U.S. Department
of Transportation

**Federal Railroad
Administration**

Memorandum

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Subject: Technical Bulletin T-13-02, Guidance Regarding the Application of Vehicle/Track Interaction Safety Standards; High-Speed and High Cant Deficiency Operations; Final Rule: Track Classes 6–9

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To: Regional Administrators, Deputy Regional Administrators, Track Specialists, Chief Inspectors, Railroad System Oversight Managers, State Program Managers, and Federal and State Track Inspectors

Purpose: This technical bulletin is intended to provide guidance to all Federal and State inspectors who perform inspections of track Classes 6 to 9.

Background: On March 13, 2013, FRA published a final rule in the Federal Register titled, "Vehicle/Track Interaction Safety Standards; High-Speed and High Cant Deficiency Operations" (Vol. 78, 16052–16126). The rule became effective on July 11, 2013. The rule revises standards for track geometry and safety limits for vehicle response to track conditions, enhances vehicle/track qualification procedures, and adds flexibility for permitting high cant deficiency train operations through curves at conventional speeds. The rule accounts for a range of vehicle types that are currently in operation, as well as vehicle types that may likely be used in future high-speed or high cant deficiency rail operations, or both. In order to take advantage of high cant deficiency operations and the resultant savings in travel time, the equipment must be qualified and the track must be maintained to more stringent standards to permit the higher speeds through curves.

As a result of the new final rule, the current Track and Rail and Infrastructure Integrity Compliance Manual needs to be updated and republished. In the interim, this technical bulletin provides guidance for the provisions that have been changed and also serves as a reference in lieu of the entire compliance manual.

For ease of reference, this technical bulletin is formulated in a style similar to the current Track and Rail and Infrastructure Integrity Compliance Manual. Only the applicable sections of

Title 49 Code of Federal Regulations (CFR) part 213, subpart G, that have been modified under this rule are shown.

PART 213—[AMENDED]

Subpart G—Train Operations at Track Classes 6 and Higher

11. Section 213.305 is amended by revising paragraphs (a)(2)(i) and (b)(2)(i) to read as follows:

§ 213.305 Designation of qualified individuals; general qualifications.

* * * * *

305(a) * * *

(2) * * *

(i) Knows and understands the requirements of this subpart that apply to the restoration and renewal of the track for which he or she is responsible;

* * * * *

305(b) * * *

(2) * * *

(i) Knows and understands the requirements of this part that apply to the inspection of the track for which he or she is responsible;

* * * * *

Guidance: This section clarifies that the requirements for a person to be qualified under subpart G concern those portions of this subpart necessary for the performance of that person's duties. This section continues to require that a person designated under it has the knowledge, understanding, and ability necessary to supervise the restoration and renewal of subpart G track, or to perform inspections of subpart G track, or both, for which he or she is responsible. At the same time, adding the text makes clear that such a designated person is not required to know or understand specific requirements of this subpart that are not necessary to fulfill that person's duties. Safety is not diminished by these changes. These changes reflect what was intended when this section was established in the 1998 final rule.

12. Section 213.307 is amended by revising the section heading and paragraph (a) to read as follows:

§ 213.307 Classes of track: operating speed limits.

307(a) *Except as provided in paragraph (b) of this section and as otherwise provided in this subpart G, the following maximum allowable speeds apply:*

Over track that meets all of the requirements prescribed in this subpart for—	*The maximum allowable operating speed for trains*

	is[1]
Class 6 track …………………………………………	*110 m.p.h.*
Class 7 track…………………………………………	*125 m.p.h.*
Class 8 track…………………………………………	*160 m.p.h.*[2]
Class 9 track…………………………………………	*220 m.p.h.*[2]

[1] *Freight may be transported at passenger train speeds if the following conditions are met:*

(1) The vehicles utilized to carry such freight are of equal dynamic performance and have been qualified in accordance with § 213.329 and § 213.345.

(2) The load distribution and securement in the freight vehicle will not adversely affect the dynamic performance of the vehicle. The axle loading pattern is uniform and does not exceed the passenger locomotive axle loadings utilized in passenger service, if any, operating at the same maximum speed.

(3) No carrier may accept or transport a hazardous material, as defined at 49 CFR 171.8, except as provided in Column 9A of the Hazardous Materials Table (49 CFR 172.101) for movement in the same train as a passenger-carrying vehicle or in Column 9B of the Table for movement in a train with no passenger-carrying vehicles.

[2] *Operating speeds in excess of 125 m.p.h. are authorized by this part only in conjunction with FRA regulatory approval addressing other safety issues presented by the railroad system. For operations on a dedicated right-of-way, FRA's regulatory approval may allow for the use of inspection and maintenance criteria and procedures in the alternative to those contained in this subpart, based upon a showing that at least an equivalent level of safety is provided.*

*   *   *   *   *

Guidance: The maximum speed for Class 9 track has been raised to 220 m.p.h.. This is to address the need for the highest speeds likely to be achieved by the most forward-looking, high-speed rail projects. FRA, through the Volpe Center, conducted research and vehicle/track interaction simulations at higher speeds and concluded that Class 9 vehicle/track safety standards can be safely extended up to 220 m.p.h. - the highest speeds proposed to date.

The rule requires the testing and evaluation of equipment for qualification purposes at a speed of 5 m.p.h. above the maximum intended operating speed, in accordance with § 213.345. For example, this will require equipment intended to operate at Class 8 track's maximum speed of 160 m.p.h. to be tested at 165 m.p.h.. The rule makes clear that operating at speeds up to 165 m.p.h. for vehicle qualification purposes under this subpart will be permitted to continue on Class 8 track, subject to the requirements for the planning and safe conduct of such test operations. These test operations are distinct from service operations on Class 8 track that will be limited to a maximum speed of 160 m.p.h..

The section heading is modified to read ''Classes of track: operating speed limits,'' using the plural form of "class." This change makes the section heading consistent with the heading for § 213.9, the counterpart to this section for lower-speed track classes.

Footnote 1 has been modified. Footnote 1 provides conditions under which freight may be transported at passenger train speeds. The second clause of footnote 1 references passenger locomotive axle loadings used in passenger service along with the freight. This clause is modified by adding the words "if any" after the reference to passenger service, to make clear that there need not be any passenger service on the same line with the freight service.

Footnote 2 has also been modified. This footnote formerly provided that operations at speeds in excess of 150 m.p.h. were authorized by FRA only in conjunction with a rule of particular applicability (RPA) addressing the overall safety of the operation as a system. As revised, footnote 2 provides that operating speeds in excess of 125 m.p.h. are authorized by this part only in conjunction with FRA regulatory approval addressing other safety issues presented by the railroad system. This change recognizes that while high-speed rail operations are subject to FRA regulatory approval, it is no longer necessary to specify that FRA regulatory approval be provided through an RPA. Likewise, this footnote also recognizes that high-speed rail operation begins at speeds above 125 m.p.h., consistent with FRA's Tier II Passenger Equipment Safety Standards in 49 CFR part 238.

In addition, Footnote 2 provides that for operations on a dedicated right-of-way, FRA's regulatory approval may allow for the use of inspection and maintenance criteria and procedures in the alternative to those contained in this subpart, based upon a showing that at least an equivalent level of safety is provided. This addition acknowledges the unique system attributes inherent in a dedicate right-of-way operation, allowing for FRA approval of alternative criteria and procedures that are appropriate and safe in such a defined operating environment.

13. Section 213.313 is added to read as follows:

§ 213.313 Application of requirements to curved track.

Unless otherwise provided in this part, requirements specified for curved track apply only to track having a curvature greater than 0.25 degree.

Guidance: This new section states that, unless otherwise provided in this part, requirements specified for curved track apply only to track having a curvature greater than 0.25 degree. This definition is intended to apply to all sections where limits for curved track are specified, unless otherwise provided.

14. Section 213.323 is amended by revising paragraph (b) to read as follows:

§ 213.323 Track gage.

* * * * *

323(b) *Gage shall be within the limits prescribed in the following table:*

Class of track	*The gage must be at least—*	*But not more than—*	*The change of gage within 31 feet must not be greater than—*
Class 6 track	4′8″………………	4′9¼″…………………	¾″
Class 7 track	4′8″………………	4′9¼″…………………	½″
Class 8 track	4′8″………………	4′9¼″…………………	½″
Class 9 track	4′8¼″……………	4′9¼″…………………	½″

Guidance: This section contains the minimum and maximum limits for gage, including limits for the change in gage within any 31-foot distance. For Class 6 track, the limit for the change in gage within any 31-foot distance has been revised from ½ inch to ¾ inch. The change is meant to address gage changes as a result of variations in track construction and daily rail temperature fluctuations. FRA conducted modeling of track with variations in gage up to ¾ inch in 31-foot distances and found no safety concerns for the equipment modeled. The modeling included actual measured track geometry with the gage variations for speeds up to 115 m.p.h.. Therefore, the revised limit for the change of gage for Class 6 track, which has a maximum permitted speed of 110 m.p.h., while reducing the burden on the track owner or railroad to maintain safe gage, will not diminish safety.

Inspectors should pay attention to special cases regarding the application of the ½-inch limit for the change in gage within any 31-foot distance in Classes 7 through 9 track. A suggestion was made to exclude up to a ¼-inch, designed widening of the gage at switch point locations to enable the stock rail and the switch point to fit smoothly together. The suggestion is not adopted in this section because such exclusion could have safety implications in these high-speed track classes, especially if the switch point geometry is poorly maintained. However, when assessing a gage change defect, inspectors should make an appropriate safety determination upon inspection of the rail head profile at the local points of concern. It is recommended that inspectors exercise their discretion to give up to ¼-inch tolerance to design modifications that are made to ensure the proper functioning of switches where adjacent gage change occurs within 31 feet of the switch point. No such consideration should be given to improperly maintained switch-point geometry.

15. Section 213.327 is revised to read as follows:

§ 213.327 Track alinement.

327(a) Uniformity at any point along the track is established by averaging the measured mid-chord offset values for nine consecutive points that are centered around that point and spaced according to the following table:

Chord Length	*Spacing*
31′……………………………………………….	*7′9″*
62′……………………………………………….	*15′6″*
124′………………………………………………..	*31′0″*

Guidance: This section is the subpart G counterpart to § 213.55. The section heading has been modified so that it reads, "Track alinement," instead of "Alinement," for clarity. The text in paragraph (a) remains substantively unchanged.

