of Presentation

- Protective feature options for tank cars
- Approaches to assessing damage resistance of tank cars in accidents
- RSI-AAR Tank Car Safety Research Project
- RSI-AAR tank car accident data
- Conditional Probabilities of Release (CPRs)
- CPR estimates for selected tank cars
- Other aspects of accident performance
- Other research areas
Four Key Components

These are the four components of the car that can release lading when damaged in an accident
Protective Feature Options

- Tank Head
  - Thicker tank
  - Jacket, with or without thermal protection system
  - Head shield
- Tank Shell
  - Thicker tank
  - Jacket, with or without thermal protection system
- Top Fittings
  - Protective housing
- Bottom Fittings
  - Handle securement
Examples of Protective Systems

Top Fittings Housing

Jacket

Head Shields

Trapezoidal for Non-Jacketed Cars

Incorporated Into Jacket

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## Approaches to Assessing Damage Resistance

<table>
<thead>
<tr>
<th>Approach</th>
<th>Accident Scenarios Accounted For</th>
<th>Cost per Analysis</th>
<th>Ability to Analyze New Design Elements Not Already in Fleet</th>
<th>Ability to Quantify Expected Releases in Operation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Testing</td>
<td>One Idealized Scenario per Test</td>
<td>Very High</td>
<td>Good</td>
<td>None*</td>
</tr>
<tr>
<td>Modeling</td>
<td>One Idealized Scenario per Run</td>
<td>Moderate, Once Model is Developed</td>
<td>Good</td>
<td>None*</td>
</tr>
<tr>
<td>Statistical Analysis of Empirical Data</td>
<td>Entire Spectrum of Actual Scenarios</td>
<td>Low, Once Model is Developed</td>
<td>Limited*</td>
<td>Good</td>
</tr>
</tbody>
</table>

* Project underway to enable this for tank car analyses

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RSI-AAR Tank Car Safety Research Project

• Origin 1970
  - 1960s flammable gas accidents
  - Collaborative effort led to effective changes implemented in HM-144: head shields, thermal protection, and shelf couplers
  - RSI and AAR saw benefits of continuing the partnership

• Co-funded and co-directed by RSI and AAR
• Dedicated to producing reliable and objective research for the sponsors and other stakeholders
RSI-AAR Tank Car Accident Data (TCAD)

- Collected since 1970
- 46,400 cars damaged in 29,900 accidents
- Fields
  - 37 describing nature of accident
  - 40 describing car properties
  - 34 describing damage and performance of car
- Used to provide objective, quantitative information on safety options
Conditional Probability of Release (CPR)

- CPR = the probability that a single tank car releases any quantity of lading, given that it is derailed in an FRA-reportable accident

- RSI-AAR Tank Car Accident Data are analyzed with advanced statistical techniques to quantify the CPR performance of each car configuration
# CPR Estimates for Selected Tank Cars

<table>
<thead>
<tr>
<th>Car</th>
<th>Tank (Head &amp; Shell)</th>
<th>Jacket</th>
<th>Head Shield</th>
<th>Top Fittings Protection</th>
<th>Estimated Mainline CPR</th>
<th>Estimated Mainline CPR&gt;100*</th>
</tr>
</thead>
<tbody>
<tr>
<td>“Legacy” Bare Tank</td>
<td>7/16”</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>0.266</td>
<td>0.196</td>
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<tr>
<td>“Legacy” Jacketed</td>
<td>7/16”</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>0.128</td>
<td>0.085</td>
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<tr>
<td>CPC-1232 #1</td>
<td>1/2”</td>
<td>No</td>
<td>Half-height</td>
<td>Yes</td>
<td>0.132</td>
<td>0.103</td>
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<tr>
<td>CPC-1232 #2</td>
<td>7/16”</td>
<td>Yes</td>
<td>Full-height</td>
<td>Yes</td>
<td>0.064</td>
<td>0.046</td>
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<td>AAR 2014 Proposal</td>
<td>9/16”</td>
<td>Yes</td>
<td>Full-height</td>
<td>Yes</td>
<td>0.042</td>
<td>0.029</td>
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</tbody>
</table>

* CPR_{>100} = The CPR for a release of more than 100 gallons
Other Aspects of Accident Performance

• Quantity of lading lost, given a release
  – Distributions of quantities lost are different for the four car components
  – Therefore different packaging options affect quantities lost differently

• EQR = Expected Quantity Released, given derailment
  – Risk metric combining CPR and quantity lost distributions

• Fire survival
  – Fire increases internal pressure, can lead to tank failure
  – AFFTAC fire simulation estimates survival time for combinations of car and commodity properties
Other Research

• Data collection at key accident scenes

• Advanced Tank Car Collaborative Research Program (ATCCRP) developing the future car for Toxic Inhalation Hazard (TIH) materials such as chlorine and anhydrous ammonia

• Tank Car Integrated Database allows tracking and analysis of tank and stub sill inspection records and service damage