Part 1: Introduction

On March 9, 2011, the Association of American Railroads (AAR), on behalf of its members and the Tank Car Committee (TCC), jointly petitioned the Pipeline and Hazardous Materials Safety Administration (PHMSA) and Transport Canada (TC) to establish new standards for DOT Class 111 tank cars used to transport hazardous materials in packing groups I and II[1.] The petition (P-1577), which was an outgrowth of a TCC executive working group, proposed new construction standards and specifically recommended no modification for existing tank cars. The AAR agreed to forward the petition to PHMSA on behalf of the TCC as a result of a unanimous decision by the Committee.

On May 10, 2011 FRA met with the Railway Supply Institute's (RSI) Tank Car Committee to discuss improvements to tank cars used for the transportation of crude oil in unit trains. FRA requested this meeting to discuss improving tank car safety specific to crude oil tank cars given the recent increase in demand for these cars[2]. At the meeting FRA presented information from a recent unit train accident in Arcadia, Ohio[3].The intent of the meeting was to spur discussion about innovative solutions that improve tank car safety for future changes in the hazardous materials transportation supply chain. The advent of increased shipments of crude oil in unit train quantities provided an avenue to discuss safety enhancements prior to a major tank car build. The FRA suggested a number of potential safety enhancement technologies such as spray-on thermal protection, manway redesign, and tank car design improvements (rounding edges of components) for consideration by the tank car builders/owners. The meeting resulted in the RSI members offering to develop an industry standard (non-regulatory) in collaboration with the AAR, the Renewable Fuels Association (RFA), Growth Energy, and the American Petroleum Institute (API)[4]. This effort is being conducted through a TCC Task Force led by the FRA.

On June 15, 2011 an Industry Consortium consisting of RSI, AAR, API, Growth Energy and the RFA submitted an action plan for the continuous reduction of risk associated with rail transportation of Crude Oil classified as PG I and II and Ethanol. The objectives of the action plan are to make recommendations on derailment risk reduction actions that can be quickly implemented; develop a new specification for tank cars transporting the aforementioned commodities and allowance for new cars for these services to be constructed to the standard proposed in P-1577. The Industry Consortium met with the FRA on July 12, 2011 to review the plan. The FRA concurred with the objectives and supported the proposed approach.

At the July 20, 2011 Tank Car Committee meeting, the committee approved a new standard for tank cars carrying packing group I and II crude oil, alcohols n.o.s. (denatured alcohol) and ethanol/gasoline mixtures. That standard was in line with the petition for rulemaking sent to PHMSA in March 2011, except it was limited to these commodities. That standard was issued for public comment on July 26, 2011, and finalized via circular letter CPC-1232 on August 31, 2011 for cars ordered after October 1, 2011.

On July 20, 2011, at the summer AAR Tank Car Committee meeting docket T87.6 was created with a dual charge to develop an industry standard for tank cars used to transport crude oil, denatured alcohol and ethanol/gasoline mixtures as well as consider operating requirements to reduce the risk of derailment of tank cars carrying Crude Oil classified as PG I and II, and Ethanol. This report will summarize the efforts of both working groups of the T87.6 Task Force.

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1 Packing groups are used in the Hazardous Materials Regulations to denote the degree of hazard within each hazard class, except for class 2 (gases), 7 (radioactive materials), and division 6.2 (infectious substances). Packing group I and II indicate high and medium hazard, respectively.
2 RSI members report an increase in car orders in 2011 for use in transporting crude from new drilling operations in North Dakota and Canada.
3 At 2:20 am, on 2/6/11, NS freight train 68-KL-305, a unit Ethanol train, derailed 32 Ethanol cars in Arcadia, OH.
4 API members represent the majority of crude oil shippers.

Safety in Shipping denatured Alcohol by Rail

Since 2006 there have been an estimated 1,391,635 loaded originations[5] of tank cars containing denatured alcohol (alcohols, nos). In that same 6 year period 163 tank cars have been involved in 10 derailments. Sixty six of the derailed cars lost containment of their lading. It is evident the incidents this task force are addressing are very rare events. Unfortunately, while they are low frequency such incidents can represent very high consequence and, in the case of flammable liquids such as denatured alcohol, are very news-worthy even when there are no injuries or extensive property damage. In the effort to decrease the frequency of a rare event, options become fewer and more difficult to implement. It was important that the task force consider not only the effectiveness of proposed solutions but also the potential for those solutions to create other safety issues that do not exist.

Part 2: The Tank Car Design Working Group

Between August and December of 2011, the T87.6 Design Task Force held six (6) meetings; four (4) face-to-face meetings and two (2) via conference call:

1. August 17 at GATX offices in Chicago, IL
2. September 9 via conference call
3. September 23 at FRA Headquarters in Washington, DC
4. October 27 at FRA Headquarters in Washington, DC
5. November 9 via conference call
6. December 14 and 15 at GE Capital Headquarters in Chicago, IL

With the completion of work related to its charge, this Task Force urges PHMSA to make the adoption of the ethanol and crude oil portion (CPC-1232) of P-1577 a high priority. As will be discussed below, many of the concerns related to the survivability of tank cars in an accident have been addressed in P-1577. This petition contains the elements of CPC-1230 and CPC-1232 which was a product of AAR Task Force T87.5. Industry recognized the need for a car with design enhancements that would improve survivability and developed a proposal via the AAR Tank Car Committee which offers the most expeditious means of implementing changes to tank car design and construction requirements.

Description of Petition P-1577 Tank Car

P-1577 is a proposed requirement for tank cars transporting PG I and II materials. TF T87.6 is focused on an industry standard for specifically, denatured alcohol and crude oil and represents an industry effort to expeditiously address concerns regarding the documented damage to the tank cars involved in recent derailments. As it relates to this task force, the specifications for a tank car meeting the requirements of P-1577 and used in either denatured alcohol or crude oil service is as follows.