327(b) Except as provided in paragraph (c) of this section, a single alinement deviation from uniformity may not be more than the amount prescribed in the following table:

Class of track	*Tangent/ curved track*	*The deviation from uniformity of the mid-chord offset for a 31-foot chord may not be more than— (inches)*	*The deviation from uniformity of the mid-chord offset for a 62-foot chord may not be more than— (inches)*	*The deviation from uniformity of the mid-chord offset for a 124-foot chord may not be more than—(inches)*
Class 6 track	*Tangent*	*½*	*¾*	*1½*
	Curved	*½*	*⅝*	*1 ½*
Class 7 track	*Tangent*	*½*	*¾*	*1¼*
	Curved	*½*	*½*	*1 ¼*
Class 8 track	*Tangent*	*½*	*¾*	*1*
	Curved	*½*	*½*	*¾*
Class 9 track	*Tangent*	*½*	*½*	*¾*
	Curved	*½*	*½*	*¾*

Guidance: The single-deviation track alinement limits in paragraph (b) have been revised to distinguish between limits for tangent and curved track. Specifically, the 62-foot mid-chord offset (MCO) limit for Class 6 curved track has been narrowed to 5/8 inch, while the tangent track limit remains at the value of ¾ inch. This change is intended to provide consistency between the track alinement limits for track Classes 5 and 6, as the Class 5 limit for curved track in § 213.55 is 5/8 inch. The 62-foot MCO limits for Class 7 and Class 8 tangent track have been increased to ¾ inch, while the curved track limits remain at the value of ½ inch. Further, the 124-foot MCO limit for Class 8 tangent track has been increased to 1 inch, while the curved track limit remains at the value of ¾ inch. These changes are based on the results of the simulation studies for determining safe amplitudes of track geometry alinement variations. The table in paragraph (b) has been reformatted to reflect these changes.

327(c) *For operations at a qualified cant deficiency, Eu, of more than 5 inches, a single alinement deviation from uniformity of the outside rail of the curve may not be more than the amount prescribed in the following table:*

Class of track	*Track type*	*The deviation from uniformity of the mid-chord offset for a 31-foot chord may not be more than—(inches)*	*The deviation from uniformity of the mid-chord offset for a 62-foot chord may not be more than—(inches)*	*The deviation from uniformity of the mid-chord offset for a 124-foot chord may not be more than—(inches)*
Class 6 track	*Curved*	½	⅝	1¼
Class 7 track	*Curved*	½	½	1
Class 8 track	*Curved*	½	½	¾
Class 9 track	*Curved*	½	½	¾

Guidance: The former text of paragraph (c) has been moved to a new paragraph (d). This revised paragraph (c) adds tighter, single-deviation geometry limits for operations above 5 inches of cant deficiency. These additions include 31-foot, 62-foot, and 124-foot MCO limits. The track geometry limits in this paragraph are based on the results of simulation studies to determine the safe amplitudes of track geometry alinement variations. Adding these track geometry limits is necessary to provide an equivalent margin of safety for operations at higher cant deficiency.

327(d) *For three or more non-overlapping deviations from uniformity in track alinement occurring within a distance equal to five times the specified chord length, each of which exceeds the limits in the following table, each track owner shall maintain the alinement of the track within the limits prescribed for each deviation:*

Class of track	*The deviation from uniformity of the mid-chord offset for a 31-foot chord may not be more than—*	*The deviation from uniformity of the mid-chord offset for a 62-foot chord may not be more*	*The deviation from uniformity of the mid-chord offset for a 124-foot chord may not be more*

	(inches)	*than—(inches)*	*than— (inches)*
Class 6 track	⅜	½	*1*
Class 7 track	⅜	⅜	⅞
Class 8 track	⅜	⅜	½
Class 9 track	⅜	⅜	½

Guidance: This paragraph has been designated as (d) from the former paragraph (c). The text remains unchanged.

327(e) *For purposes of complying with this section, the ends of the chord shall be at points on the gage side of the rail, five-eighths of an inch below the top of the railhead. On tangent track, either rail may be used as the line rail; however, the same rail shall be used for the full length of that tangential segment of the track. On curved track, the line rail is the outside rail of the curve.*

Guidance: This newly added paragraph is an adaptation of footnotes 1 and 2 from § 213.55, and describes the ends of the chord and the line rail for purposes of complying with this section. This paragraph applies to all of the requirements in this section and is consistent with current practice.

16. Section 213.329 is revised to read as follows:

§ 213.329 Curves; elevation and speed limitations.

329(a) *The maximum elevation of the outside rail of a curve may not be more than 7 inches. The outside rail of a curve may not be lower than the inside rail by design, except when engineered to address specific track or operating conditions; the limits in § 213.331 apply in all cases.*

Guidance: Formerly, the provision had been stated in terms of the maximum crosslevel of the outside rail, with the same limits. As crosslevel is a function of elevation differences between two rails, and is specifically addressed by other provisions of this rule, specifically § 213.331, this clarification is intended to focus the provision on the maximum allowable elevation of a single rail.

The phrase "*except when engineered to address specific track or operating conditions*" is intended to address special cases, such as a turnout that comes off the high rail in a curve, to allow reverse elevation to be designed into the curve out of necessity and for safety reasons.

329(b) *The maximum allowable posted timetable operating speed for each curve is determined by the following formula—*

$$V_{max} = \sqrt{\frac{E_a + E_u}{0.0007D}}$$

Where—
V_{max} = *Maximum allowable posted timetable operating speed (m.p.h.).*
E_a = *Actual elevation of the outside rail (inches).*[6]
E_u = *Qualified cant deficiency*[7] *(inches) of the vehicle type.*
D = Degree of curvature (degrees).[8]

Guidance: The designation of V_{max} has been changed from "maximum allowable operating speed" to "maximum allowable posted timetable operating speed." The track owners/railroads can use it to establish the "posted timetable operating speed" based on the qualified cant deficiency (E_u) and the design values of elevation (E_a) and curvature (*D*). The Vmax value will then be the target or reference speed. Track inspectors can use the formula to assess compliance in two ways:

1. Calculating cant deficiency by inserting the reference V_{max}, elevation (E_a), and curvature (*D*) at the time of inspection. If the resulting actual cant deficiency is higher than the qualified cant deficiency, there is potentially a limiting speed defect.
2. Calculating maximum allowable speed by inserting the elevation (E_a), curvature (*D*) at the time of inspection, and the qualified cant deficiency (E_u). If the resulting speed is lower than the reference speed, there is potentially a limiting speed defect.

Footnote 6 was redesigned from former footnote 4. A statement within the former footnote was removed regarding the application of the V_{max} equation to the spirals on both ends of the curve if E_u exceeds 4 inches. The footnote establishes that the actual elevation, E_a, for each 155-foot track segment in the body of the curve is determined by averaging the elevation for 11 points through the segment at 15.5-foot spacing. This clarification to the footnote makes it more consistent with the manner in which the rule is intended to be applied. In calculating elevation, 10 measurements are taken from the point of concern—5 on each side—so that 11 points are actually averaged, which includes the point of concern. The V_{max} equation is intended to be applied in the body of the curve, and the actual elevation and degree of curvature are determined using the average technique defined in Footnote 6. Within spirals, where the degree of curvature

[6] *Actual elevation, E_a, for each 155-foot track segment in the body of the curve is determined by averaging the elevation for 11 points through the segment at 15.5-foot spacing. If the curve length is less than 155 feet, the points are averaged through the full length of the body of the curve.*

[7] *If the actual elevation, E_a, and degree of curvature, D, change as a result of track degradation, then the actual cant deficiency for the maximum allowable posted timetable operating speed, V_{max}, may be greater than the qualified cant deficiency, E_u. This actual cant deficiency for each curve may not exceed the qualified cant deficiency, E_u, plus one-half inch.*

[8] *Degree of curvature, D, is determined by averaging the degree of curvature over the same track segment as the elevation.*

and elevation are changing continuously, local deviations from uniform elevation and degree of curvature are governed by the limits in § 213.327 and § 213.331.

A new Footnote 7 is added to permit the vehicle type to operate at the cant deficiency for which it is approved, E_u, plus ½ inch, if the actual elevation of the outside rail, E_a, and the degree of track curvature, *D*, change as a result of track degradation. The note is intended to provide a tolerance to account for the effects of local crosslevel or curvature conditions on V_{max} that may result in the actual cant deficiency exceeding the cant deficiency approved for the equipment. The intent is to allow this tolerance for "local crosslevel or curvature conditions" that result in track degradation below the maintenance limits of the track owner/railroad. The footnote is not intended to provide a tolerance to be factored into the maintenance limits themselves. For example, if the "maximum allowable posted timetable operating speed" is based on a V_{max} corresponding to 3 inches of cant deficiency, the track owner/railroad cannot establish maintenance practices that are intended to result in operation of equipment at a speed that produces up to 3.5 inches of cant deficiency. Yet, in this example, should the equipment actually operate at a speed that produces over 3 inches of cant deficiency due to track degrading below the intended maintenance limits of the track owner/railroad, the track owner/railroad should not be penalized merely because the cant deficiency exceeds 3 inches (see below for additional guidance).

The limiting speed defect can range from a few feet to the entire curve length. Therefore, the defect length alone cannot determine whether the limiting speed defect arose from track degradation or from the failure to carry out appropriate track maintenance.

As noted above, footnote 7 provides that if the actual elevation and degree of curvature change as a result of track degradation, the actual amount of cant deficiency in a curve may be greater than the approved amount of cant deficiency, E_u, but not by more than ½ additional inch. This footnote is consistent with FRA's enforcement practice – namely, to provide a tolerance for limited exceedances of the approved amount of cant deficiency, E_u, in curves. Because a tolerance is now part of the regulation, not all exceedances are actual defects (instances of noncompliance). The inspector should only record the condition as a defect if there is evidence that the maintenance practices of the track owner/railroad created a condition where the actual amount of cant deficiency exceeded the approved value. In such case, FRA expects the track owner/railroad to take appropriate remedial actions. The inspector should consider writing a recommendation for civil penalty if the level of cant deficiency based on the maximum speed, elevation, and curvature exceeds the approved value, E_u, by more than 0.5 inch. When the actual cant deficiency is found to exceed the approved level, there are many scenarios that could involve compliance or noncompliance with the regulation, and all of these different scenarios cannot be easily described here. The inspector should consider multiple factors when determining whether to assess a defect or recommend a violation. For example, if the inspector can establish that a track has been recently machine-tamped and that it was not possible for the track to have degraded to the level of causing an exceedance of the approved cant deficiency in the time period after the tamping, the inspector may assess a defect. In another example, if the track owner/railroad voluntarily performs spot maintenance on a curve, typically by manual tamping, to bring the curve to uniformity (in terms of curvature and elevation), and the amount of cant deficiency still exceeds the approved level by a nominal amount, the inspector should exercise his or her discretion whether to assess a defect. The inspector should consider assessing a defect when the exceedance is close to the maximum tolerance, which leaves little room for further track degradation. In all cases, if the inspector cannot determine whether a condition is out of compliance, or whether to assess a defect or recommend a civil penalty, he or she should consult with the regional track specialist.

Former footnote 5 has been redesignated as footnote 8 without substantive change.

329(c) *All vehicles are considered qualified for operating on track with a cant deficiency, Eu, not exceeding 3 inches. Table 1 of appendix A to this part is a table of speeds computed in accordance with the formula in paragraph (b) of this section, when* E_u *equals 3 inches, for various elevations and degrees of curvature.*

Guidance: This paragraph provides that all vehicle types are considered qualified for up to 3 inches of cant deficiency, as allowed since the 1998 Track Safety Standards final rule.

