the railroad which addresses the location and quantity of the materials used, as well as vulnerability of the materials to ignition, flame spread, and smoke generation. These provisions are intended to address potential carrying portions of a vehicle’s roof and the interior structure separating the levels of a bi-level car, but do not include a flooring assembly subject to the direct impact of a vehicle’s roof. The provisions are intended to use the ASTM E 119–00a test method.


APPENDIX C TO PART 238 [RESERVED]

APPENDIX D TO PART 238—REQUIREMENTS FOR EXTERNAL FUEL TANKS ON TIER I LOCOMOTIVES

The requirements contained in this appendix are intended to address the structural and puncture resistance properties of the locomotive fuel tank to reduce the risk of fuel spillage to acceptable levels under derailment and minor collision conditions.

(a) Structural strength—(1) Load case 1—minor derailment. The end plate of the fuel tank shall support a sudden loading of one-half the weight of the car body at a vertical acceleration of 2g, without exceeding the ultimate strength of the material. The load is assumed to be supported on one rail, within an eight inch band (plus or minus) at a point nominally above the head of the rail, on tangent track. Consideration should be given in the design of the fuel tank to maximize the vertical clearance between the top of the rail and the bottom of the fuel tank.

(2) Load case 2—jackknifed locomotive. The fuel tank shall support transversely at the center a sudden loading equivalent to one-half the weight of the locomotive at a vertical acceleration of 2g, without exceeding the ultimate strength of the material. The load is assumed to be supported on one rail, distributed between the longitudinal center line and the edge of the tank bottom, with a rail head surface of two inches.

(3) Load case 3—side impact. In a side impact collision by an 80,000 pound Gross Vehicle Weight tractor/trailer at the longitudinal center of the fuel tank, the fuel tank shall withstand, without exceeding the ultimate strength, a 290,000 pound load (2.5g) distributed over an area of six inches by forty-eight inches (half the bumper area) at a height of thirty inches above the rail (standard DOT bumper height).

(4) Load case 4—penetration resistance. The minimum thickness of the sides, bottom and end plates of the fuel tank shall be equivalent to a ⅜-inch steel plate with a 25,000 pounds-per-square-inch yield strength (where the thickness varies inversely with the square root of yield strength). The lower one third of the end plates shall have the equivalent penetration resistance by the above method of a ⅛-inch steel plate with a 25,000 pounds-per-square-inch yield strength. This may be accomplished by any combination of materials or other mechanical protection.

(b) Sideswipe. To minimize fuel tank damage during sideswipes (railroad vehicles and grade crossings), all drain plugs, clean-out ports, inspection covers, sight glasses, gauge openings, etc., must be flush with the tank surface or adequately protected to avoid catching foreign objects or breakage. All seams must be protected or flush to avoid catching foreign objects.

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(a) Structural strength—(1) Load case 1—minor derailment. The end plate of the fuel tank shall support a sudden loading of one-half the weight of the car body at a vertical acceleration of 2g, without exceeding the ultimate strength of the material. The load is assumed to be supported on one rail, within an eight inch band (plus or minus) at a point nominally above the head of the rail, on tangent track. Consideration should be given in the design of the fuel tank to maximize the vertical clearance between the top of the rail and the bottom of the fuel tank.

(2) Load case 2—jackknifed locomotive. The fuel tank shall support transversely at the center a sudden loading equivalent to one-half the weight of the locomotive at a vertical acceleration of 2g, without exceeding the ultimate strength of the material. The load is assumed to be supported on one rail, distributed between the longitudinal center line and the edge of the tank bottom, with a rail head surface of two inches.

(3) Load case 3—side impact. In a side impact collision by an 80,000 pound Gross Vehicle Weight tractor/trailer at the longitudinal center of the fuel tank, the fuel tank shall withstand, without exceeding the ultimate strength, a 290,000 pound load (2.5g) distributed over an area of six inches by forty-eight inches (half the bumper area) at a height of thirty inches above the rail (standard DOT bumper height).

(4) Load case 4—penetration resistance. The minimum thickness of the sides, bottom and end plates of the fuel tank shall be equivalent to a ⅜-inch steel plate with a 25,000 pounds-per-square-inch yield strength (where the thickness varies inversely with the square root of yield strength). The lower one third of the end plates shall have the equivalent penetration resistance by the above method of a ⅛-inch steel plate with a 25,000 pounds-per-square-inch yield strength. This may be accomplished by any combination of materials or other mechanical protection.