- Tank Material: TC-128 Grade B normalized steel
- Head Protection: Minimum of ½" thick half height head shield
- Reclosing pressure relief device (PRD)
- Top Fittings Protection
- Non-Jacketed must be at least ½" thick and be equipped with a ½" half-height head shield
- Jacketed cars must be at least 7/16" inch thick and be equipped with a ½" head shield

Based on the distributed notes from the initial meeting on 8/17/11, by consensus of the working group it was decided the P-1577/ CPC-1232 herein after referred to as just the P-1577 tank car would be the baseline car. All proposed improvements were evaluated relative to the baseline car. Also, the Task Force evaluated the improvement in performance of the baseline car relative to tank cars built to the current regulations.

5 Source: AAR TRAIN II Waybills. The number of loaded originations for 2011 has not been tallied. For the sake of this Task Force it was assume the number of origination in 2011 equals the 2010 total. This total is likely to be a low estimation.

The remainder of this document discusses the considerations of the Task Force regarding the following attributes of the baseline tank car:

- Thermal Protection
- Puncture Resistance
- Top Fittings
- Bottom Fittings
- Outage

Thermal Protection

In a recent derailment breaches in six tank cars were attributed to the exposure to fire conditions. The P-1577 specification does not require thermal protection. A tank car constructed to the requirements of P-1577 would have thicker (than that required by the current regulation) tank material thus reducing the likelihood of a release in a derailment and therefore decreases the likelihood of a fire and the resulting exposure of the tank car. The proposal was made to evaluate thermal protection options. Three general options were evaluated; spray-on thermal protection, thermal protection system, and increased flow capacity of the PRD.

A review of the current list of thermal protection systems meeting the performance standards of Appendix B of Part 179 of the Hazardous Material Regulations (HMR) was surveyed. A new intumescent material, Nanochar®, was proposed because it offered the required protection with minimal thickness (3.2 mm). A number of concerns were raised regarding the use of Nanochar®.

- Experience with other spray on thermal protection systems (Char-Tech and Thermolag) is not favorable. They have proven to be difficult to maintain and have been found to contribute to corrosion of the tank shell.
- There was concern regarding the application of Nanochar®. A 30,000 gallon tank has a large surface area and requires a long time to coat. The pot life of the Nanochar® spray on coating is short. As such, multiple applications will be required and may result in a non-continuous coating which could affect performance. Further,
- There is no experience using Nanochar® on tank cars and very little experience in transportation vehicles in general.

Given this information, the working group will not recommend a requirement for spray on thermal protection. Use of spray on thermal protection will require field tests in order to understand the behavior over time. Testing over a range of conditions will likely require years.

Typically tank cars requiring thermal protection are equipped with a system (i.e. Fiberfrax) meeting the performance standard of §179.18 and an 11-gauge jacket. These systems provide the necessary protection by limiting the heat radiated or conducted to the commodity tank. Another option currently under consideration by another AAR task force is a jacket without an underlying thermal protection material. Both of these options were evaluated using AFFTAC (Analysis of Fire Effects on Tank Cars)[6].

Consistent with current minimum industry standards and federal regulations for pressure cars for Class 2 materials, the working group agreed that a survivability time of 100 minutes would be used as a benchmark for adequate performance. The 100-minute survival time is the performance standard for pressure tank cars equipped with a thermal protection system and was established to provide Emergency Responders with the time to assess a derailment, establish perimeters, evacuate as needed, while permitting all lading to be expelled from the tank to prevent a high-energy event[7]. The results of these analyses were used to evaluate the relative

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6 It is important to note that the simulation results (time to failure of the tank) were not considered an absolute indicator of their performance in fire conditions. Rather the results were compared to other simulation results to understand the relative difference in survival time.

7 Preamble to HM-144, Notice Number 76-12, page 2.

performance of the differently equipped tank cars. As with any simulation there are uncertainties in the absolute survival times estimates. The working group, recalling the concern regarding the violent failures of the tank cars in Arcadia, considered the potential for similar failures as the best metric. Based on a paper prepared by Queen's University[8], there is a direct relationship between the amount of material remaining in the tank at the time of breach and the violence of the overall failure. Reviewing the data from the AFFTAC simulations performed, the volume of lading in the tank at the time of breach was noted. In all of the cases at the time when the tank failed all of the lading had been vaporized. There is little energy remaining in the tank to produce a violent rupture.

Initially, a simulation was conducted using the specification of a tank car involved in the Arcadia derailment. The simulation was run to understand the performance relative to the P-1577 tank car and subsequent simulations incorporated possible improvements. ADMX29420 was the initial point of comparison. This tank car experienced a violent failure after the derailment and resultant fire. The simulation indicated an undamaged tank car (overturned to 120° in a pool fire) would have survived 103 minutes. The basic P-1577 tank car survived the same conditions 108 minutes. When equipped with a jacket with no thermal protection system in the annular space the P-1577 survives 180 minutes. The same tank car equipped with a thermal protection system and an 11-gauge jacket survives over 1,000 minutes. The AFFTAC runs demonstrate that adequate PRD capacity should prevent high energy events. The runs also suggest that the high energy events exhibited in Arcadia could have been due to damage to the PRD or the structural integrity of the tank. The existence of such damage has not been verified. In the P-1577 car the potential for this damage would be reduced by the addition of top fittings protection, head shields and a thicker tank. **In summary, neither thermal protection nor a jacket is required to meet the 100 minute benchmark.**

An important caveat to the results presented is that AFFTAC assumes flawless condition of the tank material. In the same paper referenced above (Queen's University, 1997), it was concluded that inherent defects in the steel or corrosion hidden by a jacket may result in failure of the tank in advance of the predicted time. This may occur at a point the where the pressure in the tank approaches the theoretical burst pressure (based on the assumption of a flawless tank) but exceeds the actual burst pressure, which is lower because of defects (such as hidden corrosion).

New tank cars will have improved crashworthiness as a benefit of the increased tank shell and head thickness as well as head shields. Pressure relief valves will also be less likely to be damaged because of the required top fittings protection. This is a very important upgrade to the existing requirements. Using AFFTAC it was learned that severely reduced flow from a PRD has major detrimental effects on the survivability of a tank car in a pool fire. The simulation results indicate the tank bursts at less than the 100-minute benchmark survival time. Also, based on the simulation results there is a large portion of the lading remaining in the tank providing the fuel for an energetic event at the time the tank bursts.