329(d) *Each vehicle type must be approved by FRA to operate on track with a qualified cant deficiency,* E_u*, greater than 3 inches. Each vehicle type must demonstrate, in a ready-for-service load condition, compliance with the requirements of either paragraph (d)(1) or (2) of this section.*

(1) When positioned on a track with a uniform superelevation equal to the proposed cant deficiency:
  (i) No wheel of the vehicle type unloads to a value less than 60 percent of its static value on perfectly level track; and
  (ii) For passenger cars, the roll angle between the floor of the equipment and the horizontal does not exceed 8.6 degrees; or

(2) When operating through a constant radius curve at a constant speed corresponding to the proposed cant deficiency, and a test plan is submitted to and approved by FRA in accordance with § 213.345(e) and (f):
  (i) The steady-state (average) load on any wheel, throughout the body of the curve, is not less than 60 percent of its static value on perfectly level track; and
  (ii) For passenger cars, the steady-state (average) lateral acceleration measured on the floor of the carbody does not exceed 0.15g.

Guidance: The paragraph has been modified to specify the requirements for vehicle qualification over track with more than 3 inches of cant deficiency in Track Classes 6 through 9. The requirements, consistent with the standards in § 213.57 (for lower-speed track classes), limit both the vertical wheel load remaining on the raised wheels to no less than 60 percent of their static level values and carbody roll for passenger cars to no more than 8.6 degrees, with respect to the horizontal, when the vehicle is standing (stationary) on track with a uniform superelevation equal to the proposed cant deficiency.

The requirements in this paragraph (d) may be met by either static or dynamic testing, and are consistent with the requirements in § 213.57. As in § 213.57, the vehicle type must be tested in a ready-for-service condition. The rule clarifies that the vehicle type be tested in a ready-for-service condition, i.e., in the same vehicle/track performance condition in which it would be in passenger service. For example, the vehicle type may or may not be loaded to simulate passengers on board, and this information would be necessary for a complete evaluation of the vehicle's performance.

As noted, the static lean test limits the vertical wheel load remaining on the raised wheels to no less than 60 percent of their static level values and limits the roll of a passenger carbody to 8.6 degrees with respect to the horizontal, when the vehicle is standing on track with superelevation equal to the proposed cant deficiency. The dynamic test limits the steady-state vertical wheel load remaining on the low rail wheels to no less than 60 percent of their static level values and limits the lateral acceleration in a passenger car to 0.15g steady-state, when the vehicle operates through a curve at the proposed cant deficiency. This 0.15g steady-state lateral acceleration limit in the dynamic test is consistent with the 8.6-degree roll limit in the static lean test, in that it corresponds to the lateral acceleration that a passenger would experience in a standing (stationary) vehicle whose carbody is at a roll angle of 8.6 degrees with respect to the horizontal.

Measurements and supplemental research have indicated that a steady-state, carbody lateral acceleration limit of 0.15g is considered to be the maximum, steady-state lateral acceleration above which jolts from vehicle dynamic response to track deviations can present a hazard to passenger safety. While other FRA vehicle/track interaction safety criteria principally address external safety hazards that may cause a derailment, such as damage to track structure and other conditions at the wheel/rail interface, the steady-state, carbody lateral acceleration limit specifically addresses the safety of the interior occupant environment. This steady-state, carbody lateral acceleration will result in a lateral force, pulling passengers to one side of the carbody. It is not the same as sustained, carbody lateral oscillatory accelerations, or continuous side-to-side oscillations (hunting) of the carbody in response to track conditions, which could exist on both curved and tangent track.

The less stringent steady-state, carbody lateral acceleration limit and carbody roll angle limit adopted in this final rule will minimize both the need to equip vehicles with tilt systems at higher cant deficiencies and the costs associated with such features, as well. Moreover, by facilitating higher cant deficiency operations, savings may also result from shortened trip times. These savings may be particularly beneficial to passenger operations in emerging high-speed rail corridors, enabling faster operations through curves.

So that such savings will not compromise safety, FRA has adopted additional track geometry requirements for operations above 5 inches of cant deficiency, whether or not the vehicles are equipped with tilt systems. These additional track geometry requirements were developed to control undesirable vehicle response to track conditions that could pose derailment risk.

329(e) *The track owner or railroad shall transmit the results of the testing specified in paragraph (d) of this section to FRA's Associate Administrator for Railroad Safety/Chief Safety Officer (FRA) requesting approval for the vehicle type to operate at the desired curving speeds allowed under the formula in paragraph (b) of this section. The request shall be made in writing and contain, at a minimum, the following information—*

(1) A description of the vehicle type involved, including schematic diagrams of the suspension system(s) and the estimated location of the center of gravity above top of rail;

(2) The test procedure,[9] *including the load condition under which the testing was performed, and description of the instrumentation used to qualify the vehicle type, as well as the maximum values for wheel unloading and roll angles or accelerations that were observed during testing; and*

(3) For vehicle types not subject to parts 229 or 238 of this chapter, procedures or standards in effect that relate to the maintenance of all safety-critical components of the suspension system(s) for the particular vehicle type. Safety-critical components of the suspension system are those that impact or have significant influence on the roll of the carbody and the distribution of weight on the wheels.

Guidance: This paragraph clarifies the submittal requirements to FRA to obtain approval for the qualifying cant deficiency of a vehicle type, including that the load condition under which the testing is performed is included in the description of the test procedure. Additional clarification in this paragraph has been included for submitting suspension system maintenance information. The requirement for submitting suspension system maintenance information applies to vehicle types not subject to 49 CFR parts 238 or 229, such as a freight car operated in a freight train, and then only to safety-critical components.

Footnote 9 (former footnote 6) has been modified in conformance with the changes in this final rule. This footnote has been modified to reference testing at "the proposed cant deficiency," rather than a specific condition, consistent with the requirements of this section. The statement in the former footnote that the "test procedure may be conducted in a test facility" has been removed. The statement could cause confusion that testing may be conducted only in a test facility. No such limitation is intended.

329(f) *In approving the request made pursuant to paragraph (e) of this section, FRA may impose conditions necessary for safely operating at the higher curving speeds. Upon FRA approval of the request, the track owner or railroad shall notify FRA in writing no less than 30 calendar days prior to the proposed implementation of the approved higher curving speeds allowed under the formula in paragraph (b) of this section. The notification shall contain, at a*

[9] *The test procedure may be conducted whereby all the wheels on one side (right or left) of the vehicle are raised to the proposed cant deficiency, the vertical wheel loads under each wheel are measured, and a level is used to record the angle through which the floor of the vehicle has been rotated.*

minimum, identification of the track segment(s) on which the higher curving speeds are to be implemented.

Guidance: The paragraph requires that a track owner/railroad notify FRA prior to the implementation of the approved higher curving speeds. The paragraph also clarifies that in approving the request made pursuant to paragraph (e), FRA may impose conditions necessary for safely operating at the higher curving speeds.

329(g) *The documents required by this section must be provided to FRA by:*

(1) The track owner; or

(2) A railroad that provides service with the same vehicle type over trackage of one or more track owner(s), with the written consent of each affected track owner.

Guidance: This paragraph (g) (formerly paragraph (f)) is identical to two other provisions in § 213.57(g)—the counterpart to this section for lower-speed track classes—and § 213.345(i) (see guidance for § 213.345(i)).

329(h) *(1) Vehicle types permitted by FRA to operate at cant deficiencies, E_u, greater than 3 inches but not more than 5 inches shall be considered qualified under this section to operate at those permitted cant deficiencies for any Class 6 track segment. The track owner or railroad shall notify FRA in writing no less than 30 calendar days prior to the proposed implementation of such curving speeds in accordance with paragraph (f) of this section.*

(2) Vehicle types permitted by FRA to operate at cant deficiencies, Eu, greater than 5 inches on Class 6 track, or greater than 3 inches on Class 7 through 9 track, shall be considered qualified under this section to operate at those permitted cant deficiencies only for the previously operated or identified track segments(s). Operation of these vehicle types at such cant deficiencies and track class on any other track segment is permitted only in accordance with the qualification requirements in this subpart.

Guidance: This paragraph provides "portability" by allowing vehicles already qualified to operate between 3 and 5 inches cant deficiency to operate on different track segments and by eliminating redundant testing for vehicle types that have been safely operated at the permitted cant deficiency. The rationale for this portability is that the tests in this section, as in § 213.57 for lower-speed track classes, are not location-specific because they can be conducted at a static testing facility, and this portability of qualification for these amounts of cant deficiency can be safely allowed for Class 6 track speeds. Nonetheless, this paragraph (f) does require that the track owner/railroad still needs to notify FRA no less than 30 calendar days prior to the proposed implementation of such curving speeds on another Class 6 track segment. This notice is intended to identify the new track segments so that FRA can ensure that appropriate permission has been provided for the proposed operation, and otherwise administer the requirements of this rule.

The provision in paragraph (h)(2) restricts the "portability" of cant deficiency qualification for vehicle types that have been permitted by FRA to operate at cant deficiencies greater than 5 inches on Class 6 track, or greater than 3 inches on Class 7 to 9 track. Operations under these conditions over different track segments must be newly qualified in accordance with this rule.

329(i) *As used in this section and in §§ 213.333 and 213.345—*

(1) Vehicle means a locomotive, as defined in § 229.5 of this chapter; a freight car, as defined in § 215.5 of this chapter; a passenger car, as defined in § 238.5 of this chapter; and any rail rolling equipment used in a train with either a freight car or a passenger car.

(2) Vehicle type means like vehicles with variations in their physical properties, such as suspension, mass, interior arrangements, and dimensions that do not result in significant changes to their dynamic characteristics.

Guidance: This paragraph (i) clarifies "vehicle" and "vehicle type." The paragraph is of particular importance when determining if a vehicle type is subject to the qualification requirements of this section. For example, a vehicle type with modified primary springs to improve high-speed performance may be considered a new vehicle type.

17. Section 213.331 is revised to read as follows:

§ 213.331 Track surface.

331(a) *For a single deviation in track surface, each track owner shall maintain the surface of its track within the limits prescribed in the following table:*

Track surface (inches)	*Class of track*			
	6	*7*	*8*	*9*
The deviation from uniform[1] profile on either rail at the mid-ordinate of a 31-foot chord may not be more than ……………………	*1*	*1*	*¾*	*½*
The deviation from uniform profile on either rail at the mid-ordinate of a 62-foot chord may not be more than …………………….	*1*	*1*	*1*	*¾*
Except as provided in paragraph (b) of this section, the deviation from uniform profile on either rail at the mid-ordinate of a 124-foot chord may not be more than ……………….	*1¾*	*1½*	*1¼*	*1*
The deviation from zero crosslevel at any point on tangent track may not be more than[2] ……….	*1*	*1*	*1*	*1*
Reverse elevation on curves may not be more than ………………………………………	*½*	*½*	*½*	*½*
The difference in crosslevel between any two points less than 62 feet apart may not be more than[3] ………………………………….	*1½*	*1½*	*1¼*	*1*

On curved track, the difference in crosslevel between any two points less than 10 feet apart (short warp) may not be more than	*1¼*	*1⅛*	*1*	*¾*

[1] Uniformity for profile is established by placing the midpoint of the specified chord at the point of maximum measurement.
[2] If physical conditions do not permit a spiral long enough to accommodate the minimum length of runoff, part of the runoff may be on tangent track.
[3] However, to control harmonics on jointed track with staggered joints, the crosslevel differences shall not exceed 1 inch in all of six consecutive pairs of joints, as created by seven low joints. Track with joints staggered less than 10 feet apart shall not be considered as having staggered joints. Joints within the seven low joints outside of the regular joint spacing shall not be considered as joints for purposes of this footnote.