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(2) Load case 2—jackknifed locomotive. The fuel tank shall support transversely at the center a sudden loading equivalent to one-half the weight of the locomotive at a vertical acceleration of 2g, without exceeding the ultimate strength of the material. The load is assumed to be supported on one rail, distributed between the longitudinal center line and the edge of the tank bottom, with a rail head surface of two inches.

(3) Load case 3—side impact. In a side impact collision by an 80,000 pound Gross Vehicle Weight tractor/trailer at the longitudinal center of the fuel tank, the fuel tank shall withstand, without exceeding the ultimate strength, a 290,000 pound load (2.5g) distributed over an area of six inches by forty-eight inches (half the bumper area) at a height of thirty inches above the rail (standard DOT bumper height).

(4) Load case 4—penetration resistance. The minimum thickness of the sides, bottom and end plates of the fuel tank shall be equivalent to a ⅜-inch steel plate with a 25,000 pounds-per-square-inch yield strength (where the thickness varies inversely with the square root of yield strength). The lower one third of the end plates shall have the equivalent penetration resistance by the above method of a ⅛-inch steel plate with a 25,000 pounds-per-square-inch yield strength. This may be accomplished by any combination of materials or other mechanical protection.

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requires redesign to alter its failure consequences. Scheduled maintenance is also required for any item whose functional failure will not be evident to the operating crew, and therefore requires corrective action. In all other cases the consequences of failure are economic, and maintenance tasks directed at preventing such failures must be judged on economic grounds. All failure consequences, including economic consequences, are established by the design characteristics of the equipment and can be altered only by basic changes in the design. Safety consequences can, in nearly all cases, be reduced to economic consequences by the use of redundancy. Hidden functions can usually be made evident by instrumentation or other design features. The feasibility and cost effectiveness of scheduled maintenance depend on the inspectability of the component, and the cost of corrective maintenance depends on its failure modes and design reliability.

(d) The design reliability of equipment or components will only be achieved with an effective maintenance program. This level of reliability is established by the design of each component and the manufacturing processes that produced it. Scheduled maintenance can ensure that design reliability of each component is achieved, but maintenance alone cannot yield a level of reliability beyond the design reliability.

(e) When a maintenance program is developed, it includes tasks that satisfy the criteria for both applicability and effectiveness. The applicability of a task is determined by the characteristics of the component or equipment to be maintained. The effectiveness is stated in terms of the consequences that the task is designed to prevent. The basics types of tasks that are performed by maintenance personnel are each applicable under a unique set of conditions. Tasks may be directed at preventing functional failures or preventing a failure event consisting of the sequential occurrence of two or more independent failures which may have consequences that would not be produced by any of the failures occurring separately. The task types include:

(1) Inspections of an item to find and correct any potential failures;
(2) Rework/repair/manufacture/overhaul of an item at or before some specified time or age limit;
(3) Discard of an item (or parts of it) at or before some specified life limit; and
(4) Failure finding inspections of a hidden-function item to find and correct functional failures that have already occurred but were not evident to the operating crew.

(b) Components or systems in a reliability-based maintenance program may be defined as simple or complex. A simple component or system is one that is subject to only one or a very few failure modes. This type of component or system frequently shows decreasing reliability with increasing operating age. An age/time limit may be used to reduce the overall failure rate of simple components or systems. Here, safe-life limits, fail-safe designs, or damage tolerance-based residual life calculations may be imposed on a single component or system to play a crucial role in controlling critical failures. Complex components or systems are ones whose functional failure may result from many different failure modes and show little or no decrease in overall reliability with increasing age unless there is a dominant failure mode. Therefore, age limits imposed on complex components or systems have little or no effect on their overall failure rates.

