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Operator Protection Features for Rail Transit Vehicles

Abstract: This *Recommended Practice* gives guidance to rail transit systems on vehicle features to consider to improve operator protection when procuring new rail transit vehicles.

Keywords: crash energy management, operator protection, rail transit vehicle

Summary: The safety of a rail transit operator and his or her ongoing ability to operate the vehicle are critical. The operator must be able to bring the vehicle safely to a stop after an incident, to remove the vehicle and its passengers from the immediate area of a threat, or to use the vehicle to support emergency response activities. This document describes features that should be considered for inclusion in the design of rail transit vehicles to provide protection for the operator.

Scope and purpose: This *Recommended Practice* should be considered by rail transit systems that are in the process of procuring new vehicles, retrofitting existing vehicles or overhauling existing vehicles. This document gives rail transit systems guidance on features to include in the design of a rail transit vehicle to provide greater protection to the operator.

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The American Public Transportation Association greatly appreciates the contributions of **Tom Peacock and Gordon Campbell**, who provided the primary effort in the drafting of this *Recommended Practice*.

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Introduction

(This introduction is not a part of APTA RT-VIM-RP-025-15, "Recommended Practice for Operator Protection Features for Rail Transit Vehicles".

This *Recommended Practice* outlines the various operator protection features that rail transit systems (RTS) should consider when purchasing new vehicles. This recommended practice outlines the design requirements for many of these systems. For the operator protection features outlined in this document, the industry determined that for some of these systems it may not be necessary to mandate the requirements given the uniqueness of many of the rail transit systems. For these operator protection features, considerations or guidelines are provided to help the Rail Transit System address the needs or design requirements of such systems.

Operator Protection Features for Rail Transit Vehicles

1. Overview

In most rail transit systems, drivers operate vehicles autonomously. For this reason, the safety of the operator and his or her ongoing ability to operate the vehicle are critical; the operator must be able to bring the vehicle safely to a stop after an incident, to remove the vehicle (and its passengers) from the immediate area of a threat, or to use the vehicle to support emergency response activities. All of this is subject to the operator surviving a collision or an attack on the vehicle and the vehicle control systems remaining functional.

On heavy rail vehicles, the operator is usually isolated from passengers in a secured compartment. However, in light rail vehicles, the operator can sit in the main body of the vehicle. While these operators need to be able to interact with passengers, threats against them can be minimized through vehicle design.

In the event of an incident on board a transit vehicle, responding law enforcement and emergency response agencies need to be able to assess the situation as quickly and as easily as possible. Their ability to see what has taken place in the vehicle, or what is currently happening, will enable them to respond in a manner that helps protect the transit passengers, the operator of the vehicle and the first responders. Similarly, improving a vehicle operator's ability to see what is taking place around the vehicle enables the operator to respond more quickly to impending threats and developing situations.

The operator of a rail transit vehicle needs the vehicle design to afford him or her as much protection as possible for three primary reasons:

- The operator is vulnerable to the forces of front end and side collisions.
- An incapacitated operator puts the safety of the passengers at greater risk.
- The operator is a potential target for criminal/terrorist acts.

The U.S. and European rail industries have created a Crash Energy Management (CEM) standards published by the American Society of Mechanical Engineers (ASME) and European Standards. These standards require the rail vehicle to absorb energy in a collision and thus reducing injuries to the operator and passengers. CEM systems are becoming mandatory on equipment that are governed by the Federal Railroad Administration and are mandatory for all new European vehicles, including street trams, commuter trains, regional trains and inter-city trains.

Certainly from a collision perspective, rail transit vehicles operate in a less severe environment than commuter rail vehicles. For example:

- Rail transit vehicles operate at lower speeds.
- Rail transit vehicles sometimes operate in unsignalled (dark) signal territory.
- Rail transit vehicles often operate on a dedicated right-of-way, operating with like equipment.
- Rail transit vehicles are lighter in weight.
- Rail transit vehicles, should they become involved in collision accidents face lighter weight obstacles and tend to hit lighter objects.
- Rail transit vehicles have higher braking rates to avoid collisions.
- Collision avoidance technology from signal and train control systems is often superior.

While rail transit vehicles do not need the same energy absorption capability than those installed on heavier commuter rail vehicles, attention must be paid to installing key crashworthiness features to protect the operator and passengers.