Guidance: There are three changes to the single-deviation, track surface limits in this paragraph:

1. The 124-foot MCO limit for Class 9 track has been reduced to 1 inch, based on a review of simulation results of Acela equipment performance.
2. The limit for the difference in crosslevel between any two points less than 62 feet apart (62-foot warp) has been reduced to 1¼ inches for Class 8 track, and 1 inch for Class 9 track. These two changes are intended to provide more consistent safety limits and are based on simulation studies conducted for short warp conditions.
3. New limits have been added:
   a. The deviation from zero crosslevel on tangent track is carried over from Class 5 track.
   b. The ½-inch reverse elevation limit for curved track was transcribed from the text formerly specified in § 213.329(a).
   c. A new limit for the difference in crosslevel between any two points less than 10 feet apart (short warp) has been added to this paragraph.

331(b) *For operations at a qualified cant deficiency, Eu, of more than 5 inches, a single deviation in track surface shall be within the limits prescribed in the following table:*

Track surface (inches)	*Class of track*			
	6	*7*	*8*	*9*
The difference in crosslevel between any two points less than 10 feet apart (short warp) may not be more than	*1¼*	*1*	*1*[1]	*¾*
The deviation from uniform profile on either rail at the mid-ordinate of a 124-foot chord may not be more than	*1½*	*1¼*	*1¼*	*1*

[1] For curves with a qualified cant deficiency, E_u, of more than 7 inches, the difference in crosslevel between any two points less than 10 feet apart (short warp) may not be more than three-quarters of an inch.

Guidance: Former paragraph (b) has redesignated as paragraph (c). New paragraph (b) contains tighter geometry limits for operations above 5 inches of cant deficiency on curves. These include tighter limits for 124-footMCO and 10-foot warp (the difference in crosslevel between any two points less than 10 feet apart). Please note that the limits in paragraph (a) continue to apply unless they are superseded by the limits in paragraph (b). Specifically, for operations above 5 inches of cant deficiency, the limits in rows 1 to 2 and 4 through 6 in paragraph (a) are still applicable.

Further, inspectors are reminded that the trigger for the limits in paragraph (b) is a cant deficiency greater than 5 inches. If a geometry exception in table (b) is encountered, the railroad may lower the speed that will no longer result in a cant deficiency more than 5 inches. In this case, the limits in table (a) apply. In case the speed reduction effectively places the track into track Class 5 or even lower, the limits in 213.63 apply.

331(c) *For three or more non-overlapping deviations in track surface occurring within a distance equal to five times the specified chord length, each of which exceeds the limits in the following table, each track owner shall maintain the surface of the track within the limits prescribed for each deviation:*

Track surface (inches)	*Class of track*			
	6	*7*	*8*	*9*
The deviation from uniform profile on either rail at the mid-ordinate of a 31-foot chord may not be more than	¾	¾	½	⅜
The deviation from uniform profile on either rail at the mid-ordinate of a 62-foot chord may not be more than	¾	¾	¾	½
The deviation from uniform profile on either rail at the mid-ordinate of a 124-foot chord may not be more than	1¼	1	⅞	⅝

Guidance: The paragraph has been redesignated from former paragraph (b). The limits in this paragraph are intended to restrict repeating occurrences of track geometry conditions, each of which may not represent an exception as an individual event. Please note that the 124-ft profile MCO limit has been tightened from 7/8 inch to 5/8 inch.

18. Section 213.332 is added to subpart G to read as follows:

§ 213.332 Combined track alinement and surface deviations.

332(a) *This section applies to any curved track where operations are conducted at a qualified cant deficiency, Eu, greater than 5 inches, and to all Class 9 track, either curved or tangent.*

332(b) *For the conditions defined in paragraph (a) of this section, the combination of alinement and surface deviations for the same chord length on the outside rail in a curve and on any of the two rails of a tangent section, as measured by a TGMS, shall comply with the following formula: On any curved track where operations are conducted at a qualified cant deficiency, Eu, greater than 5 inches, the combination of alinement and surface deviations for the same chord length on the outside rail in the curve, as measured by a TGMS, shall comply with the following formula:*

$$\frac{3}{4} \times \left| \frac{A_m}{A_L} + \frac{S_m}{S_L} \right| \leq 1$$

Where—

A_m = measured alinement deviation from uniformity (outward is positive, inward is negative).

A_L = allowable alinement limit as per § 213.327(c) (always positive) for the class of track.

S_m = measured profile deviation from uniformity (down is positive, up is negative).

S_L = allowable profile limit as per § 213.331(a) and § 213.331(b) (always positive) for the class of track.

$\left| \frac{A_m}{A_L} + \frac{S_m}{S_L} \right|$ *= the absolute (positive) value of the result of* $\frac{A_m}{A_L} + \frac{S_m}{S_L}$.

Guidance: This new section contains limits addressing combined track alinement and surface deviations. These limits apply to high-speed operations on curved track above 5 inches of cant deficiency, as well as to any operation at Class 9 speeds.

The equation is given for computing the combined track alinement and surface deviations within a single chord length. The limits are intended to be used only with a TGMS. These limits are applicable on the outside rail in curves, as well as to any of the two rails of a tangent section in Class 9 track. The rationale discussed in section § 213.65, the companion provision to this section for lower-speed classes of track, also applies to this section. Please also note that in accordance with § 213.313, the limits specified for curved track apply only to track having a curvature greater than 0.25 degree.

19. Section 213.333 is amended by revising the section heading, paragraphs (a), (b)(1) and (2), and (c), paragraph (g) introductory text, paragraphs (h) through (m), and the Vehicle/Track Interaction Safety Limits table to read as follows:

§ 213.333 Automated vehicle-based inspection systems.

General Guidance: This section contains requirements for automated, vehicle-based measurement systems - i.e., track geometry measurement systems, gage restraint measurement systems, and the systems necessary to monitor vehicle/track interaction (acceleration and wheel/rail forces). The section heading is revised as "Automated vehicle inspection systems" to reflect more clearly that the inspection systems are vehicle-based and are for inspecting track conditions and monitoring vehicle/track interactions.

333(a) *A qualifying Track Geometry Measurement System (TGMS) shall be operated at the following frequency:*

(1) For operations at a qualified cant deficiency, Eu, of more than 5 inches on track Classes 1 through 5, at least twice per calendar year with not less than 120 days between inspections.

(2) For track Class 6, at least once per calendar year with not less than 170 days between inspections. For operations at a qualified cant deficiency, Eu, of more than 5 inches on

track Class 6, at least twice per calendar year with not less than 120 days between inspections.

(3) For track Class 7, at least twice within any 120-day period with not less than 25 days between inspections.

(4) For track Classes 8 and 9, at least twice within any 60-day period with not less than 12 days between inspections.

Guidance: Paragraph (a)(1) specifies new TGMS inspection requirements for low-speed, high cant deficiency operations, which apply as required by, but are not provided in, § 213.57(i). These requirements are considered necessary for safe operations at high cant deficiency on lower-speed track classes.

Paragraph (a)(2) specifies TGMS inspection requirements for Class 6 track, with two different inspection frequencies depending on the amount of cant deficiency. The twice-yearly TGMS inspection requirements are for operations at a qualified cant deficiency of more than 5 inches. The inspection requirements can be fulfilled by either the track owner or the railroad.

Paragraph (a)(3) concerns TGMS inspections for Class 7 track. The number of days between inspections has been reduced from 30 days to 25 days.

Paragraph (a)(4) concerns TGMS inspections for Class 8 and 9 track. The number of days between two inspections has been reduced from 15 to 12 days.

333(b) * * *

(1) Track geometry measurements shall be taken no more than 3 feet away from the contact point of wheels carrying a vertical load of no less than 10 kips per wheel, unless otherwise approved by FRA;

(2) Track geometry measurements shall be taken and recorded on a distance-based sampling interval preferably at 1 foot not exceeding 2 feet; and

* * * * *

Guidance: The phrase "unless otherwise approved by FRA" is added to the end of paragraph (b)(1). As qualified, paragraph (b)(1) specifies the requirement that track geometry measurements be taken no more than 3 feet away from the contact point of wheels carrying a vertical load of no less than 10,000 pounds (10 kips) per wheel. By adding the above phrase, the rule provides flexibility to conduct track geometry measurements using GRMS, hi-rail geometry equipment, and other test platforms that do not meet the measurement point or axle load requirement.

Paragraph (b)(2) specifies the track geometry measurement interval. Although most existing track geometry measurement systems record measurements at 1 foot or shorter intervals, there are systems that record the measurements at up to 2 foot intervals.

Adequate sampling intervals provide sufficient data to identify track geometry perturbations. The rule states that the 1-foot sampling interval is the preferable distance. However, an allowance is provided for sampling at up to a 2-foot interval depending on the circumstances involved so that track owners/railroads may continue to use existing equipment. In this regard, the rule allows for the use of GRMS, which takes measurement at 16-inch intervals.

In addition, the use of equipment that takes measurement samples on a time-based interval at a rate that corresponds to the distance-based interval specified in this section is permitted.

333(c) *A qualifying TGMS shall be capable of measuring and processing the necessary track geometry parameters to determine compliance with—*

(1) For operations at a qualified cant deficiency, Eu, of more than 5 inches on track Classes 1 through 5: § 213.53, Track gage; § 213.55(b), Track alinement; § 213.57, Curves; elevation and speed limitations; § 213.63, Track surface; and §213.65, Combined track alinement and surface deviations.

(2) For track Classes 6 through 9: § 213.323, Track gage; § 213.327, Track alinement; § 213.329, Curves; elevation and speed limitations; § 213.331, Track surface; and for operations at a cant deficiency of more than 5 inches § 213.332, Combined track alinement and surface deviations.

* * * * *

Guidance: Paragraph (c) specifies the application of the added TGMS inspection requirements for high cant deficiency operations on lower-speed track classes. These requirements apply to vehicle types intended to operate at any curving speed producing more than 5 inches of cant deficiency, as provided in § 213.57(i). Requirements for track Classes 6 through 9 have been amended to reference § 213.332, the new section for combined track alinement and surface deviations. The reference to distance has been removed altogether in paragraph (c), as it is adequately addressed in paragraph (b).

333(g) *The track owner or railroad shall maintain for a period of one year following an inspection performed by a qualifying TGMS, a copy of the plot and the exception report for the track segment involved, and additional records which:*

* * * * *

Guidance: This paragraph updates the requirement for TGMS data retention to support appropriate usage of electronic information to comply with FRA's requirements. FRA has clarified the paragraph by replacing "exception printout" with "exception report" to accommodate (immediate) dissemination of the information in electronic form, if the track owner/railroad chooses to do so.

333(h) *For track Classes 8 and 9, a qualifying Gage Restraint Measurement System (GRMS) shall be operated at least once per calendar year with at least 170 days between inspections. The lateral capacity of the track structure shall not permit a Gage Widening Projection (GWP) greater than 0.5 inch.*

Guidance: This paragraph mandates annual GRMS inspections for track Classes 8 and 9. The number of days (180 days) between inspections has been reduced to 170 days to provide additional operational flexibility in scheduling inspections.

The former Gage Widening Ratio (GWR) has been replaced by Gage Widening Projection (GWP) with the same limit of 0.5 inch. The method to determine the GWP is given in paragraph (i) of this section.

