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
portions include equipment carrying por-
tions 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 as a result of the undetected failure of a hid-
ding over an area of six inches by forty-eight
ing for the location and priority of a maintenance effort.

(b) Reliability-based maintenance pro-
grams are based on the following general
principles. A failure is an unsatisfactory con-
dition. There are two types of failures: func-
tional and potential. Functional failures are
usually reported by operating crews. Con-
versely, maintenance crews usually discover
potential failures. A potential failure is an
identifiable physical condition, which indi-
cates that a functional failure is imminent.
Potential failures are usually reported by
operating crews. Con-
versely, maintenance crews usually discover
potential failures. A potential failure is an
identifiable physical condition, which indi-
cates that a functional failure is imminent.

(1) Safety consequences, involving possible
loss of the equipment and its occupants;
(2) Operational consequences, which in-
volve an indirect economic loss as well as
the direct cost of repair;
(3) Non-operational consequences, which
involve only the direct cost of repair; or
(4) Hidden failure consequences, which in-
volve exposure to a possible multiple failure
as a result of the undetected failure of a hid-
den function.
(c) In a reliability-based maintenance pro-
gram, scheduled maintenance is required for
any item whose loss of function or mode of
failure could have safety consequences. If
preventative tasks cannot reduce the risk of
such failures to an acceptable level, the item

APPENDIX C TO PART 238 [RESERVED]

APPENDIX D TO PART 238—REQUIRE-
MENTS FOR EXTERNAL FUEL TANKS
ON TIER I LOCOMOTIVES

The requirements contained in this appen-
dix are intended to address the structural and
puncture resistance properties of the lo-
comotive fuel tank to reduce the risk of fuel
spillage to acceptable levels under derail-
ment 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 ul-
timate 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 tan-
gent 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 ul-
timate 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 im-
pact collision by an 80,000 pound Gross Vehi-
cle 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) distrib-
uted 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
sheet and end plates of the fuel tank shall be
equivalent to a 3/8-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
vertical clearance between the top of the rail
and the bottom of the fuel tank.

Load case 4—penetration resistance. The
minimum thickness of the sides, bottom
sheet and end plates of the fuel tank shall be
equivalent to a 3/8-inch steel plate with a
25,000 pounds-per-square-inch yield strength.
This may be accomplished by any combina-
tion of materials or other mechanical pro-
tection.
(b) Sideswipe. To minimize fuel tank dam-
age 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.
(c) Spill controls. Vents and fills shall be de-
signed to avert spillage of fuel in the event
of a roll over.

APPENDIX E TO PART 238—GENERAL
PRINCIPLES OF RELIABILITY-BASED
MAINTENANCE PROGRAMS

(a) Any maintenance program has the fol-
lowing four basic objectives:
(1) To ensure realization of the design level
of safety and reliability of the equipment;
(2) To restore safety and reliability to
their design levels when deterioration has
occurred;
(3) To obtain the information necessary for
design improvements of those items whose
design reliability proves inadequate; and
(4) To accomplish these goals at a min-
imum total cost, including maintenance
costs and the costs of residual failures.

(b) Reliability-based maintenance pro-
grams are based on the following general
principles. A failure is an unsatisfactory con-
dition. There are two types of failures: func-
tional and potential. Functional failures are
usually reported by operating crews. Con-
versely, maintenance crews usually discover
potential failures. A potential failure is an
identifiable physical condition, which indi-
cates that a functional failure is imminent.

The consequences of a functional failure de-
termines the priority of a maintenance effort.
These consequences fall into the following
general categories:
(1) Safety consequences, involving possible
loss of the equipment and its occupants;
(2) Operational consequences, which in-
volve an indirect economic loss as well as
the direct cost of repair;
(3) Non-operational consequences, which
involve only the direct cost of repair; or
(4) Hidden failure consequences, which in-
volve exposure to a possible multiple failure
as a result of the undetected failure of a hid-
den function.
(c) In a reliability-based maintenance pro-
gram, scheduled maintenance is required for
any item whose loss of function or mode of
failure could have safety consequences. If
preventative tasks cannot reduce the risk of
such failures to an acceptable level, the item
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 justifiable 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. 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.

(h) A successful reliability-based maintenance program must be dynamic. Any prioritized 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:
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.

**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 have a width of no more than 36 inches and a diameter of no more than 48 inches; (iii) The center of the striking surface 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 (iv) 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:

\[ E_a = E_b - E_r \]

Where:

- \( E_b \) = Energy of initially moving object at impact = \( \frac{1}{2} m_1 V_0^2 \)
- \( E_r \) = Energy after impact = \( \frac{1}{2} (m_1 + m_2) V_r^2 \)
- \( V_0 \) = Speed of initially moving object at impact.
- \( V_r \) = Speed of both objects after collision = \( m_1 V_0 / (m_1 + m_2) \)
- \( m_1 \) = Mass of initially moving object.
- \( m_2 \) = 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