The working group identified the following concerns regarding the requirement for a jacket and thermal protection for tank cars transporting denatured alcohol and crude oil.

- The addition of a jacket and thermal protection will decrease the volume and weight capacity of the tank car. Reduction in tank capacity will result in additional originations and, assuming the probability of a derailment remains the same, an increased number of derailed cars.
- The addition of a jacket and thermal protection will increase construction, inspection, maintenance and transportation costs.

Another outcome of the research performed and evaluated by this task force is the importance of the start to discharge (STD) pressure of the PRD. Currently, the PRDs on tank car used in denatured alcohol and crude oil service have a STD pressure of 75 or 165 psi. The PRD maintains the internal pressure at or below the STD

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8 "Fire Tests of Propane Tanks to Study BLEVEs and Other Thermal Ruptures: Detailed Analysis of Medium Scale Test Results", Department of Mechanical Engineering, Queen's University, Kingston, Ontario, Nov 1997.

pressure. When a tank bursts as a result of exposure to fire conditions, the lower the STD pressure, and therefore internal pressure, the less energetic the failure will be. **Given this information the task force recommends that (future) tank cars in denatured alcohol or crude oil service be equipped with a pressure relief valve having a 75 psi start to discharge pressure.**

Another concept to enhance the survivability of a tank car in fire conditions evaluated by the task force was additional PRD flow capacity. In the Arcadia derailment there were three high-energy thermal failures. In two of the three cases the tank fractured into two pieces and those pieces were thrown from the derailment area. In the third case, the tank was nearly fractured around the entire circumference. The task force considered the possibility that the PRDs did not have adequate flow capacity to expel the rapidly increasing pressure. Using AFFTAC, simulations were run with tank cars equipped with PRDs having flow capacities of plus 10,000, 20,000, and 30,000 standard cubic feet per minute (SCFM) relative to the baseline car. AFFTAC simulations with tank cars having additional capacity (larger valve or multiple valves) indicate minimal improvement in the survival time. In addition, P-1577 required top fittings protection and thereby limits the space available to accommodate additional PRDs. Use of an additional PRD would require another nozzle. **Based on the AFFTAC simulation results the Task Force recommends (27,000 SCFM, 75 psi STD) for minimum flow capacity in order for P-1577 tank car to meet the 100 minute benchmark. This recommendation is subject to availability of valves with adequate flow capacity.**

<u>Puncture Resistance</u>

Two alternatives for improving the puncture resistance of the baseline car were considered by the task force: a thicker shell and redistribution of thickness between the shell and jacket (if a jacket is required). The P-1577 requirement for a head shield was not re-evaluated by this task force. A head shield is universally agreed to be a feature that will enhance the survivability of a tank car in a derailment.

It has been noted that members of the working group expressed concerns that the addition of a head shield will result in a higher tare weight and commensurate decrease in capacity of the tank car. This is especially true for cars serving either origins or destinations that are not 286,000 pound capable. Reduction in capacity will result in additional originations and, if the probability of derailment remains the same, a greater number of tank cars derailed. **The working group will support this recommendation of Petition P1577 because head shields are an established safety feature.**

For tank cars in denatured alcohol and/or crude oil service the minimum shell thickness is 1/2" compared to the current Federal requirement of 7/16". In P-1577 this requirement was justified using the Estimated Quantity of Release (EQR), a metric based on a probabilistic analysis of accident data. The working group evaluated this concept along with a redistribution of steel thickness between the shell and jacket by (deterministically) quantifying improvements.

FRA has contracted with Applied Research Associates (ARA) to model and simulate punctures of tank cars of different specifications and a redistribution of thickness between the shell and jacket. The simulation demonstrated the influence of different size indenters as well as impacts on different locations of the car and at varying angles of obliquity. Figure 1 depicts the relationship between the puncture force of two designs of tank cars and the size of the indenter. The two designs of tank cars are; the current specification (DOT 111A100W1) with and without a jacket and the P-1577 proposal (described previously in this document) with and without a jacket.

