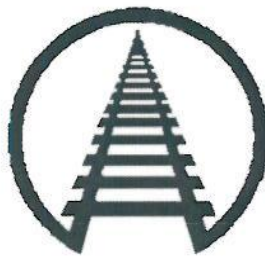


LOCOMOTIVE CRASHWORTHINESS REQUIREMENTS

**Standard
S-580
Adopted December 2004
Revised: July 2005**

Prepared for



**ASSOCIATION
OF AMERICAN
RAILROADS**

1.0 SCOPE

These specifications for crashworthiness enhancements cover requirements applicable to all new road type locomotives, except for passenger-occupied vehicles, manufactured after December 31, 2008 for use on standard gauge track on North American railroads in revenue freight service or in commuter/passenger service.

1.1 The following locomotives are exempted from this standard:

- Locomotive not equipped with an operator's cab structure.
- Locomotive which is designated and marked in cab "Trail Only-Do Not Occupy (Except Hostlers)"

2.0 PURPOSE

2.1 The primary purpose of these requirements is to minimize the potential for injuries and fatalities to train crews and others involved in the transportation of freight and passengers.

3.0 BACKGROUND

3.1 This specification provides design requirements for locomotives with improved crashworthiness features. The design requirements were developed as enhancements to AAR S-580 (1989) by the Locomotive Crashworthiness Working Group of the Railroad Safety Advisory Committee (RSAC), a federally-chartered advisory committee. This Working Group was comprised of AAR member railroads, rail labor, locomotive manufacturers, the Federal Railroad Administration, and the National Transportation Safety Board. This specification has been approved for use by the Federal Railroad Administration under the locomotive crashworthiness requirements of 49 CFR Part 229, Subpart D.

4.0 DEFINITIONS

4.1 DUAL CAB means a locomotive design incorporating cab structures at each end (longitudinally) of the vehicle.

4.2 MONOCOQUE DESIGN LOCOMOTIVE means a locomotive design where the shell or skin acts as a single unit with the supporting frame to resist and transmit the loads acting on the locomotive.

4.3 NARROW-NOSE LOCOMOTIVE means a locomotive with a short hood that spans substantially less than the full width of the locomotive.

4.4 PERMANENT DEFORMATION means the undergoing of a permanent change in shape of a structural member of a rail vehicle.

4.5 ROOF RAIL means the longitudinal structural member at the intersection of the sidewall and the roof sheathing.

4.6 SEMI-MONOCOQUE DESIGN LOCOMOTIVE means a locomotive design where the shell or skin acts, to some extent, as a single unit with the supporting frame to resist and transmit the loads acting on the locomotive.

4.7 SKIN means the outer covering of a fuel tank and a rail vehicle. The skin may be covered with another coating of material such as fiberglass.

4.8 ULTIMATE STRENGTH means the capacity of a structure to resist a load, which, when exceeded, causes the structure to fail due to excessive buckling, yielding and/or fracture such that the structure can no longer function as intended.

4.9 WIDE-NOSE LOCOMOTIVE (North American cab) means a locomotive used in revenue freight or commuter/passenger service which is not of narrow-nose or monocoque/semi-monocoque design.

4.10 YIELD STRENGTH means the capacity of a structure to resist a load which, when exceeded, causes permanent deformation of the structure.

5.0 GENERAL PROVISIONS

5.1 Unless specifically stated otherwise, all loads are applied opposite the direction of locomotive travel. The locomotive is assumed to be operated cab-end forward. For dual cab designs, both ends of the locomotive must meet applicable requirements of this standard.

6.0 REQUIREMENTS FOR WIDE-NOSE LOCOMOTIVES

6.1 ANTI-CLIMBERS

6.1.1 Width: Each locomotive must have an anti-climber that extends to the approximate 1/3 points across the width on its cab end.

6.1.2 Depth: The center of the anti-climber must extend to within 4" of the pulling face of the coupler with the draft gear fully compressed and be no less than 10" from the locomotive front plate for its required width.

