

5. APTA SS-C&S-007-98, Rev. 1 Standard for Fuel Tank Integrity on Non Passenger Carrying Locomotives

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Abstract: This standard establishes requirements, and provides guidance, for establishing a minimum level of integrity for all diesel fuel containment systems designed to accept, store, and feed fuel to primary diesel engines installed on passenger rail equipment. This includes, diesel electric and diesel electric dual mode locomotives (i.e. electrical and diesel electric compatible equipment) used in passenger revenue service. Minimum structural integrity, vehicle integration, and construction requirements applied to the fuel containment systems are covered. Specific exceptions are stated. This standard does not apply to fuel transfer, feed, or fuel tender systems.

Keywords: containment, design, diesel, electric, fuel, integrity, locomotive, spills, tanks

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Table of Contents

| | |
|---|-----|
| 1. Overview | 5.3 |
| 1.1 Scope..... | 5.3 |
| 1.2 Purpose..... | 5.3 |
| 2. References | 5.3 |
| 3. Performance requirements..... | 5.4 |
| 3.1 Bottom loading | 5.4 |
| 3.2 Side loading..... | 5.4 |
| 3.3 Penetration resistance | 5.4 |
| 4. Design guidelines and requirements | 5.5 |
| 4.1 Tank to rail clearance..... | 5.5 |
| 4.2 End plate penetration | 5.5 |
| 4.3 Fuel tank sideswipes | 5.5 |
| 4.4 Emergency shutoffs | 5.5 |
| 4.5 Ancillary structures..... | 5.5 |
| 4.6 Skid plates | 5.6 |
| 4.7 Attachment | 5.6 |
| 5. Exposed fuel and transfer lines..... | 5.6 |
| 6. Fuel spill minimization | 5.6 |
| 7. Fuel spill, emergency and associated fuel tank integrity requirements & guidelines | 5.7 |
| 8. Materials..... | 5.7 |
| 9. Workmanship | 5.7 |
| Annex A (informative)..... | 5.8 |

APTA SS-C&S-007-98, Rev. 1

Standard for Fuel Tank Integrity on Non Passenger Carrying Locomotives

1. Overview

This standard applies to the structural design of new passenger motive power fuel containment systems. The requirements laid down herein are not intended to be retroactive in their application to equipment now in service. Design attributes or considerations given as examples of recommendation, are presented merely to provide the designer with conventional options, and are not prescriptive in nature.

1.1 Scope

This standard applies to diesel fuel containment systems designed to accept, store, and feed fuel to prime movers installed on passenger rail equipment. This includes, diesel electric dual mode locomotives (i.e. electrical and diesel fuel compatible equipment) used in revenue service. Minimum structural integrity, vehicle integration, and construction requirements applied to the fuel containment systems are described. Specific exceptions are stated. This standard does not apply to the fuel transfer, feed, or fuel tender systems.

1.2 Purpose

The purpose of this standard is to provide minimum performance requirements and guidance to increase structural integrity, of new passenger internal combustion motive power fuel containment systems.

These specifications shall be applied to new fueled passenger motive power, suitable for use in revenue applications. The resultant design(s) also help ensure that new and existing cars will satisfactorily operate together with enhanced protection under all conditions of service.

2. References

This recommended practice shall be used in conjunction with the following publications. When the following publications are superseded by an approved revision, the revision shall apply.

49 CFR Part 229, FRA rail clearance, venting and other requirements applied to “locomotives”

AAR Report WP-161, Locomotive Fuel Tank Integrity Study, February 1994

AAR RP-506, Performance Requirements for Diesel Electric Locomotive Fuel Tanks, September 1, 1995

AWS D1.1, Structural Welding Code – Steel

AWS D15.1, Railroad Welding Specification - Car and Locomotives

Federal Register: September 23, 1997 (Volume 62, Number 184), Passenger Equipment Safety

Standards; Proposed Rule, pp. 49727-49824

NFPA 130, Fixed Guideway Transit Systems, 1997

North American Railroad Industry Standards for Locomotive Fuel Delivery and Automatic Shut-off System, Pending, AAR

NTSB Report NTSB/SS-92-04, PB92-917009, Locomotive Fuel Tank Integrity - Safety Study, 1991

NTSB/RAR-97/02), Collision and Derailment of Maryland Rail Commuter MARC Train 286 and National Railroad Passenger Corporation Amtrak Train 29, near Silver Spring, Maryland, on February 16, 1996. Corresponding letter of recommendation to industry, dated 28 August 1997.