333(i) *A GRMS shall meet or exceed minimum design requirements specifying that—*

(1) Gage restraint shall be measured between the heads of the rail:

(i) At an interval not exceeding 16 inches;

(ii) Under an applied vertical load of no less than 10 kips per rail; and

(iii) Under an applied lateral load that provides a lateral/vertical load ratio of between 0.5 and 1.25[10], and a load severity greater than 3 kips but less than 8 kips per rail. Load severity is defined by the formula:

$$S = L - cV$$

Where—

S = Load severity, defined as the lateral load applied to the fastener system (kips).

L = Actual lateral load applied (kips).

c = Coefficient of friction between rail/tie, which is assigned a nominal value of 0.4.

V = Actual vertical load applied (kips), or static vertical wheel load if vertical load is not measured.

(2) The measured gage and load values shall be converted to a GWP as follows:

$$GWP = (LTG - UTG) \times \frac{8.26}{L - 0.258 \times V}$$

Where—

UTG = Unloaded track gage measured by the GRMS vehicle at a point no less than 10 feet from any lateral or vertical load application.

LTG = Loaded track gage measured by the GRMS vehicle at a point no more than 12 inches from the lateral load application.

L = Actual lateral load applied (kips).

V = Actual vertical load applied (kips), or static vertical wheel load if vertical load is not measured.

GWP = Gage Widening Projection, which means the measured gage widening, which is the difference between loaded and unloaded gage, at the applied loads, projected to reference loads of 16 kips of lateral force and 33 kips of vertical force.

Guidance: Paragraph (i)(1) concerns specifications for a GRMS. The unit for loads has been changed to kips. Vertical load can be taken as static wheel load where vertical load is not measured.

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[10] GRMS equipment using load combinations developing L/V ratios that exceed 0.8 shall be operated with caution to protect against the risk of wheel climb by the test wheelset.

Paragraph (i)(2) describes the new GWP equation. The equation incorporates a correction for the weight of the testing vehicle. This correction is also intended to result in more uniform strength measurements across the variety of testing vehicles that are in operation.

A concern was raised during the development of the rule regarding the requirements for GRMS testing on Class 9 track, which is expected to have a superior track structure to the extent it supports high-speed operations on a dedicated right-of-way. A GRMS requirement on such structure may yield no safety benefit but incur significant cost.

This concern is addressed in section § 213.307. FRA's regulatory approval of high-speed operations on a dedicated right-of-way may allow for the use of inspection and maintenance criteria and procedures in the alternative to those contained in this subpart, including the GRMS inspection requirements in this paragraph, based upon a showing that at least an equivalent level of safety is provided.

333(j) *As further specified for the combination of track class, cant deficiencies, and vehicles subject to paragraphs (j)(1) through (3) of this section, a vehicle having dynamic response characteristics that are representative of other vehicles assigned to the service shall be operated over the route at the revenue speed profile. The vehicle shall either be instrumented or equipped with a portable device that monitors onboard instrumentation on trains. Track personnel shall be notified when onboard accelerometers indicate a possible track-related problem. Testing shall be conducted at the frequencies specified in paragraphs (j)(1) through (3) of this section, unless otherwise determined by FRA after reviewing the test data required by this subpart.*

(1) For operations at a qualified cant deficiency, Eu, of more than 5 inches on track Classes 1 through 6, carbody acceleration shall be monitored at least once each calendar quarter with not less than 25 days between inspections on at least one passenger car of each type that is assigned to the service; and

(2) For operations at track Class 7 speeds, carbody and truck accelerations shall be monitored at least twice within any 60-day period with not less than 12 days between inspections on at least one passenger car of each type that is assigned to the service; and

(3) For operations at track Class 8 or 9 speeds, carbody acceleration shall be monitored at least four times within any 7-day period with not more than 3 days between inspections on at least one non-passenger and one passenger carrying vehicle of each type that is assigned to the service, as appropriate. Truck acceleration shall be monitored at least twice within any 60-day period with not less than 12 days between inspections on at least one passenger carrying vehicle of each type that is assigned to the service, as appropriate.

Guidance: Paragraph (j) concerns the monitoring of carbody and truck accelerations with emphasis on monitoring frequency. The rule also provides an option to use a portable device when performing the acceleration monitoring.

Paragraph (j)(1) includes monitoring requirements for operations above 5 inches of cant deficiency on track Classes 1 through 6. These requirements for monitoring apply to vehicle types qualified to operate at any curving speed producing more than 5 inches of cant deficiency, as provided in § 213.57(i) and § 213.345(a), as appropriate.

Paragraph (j)(2) applies to operations at track Class 7 speeds, and requires that carbody and truck accelerations be monitored at least twice within any 60-day period, with not less than 12 days between inspections on at least one passenger car of each type that is assigned to the service. This paragraph essentially restates the provision in the former paragraph (k), but reduces the minimum period between inspections in the 60-day period to 12 days from 15 days.

Paragraph (j)(3) contains the revised requirements for monitoring carbody and truck accelerations of equipment operating at Track Class 8 and 9 speeds. The monitoring frequency has been reduced from once per day to four times within any 7-day period for carbody accelerations, and twice within 60 days for truck accelerations. The changes are intended to reduce the unnecessary burden on the track owner or railroad operating the vehicle type and are supported by data collected to date.

The text of paragraph (j) makes clear that the requirements apply as specified for the combination of track class, cant deficiencies, and vehicles subject to paragraphs (j)(1) through (3). Consequently, the acceleration monitoring requirements in paragraphs (j)(1) and (2) for speeds up to 125 m.p.h. do not apply to equipment operated in a freight train. Requirements in paragraph (j)(3) apply to equipment operating in a freight train only at speeds above 125 m.p.h., and only as appropriate. If no passenger-carrying vehicles are assigned to the service, there are no passenger-carrying vehicles to monitor. FRA also makes clear that, in the case of Amtrak's Acela service at track Class 8 speeds, the carbody acceleration monitoring requirements of paragraph (j)(3) require only one power car (locomotive), i.e., non-passenger carrying vehicle, and one trailer car (passenger coach) to be monitored. FRA recognizes that only one type of passenger-carrying vehicle is currently assigned to this Acela service—the café cars, first class cars, and business class cars are all passenger-carrying vehicles of the same dynamic response type.

333(k) *(1) The instrumented vehicle or the portable device, as required in paragraph (j) of this section, shall monitor lateral and vertical accelerations of the carbody. The accelerometers shall be attached to the carbody on or under the floor of the vehicle, as near the center of a truck as practicable.*

(2) In addition, a device for measuring lateral accelerations shall be mounted on a truck frame at a longitudinal location as close as practicable to an axle's centerline (either outside axle for trucks containing more than 2 axles), or, if approved by FRA, at an alternate location. After monitoring this data for 2 years, or 1 million miles, whichever occurs first, the track owner or railroad may petition FRA for exemption from this requirement.

(3) If any of the carbody lateral, carbody vertical, or truck frame lateral acceleration safety limits in this section's table of vehicle/track interaction safety limits is exceeded, corrective action shall be taken as necessary. Track personnel shall be notified when the accelerometers indicate a possible track-related problem.

Guidance: Paragraph (k) concerns the monitoring of carbody and truck accelerations with emphasis on monitoring methods and remedial actions.

Paragraph (k)(1) clarifies the requirements for locating the carbody accelerometers.

Paragraph (k)(2) clarifies the requirements for locating the truck accelerometers. It also gives the track owner or railroad an option to petition FRA for exemption from this monitoring requirement after the specified monitoring criteria in this paragraph have been met.

Paragraph (k)(3) clarifies the requirements for remedial actions when carbody or truck frame lateral acceleration safety limits in this section's table of vehicle/track interaction safety limits are exceeded. Track personnel must be notified when the accelerometers indicate a possible track-related problem.

333(l) *For track Classes 8 and 9, the track owner or railroad shall submit a report to FRA, once each calendar year, which provides an analysis of the monitoring data collected in accordance with paragraphs (j) and (k) of this section. Based on a review of the report, FRA may require that an instrumented vehicle having dynamic response characteristics that are representative of other vehicles assigned to the service be operated over the track at the revenue speed profile. The instrumented vehicle shall be equipped to measure wheel/rail forces. If any of the wheel/rail force limits in this section's table of vehicle/track interaction safety limits is exceeded, appropriate speed restrictions shall be applied until corrective action is taken.*

Guidance: Paragraph (l) concerns the requirement for conducting instrumented wheelset (IWS) testing on Class 8 and 9 track. IWS testing is no longer a general requirement applicable for all Class 8 and 9 track. The specific need to perform IWS testing shall be determined by FRA on a case-by-case basis, after reviewing a report submitted annually by the track owner or railroad detailing the accelerometer monitoring data collected in accordance with paragraphs (j) and (k) of this section.

A thorough review of Acela Express trainset IWS data, as well as consideration of the economics associated with the testing, revealed that there was significant cost and little apparent safety benefit to justify continuing IWS testing as a general requirement on an annual basis. As a result, the requirement has been revised so that the testing and monitoring using IWS will be determined by FRA as needed to maintain safety at a lower cost.

333(m) *The track owner or railroad shall maintain a copy of the most recent exception records for the inspections required under paragraphs (j), (k), and (l) of this section, as appropriate.*

Guidance: Conforming changes have been made to paragraph (m), which requires that the track owner or railroad maintain a copy of the most recent exception records for the inspections required under paragraphs (j) and (k) of this section, and, as appropriate, paragraph (l) should IWS testing be required.

The paragraph makes clear that exception data shall be maintained as a record, but not necessarily a printed record. Each railroad or track owner is in the best position to determine the most efficient and effective method for keeping this information. The information may be maintained electronically. In this regard, § 213.369(f) requires that each vehicle/track interaction safety record required under § 213.333(g) and (m) be made available for inspection and copying by FRA, and § 213.369(e) sets forth conditions for maintaining records in an electronic system.