2. Operator protection features

Rail transit systems that are in the process of procuring new vehicles, retrofitting existing vehicles or overhauling existing vehicles should consider including the following vehicle features to provide greater protection to the operator:

1. structural strength of the front end structure;
2. structural strength of the side structure;
3. cab glazing;
4. use of interior compartment padding and avoiding sharp corners, etc.;
5. use of pushback couplers with energy absorption;
6. design of anti-climbers to prevent override;
7. design of pilot and other front end structure to push highway vehicles and other objects down and deflect them from the vehicle;
8. use of crash energy management collision energy absorption design principals;
9. preserving a survival space for the operator and passengers after a collision;
10. ergonomics of the seat;
11. cab emergency lighting;
12. cab design for rapid evacuation;
13. secondary emergency exit for the cab;
14. cab covert alarms;
15. fire suppression in the cab;
16. ventilation control of the cab;
17. visibility of the cab area from the exterior;
18. the operator’s field of view of his or her surroundings;
19. automated vehicle tracking;
20. redundant means for operator communication with central control;
21. means to secure cab against entry by the public; and
22. manual override of the car-borne public address system.

The need to incorporate any of these or other features required by the RTS should be evaluated in terms of safety risk. For example, vehicles operating under advanced train control systems that enforce train separation might not require the addition of structural reinforcements and collision energy absorbing equipment, which is designed to protect the crew and passengers from forces that would occur if there is an unacceptable risk that vehicles could collide due to human or single point equipment failures. Grade separations and advanced signaling systems with integrated grade crossing protection significantly reduce the risk of a severe collision. Under certain circumstances, an investment in right-of-way safeguards balances the need to add vehicle structure and equipment to achieve collision survival. Crashworthiness aspects should always be assessed pursuant to the Safety Certification of the entire vehicle acquisition project.

2.1 Structural strength of the front end structure

The structural strength of the front end structure provides the primary protection to the operator in the event of a collision. A front end structure may consist of a corner post at each corner and collision posts at approximately the one-third points laterally or a modern CEM system.

The collision and corner posts should be joined to the carbody with an attachment strength that allows the full strength of the posts to come into play before the joints fail. Collision and corner posts should be made from material that allows the post a large deflection in bending before failure. This ductile rather than brittle failure absorbs more energy. Alternatively, a CEM system in compliance with ASME RT1/RT2 or EN 15227 which absorbs energy and provides a collision wall can also be used.

For light rail operation without operation on the general railroad system, refer to ASME's "Safety Standard for Structural Requirements for Light Rail Vehicles" or European Standard Crashworthiness requirements for railway vehicle bodies for guidance on front end structure structural strength requirements.

For heavy rail vehicles, refer to ASME's, "Safety Standard for Structural Requirements for Heavy Rail Transit Vehicles" for guidance on front end structure structural strength requirements.

The rail transit system should hold the car builder responsible to design the front end structure for a specific performance under collision scenarios approved by the rail transit system. Validation of the design should be through a combination of component structural tests and modeling with a validated computer model.

2.2 Structural strength of the side structure

The strength of the side structure protects the operator and passengers in the event of side impact and supports the roof on the event of a rollover.

For light-rail operation without operation on the general railroad system, refer to ASME's, *"Safety Standard for Structural Requirements for Light Rail Vehicles"* for guidance on side structure structural strength requirements.

For heavy rail vehicles, refer to ASME's, *"Safety Standard for Structural Requirements for Heavy Rail Transit Vehicles"* for guidance on side structure structural strength requirements.

The rail transit system should hold the car builder responsible to design the side structure for a specific performance under collision scenarios approved by the rail transit system. Validation of the design should be through a combination of component structural tests and modeling with a validated computer model.

2.3 Cab glazing

Cab glazing provides the operator's field of view while protecting him from objects entering the cab. Glazing requirements should consider features like tint, optical characteristics, etc. as outlined in ANSI Standard Z26.1 *"American National Standard for Safety Glazing Materials for Glazing Motor Vehicles and Motor Vehicle Equipment Operating on Land Highways – Safety Code."*

The front windshield should comply with FRA Type 1 level certification for ballistic and large object and small impacts per 49 CFR Part 223 or alternate international standards approved by the RTSS.

All cab side glazing should comply with FRA Type II level certification for ballistic and large and small object impacts or alternate international standards approved by the RTS.

The cab rear interior glazing, at a minimum, should be constructed of laminated safety glass that meets the requirements of ANSI Standard Z26.1 *"American National Standard for Safety Glazing Materials for Glazing Motor Vehicles and Motor Vehicle Equipment Operating on Land Highways – Safety Code."*

2.4 Padding and avoiding sharp corners

Surfaces that the operator is likely to impact due to rapid deceleration caused by a derailment or collision should be padded. Sharp corners or other protrusions in the cab that could cause operator injury should be avoided.