US DOT FRA, Locomotive Crashworthiness and Cab Working Conditions, Report to Congress, September 1996

3. Performance requirements

3.1 Bottom loading

3.1.1. Unless exempted by the provisions of Section 4.1.2 or 4.1.3, Tank to Rail Clearance, fuel tanks shall be capable of supporting at any point across the transverse width of either the forward or aft end plate structure of the fuel tank, a loading of one half the total weight (i.e. with opposing truck in contact with ground) of the fully loaded car body at 2g without rupture of the fuel tank, assuming tangent track.

3.1.2. Unless exempted by the provisions of Section 4.1.3, Tank to Rail Clearance, fuel tanks must also support one half the weight of the locomotive at a vertical acceleration of 2g without rupture of the fuel tank while being supported on one railhead surface with a width of two inches. The locomotive is assumed to be perpendicular to the track.

3.2 Side loading

In all cases, fuel tanks shall be capable of averting a rupture and fuel release, when the side is loaded on any 6" vertical by 48" horizontal area, centered at 30" above the rail, to 200,000 lbs. load uniformly applied.

3.3 Penetration resistance

The minimum thickness of the sides, bottom sheet and end plates of the fuel tank shall be equivalent to 5/16 inch steel plate at 25,000 psi yield strength (where the thickness varies inversely with the square root of the yield strength). For fuel tanks less than 18 inches above the rail with fully worn wheels, the lower one third of the end plates shall have the equivalent penetration resistance of 3/4 inch steel plate at 25,000 psi yield strength. This may be accomplished by any combination of materials or other mechanical protection.

4. Design guidelines and requirements

4.1 Tank to rail clearance

4.1.1 Fuel tank to rail static clearance shall not be less than 6.0”, when the equipment is in a fully serviced condition, with fully worn wheels.

4.1.2 Fuel tank designs which achieve rail to tank bottom clearances greater than 18”, under the aforementioned serviced and worn wheel conditions, are exempt from the bottom load performance specifications detailed in Section 3.1.1; and the skid plate recommendation of section 4.6

4.1.3 If the passenger motive power fuel tank design achieves a tank bottom clearance of *greater than 27”* above the rail, under all operating conditions and worn wheels, then the equipment is exempt from fuel tank, bottom load performance specifications detailed in Section 4.1.1 and 4.1.2; and the skid plate recommendation of section 4.6.

4.2 End plate penetration

Penetration resistance of the fuel tank end plate structures, shall be enhanced with forward (and aft, if a locomotive is operated in revenue service in the long hood lead configuration) deflection, containment, capture, other design attributes, or a combination of such, capable of averting a puncture of the fuel tank by items passing below the pilot. Such designs might include: angled reinforcements; downward angled fuel tank front plates; fuel tank guards, strategically located ancillary structures, or other designs, or combination of designs, capable of adequate catch, break away, deflection, or otherwise puncture averting characteristics.

4.3 Fuel tank sideswipes

Fuel tanks shall be protected against sideswipes. All gauges, fuel fills, vents, clean out ports, fuel monitors, and other fuel tank extensions shall be recessed, guarded, located, or otherwise protected against catch and tear scenarios that could result in fuel release under normal revenue service conditions.

4.4 Emergency shutoffs

Fuel flow to the prime mover shall be capable of cut off from no less than the three locations required by FRA rules in accordance with *49 CFR 229*.¹

4.5 Ancillary structures

Ancillary structures affixed to the under-body of motive power equipment (e.g. a crossing bell located in close proximity to the fuel tank, which can act as a “knife” when forced back into the tank), shall be located and attached to the motive power unit in such a way, that their presence does not increase the risk of compromising the fuel tanks to an unacceptable level. If such placement is necessary, additional, local protection must be employed to prevent credible intrusions into the tank.