6.1.3 Load: The anti-climber must be able to resist an upward or downward vertical force of 100,000 lbs. applied over a 12" width anywhere along the anti-climber perimeter.

6.1.4 Criteria: The load must be applied without exceeding the ultimate strength of the anti-climber.

6.2 COLLISION POSTS (See Figure 1)

6.2.1 Each locomotive must be equipped with at least two collision posts or equivalent structures which are located:

- at the approximate 1/3 points across the width of the locomotive,
- in their entirety forward of the seating position of any crew person, and
- must extend in height to a distance 24" above the finished cab floor.

6.2.2 Each collision post must be continuously attached /welded to the front skin and roof of the short hood.

6.2.3 Each collision post must withstand the following loads without exceeding the ultimate strength of the posts and their attachments to the underframe:

- A 750,000-lb.load applied over the bottom 10% of the overall height of the collision post at the base (Ps), at any angle in the horizontal plane in the range of +/- 15 degrees of the longitudinal axis of the locomotive;
- A 500,000-lb.load applied over an area, the width of the post structure and the height of 10% of the overall height of the post on each collision post, centered at a height 30 inches above the top of the underframe (Pm-1), at any angle in the horizontal plane in the range of +/- 15 degrees of the longitudinal axis of the locomotive; and
- Any load (Pm-2):
 - o that is applied at a vertical location greater than 30 inches above the top of the underframe up to the top of the collision post,
 - o which develops the same moment at the base as a 500,000-lb. load applied at 30 inches above the underframe ($F*L=15,000,000$ inch-pounds for $L>30$ inches where L =height above underframe),
 - o that is applied at any angle in the horizontal plane in the range of +/- 8 degrees of the longitudinal axis of the locomotive, and
 - o that is distributed over an area the width of the post and 10% of the height of the post.

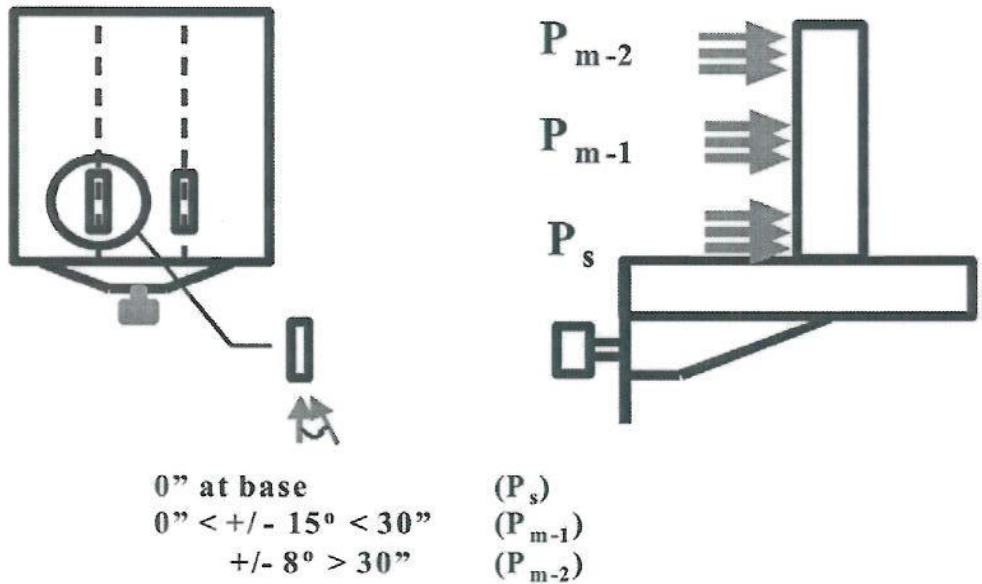


Figure 1. Schematic of Collision Post Loads.

6.3 EMERGENCY EGRESS

6.3.1 The locomotive cab must allow for exit through at least one opening (e.g. engineer's side door, nose door, windows) in any locomotive orientation.

6.4 EMERGENCY INTERIOR LIGHTING

6.4.1 Illumination design shall provide sufficient illumination, within the cab area, to allow for safe egress from the locomotive cab in the event of a collision.