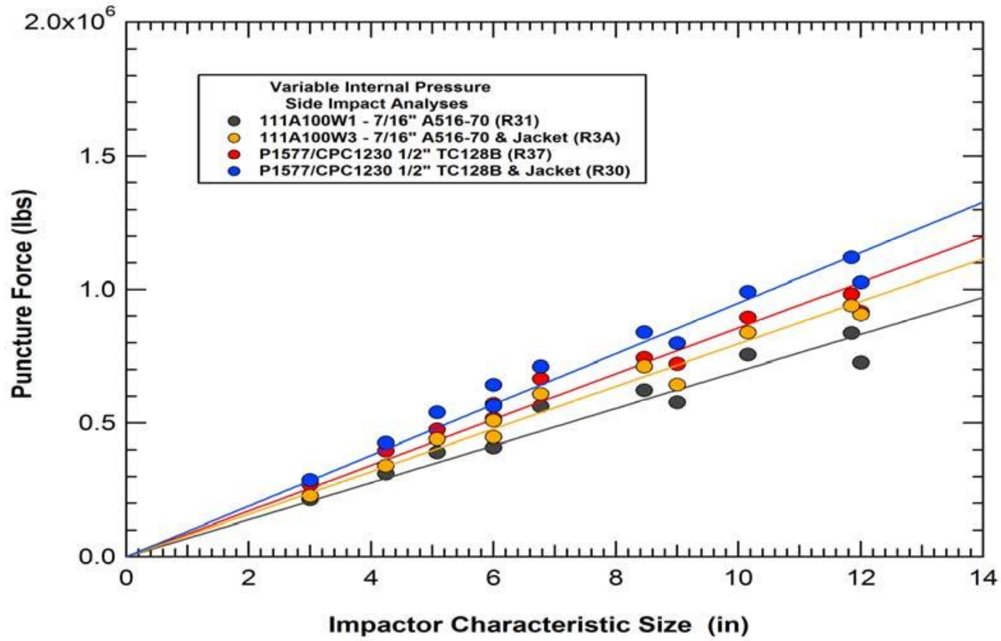

Figure 1: Relationship between Puncture Force and Indenter Size

Another research project related to this evaluation was performed by Sharma & Associates who simulated a 10 car derailment to determine the distribution of forces experience by the tank cars. Figure 2 shows a histogram of the distribution of collision forces of the 47 impacts occurring during the simulated derailment in which the train speed prior to the derailment is 40 miles per mile. However the derailment simulation model does not associate collision forces with size of the impacting object. Therefore, when comparing Figure 1 and Figure 2 a characteristic size[9] must be assumed. For example, seven impacts with an indenter with a 10" characteristic size would not exceed the puncture force of tank cars meeting the referenced specifications.

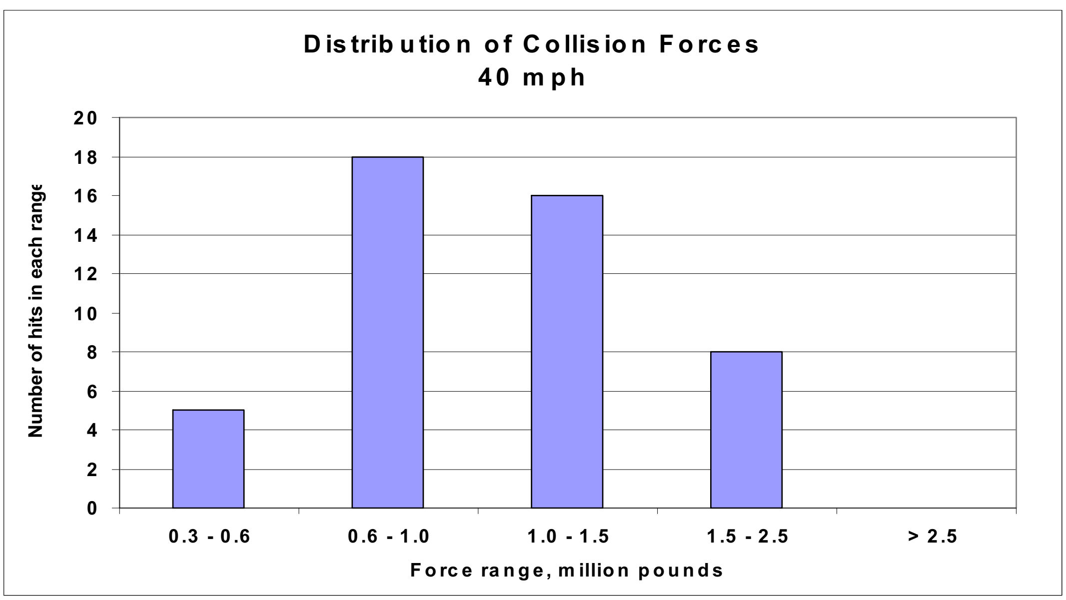

Figure 2: Distribution of forces encountered by tank cars involved in a derailment of a 10 car train

[9] Characteristic size is defined by ARA as the square root of the area of the impacting item. It is also worth noting that based on related research ARA has determined that a coupler head exhibits the same puncture force as an indenter with a 12" x 12" characteristic length.

There are two things worth noting when reviewing the research. First, the P-1577 proposal provides a considerable improvement in puncture force when compared to a tank car meeting the current specification for both the bare and jacketed cases. Second, the differences in puncture force decreases with decreasing indenter size. As a point of interest, it was suggested that indenters rarely hit a tank such that the contacting surfaces are "flat" against one another, so a 12" x 12" indenter hitting a tank shell may impart forces similar to a 3" x 3" indenter due to the orientation of the impact. Therefore, this research only demonstrates the relative performance of the two specifications and provides an indicator of how tank cars built to the different specification would perform in a derailment.

Finally, the Volpe Center presented results which are an extension of concepts developed during a previous rulemaking. The work involved correlating puncture energy with conditional probability of release (CPR). The narrow focus of this Task Force provided an ideal vehicle to exercise the concept. A comparison, in the form of a decrease in the CPR, between existing 111A100W1 specification tank car and the P-1577 tank cars was provided. The results indicate the P-1577 tank car provides an 18.9% reduction in CPR, with a 95% confidence interval of 18.6% to 19.2%. The Volpe Study only considered shell thickness. The P-1577 tank car is equipped with a minimum of a ½ inch half head shield which will further decrease the CPR.

Simulations indicate a tank car built to the proposed requirements of P-1577 would have a better chance of surviving (no puncture of the shell) a derailment than a tank car built to the current requirement. Enhanced puncture resistance could be achieved with the requirement for a jacket or a thicker shell. However, this would result in a decrease in the capacity of the tank and a commensurate increase in the number of shipments required to meet customer demand. Additional shipments would result in an increase in the number of tank cars derailed. **Therefore, with respect to puncture resistance the task force supports the proposed requirements of P-1577.**

<u>Top Fittings</u>

The task force considered three options related to top fittings with the dual purpose of improved crashworthiness and reduction of Non-accident Releases (NARs). The volume of releases from top fittings is typically less than tank shell and head punctures. Nonetheless, they represent a significant portion of the damage found in recent derailments. The three top fittings protection options evaluated by the task force are removal of vacuum relief valves, elimination of hinged and bolted manways, and use of roll-over protection[10] in favor of top fitting protection[11].