Vehicle/Track Interaction Safety Limits

Wheel-Rail Forces [1]			
Parameter	***Safety Limit***	***Filter/ Window***	***Requirements***
Single Wheel Vertical Load Ratio	≥ 0.15	*5 ft*	*No wheel of the vehicle shall be permitted to unload to less than 15 percent of the static vertical wheel load for 5 or more continuous feet. The static vertical wheel load is defined as the load that the wheel would carry when stationary on level track.*
Single Wheel L/V Ratio	$\leq \frac{\tan(\delta) - 0.5}{1 + 0.5\tan(\delta)}$	*5 ft*	*The ratio of the lateral force that any wheel exerts on an individual rail to the vertical force exerted by the same wheel on the rail shall not be greater than the safety limit calculated for the wheel's flange angle (δ) for 5 or more continuous feet.*
Net Axle Lateral L/V Ratio	$\leq 0.4 + \frac{5.0}{Va}$	*5 ft*	*The net axle lateral force, in kips, exerted by any axle on the track shall not exceed a total of 5 kips plus 40 percent of the static vertical load that the axle exerts on the track for 5 or more continuous feet.* *Va = static vertical axle load (kips)*
Truck Side L/V Ratio	≤ 0.6	*5 ft*	*The ratio of the lateral forces that the wheels on one side of any truck exert on an individual rail to the vertical forces exerted by the same wheels on that rail shall not be greater than 0.6 for 5 or more continuous feet.*
Carbody Accelerations [2]			
Parameter	***Passenger Cars***	***Other Vehicles***	***Requirements***
Carbody Lateral (Transient)	*≤ 0.65g peak-to-peak* *1 sec window*[3] *excludes peaks*	*≤ 0.75g peak-to-peak* *1 sec window*[3] *excludes peaks*	*The peak-to-peak accelerations, measured as the algebraic difference between the two extreme values of measured acceleration in any 1-second time period, excluding*

	< 50 msec	*< 50 msec*	*any peak lasting less than 50 milliseconds, shall not exceed 0.65g and 0.75g for passenger cars and other vehicles, respectively.*
Carbody Lateral (Sustained Oscillatory)	*$\leq$ 0.10g RMS_t[4]* *4 sec window[3]* *4 sec sustained*	*$\leq$ 0.12g RMS_t[4]* *4 sec window[3]* *4 sec sustained*	*Sustained oscillatory lateral acceleration of the carbody shall not exceed the prescribed (root mean squared) safety limits of 0.10g and 0.12g for passenger cars and other vehicles, respectively. Root mean squared values shall be determined over a sliding 4- second window with linear trend removed and shall be sustained for more than 4 seconds.*
Carbody Vertical (Transient)	*$\leq$ 1.0g peak-to-peak* *1 sec window[3]* *excludes peaks < 50 msec*	*$\leq$ 1.25g peak-to-peak* *1 sec window[3]* *excludes peaks < 50 msec*	*The peak-to-peak accelerations, measured as the algebraic difference between the two extreme values of measured acceleration in any one second time period, excluding any peak lasting less than 50 milliseconds, shall not exceed 1.0g, or 1.25g, as specified.*
Carbody Vertical (Sustained Oscillatory)	*$\leq$ 0.25g RMS_t[4]* *4 sec window[3]* *4 sec sustained*	*$\leq$ 0.25g RMS_t[4]* *4 sec window[3]* *4 sec sustained*	*Sustained oscillatory vertical acceleration of the carbody shall not exceed the prescribed (root mean squared) safety limit of 0.25g. Root mean squared values shall be determined over a sliding 4-second window with linear trend removed and shall be sustained for more than 4 seconds.*

Truck Lateral Acceleration[5]

Parameter	***Safety Limit***	***Filter/ Window***	***Requirements***
Truck Lateral	*$\leq$ 0.30g RMS_t[4]*	*2 sec window[3]* *2 sec sustained*	*Truck hunting shall not develop below the maximum authorized speed. Truck hunting is defined as a sustained cyclic oscillation of the truck evidenced by lateral accelerations exceeding 0.3g root mean squared for more than 2 seconds. Root mean squared values shall be determined over a sliding 2-second window with linear trend removed.*

[1] *The lateral and vertical wheel forces shall be measured and processed through a low pass filter (LPF) with a minimum cut-off frequency of 25 Hz. The sample rate for wheel force data shall be at least 250 samples per second.*

[2] *Carbody accelerations in the vertical and lateral directions shall be measured by accelerometers oriented and located in accordance with § 213.333(k).*

[3] *Acceleration measurements shall be processed through an LPF with a minimum cut-off frequency of 10 Hz. The sample rate for acceleration data shall be at least 100 samples per second.*

[4] *RMS_t = RMS with linear trend removed.*

[5] *Truck lateral acceleration shall be measured on the truck frame by accelerometers oriented and located in accordance with § 213.333(k).*

Guidance (on the Vehicle/Track Interaction Safety Limits): Most of the limits have been clarified or updated in the table.

- The single wheel vertical load ratio limit has been tightened from 0.10 to 0.15 to ensure an adequate safety margin for wheel unloading. The ratio actually means percentage, as explained in the "Requirements" column on the right.

- The net axle lateral L/V ratio limit has been modified from 0.5, to 0.4 + 5.0/Va, so as to take into account the effect of axle load and more appropriately reflect the cumulative, detrimental effect of track panel shift from heavier vehicles. This net axle lateral load limit is intended to control excessive lateral track shift and is sensitive to a number of track parameters. The well-established, European Prud'homme limit is a function of the axle load and this sensitivity is desired to differentiate between coach car and heavier locomotive loads. Computer simulations and testing indicated the dependence on axle load and the importance of initial, small lateral deflections.

- To accommodate variations in vehicle design requirements and passenger ride safety, the carbody accelerations now have separate limits for "Passenger Cars" and "Other Vehicles" (such as conventional locomotives).

- The lateral carbody transient acceleration limit has been modified from 0.5g for all vehicles to 0.65g for passenger cars and 0.75g for other vehicles.

- The vertical carbody transient acceleration has been modified from 0.6g for all vehicles to 1.0g for passenger cars and 1.25g for other vehicles.

  These changes were developed after considerable research into the performance of existing vehicles during qualification testing and revenue operations. It was found that the carbody transient acceleration limits need not be as stringent (as the former limits) to protect against events leading to vehicle or passenger safety issues. In addition, transient acceleration peaks lasting less than 50 milliseconds have been excluded because the energy content associated with high-frequency carbody acceleration events is small.

- New limits for sustained carbody lateral and vertical oscillatory accelerations have been added. The sustained lateral carbody oscillatory acceleration limits are 0.10g RMS_t (root mean squared with linear trend removed) for passenger cars and 0.12g RMSt for other vehicles. The sustained vertical carbody oscillatory acceleration limits are 0.25g RMSt for both passenger cars and other vehicles.

  These new limits require that the RMS_t value be used in order to attenuate the effects of the linear variation in oscillatory accelerations resulting from a vehicle negotiating track segments with changes in curvature or grade by design, such as spirals. Root mean squared values shall be determined over a sliding 4-second window with linear trend removed and be sustained for more than 4 seconds.

- Minimum requirements for sampling and filtering of the acceleration data have been added. Acceleration measurements shall be processed through a low-pass filter with a minimum cut-off frequency of 10 Hz, and the sample rate for oscillatory acceleration data need be at least 100 samples per second.

- The truck lateral acceleration limit used for the detection of truck hunting has been tightened from 0.4g to 0.3g. The value must exceed that limit for more than 2 seconds to be considered as an exceedance. Analyses conducted by FRA have shown that this change will help to better identify the occurrences of excessive truck hunting, while excluding high-frequency, low-amplitude oscillations that do not require immediate attention. In addition, this revised limit requires that the RMS_t value be used rather than the RMSm (root mean squared with mean removed) value. This revision will improve the process for analyzing data while the vehicle is negotiating spiral track segments.

20. Section 213.345 is revised to read as follows:

§ 213.345 Vehicle/track system qualification.

General Guidance to § 213.345: The 1998 Track Safety Standards final rule requires that all (passenger and freight) rolling stock be qualified for operation for its intended track class. Qualification testing was intended to demonstrate that the equipment not exceed the VTI limits specified in § 213.333 at any speed less than 10 m.p.h. above the proposed maximum operating speed. An exception was provided for equipment that had already operated in specified track classes. Rolling stock operating in Class 6 track within one year prior to the promulgation of the 1998 final rule was considered qualified. Further, vehicles operating at Class 7 track speeds under conditional waivers prior to the promulgation of the 1998 final rule were qualified for Class 7 track, including equipment that was then-operating on the Northeast Corridor at Class 7 track speeds.

FRA has made a number of significant changes to this section. The heading is modified from "Vehicle qualification testing" to "Vehicle/track system qualification," to reflect more appropriately the interaction of the vehicle and the track over which it operates as a system. Changes in the text include modifying and clarifying this section's substantive requirements, reorganizing the structure and layout of the rule text, and revising the qualification procedures. Among the specific changes, high cant deficiency operations on lower-speed track classes are subject to the requirements of this section in accordance with § 213.57(i).

All requirements contained in paragraphs 345(a)–(d) are summarized in the following table for quick reference:

Vehicle/Track System Qualification Reference Chart

Cant Deficiency, E_u (in)	New Vehicle Type									Qualified Vehicle Type								
	Track Class & Maximum Allowable Operating Speed (m.p.h.)																	
	1	2	3	4	5	6	7	8	9	1	2	3	4	5	6	7	8	9
	15 (10)[1]	30 (25)	60 (40)	80 (60)	90 (80)	110	125	160	220	15 (10)	30 (25)	60 (40)	80 (60)	90 (80)	110	125	160	220
$E_u \leq 3$	No Testing or Simulations					$A_C + A_T$ +(W or S)	$A_C + A_T$ + W + S			No Testing or Simulations						$A_C + A_T$		
$3 < E_u \leq 5$	L					L $+A_C$ $+ A_T$ +(W or S)	L $+A_C$ $+A_T$ + W + S			N						$N + A_C + A_T$		
$5 < E_u \leq 6$	$L + A_C$									$N + A_C$						$N + A_C + A_T$ +(W or S)		
$E_u > 6$	$L + A_C$ + W + S									$N + A_C$ + (W or S)								

A_C = Car body accelerations **A_T** = Truck accelerometers **L**[2] = Lean test
N[3] = FRA Notification **S** = Simulation (MCAT & Segment) **W** = Wheel-Rail force measurement

1. Numbers in parentheses are maximum allowable operating speed for freight trains
2. Lean test requirements may be met by static or dynamic testing (W+A), see sections 213.57(d) & 213.329(d)
3. See sections 213.57(h) & 213.329(h)

345(a) *General. All vehicle types intended to operate at track Class 6 speeds or above, or at any curving speed producing more than 5 inches of cant deficiency, shall be qualified for operation for their intended track classes in accordance with this subpart. A qualification program shall be used to demonstrate that the vehicle/track system will not exceed the wheel/rail force safety limits and the carbody and truck acceleration criteria specified in § 213.333—*

(1) At any speed up to and including 5 m.p.h. above the proposed maximum operating speed; and

(2) On track meeting the requirements for the class of track associated with the proposed maximum operating speed. For purposes of qualification testing, speeds may exceed the maximum allowable operating speed for the class of track in accordance with the test plan approved by FRA.

Guidance: Paragraph (a) specifies criteria for vehicle types to be qualified for operation.

Paragraph (a)(1) specifies that for qualification purposes, the over-speed testing requirement has been reduced from 10 m.p.h. to 5 m.p.h. above the maximum proposed operating speed. The former 10 m.p.h. over-speed testing requirement established as part of the 1998 final rule has become overly conservative based on improved speed control and display technology deployed in current operations.

Paragraph (a)(2) clarifies that for purposes of qualification testing, speeds may exceed the maximum allowable operating speeds for the class of track in accordance with the test plan approved by FRA. This eliminates any potential need for additional regulatory approval to allow qualification testing above the maximum speeds proposed for the operation. Upon FRA's approval of the qualification test plan, testing at such speeds conducted in accordance with this plan is deemed in compliance with this part 213.

Note that for operations on Class 1 through 5 track at curving speeds producing more than 5 inches of cant deficiency, testing at 5 m.p.h. above the proposed maximum operating speed, in combination with track class and curvature and elevation, could result in a cant deficiency more than 3 inches above the proposed maximum cant deficiency. Should this happen, the speed of 5 m.p.h. over the proposed maximum operating speed would still apply.