2.5 Telescoping draft gear/pushback couplers

Couplers and draft gear systems should have energy absorbing elements to reduce structural damage to the vehicle and to protect the operator and passengers from coupling and collision shock loads.

The performance of new pushback coupler/energy absorbing draft gear should be verified through a combination of prototype testing and modeling with a validated computer model.

Couplers should be self-gathering, positive engagement hook and receptacle design that restrain carbodies from slewing or overriding in the event of a collision between two similarly equipped vehicles.

2.6 Anti-climbing devices

The carbody structure shall be designed to resist, in a collision, the tendency for the structure of the colliding vehicle(s) to override and penetrate into the survival space of impacted carbodies.

The vehicle shall include an anti-climbing device designed to resist the tendency to override and penetrate into the survival space of impacted carbodies in the event of collision that causes the coupler to collapse.

The anti-climbing device shall be proven effective for head-on collisions that occur on tangent track as well as an off-center contact collision that might occur on the system.

2.7 Pilot

The purpose of the pilot is to push objects off the track before they can get under the wheels of a rail transit vehicle in the event of a collision. Many other devices or structures with a different name may serve the purpose of a pilot.

The car builder should be responsible for designing the pilot to a specific design criteria approved by the rail transit system.

For light-rail operation refer to ASME's, *"Safety Standard for Structural Requirements for Light Rail Vehicles"* for guidance on cab end design and the use of pilots.

2.8 Crash energy management

After completing the hazard analyses where there is determination of an unacceptable risk of collision due to human error or a single point equipment failure, the vehicle should be protected by a CEM system that attenuates collision energy and preserves survivable space for the operator.

CEM design parameters should afford a safe operation for the operator as well as the passengers. Acceptable standards that meet these requirements include ASME's "Safety Standard for Structural Requirements for Light Rail Vehicles" and the European Standard Crashworthiness requirements for railway vehicle bodies. The crash energy management system design should be verified through a combination of component structural tests and modeling with a validated computer model.

2.9 Survival space

After a collision, space within the interior of the cab must be maintained to ensure occupant survival. Structural collapse must not intrude on a minimum volume within or around the operator. For further design parameters and further guidance on preserving a survival space for the operator, refer to the European standard EN 15227 *"Railway applications – Crashworthiness requirements of railway vehicle bodies"*.

2.10 Ergonomics of the cab seat

An ergonomically designed operator's seat should be installed that provides the range of adjustment and comfort required to minimize operator discomfort and fatigue for the duration of the longest work period. Selection of operator's seating shall be based on a documented ergonomics study or a history of acceptable in-service experience of identical seating.

2.11 Cab emergency lighting

The cab should be designed with emergency lighting that meets the requirements of APTA Standard APTA RT-VIM-S-020-10 *"Standard for Emergency Lighting System Design for Rail Transit Vehicles".*

2.12 Cab design for rapid evacuation

The cab should be designed to be free of any obstructions that may impede the operator from rapid evacuation of the cab in the event of fire, impeding collision or other emergency situations. See sections 2.13 and 2.21 for additional recommendations.

2.13 Secondary emergency exit from cab

The operator's cab should be designed with a secondary means of escape that will allow the operator to self-evacuate the cab in the event that the primary exit becomes inoperable or blocked.

2.14 Cab covert alarm

The operator's cab should be equipped with a covert alarm that allows the operator to inform central control of a duress situation without alerting any perpetrators that an alarm has been sent. This system shall also be designed to operate in the event of a vehicle power failure.

2.15 Fire suppression

Automatic fire suppression or overheat alarms should be installed in locations where early detection of a fire is impeded and fire suppression or evacuation may be delayed. Care should be taken that such systems not pose a risk to the operator or passengers. For example, avoid systems that suppress the fire by displacing oxygen. Refer to NFPA 130 *"Fixed Guideway Transit & Passenger Rail Systems"* for fire detecting suppression and protection requirements.

2.16 Ventilation control

The operator's cab should be equipped with manual ventilation controls that allow the operator to select how to set the ventilation system.

2.17 Visibility of the cab from the exterior

The operator's cab should be designed to enable police, fire department and other emergency responders to see inside the cab to assess the operator's condition.

2.18 Operator's field of view of surroundings

The operator's cab should be designed to provide the operator a maximum field of view of his or her surroundings. An uninhibited field of view allows the operator maximum response time to avoid accidents and enables the operator to detect potential security threats.

2.19 Automated vehicle tracking

The RTS rail control room should be able to determine a vehicles position on the system consistent with the requirements of the RTS system safety plan.