Vacuum Relief Valves (VRV), if operated properly, are an important feature of the tank car's service equipment. They provide an additional safeguard against implosion of tank cars which are filled with elevated temperature material or are cleaned with steam or hot liquid. For this reason they are a specification option for many shippers of the commodities under consideration by this working group. New design features may help prevent releases through the VRV observed at a number of the recent derailments as well as NARS. The new design features include a non-step shroud and tighter clamping force on the poppet. The effect of these design features has not been fully evaluated. The task force agreed that consideration for elimination of VRVs should wait until a significant amount of data can be gather and analyzed to make an informed decision. In addition, the AAR has recently distributed CPC-1232 for comment. CPC-1232 includes the recommendations AAR Task Force T50.54 whose charge was to evaluate the design and testing of VRVs. **The proposed requirements in CPC-1232 address all of the design concerns raised by the Task force T87.6.**

A significant portion of the problem (with leaking through the VRV) is the compatibility of the o-ring material specified with the commodity (and its components such as denaturants). The current material is compatible with the commodities under consideration but inexpensive versions are formulated with plasticizers and fillers that are not compatible. These formulations are inconsistent and therefore unpredictable. The Renewable Fuels Association (RFA) provided an update of research regarding compatibility of denatured alcohol with

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[10] 49CFR179.102-3

[11] AAR Specification for Tank Cars, C-III, Appendix E, Paragraph 10.

different fluid sealing materials. Based on the research RFA has made recommendations to its member companies and the industry.

Roll-over protection vs. top fittings protection

Petition P-1577 includes top fittings protection. Currently, it is uncertain whether roll-over protection provides better protection than top fitting protection. Sharma & Associates are currently under contract with FRA to evaluate alternative top fittings and roll-over protection systems. As part of the research project, they are comparing the performance of the different systems under both the static requirements of top fittings protection and dynamic conditions of roll-over protection. Sharma provided an update of their research including the stresses in both the protective structure and the tank shell. It is evident that the protective structure must both prevent the top valve/fitting from being damaged and limit the stresses transferred from the protective structure to the shell. The results were preliminary and the research is ongoing and therefore there was not enough information for the task force to make a recommendation. Final results will be shared with the AAR Tank Car Committee.

Eliminate hinged and bolted manways in favor of pressure arrangement

Five hinged and bolted manways were damaged (creating a leak point) in the Arcadia derailment. The damage included a shattered manway cover and sheared bolts. In addition, hinged and bolted manways account for nearly 50% of all NARS. For these reasons the task force evaluated elimination of hinged and bolted manways.

Representatives of the shipping community expressed the following concerns regarding the elimination of hinged and bolted manways.

- The existing infrastructure at the loading and unloading facilities has been designed make use of the 20” manway.
- Through the manway the facilities recover vapor, inspect the interior of the cars, obtain samples of heels in the tanks, insert a stinger used to dissipate energy of a fluid moving at a high flow rate, gauge the volume in the car during loading, access the car for periodic and ad hoc cleaning. In some cases all of the loading/unloading appurtenances have been incorporated onto a housing that fits over the manway.
- If a bolted pressure plate like assembly is required the loaded volume may be determined using existing technology. The specific gravity of crude oil varies from 0.6 to 1.0 limiting the usefulness of a magnetic gauging device.

Alternatives to hinged and bolted securement are currently under development and testing. AAR Task Force T94.21.5 was created to review the design and application of hinged and bolted manways with the goal of eliminating NARS. **Task Force T87.6 will defer to the recommendations of the T94.21.5. T87.6 requests T94.21.5 consider a performance specification for manway fasteners in a roll-over.**

<u>Bottom Fittings</u>

The Task Force considered elimination of bottom outlet valves. Representatives of the shipping community expressed the following concerns regarding this idea.

- BOVs are a valued feature of the tank car for the shipping community. The BOV is used to unload, and in some cases, load the tank cars.
- The BOV is necessary when the car is cleaned to drain the rinse liquid.
- Eliminating the allowance for BOV will require major alterations of existing infrastructure of loading and unloading facilities

The working group concluded elimination of the allowance for BOVs is not a viable option in the near term. The Task Force then considered enhanced protection of the bottom outlet valve. Appendix E of the AAR’s Tank Car Specifications provides the standards for bottom discontinuity protection. In order to move forward with this concept, the design criteria will need to be developed. Time constraints prohibit this task force from advancing this concept. Also, inspection of the 10 cars involved in a recent derailment indicates the bottom outlet protection functions as designed and no valve were significantly damaged.

AAR TCC created a docket T10.5 and a task force to evaluate bottom outlet performance. Task force T87.6 recommends that the TCC add development of design criteria for enhanced bottom outlet protection to the T10.5 charge. The following are other ideas being investigated by T10.5 that are germane to T87.6.

- Shipment of the car without the BOV handle attached and development of a standard/universal handle attachment.
- Eliminate use of overly strong handle
- Incorporating operating stops on valve bodies
- The working group will also engage BOV manufacturers to determine if valve configurations or design be altered to prevent damage documented in recent derailments.

Task Force T87.6 will defer to the findings and recommendations of T10.5.

Outage

The final consideration was a required increase in the allowable minimum outage from 1% to 2% to improve puncture resistance. It has been demonstrated through simulation of puncture scenarios that increasing the outage from 1% to 2% provides a significant increase in the energy required to puncture a loaded tank car.

Increasing the minimum allowed outage was a difficult option to evaluate because the commodities are loaded below the reference temperature and the outage at the loading temperature is well above the regulatory minimum. It was reported Ethanol was loaded to an outage of approximately 4%. The American Petroleum Institute (API) surveyed a number of its members to learn the outage of ethanol as received. The outages ranged from 2.86% to 6.23%.

To further evaluate the benefit of this option, the AFFTAC subgroup performed simulations to determine the benefit (to survivability in a pool fire) offered by increased outage. Based on the results of the simulation a tank car with 2% outage had an insignificant change in performance when exposed to a pool fire.

Based on this information the Task force will not make a recommendation regarding increasing outage.

Summary of the Design Working Group

The working group evaluated a number of concepts intended to improve the performance of a tank car meeting the requirements of P-1577 in a derailment. There are recommendations contained in this report and the Task Force agrees that the P-1577 car equipped with the recommended 75 psi pressure relief device successfully addresses the issues evaluated.