345(b) *Existing vehicle type qualification. Vehicle types previously qualified or permitted to operate at track Class 6 speeds or above or at any curving speeds producing more than 5 inches of cant deficiency prior to March 13, 2013, shall be considered as being successfully qualified under the requirements of this section for operation at the previously operated speeds and cant deficiencies over the previously operated track segment(s).*

Guidance: This paragraph addresses the portability of qualification for previously qualified vehicle types. The portability provision is applicable to vehicle types previously qualified for track Class 6 speeds or above, or cant deficiency operation of more than 5 inches regardless of speed, and applies for previously operated track segment(s) only.

To qualify such vehicle types to operate over new routes (even at the same track speeds), the qualification requirements contained in other paragraphs of this section must be met.

345(c) *New vehicle type qualification. Vehicle types not previously qualified under this subpart shall be qualified in accordance with the requirements of this paragraph (c).*

(1) Simulations or measurement of wheel/rail forces. For vehicle types intended to operate at track Class 6 speeds, simulations or measurement of wheel/rail forces during qualification testing shall demonstrate that the vehicle type will not exceed the wheel/rail force safety limits specified in § 213.333. Simulations, if conducted, shall be in accordance with paragraph (c)(2) of this section. Measurement of wheel/rail forces, if conducted, shall be performed over a representative segment of the full route on which the vehicle type is intended to operate.

(2) Simulations. For vehicle types intended to operate at track Class 7 speeds or above, or at any curving speed producing more than 6 inches of cant deficiency, analysis of vehicle/track performance (computer simulations) shall be conducted using an industry recognized methodology on:

(i) An analytically defined track segment representative of minimally compliant track conditions (MCAT—Minimally Compliant Analytical Track) for the respective track class(es) as specified in appendix D to this part; and

(ii) A track segment representative of the full route on which the vehicle type is intended to operate. Both simulations and physical examinations of the route's track geometry shall be used to determine a track segment representative of the route.

(3) Carbody acceleration. For vehicle types intended to operate at track Class 6 speeds or above, or at any curving speed producing more than 5 inches of cant deficiency, qualification testing conducted over a representative segment of the route shall demonstrate that the vehicle type will not exceed the carbody lateral and vertical acceleration safety limits specified in § 213.333.

(4) Truck lateral acceleration. For vehicle types intended to operate at track Class 6 speeds or above, qualification testing conducted over a representative segment of the route shall demonstrate that the vehicle type will not exceed the truck lateral acceleration safety limit specified in § 213.333.

(5) Measurement of wheel/rail forces. For vehicle types intended to operate at track Class 7 speeds or above, or at any curving speed producing more than 6 inches of cant deficiency, qualification testing conducted over a representative segment of the route shall demonstrate that the vehicle type will not exceed the wheel/rail force safety limits specified in § 213.333.

Guidance: Paragraph (c) contains the requirements for qualifying new vehicle types. This section references § 213.333 for the applicable VTI limits for accelerations and wheel/rail forces.

Paragraph (c)(1) allows for vehicle types intended to operate at track Class 6 speeds to be qualified either through simulations or the use of IWS to demonstrate compliance with the wheel/rail force limits specified in § 213.333. It makes clears that computer simulations are an alternative to IWS and does not eliminate use of IWS testing. If opted, simulations must be conducted in accordance with paragraph (c)(2). Note that validation of simulations results need not be done prior to the qualification testing, but can be done during/after the qualification test, using data from the test.

Paragraph (c)(2) requires computer simulations for new vehicle types intended to operate at track Class 7 speeds or above, as well at any curving speed producing more than 6 inches of cant deficiency. This requirement is in addition to IWS testing as specified in (c)(5).

Please also note that, although in accordance with § 213.57(i), vehicle types intended to operate at cant deficiencies greater than 5 inches on Class 1-5 track are subject to the requirements of this section, the requirements of this paragraph (c)(2) apply only to operations at cant deficiencies greater than 6 inches on these classes.

This paragraph (c)(2) requires computer simulations to be conducted on both an analytically defined track segment representative of minimally compliant track conditions (MCAT) for the respective track classes as specified in appendix D, and on a track segment representative of the full route on which the vehicle type is intended to operate (See the guidance for MCAT in appendix D.)

Paragraph (c)(3) requires carbody acceleration testing for all operations at track Class 6 speeds or above, or for any operation above 5 inches of cant deficiency. Note that, in accordance with § 213.57(i), vehicle types intended to operate at cant deficiencies greater than 5 inches on Class 1-5 track are subject to these requirements.

Paragraph (c)(4) requires truck acceleration testing for all operations at track Class 6 speeds or above.

Paragraph (c)(5) requires measurement of wheel/rail forces, through the use of IWS (or equivalent devices) for all operations at track Class 7 speeds or above, or for any operation above 6 inches of cant deficiency. Again, the requirements of paragraph (c)(5) apply to Class 1-5 track only for operations at cant deficiencies greater than 6 inches.

345(d) *Previously qualified vehicle types. Vehicle types previously qualified under this subpart for a track class and cant deficiency on one route may be qualified for operation at the same class and cant deficiency on another route through analysis or testing, or both, to demonstrate compliance with paragraph (a) of this section in accordance with the following:*

(1) Simulations or measurement of wheel/rail forces. For vehicle types intended to operate at any curving speed producing more than 6 inches of cant deficiency, or at curving speeds that both correspond to track Class 7 speeds or above and produce more than 5 inches of cant deficiency, simulations or measurement of wheel/rail forces during qualification testing shall demonstrate that the vehicle type will not exceed the wheel/rail force safety limits specified in § 213.333. Simulations, if conducted, shall be in accordance with paragraph (c)(2) of this section. Measurement of wheel/rail forces, if conducted, shall be performed over a representative segment of the new route.

(2) *Carbody acceleration. For vehicle types intended to operate at any curving speed producing more than 5 inches of cant deficiency, or at track Class 7 speeds and above, qualification testing conducted over a representative segment of the new route shall demonstrate that the vehicle type will not exceed the carbody lateral and vertical acceleration safety limits specified in § 213.333.*

(3) *Truck lateral acceleration. For vehicle types intended to operate at track Class 7 speeds or above, measurement of truck lateral acceleration during qualification testing shall demonstrate that the vehicle type will not exceed the truck lateral acceleration safety limits specified in § 213.333. Measurement of truck lateral acceleration, if conducted, shall be performed over a representative segment of the new route.*

Guidance: Paragraph (d) contains the qualification requirements and provisions for portability of qualification for previously qualified vehicle types intended to operate on new track routes.

Although the vehicle type may remain unchanged, the vehicle/track system still needs to be appropriately examined for deficiencies prior to its service operation on a new route where performance-based standards are relied upon at track Class 7 speeds or above and at cant deficiencies exceeding 5 inches. This seemed to be supported by past experience with the high-speed and high cant deficiency qualification of the Acela trainset where testing at a well-maintained Class 8 test track did not uncover performance issues that were later identified during the local vehicle/track system testing on the Northeast Corridor. It is therefore considered necessary that a new vehicle/track system be examined during qualification testing to demonstrate system safety.

Paragraph (d)(1) provides that for all operations at track Class 7 speeds or above and cant deficiencies exceeding 5 inches, or for any operation above 6 inches of cant deficiency, simulations or measurement of wheel/rail forces is required to demonstrate safe, local vehicle/track system performance on a new route. For performance-based standards that address the vehicle/track system, simulations are especially useful for demonstrating that when qualified vehicles are intended to operate on a new route, the new vehicle/track system is adequately examined for deficiencies prior to revenue service operation. It is noted that, once run for analyzing the MCAT deviations in Appendix D, below, a fully-validated vehicle model required for qualifying new vehicle types under this final rule need not be repeated. Only a simulation for a representative track segment from the new route is required, as the results of the MCAT simulations will be kept on file and be available for reference.

Paragraph (d)(2) specifies the requirements for carbody acceleration testing for vehicle types intended to operate at cant deficiencies exceeding 5 inches or at track Class 7 speeds or above. The testing is intended to demonstrate safe, local vehicle/track system performance on a new route.

Paragraph (d)(3) provides that for previously qualified vehicle types intended to operate on new routes at track Class 7 speeds or above, truck acceleration testing is required to demonstrate safe, local vehicle/track system performance.

345(e) *Qualification testing plan. To obtain the data required to support the qualification program outlined in paragraphs (c) and (d) of this section, the track owner or railroad shall submit a qualification testing plan to FRA's Associate Administrator for Railroad Safety/Chief Safety Officer (FRA) at least 60 days prior to testing, requesting approval to conduct the testing at the desired speeds and cant deficiencies. This test plan shall provide for a test program sufficient to evaluate the operating limits of the track and vehicle type and shall include:*

(1) Identification of the representative segment of the route for qualification testing;
(2) Consideration of the operating environment during qualification testing, including operating practices and conditions, the signal system, highway-rail grade crossings, and trains on adjacent tracks;
(3) The maximum angle found on the gage face of the designed (newly-profiled) wheel flange referenced with respect to the axis of the wheelset that will be used for the determination of the Single Wheel L/V Ratio safety limit specified in § 213.333;
(4) A target maximum testing speed in accordance with paragraph (a) of this section and the maximum testing cant deficiency;
(5) An analysis and description of the signal system and operating practices to govern operations in track Classes 7 through 9, which shall include a statement of sufficiency in these areas for the class of operation; and
(6) The results of vehicle/track performance simulations that are required by this section.

Guidance: Paragraph (e) clarifies the requirements for the content of the qualification testing plan and adds a requirement for the plan to be submitted to FRA at least 60 days prior to conducting the testing.

The paragraph requires that the test plan:

- Identify the test track segment representative of the route ((e)(1)).

- Identify the maximum angle found on the gage face of the designed (newly profiled) wheel flange referenced with respect to the axis of the wheelset ((e)(3)).

- Identify the target maximum testing speed in accordance with paragraph (a) of this section and the maximum testing cant deficiency ((e)(4)).

  The maximum testing speed will be the maximum allowable operating speed + 5 m.p.h. and the maximum testing cant deficiency will be that intended to achieve during qualification testing.

- Include the results of vehicle/track performance simulations ((e)(6)).

345(f) *Qualification testing. Upon FRA approval of the qualification testing plan, qualification testing shall be conducted in two sequential stages as required in this subpart.*

(1) Stage-one testing shall include demonstration of acceptable vehicle dynamic response of the subject vehicle as speeds are incrementally increased—
  (i) On a segment of tangent track, from acceptable track Class 5 speeds to the target maximum test speed (when the target speed corresponds to track Class 6 and above operations); and
  (ii) On a segment of curved track, from the speeds corresponding to 3 inches of cant deficiency to the maximum testing cant deficiency.

(2) When stage-one testing has successfully demonstrated a maximum safe operating speed and cant deficiency, stage-two testing shall commence with the subject equipment over a representative segment of the route as identified in paragraph (e)(1) of this section.
  (i) A test run shall be conducted over the route segment at the speed the railroad will request FRA to approve for such service.
  (ii) An additional test run shall be conducted at 5 m.p.h. above this speed.