6.4.2 Emergency interior lighting shall activate automatically upon emergency brake application for a minimum of 20 minutes at the following levels: the exit path from each seat position to each exit door shall be automatically illuminated to a level of 0.5 LUX in general and 2.5 LUX on each stair step to be negotiated to the exit door and 2.5 LUX at each door threshold higher than one inch. Illumination shall be measured at floor level and perpendicular to the floor.

6.4.3 Emergency interior lighting shall operate in all equipment orientations.

6.4.4 The locomotive main battery system or a separate battery power source shall provide for a manual reset to extinguish emergency interior lighting (not required if other power source is utilized).

6.5 FUEL TANK

6.5.1 Each main diesel fuel tank used for the propulsion prime mover must meet the requirements of AAR Standard S-5506, PERFORMANCE REQUIREMENTS FOR DIESEL ELECTRIC LOCOMOTIVE FUEL TANKS (October 1, 2001), latest revision.

6.6 INTERIOR CONFIGURATION

6.6.1 Protruding parts, sharp edges, and corners in a locomotive cab must be rounded, radiused, or padded to mitigate the consequences of an occupant impact with such surfaces.

6.6.2 All appurtenances mounted in the locomotive cab, including cab seats, must be securely fastened and capable of withstanding without permanent deformation the following service forces:

- Longitudinal: 3.0 g
- Lateral: 1.5 g
- Vertical: 2.0 g

6.7 SHORT HOOD STRUCTURE

6.7.1 The short hood must be capable of supporting a longitudinal load of 400,000 lbs. applied to the front of the short hood in the upper corner over an area that is 12 inches wide starting 30 inches above the top of the deck and extending to the nose cab roof sheet without exceeding ultimate strength (see Figure 2). An acceptable method other than finite element analysis of determining compliance with above is the load-thickness formula that follows. A short hood capable of meeting this requirement has its side and top surface material properties determined by the formula contained in Section 6.7.2. The length of the short hood must be at least one-half the total height for the equation to be applicable. The base of the short hood must be securely and continuously attached to the locomotive underframe to develop the full strength of the connection.

6.7.2 The minimum sheet thicknesses of the short hood skin must be selected to satisfy the formula:

$$P_m = 6.36 \sigma_o (b_1 t_1^2 + b_2 t_2^2)^{1/3} (t_1 t_2) / (t_1 + t_2)$$

Where: P_m = mean crush force (400,000 lbs.)

b_1 = half dimension of short hood roof width (~60 inches ("))

b_2 = average hood height (~60")

t_1 = thickness of short hood roof structure

t_2 = thickness of side-walls

σ_o = material flow stress ($\sim (\sigma_y * \sigma_u)^{0.5}$) [See Section 6.7.2.1]

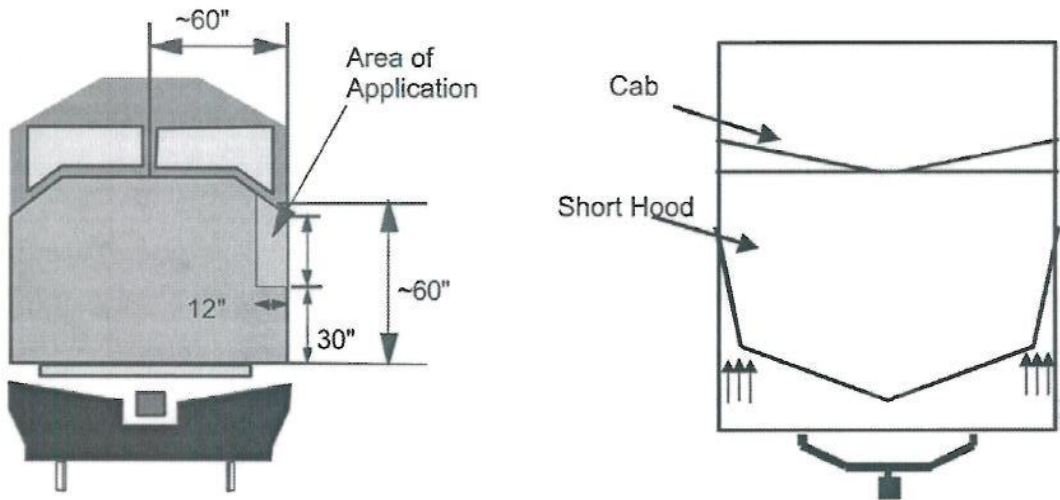


Figure 2. Diagram of Short Hood Load Application.