Part 3: The Operations Working Group

The operations working group was charged with evaluating alternative operational concepts intended to reduce the number of derailments and the number of tank cars involved in the event a derailment occurs. After its first two meetings, the working group has narrowed its focus to minimizing the number of cars involved in a derailment. The concepts considered to reduce the number of tank cars involved in a derailment include alternative brake signal propagation systems and speed restrictions. Additional discussions focused on emergency response assistance. Recognizing the ongoing work of RSAC committees and upcoming DOT rulemakings related to track integrity; the working group strongly encourages and supports the continued development of improved rail integrity systems and procedures. In addition the working group evaluated the applicability of the recommendation.

This document summarizes the discussions of the Task Force in considering the following topics:

- Rail Integrity
- Alternative Brake Signal Propagations Systems
- Speed Restriction (for Key Trains)
- Emergency Response

Rail Integrity

Broken rails are an indisputable factor in the creation of the T87.6 operations Task Force. Had it not been for the broken rails that caused the derailments at New Brighton, Cherry Valley and Arcadia, the AAR Tank Car Committee would not have convened a task force with the charge to reduce the number and severity of hazardous material derailments. In addition, statistical analysis supports the concern that broken rails results in the highest severity and frequency of derailments.

Figure 3 indicates that broken rails or welds resulted in approximately 670 derailments between 2001 and 2010, which far exceed the average of 89 derailments for all other causes. Also, in the same figure, the severity (using number of cars derailed as an index) of the derailments associated with broken rails or welds is 13 as compared to the average for all causes of 8.6.

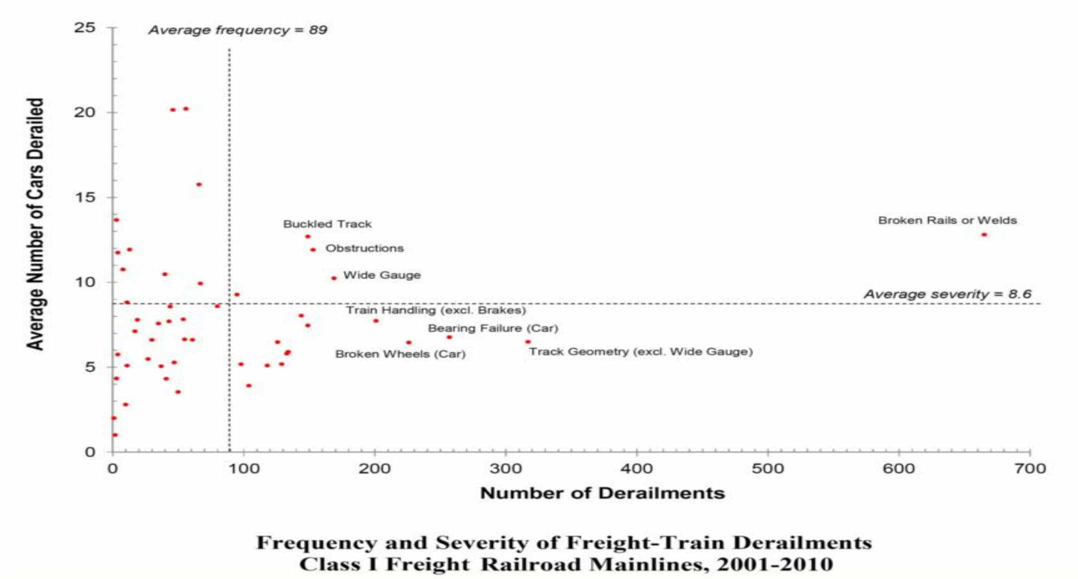

Figure 3: Frequency and Severity of freight train derailments on Class 1 railroads, 2001-2010 (source: AAR)

Figure 4 provides a comparison of causes of derailment as a percentage of the total number of derailments[12]. Broken rails and welds outnumber the next highest cause by a factor of two.

12 Train accidents with Hazmat release on main track, class I freight railroads, by aggregarted cause group, 1999-2008, from AAR Analysis of freight Train Accident Database.

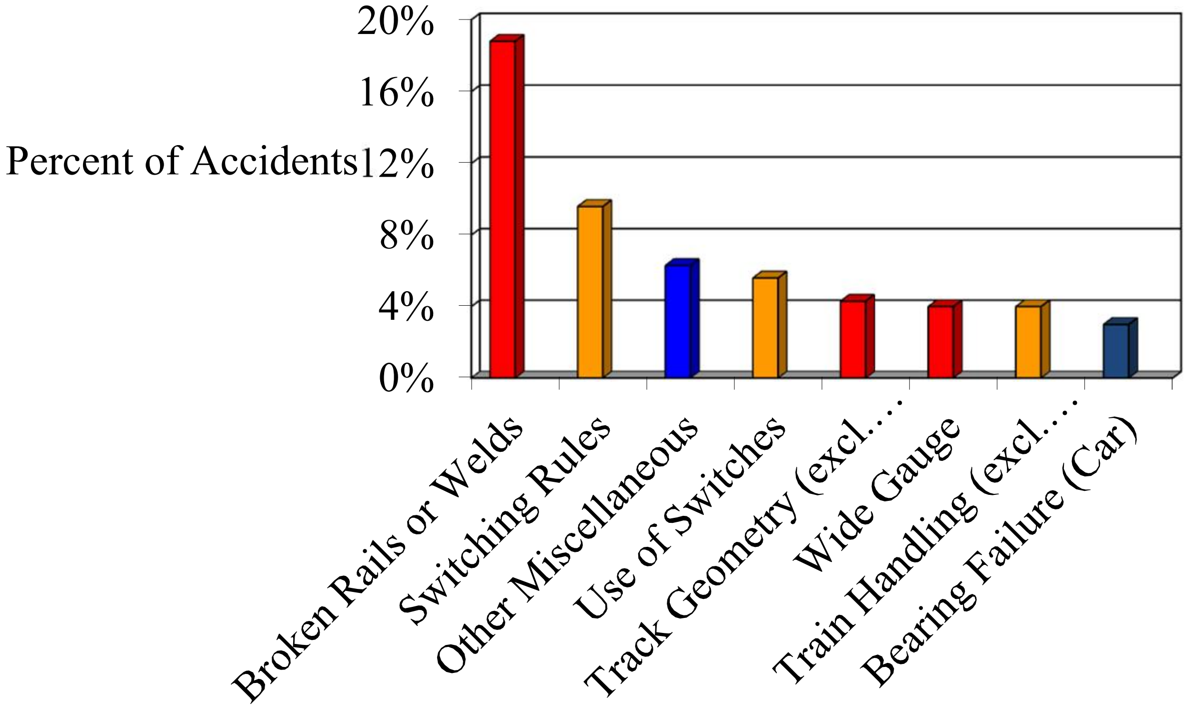

Figure 4: Causes of derailments as a percentage of total number of derailments (source: AAR)