(g) When planning the maintenance of a component or system to protect the safety and operating capability of the equipment, a number of items must be considered in the reliability assessment process:

(1) The consequences of each type of functional failure;
(2) The visibility of a functional failure to the operating crew (evidence that a failure has occurred);
(3) The visibility of reduced resistance to failure (evidence that a failure is imminent);
(4) The age-reliability characteristics of each item;
(5) The economic tradeoff between the cost of scheduled maintenance and the benefits to be derived from it;
(6) A multiple failure, resulting from a sequence of independent failures, may have consequences that would not be caused by any one of the individual failures alone. These consequences are taken into account in the definition of the failure consequences for the first failure; and
(7) A default strategy governs decision making in the absence of full information or agreement. This strategy provides for conservative initial decisions, to be revised on the basis of information derived from operating experience.

(h) A successful reliability-based maintenance program must be dynamic. Any prior-service program is based on limited information. As such, the operating organization must be prepared to collect and respond to real data throughout the operating life of the equipment. Management of the ongoing maintenance program requires an organized information system for surveillance and analysis of the performance of each item under actual operating conditions. This information is needed to determine the refinements and modifications to be made in the initial maintenance program (including the adjustment of task intervals) and to determine the need for product improvement. The information derived from operating experience may be considered to have the following hierarchy of importance in the reliability-based maintenance program:
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APPENDIX F TO PART 238—ALTERNATIVE Dynamic PERFORMANCE REQUIREMENTS FOR FRONT END STRUCTURES OF CAB CARS AND MU LOCOMOTIVES

As specified in §238.209(b), the forward end of a cab car or an MU locomotive may comply with the requirements of this appendix in lieu of the requirements of either §238.211 (Collision posts) or §238.213 (Corner posts), or both. The requirements of this appendix are intended to be equivalent to the requirements of those sections and allow for the application of dynamic performance criteria to cab cars and MU locomotives as an alternative to the requirements of those sections. The alternative dynamic performance requirements are applicable to all cab cars and MU locomotives, and may in particular be helpful for evaluating the compliance of cab cars and MU locomotives with shaped-noses or crash energy management designs, or both. In any case, the end structure must be designed to protect the occupied volume for its full height, from the underframe to the anti-telescoping plate (if used) or roof rails.

The requirements of this appendix are provided only as alternatives to the requirements of §§238.211 and 238.213, not in addition to the requirements of those sections. Cab cars and MU locomotives are not required to comply with both the requirements of those sections and the requirements of this appendix, together.

ALTERNATIVE REQUIREMENTS FOR COLLISION POSTS

(a)(1) In lieu of meeting the requirements of §238.211, the front end frame acting together with its supporting car body structure shall be capable of absorbing a minimum of 135,000 foot-pounds of energy (0.18 megajoule) prior to or during structural deformation by withstanding a frontal impact with a rigid object in accordance with all of the requirements set forth in paragraphs (a)(2) through (a)(4) of this appendix:

(2)(i) The striking surface of the object shall be centered at a height of 30 inches above the top of the underframe;

(ii) The striking surface of the object shall be offset by 19 inches laterally from the center of the cab car or MU locomotive, and on the weaker side of the end frame if the end frame’s strength is not symmetrical; and

(iii) Only the striking surface of the object interacts with the end frame structure.

(3) As a result of the impact, there shall be no more than 10 inches of longitudinal, permanent deformation into the occupied volume. There shall also be no complete separation of the post, its connection to the underframe, its connection to either the roof structure or the anti-telescoping plate (if used), or of its supporting car body structure. (A graphical description of the frontal impact is provided in Figure 1 to this appendix.)

(4) The nominal weights of the object and the cab car or MU locomotive, as ballasted, and the speed of the object may be adjusted to impart the minimum of 135,000 foot-pounds of energy (0.18 megajoule) to be absorbed (Ea), in accordance with the following formula:

\[ E_a = E_f - E_i \]

Where:

\[ E_i = \text{Energy of initially moving object at impact} = \frac{1}{2} m_1 V_0^2 \]

\[ E_f = \text{Energy after impact} = \frac{1}{2} (m_1 + m_2) V_f^2 \]

\[ V_0 = \text{Speed of initially moving object at impact} \]

\[ V_f = \text{Speed of both objects after collision} = m_1 V_0/(m_1 + m_2) \]

\[ m_1 = \text{Mass of initially moving object} \]

\[ m_2 = \text{Mass of initially standing object} \]

(Figure 1 shows as an example a cab car or an MU locomotive having a weight of 100,000 pounds and the impact object having a weight of 14,000 pounds, so that a minimum