6.7.2.1 The flow stress is given by the formula:

$$\sigma_o = (\sigma_y * \sigma_u)^{0.5}$$

Where: σ_y = the material yield stress, in pounds per square inch (PSI), and

σ_u = the material ultimate stress, in PSI.

6.7.3 All skin on the front-facing portion of the short hood, including personnel doors, must be the equivalent strength of 1/2-inch thick steel plate at 25,000 PSI yield strength (Thinner high strength steel may be substituted where thickness varies inversely with the square root of yield strength).

6.7.4 Any windows must meet FRA glazing standards per 49 CFR Part 223.

6.8 TRUCK ATTACHMENT

6.8.1 Attachment of each truck to the frame of the locomotive must withstand an equivalent ultimate shear value of 250,000 pounds in line with the longitudinal centerline of the locomotive.

6.9 UNDERFRAME STRENGTH

6.9.1 The underframe must be capable of withstanding a longitudinal load of 1,000,000 lbs. applied at the inner draft stops without permanent deformation of the body structure.

7.0 REQUIREMENTS FOR NARROW-NOSE LOCOMOTIVES

7.1 ANTI-CLIMBERS

7.1.1 Narrow-nose locomotives must meet the anti-climber requirements for wide-nose locomotives in Section 6.1 of this Standard.

7.2 COLLISION POSTS

7.2.1 Narrow-nose locomotives must meet collision post requirements for wide-nose locomotives in Section 6.2 of this Standard.

7.3 EMERGENCY EGRESS

7.3.1 The locomotive cab must allow for exit through at least one opening (e.g. engineer's side door, nose door, windows) in any locomotive orientation.

7.4 EMERGENCY INTERIOR LIGHTING

7.4.1 Illumination design shall provide sufficient illumination, within the cab area, to allow for safe egress from the locomotive cab in the event of a collision.

7.4.2 Emergency interior lighting shall activate automatically upon emergency brake application for a minimum of 20 minutes at the following levels: the exit path from each seat position to each exit door shall be automatically illuminated to a level of 0.5 LUX in general and 2.5 LUX on each stair step to be negotiated to the exit door and 2.5 LUX at each door threshold higher than one inch. Illumination shall be measured at floor level and perpendicular to the floor.

7.4.3 Emergency interior lighting shall operate in all equipment orientations.

7.4.4 The locomotive main battery system or a separate battery power source shall provide for a manual reset to extinguish emergency interior lighting (not required if other power source is utilized).

7.5 FUEL TANK

7.5.1 Narrow-nose locomotives must meet fuel tank requirements for wide-nose locomotives in Section 6.5 of this Standard.

7.6 OPERATOR'S CAB CORNER POSTS

7.6.1 Corner posts must be provided at all corners of the cab structure.

7.6.2 Each corner post, supporting structure, and intervening connection must resist the following horizontal loads individually applied in the direction stated:

- Minimum of 300,000 lbs. applied at a point even with the top of the underframe without exceeding the ultimate strength of the post. This load must be applied at any angle in the horizontal plane in the range of +/- 8 degrees from the longitudinal axis of the locomotive.
- Minimum of 100,000 lbs. applied at a height from the finished cab floor to a point 30 inches above the finished floor of the cab. This load must be applied at any angle in the horizontal plane in the range of +/- 8 degrees from the longitudinal axis of the locomotive. This load must be applied without exceeding the ultimate strength of the post or its connections.
- Minimum of 45,000 lbs. applied anywhere between the top of the post at its connection to the roof structure and the top of the underframe without exceeding the ultimate strength of the post or its connections. This load must be applied toward the inside of the locomotive in any direction from the longitudinal to the transverse.