The reduction in broken rails must be central to the effort to improve the safety of tank car operations. The Task Force is aware of a number of other working groups charged with addressing rail integrity issues. There are two Railroad Safety Advisory Council (RSAC) working groups; the Rail Inspection working group and the Rail Integrity Working Group. The Rail Inspection Working Group is evaluating more advanced testing/inspection regimens and possible changes to the current FRA regulation regarding the inspection and repair requirements. The Rail Integrity Working Group is addressing the NTSB conclusions regarding the New Brighton, PA derailment. The work of this group will result in a Notice of Proposed Rulemaking (NPRM) that is slated for publication in the Federal Register in 2012.

While addressing the causes of derailments is not a charter of this Task Force, we urge the groups charged with addressing track integrity issues to aggressively work toward a quick and meaningful resolution. In addition, the Task Force urges developers and suppliers of rail flaw detection technology to continue to make the advancement and production of the technologies a priority.

Alternative Brake Signal Propagation Systems

The alternative brake signal propagation systems considered included conventional air brakes, electronically controlled pneumatic brakes (ECP), distributed power (DP), and two-way end of train device (EOT). As the name suggests the baseline system was conventional with ECP, DP, and EOT the proposed alternatives. The EOT device performs the same as DP with locomotives at the front and rear. Intermediate EOT technology is a system not currently in use nor developed.

A simulation program, Train Energy & Dynamics Simulator (TEDS) was used to study the dynamics and energy levels of trains under a variety of operational conditions[13]. Specifically, TEDS was used to determine the stopping distance and the rate of dissipation of kinetic energy (KE) of a generic, 100 tank car train on level tangent track equipped with the candidate brake signal propagation systems. The simulations were used to determine the relative performance of the different systems. The model was validated using brake signal propagation data from Wabtec and data from a BNSF test performed in 2008.

This modeling tool was then used to determine the remaining energy to be dissipated and the speed at selected locations in the train when that tank car reached a defined point specified as the Point of Derailment (POD). By comparing the results for each technology, assumptions were made for the difference in number of cars reaching the point of derailment, remaining kinetic energy of all of the cars in the train at a set time interval, and conditional probability of release (CPR) of the train. The metrics are summarized in Table 1. The values in Table 1 represent a comparison of the results of simulations using the TEDS program between a train equipped with a conventional brake signal propagation system and ECP or DP brake signal propagation systems. All other variables (brake ratio, initial speed, etc.) remained constant.

Table 1: Metrics to evaluate relative performance of ECP and DP systems compared to the conventional system[14]

Metric	ECP	DP[15]
Difference in KE (10^6 ft-lbs)[16]	93.7	76.1
No. of cars not reaching point of derailment	0-5	0-3
Reduction in CPR[17] (%)	6.25	4.2

A rough estimate of the conditional probability of release for a train equipped with ECP brakes was calculated as follows. The ratio of the KE of the cars equipped with ECP to that of conventional was determined to be 0.863. The square root of this number represents the ratio of the speed of the all of cars in the ECP train to the conventional train. This ratio is 0.938. Assuming the speed of the conventional train was 50 mph, the calculated speed of the ECP train is 46.5 mph. Using previous work relating train speed to train CPR[18], the calculated CPR_{50} is 0.48 and the CPR_{46} is 0.45. The ratio of the CPRs is 0.938 resulting is a 6.25% reduction in the CPR. The objective is to reduce the CPR and use of ECP brakes represents the upper limit in the reduction of CPR. In similar analyses[19] industry has considered options resulting in a 20% reduction in the CPR to be worthy of further consideration and/or adoption.

Concurrently, the Task Force evaluated the obstacles to implementation for the candidate brake signal propagation systems.

ECP

- Cost for equipment (tank cars and locomotives)[20]

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13 Analysis performed by Sharma &Associates.
14 Models are based on a number of assumptions and the results are not intended to predict the outcome of an actual derailment. The results are strictly intended to provide a relative performance of alternative brake signal propagation systems. The tabulated values assume an initial speed of 50 mph.
15 Distributed power with one locomotive at the front, middle and end of the train.
16 The difference in KE represents the additional energy dissipated/absorbed by the brakes. The quicker the signal is propagated through the systems the quicker the brakes are actuated and the greater amount of energy removed from the train.
17 This number represents the reduction in the CPR of tank cars involved in the derailment. The results basically indicate that the speeds of the derailing cars with alternative brake signal propagation systems are lower than cars with conventional systems. With lower speed at the point of derailment there is a commensurate decrease in CPR.
18 Kawprasert, A. and Barkan, C.P.L, “Effect of Train Speed on Risk Analysis of Transporting Hazardous Material by Rail”, Transportation Research Record: Journal of the Transportation Research Board, 2011, pp 59-68 (Figure 2).
19 AAR Task Force T87.5 evaluating design improvements for tank car used to transport packing group I and II materials.
20 Costs obtained from a 2006 Booz Allan Hamilton study. It is likely the current cost for the same or comparable

    - $4,500/car (new construction for overlay)
    - $5,000/car (retrofit for overlay)
    - $44,000/locomotive
- Required training for train crew
- Many of the denatured alcohol producers are on short line and regional railroads which do not have ECP equipped locomotives.
- All cars in the train must be equipped with ECP therefore the train must be made of all tank cars constructed per the recommendation of this working group. Requiring that trains be made of only newly constructed tank cars and locomotives equipped for ECP operations results in onerous logistical limitation on both railroads and shippers as well as a long phase-in period.