¹ For references in Italics, see Section 2

Fuel tank construction shall employ provisions to minimize the attachment of structures to fuel tanks. Employment of breakaway, or crash energy management methodologies, capable of minimizing collision related fuel release, are required where so identified by the applicable system safety plan (e.g. use in underground passenger stations, etc.).

4.6 Skid plates

Use of above rail skid plate fortification of critical tank bottom zones, shall be considered in weight critical, and other unique applications. This practice is required in all cases where tank to clearance falls to below 18" from rail to tank bottom surface (i.e. nominally centered over standard rail). The plate(s) need not run the entire length of the tank.

4.7 Attachment

Attachment of fuel tanks to body shall be in accordance with *APTA SS-C&S-034-99, Revision 1 Standard for the Design and Construction of Passenger Railroad Rolling Stock.*²

5. Exposed fuel and transfer lines

Fuel tank piping or transfer systems supplying the prime mover with fuel shall incorporate the means to interrupt fuel loss upon damage. If this is not practical, then shields, or some other means that satisfy this requirement shall be employed.

6. Fuel spill minimization

In all passenger applications, fuel tank capacities shall be limited to volumes of no more than 1000 useable US gallons unless additional measures are taken to minimize fuel spillage, such as compartmentalization, increased wall and end thickness, bladders, or other similar means.

- a) If compartmentalization is chosen as a means of fuel spill minimization, the following requirements shall apply:
 - Individual compartments shall be no larger than 1000 US gallons.
 - Means of preventing return fuel from entering a punctured tank while allowing use of other compartments shall be provided.
 - With a locomotive on its side, fuel shall not transfer between compartments.
 - Means to fill all compartments from a single filler shall be provided.
 - Fuel shall be drawn from all compartments simultaneously and not sequentially.
 - It is desirable for a system to automatically detect an empty compartment and shut it down prior to air being drawn resulting in an engine shutdown. Return fuel should not be allowed to enter a detected empty compartment.
 - A means shall be provided to clean all compartments.

² For references in Italics, see Section 2.

Compartmentalized designs shall be validated to ensure complete, consistent, and total fuel utilization.

- b) If increased material thickness is chosen, then the end sheets shall be 0.75” thick and the sidewalls 0.50” thick, using steel plates at 25,000 psi yield strength (where the thickness varies as the inverse of the square root of yield strength).

If bottom-loading exemptions are taken, then Section 7 Fuel spill minimization shall be required regardless of tank capacity.

7. Fuel spill, emergency and associated fuel tank integrity requirements & guidelines

Vents and fills shall be designed to avert fuel spill, even in the event of a rollover.

During fuel filling, passenger motive power equipment fuel tanks, shall not interrupt, nor cause spray or overfilling, at a fill rate 300 gpm. *North American Railroad Industry Standards for Locomotive Fuel Delivery and Automatic Shut-off System* (Pending, AAR) takes precedence where required by the assigned revenue service.

Passenger locomotive vents shall perform their function at the high acceleration/deceleration, rates as well as during all possible curve negotiation scenarios expected in revenue service.

Side roll over fuel fill leakage protection shall not be compromised in the event that a fill cap is missing or knocked off.

8. Materials

Fuel tanks shall be fabricated from a high strength ductile steel or structurally equivalent material. The materials used in the construction of motive power fuel tanks may be selected such that structural strength and load capacity requirements are met through alternative, yet structurally equivalent or better, material applications.

The material used for fuel tank exterior surface construction shall not exhibit a decrease in strain resistance in the temperature range of -40⁰F to 140⁰F.

9. Workmanship

All workmanship affecting the tank shall conform to the state of the art quality techniques. Steel welding shall be in accordance with AWS D1.1.