7.7 OPERATORS CAB AND HOOD STRUCTURE

7.7.1 The skin of the short hood end-facing area shall be equivalent to ½" steel plate at 25,000 PSI yield strength (where thickness varies inversely with the square root of yield strength).

7.7.2 This end nose plate assembly shall be securely fastened to the collision posts.

7.7.3 Any personnel doors in the short hood end-facing area shall be suitably reinforced to the equivalent strength of the short hood skin.

7.7.4 Any windows must meet Federal Railroad Administration (FRA) standards.

7.8 TRUCK ATTACHMENT

7.8.1 Attachment of each truck to the frame of the locomotive must withstand an equivalent ultimate shear value of 250,000 pounds in line with the longitudinal centerline of the locomotive.

7.9 UNDERFRAME STRENGTH

7.9.1 Narrow-nose locomotives must meet underframe strength requirements for wide-nose road freight locomotives in Section 6.8 of this standard.

8.0 MONOCOQUE OR SEMI-MONOCOQUE LOCOMOTIVE DESIGNS

8.1 ANTI-CLIMBERS

8.1.1 Monocoque design and semi-monocoque design locomotives must meet the anti-climber design requirements for wide-nose locomotives in Section 6.1 of this Standard.

8.2 CAR BODY UNDERFRAME STRENGTH

8.2.1 The underframe must be capable of withstanding a longitudinal load of 800,000 pounds applied at the inner draft stops without permanent deformation of the body structure.

8.3 COLLISION POSTS

8.3.1 Collision posts must be located at the approximate 1/3 points across the width of the vehicle and must, in their entirety, be forward of the seating position of any crew person.

8.3.2 Each collision post, supporting car body structure, and intervening connection must resist the following loads individually applied at any angle in the horizontal plane in the range of +/- 8 degrees of the longitudinal axis of the locomotive.

- Minimum 500,000 lbs. applied at a point even with the top of the underframe, without exceeding the ultimate strength of the post and its attachment;
- Minimum 200,000 lbs. applied at a point 30 inches above the top of the underframe, without exceeding the ultimate strength of the post and its attachment; and
- Minimum 60,000 lbs. applied anywhere along the post above the top of the underframe, without permanent deformation.

8.3.3 The area properties of the collision posts, including any reinforcement required to provide the specified 500,000 lb. shear strength at the top of the underframe, must extend from the bottom of the end sill to at least 30 inches above the top of the underframe.

8.4 CORNER POSTS

8.4.1 The forward end structure shall have two full-height corner posts, or equivalent structure.

8.4.2 Each corner post shall be capable of withstanding the following:

- A horizontal, longitudinal or lateral shear load 300,000 pounds applied at its joint with the underframe. This load shall be applied without exceeding the ultimate strength of the joint.
- A horizontal, longitudinal, or lateral force of 100,000 pounds applied at a point 18 inches above the top of the underframe. This load shall be applied without exceeding ultimate strength.
- A minimum load of 45,000 pounds applied anywhere between the top of the post at its connection to the roof structure and the top of the underframe, without permanent deformation.

8.4.3 Corner posts in locomotives with isolated cabs may be discontinuous at the boundary of the isolated cab, but shall otherwise meet the requirements of this part for corner posts. This may require intermediate supports for the portions of the corner posts of the locomotive platform structure and in the isolated cab, and limit stops on the possible displacement of the isolated cab.

8.5 FUEL TANK 8.5.1 Monocoque and semi-monocoque design locomotives must meet the fuel tank requirements for wide-nose locomotives in Section 6.5 of this Standard.

8.6 ROOF LOAD & END STRUCTURE

8.6.1 Each roof rail shall be able to support a longitudinal load of 80,000 pounds without permanent deformation.

8.6.2 Under load conditions that cause permanent deformation of the end structure, the roof structure must help support the load.