DP

- Intended as an operational approach to decrease in train coupler forces and improve brake recharging. Current operations assign use of DP based on track curvature and grade as well as number of cars in train. Resources are allocated accordingly and adding a new variable would require additional locomotives.
- Benefits of DP are maximized when the derailment occurs at the head of the train. The benefits decrease as the point of derailment occurs further back in the train.
    - In some applications there is a delay in emergency brake application that would negate the benefits of the enhance signal transmission. This delay is an intentional decision made by individual railroad companies and is not the result of any problems with the brakes.
- Industry not unified in the use of DP
- Many of the denatured alcohol and crude oil producers are on short line and regional railroads which do not utilize DP.

EOT

- Intended to overcome brake pipe obstruction.
- Benefits of EOT are maximized when the derailment occurs at the head of the train. The benefits decrease as the point of derailment occurs further back in the train (In some applications there is a delay in emergency brake application that would negate the benefits of the enhance signal transmission).
- In some applications there is a delay in emergency brake application that would negate the benefits of the enhance signal transmission.

Based on the simulation results and analysis of the data it was concluded the alternatives considered provided marginal benefits. Moreover the identified obstacles to implementation represent a considerable time and cost investment and the predicted benefits would not be realized for months or years in the future. As such, this working group will not make a recommendation related to alternative brake signal propagation systems.

It is worth noting that the working group acknowledged that an alternative signal transmission system, such as an intermediate EOT device, may be a promising option. Unfortunately, an intermediate device does not exist and there is no experience with this configuration and research will be needed to understand the capabilities of such a system. This Task Force recommends the Brake Systems Committee evaluate the feasibility of the concept of an intermediate brake signal propagation device.

<u>Speed Restriction</u>
During the meeting on December 12, the AAR reported that the Hazmat BOE Committee proposed to management committees that unit trains containing 20 or more loaded tank cars of Packing Groups I and II (UN #'s 1987 / 1267 / 3475 / 3494) be designated as Key Trains. All operating restrictions of OT-55 would apply to

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equipment is significantly higher. The estimated total cost is approximately $5 billion.

these trains. Implicit in this proposal is a limit on the maximum speed a Key Train at 50 miles per hour. It was noted that five of the seven Class I railroad currently treat unit trains as Key trains.

Members of the working group from the shipping community expressed a concern that significant reductions in train speed will stress the rail system when capacity constraints are increasing. An increase in car and locomotive cycle time will not be restricted to the directly affected unit trains, it will slow the entire network and cycle times for all rolling stock will be increased, resulting in lost productivity and efficiency. The AAR committed to requesting its member perform a cycle time analysis to determine the effect of the proposed speed restriction for Key Trains.

One AAR member did a cycle time analysis, and determined there would be an increase in cycle time which would result in shippers having to procure additional tank cars to meet their customer's shipping requirements particularly as additional traffic is brought on. As a result, since five of the Class 1 railroads already operate trains as key trains, but a change to OT-55 would adversely affect the cycle times for two Class 1 railroads, the railroads are not planning to incorporate unit trains of crude oil and ethanol into the definition of a key train in OT-55.

The working group concurred with the recommendation of the AAR that OT-55 not be modified due to the adverse impact on cycle times and the resulting increase in the number of tank cars which would be required to transport these commodities in the same time frame. Most of the benefit of the reduced speed restriction is already in place, since five of the seven Class 1 railroads already handle unit trains of these commodities as key trains.

<u>Emergency Response</u>

In its initial meeting the Task Force agreed that emergency response was a topic that should be addressed. An effective response will mitigate the severity of the hazards experience by response and salvage personnel, impact on the environment and delays to reopening the line to traffic. In addition, an effective response could potentially limit damage to tank cars. For example limiting the exposure of a tank car to a pool fire will limit the release of lading through a pressure relief device and could prevent a thermal rupture of the tank. Effectiveness of a response is related to both timing and availability of the appropriate equipment/material.

The location of staged reserves of aqueous film forming foam (AFFF) was provided to the Task Force by both the railroads and the Renewable Fuels Association (RFA). The railroads identified locations (existing and planned in the near future) where foam and application equipment are staged across the United States. The RFA identified 209 sites where foam is staged. Plant sites typically maintain a store of 5,000 to 10,000 gallons of foam. These stores are fixed and intended for use at the plant site. The RFA also reported great variability in the type and quantity of foam available for emergency response. Typically, the municipalities have 300 to500 gallons (in totes or buckets) available for mobile response.

The type of foam is an important consideration. The RFA reported the result of a 2007 research project in which six different foams were tested on two different grades of denatured alcohol. The results indicated that Alcohol resistant aqueous film forming foam (AR-AFFF) was the most effective and versatile material. These results prompted RFA to recommend that all Fire Departments upgrade to an alcohol resistant formulation of fire fighting foam. In addition, foam manufacturers continue to improve their formulations and offer foams that are freeze protected for use at incidents occurring in cold temperatures.

At the next RFA Plant and Employee Safety Committee meeting a recommendation will be made that plant sites should consider developing mobile response capabilities. This will likely take the form of storing foam in portable containers available to emergency personnel responding to a nearby incident (derailment or cargo tank accident) that can also be used in an onsite response. **This Task Force supports the RFA's proposed recommendation and in turn, recommends the AAR request updates from the RFA regarding the availability of mobile stores of AR-AFFF.**

Summary of Operations Working Group

The working group evaluated a number of concepts intended to reduce the number of derailments and the number of tank cars involved in the event a derailment occurs. It is evident, based on the information evaluated, the goals of this working group can be most easily achieved through elimination of track related derailments. The working group identified current industry work in this area and supports a rapid and meaningful resolution through these initiatives. The Task Force urges industry to address recommendations from this work as soon as possible.