2.20 Operator communications

The operator should be provided with redundant (at least two independent) means to communicate with central control. These means of communication should be designed to continue to operate in the event of a vehicle power failure. The vehicle should also be designed with a means for the operator to communicate with passengers and for passengers to communicate with the operator. This system should also be designed to operate in the event of a vehicle power failure.

2.21 Cab securement

For security reasons, the operator's cab door(s) should be capable of being locked to prevent unauthorized persons from interfering with the operator performing his or her duties. Locking the operator's compartment is in line with U.S. Transportation Security Administration guidance.

The passenger accessible side of the operator's cab door(s) should not be equipped with a door handle or should be designed in a manner that prevents forced entry into this compartment.

The primary exit from the operator's compartment into the passenger compartment should be equipped with a quick exit device to allow the operator to open the door of the cab almost unimpeded in the event of an impending collision or a fire.

2.22 Other rail transit system requirements

The RTS may want to consider other operator protection devices or emergency systems similar to those outlined in APTA RT-VIM-S-026-12 *"Rail Transit Vehicle Passenger Emergency Systems."* These may include:

- Covert microphone in the cab connected to recorder and central control
- Seat belts for the operator's seat
- Curved front bumper to deflect pedestrians and road vehicles in the event of collisions.

Related APTA standards

- American Public Transportation Association (APTA), *"Standard for Crew Cab Seating Design and Performance,"* APTA PR-CS-S-011-99 (Previously numbered as APTA SS-C&S-011-99).
- American Public Transportation Association (APTA*), "Standard for Emergency Lighting System Design for Rail Transit Vehicles,"* APTA RT-VIM-S-020-10 (Previously numbered as APTA RT-S-VIM-020-08, 2008).
- American Public Transportation Association (APTA) *"Rail Transit Vehicle Passenger Emergency Systems"* APTA RT-VIM-S-026-12
- American Public Transportation Association (APTA), "Standard for the Design and Construction of Passenger Railroad Rolling Stock," APTA PR-CS-S-034-06 Rev 2 (Previously numbered as APTA SS-C&S-034 Rev 2, 2006).

References

- American National Standards Institute (ANSI), *"American National Standard for Safety Glazing Materials for Glazing Motor Vehicles and Motor Vehicle Equipment Operating on Land Highways – Safety Standard,"* Z26.1, 1996.
- American Society of Mechanical Engineers (ASME), *"Safety Standard for Structural Requirements for Light Rail Vehicles,"* Standards Committee on Rail Transit Vehicles RT-1, 2009.
- American Society of Mechanical Engineers (ASME), *"Safety Standard for Structural Requirements for Heavy Rail Transit Vehicles,"* Standards Committee on Rail Transit Vehicles RT-2, 2009.
- Code of Federal Regulations, 49 CFR Part 223 and 49 CFR Part 238.
- European Committee for Standardization (CEN), *"Railway applications. Crashworthiness requirements for railway vehicle bodies"* EN 15227-2008.
- National Fire Protection Association (NFPA) *"Standard for Fixed Guideway Transit Passenger Rail Systems"* NFPA 130

Definitions

anti-climber: A structural member located at each end of the vehicle, used to engage the anti-climber of an opposing or other coupled vehicle to resist relative vertical travel between the two car bodies during a collision. In articulated vehicles, the articulation system is designed to act as an anti-climber.

crash energy management: Crash energy management is a method of design and manufacture of vehicle structures that enhances crashworthiness by assigning certain sections of the carbody the task of absorbing a portion of the energy of collision by crushing in a controlled manner in order to preserve occupant volume and minimize the consequences of occupant impacts with the vehicle interior. The controlled crushing and energy absorption functions are typically assigned to special carbody structural members in the structural energy absorption zone that are designed to crush in a predictable and stable manner over a distance that depends on the design of the member and the desired amount of energy absorption.

operator: The on-board crewmember controlling the operation of a rail transit vehicle. Also called the driver or engineer.

pilot: A component of a rail transit vehicle designed to strike and deflect objects on the track to prevent the objects from getting under the vehicle's wheels and possibly causing a derailment.

pushback coupler: A type of coupler designed to trigger at a certain coupling speed, which absorbs a specified amount of collision energy as it is pushed back through its stroke.

Abbreviations and acronyms

AAR Association of American Railroads
ANSI American National Standards Institute
APTA American Public Transportation Association
ASME American Society of Mechanical Engineers
CEM crash energy management
CFR Code of Federal Regulations
FRA Federal Railroad Administration
NATSA North American Transit Services Association
RTS Rail transit system

Summary of changes

This is a new document therefore there are no changes.

Document history

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