Annex A (informative)

Background

Fuel tanks on passenger motive power equipment can introduce a challenging fuel load in rail incidents where a compromise of the containment tank(s) is followed by fuel combustion. Passenger related incidents involving fuel fires, while often at the focus of attention when they occur, are few. More common, is the occurrence of adverse environmental impact associated with fuel spills or leaks¹. Adding to the risk of tank failure is the typical under frame location of fuel tanks, where they lie exposed to damage from side-on collision, roadbed debris and derailments.

Key to the development of a motive power fuel tank configuration is a thorough and validated risk assessment by the cognizant passenger rail authority. This is critical in deriving fact based, value added performance specifications, and ensuring prudent validation of applied designs.

The industry has continued to effect positive, productive design enhancements to tank structures, in light of residual fuel spill and fire risks. In conjunction with the Association of American Railroads (AAR), manufacturers collectively developed and adopted specifications for freight locomotive fuel tanks. The AAR specifications were generated to increase fuel tank integrity, during those situations, identified by study, which contribute to the majority of incidents.

Differences in passenger motive power configurations often require selective application of these guidelines to achieve a safe practical design. In some cases, alternative designs and technologies may provide the better fuel containment solution, and must be given practical consideration.

Motive power, new or altered, requires that system clearance specifications (e.g. system profiles, or plates) be systematically identified, and validated, before revenue service. This should occur in accordance with APTA RP-C&S-003-98, *Recommended Practice for Developing a Clearance Diagram for Passenger Equipment*

Historical Information

Flammable fossil fuels required for diesel-electric motive power operation, instill risk. The National Transportation Safety Board (NTSB) identified and published some of these concerns after reviewing 29 predominately freight, rail accidents investigated during 1991. Collectively, these incidents resulted in: 83 locomotive derailments; 55 definitive fuel tank breaches; 43 fuel loss incidents; and 25 associated fires². The NTSB, as a result of the study, recommended that industry research the integrity of fuel tanks, and apply standards accordingly.

The AAR responded with a study of its own¹. This study spanned 3 years, and involved 221 fuel spill incident reports to FRA from 1991-1993. The distribution of fuel tank spills showed that roughly 50% of the spills involved less than 1200 gallons of fuel. The conclusion was that fuel spills were not endemic, resultant fires were rare; and the need for additional research was questionable. The validity of the study was deemed indeterminate by the FRA, due to the shortcomings of the existing accident reporting criteria.

In response, the rail industry “raised the bar” on fuel tank integrity, with the issuance of an AAR

performance standard³. The issue of new fuel tank integrity on freight locomotives stabilized, when NTSB gave formal closure to open fuel tank integrity recommendations. This acknowledgment was appended with an NTSB letter to the rail industry, refreshing an appeal for crash or simulated testing and evaluation of recent incidents, as follows:

“Consideration should be given to crash or simulated testing and evaluation of recent and proposed design modifications to the locomotive fuel tank, including increasing the structural strength of end and side wall plates, raising the tank higher above the rail, and using internal tank bladders and foam inserts. (Class II, Priority Action) (R-92-10)”

The recommendation came on the heels of NTSB findings associated with the collision and derailment of MARC Train 286, and AMTRAK Train 29, near Silver Spring Maryland, on 16 February 1996. During the first quarter of 1996, an unanticipated rise in passenger rail incidences further sensitized the nation to the potential for collisions involving diesel electric freight trains, and passenger transportation sharing common infrastructure.

Fuel tank integrity during an accident often depends on complex, multi-variant and unique, dynamic structural loading scenarios. Add to that the vast number of possible fuel tank collision permutations and combinations, and, the cognizant authority ultimately faces a true challenge. In the final analysis, a prudent, fact-based level of residual risk must be determined. As such, it must recognize an unqualified range of incident velocities, resultant loads, and other contributing factors. This is in keeping with the recently released proposed rule on Passenger Rail Equipment Safety Standards; specifically the systems safety, and fire safety planning elements.

The task to develop fuel tank performance specification required a thorough degree of incident research, and focused attention on practical improvement. Again, a fuel tank integrity standard for passenger rail equipment will not provide for all contingencies; being, effectively, value added enhancement of current, recognized standards, applied to other transportation systems.