(3) When conducting stage-one and stage-two testing, if any of the monitored safety limits is exceeded on any segment of track intended for operation at track Class 6 speeds or greater, or on any segment of track intended for operation at more than 5 inches of cant deficiency, testing may continue provided that the track location(s) where any of the limits is exceeded be identified and test speeds be limited at the track location(s) until corrective action is taken. Corrective action may include making an adjustment in the track, in the vehicle, or both of these system components. Measurements taken on track segments intended for operations below track Class 6 speeds and at 5 inches of cant deficiency, or less, are not required to be reported.

(4) Prior to the start of the qualification testing program, a qualifying TGMS specified in § 213.333 shall be operated over the intended route within 30 calendar days prior to the start of the qualification testing program.

Guidance: Paragraph (f) contains the requirements for conducting qualification testing upon FRA approval of the test plan. This paragraph expressly requires that TGMS equipment be operated over the intended test route within 30 days prior to the start of the testing, to help ensure the integrity of the test results. It also makes clear that exceptions to the safety limits that occur on track or at speeds that are not part of the test do not need to be reported. Specifically, any exception to the safety limits that occurs at speeds below track Class 6 speeds when the cant deficiency is at or below 5 inches does not need to be reported.

345(g) Qualification testing results. The track owner or railroad shall submit a report to FRA detailing all the results of the qualification program. When simulations are required as part of vehicle qualification, this report shall include a comparison of simulation predictions to the actual wheel/rail force or acceleration data, or both, recorded during full-scale testing. The report shall be submitted at least 60 days prior to the intended operation of the equipment in revenue service over the route.

Guidance: Paragraph (g) contains the requirements for reporting to FRA the results of the qualification testing program. When simulations are required as part of vehicle qualification this report includes a comparison of simulation predictions to the actual wheel/rail force or acceleration data, or both, recorded during full-scale testing.

Validation of computer simulation results as required in ((e)(6)) shall be included in this report, correlating with the qualification testing data FRA has sponsored research to establish a set of procedures for validating models used in simulating vehicle/track dynamic interaction. The results are not conclusive. FRA is working on set up guidelines and procedures for validating models.

FRA encourages parties to approach FRA early in the vehicle/track system qualification process should they have any questions or concerns about correlating simulation predictions with actual wheel/rail force or acceleration test data.

345(h) *Based on the test results and all other required submissions, FRA will approve a maximum train speed and value of cant deficiency for revenue service, normally within 45 days of receipt of all the required information. FRA may impose conditions necessary for safely operating at the maximum approved train speed and cant deficiency.*

Guidance: FRA approves a maximum train speed and value of cant deficiency for revenue service, based on the test results and all other required submissions. FRA intends to provide an approval decision normally within 45 days of receipt of all the required information. This paragraph emphasizes "receipt of all the required information." If the submission is incomplete upon preliminary examination, FRA will request additional information. The 45-day period will start upon receipt of the additional information that makes the submission complete. This paragraph also makes clear that FRA may impose conditions necessary for safely operating at the maximum train speed and value of cant deficiency approved for revenue service.

345(i) *The documents required by this section must be provided to FRA by:*

(1) The track owner; or

(2) A railroad that provides service with the same vehicle type over trackage of one or more track owner(s), with the written consent of each affected track owner.

Guidance: Paragraph (i) is newly added. The paragraph states that documents required by this section must be submitted to FRA by either the tracker owner or an operating entity that provides service with the vehicle type over trackage of one or more track owners with the written consent of all affected track owners. Paragraph (i)(2) is of particular relevance when an entity, such as Amtrak, wants to operate a high-speed train over trackage owned by one or more freight railroads. A "railroad" includes an "operator of a passenger or commuter service" identified in former § 213.57(e) and § 213.329(f).

21. Section 213.355 is revised to read as follows:

§ 213.355 Frog guard rails and guard faces; gage.

The guard check and guard face gages in frogs shall be within the limits prescribed in the following table—

Class of track	*Guard check gage*	*Guard face gage*
	The distance between the gage line of a frog to the guard line[1] of its guard rail or guarding face, measured across the track at right angles to the gage line,[2] may not be less than-	*The distance between guard lines,[1] measured across the track at right angles to the gage line,[2] may not be more than -*
Class 6, 7, 8 and 9 track	*4′6½″...*	*4′5″*

[1] A line along that side of the flangeway which is nearer to the center of the track and at the same elevation as the gage line.
[2] A line five-eighths of an inch below the top of the center line of the head of the running rail, or corresponding location of the tread portion of the track structure.

Guidance: This paragraph sets limits for guard check gage and guard face gage for Track Classes 6 through 9. Minor changes have been made to the format of the text and the table.

22. Appendix A to Part 213 is revised to read as follows:

Appendix A to Part 213—Maximum Allowable Curving Speeds

This appendix contains four tables identifying maximum allowing curving speeds based on 3, 4, 5, and 6 inches of unbalance (cant deficiency), respectively.

Guidance: The tables, which are omitted in this technical bulletin, contain computed maximum allowable operating speeds in curves, by degree of curvature and inches of unbalance (cant deficiency). These values are computed using the V_{max} equation in §§ 213.57 and 213.329.

The tables are generated only for the four different levels of cant deficiency that are more commonly used.

23. Amend Appendix B to part 213:

a. Under subpart C by removing the entry for § 213.55 and adding entries for §§ 213.55 and 213.65 in numerical order;

b. By revising the subpart D heading and under it revising the entries for §§ 213.109 and 213.127, and adding the entry for § 213.110 in numerical order;

c. By adding the entry for § 213.234 in numerical order under subpart F;

d. By revising the subpart G heading and under it revising the entries for §§ 213.307, 213.327, 213.329, 213.333, and 213.345, and adding the entry for § 213.332 in numerical order.

The revisions and additions read as follows:

Appendix B to Part 213—Schedule of Civil Penalties

Section	*Violation*	*Willful Violation*[1]
SUBPART C—TRACK GEOMETRY:		
* * * * *		
213.55 Track alinement	*5,000*	*7,500*
* * * * *		
213.65 Combined track alinement and surface deviations ..	*5,000*	*7,500*
SUBPART D—TRACK STRUCTURE:		
* * * * *		
213.109 Crossties		
(a) Material used..	*1,000*	*2,000*
(b) Distribution of ties..	*2,500*	*5,000*
(c) and (d) Sufficient number of non-defective ties	*1,000*	*2,000*
(e) Joint ties	*2,500*	*5,000*
(f) Track constructed without crossties	*2,500*	*5,000*
213.110 Gage restraint measurement systems	*5,000*	*7,500*
* * * * *		
213.127 Rail Fastening Systems..............................	*2,500*	*5,000*
* * * * *		
SUBPART F—INSPECTION		
* * * * *		
213.234 Automated inspection of track constructed with concrete crossties..	*5,000*	*7,500*
* * * * *		

SUBPART G—TRAIN OPERATIONS AT TRACK CLASSES 6 AND HIGHER:

* * * * *

213.307 Classes of track: operating speed limits	*2,500*	*5,000*
* * * * *		
213.327 Track alinement	*5,000*	*7,500*
213.329 Curves; elevation and speed limits	*2,500*	*5,000*
* * * * *		
213.332 Combined track alinement and surface deviations	*5,000*	*7,500*
213.333 Automated vehicle-based inspection systems	*5,000*	*7,500*
* * * * *		
213.345 Vehicle/track system qualification (a) through (d)	*5,000*	*7,500*
(e) through (i)	*2,500*	*5,000*

* * * * *

[1] *A penalty may be assessed against an individual only for a willful violation. The Administrator reserves the right to assess a penalty of up to $105,000 for any violation where circumstances warrant. See 49 CFR part 209, appendix A.*

Guidance: Appendix B to part 213 contains a schedule of civil penalties for use in connection with this part. These penalty schedules are statements of agency policy. See 5 U.S.C. 553(b)(3)(A).

FRA amended the penalty schedule to reflect the changes made to part 213. FRA has added entries for new sections §§ 213.65 and 213.332, Combined track alinement and surface deviations. FRA has also added an entry for the revised § 213.110, Gage restraint measurement systems, which did not have any entry previously. For each of these entries, FRA has specified guideline penalty amounts that are consistent with those for similar entries in this appendix. FRA has also revised the entries for §§ 213.55, 213.307, 213.327, 213.329, 213.333, and 213.345 so that the entries conform to their respective sections; however, no change to the guideline penalty amounts has been made. FRA has revised the headings for subparts D and G to conform to the subpart headings in the rule.

Additionally, the following changes are made to this appendix corresponding to the Concrete Crossties final rule. See 76 FR 18073, April 1, 2011; 76 FR 55819, Sept. 9, 2011.

- New entry for § 213.234, Automated inspection of track constructed with concrete crossties.
- Revised entry for § 213.109, Crossties, to conform to the changes made to that section.
- Revised entry for § 213.127, Rail fastening systems, so that it conforms to the section heading, as revised by that rule.

24. Appendix C to part 213 is added and reserved.

Guidance: Appendix C is added and reserved for future use.

25. Appendix D to part 213 is added to read as follows:

Appendix D to Part 213—Minimally Compliant Analytical Track (MCAT) Simulations Used for Qualifying Vehicles to Operate at High Speeds and at High Cant Deficiencies

1. This appendix contains requirements for using computer simulations to comply with the vehicle/track system qualification testing requirements specified in subpart G of this part. These simulations shall be performed using a track model containing defined geometry perturbations at the limits that are permitted for a specific class of track and level of cant deficiency. This track model is known as MCAT, Minimally Compliant Analytical Track. These simulations shall be used to identify vehicle dynamic performance issues prior to service or, as appropriate, a change in service, and demonstrate that a vehicle type is suitable for operation on the track over which it is intended to operate.

2. As specified in § 213.345(c)(2), MCAT shall be used for the qualification of new vehicle types intended to operate at track Class 7 speeds or above, or at any curving speed producing more than 6 inches of cant deficiency. MCAT may also be used for the qualification of new vehicle types intended to operate at speeds corresponding to Class 6 track, as specified in § 213.345(c)(1). In addition, as specified in § 213.345(d)(1), MCAT may be used to qualify on new routes vehicle types that have previously been qualified on other routes and are intended to operate at any curving speed producing more than 6 inches of cant deficiency, or at curving speeds that both correspond to track Class 7 speeds or above and produce more than 5 inches of cant deficiency.

General Guidance: Appendix D is a new appendix containing the requirements for the use of computer simulations to demonstrate compliance with the vehicle/track system qualification testing requirements specified in subpart G of this part. Comprehensive computational models are capable of assessing the response of vehicle designs to a wide range of track conditions corresponding to the limiting conditions allowed for each class of track. Portions of the qualification requirements in subpart G can be met by simulating vehicle testing using a suitably-validated vehicle model instead of testing an actual vehicle over a representative track segment.

As explained in paragraph 1, the simulations described in this appendix are required to be performed using a track model containing defined geometry deviations for different track segments at the limits that are permitted for a specific class of track and level of cant deficiency. This track model is referred to as MCAT. These simulations shall be used to identify vehicle dynamic performance issues prior to service or, as appropriate, a change in service, and demonstrate that a vehicle type is suitable for operation on the track to be used. The lengths of the MCAT segments identified in this appendix are the same as the segment lengths that were used in the modeling of several representative high-speed vehicles. (For additional information, see the discussion of research and computer modeling in the Technical Background section of the final rule.)

In order to validate a computer model, the predicted results must be compared to actual data from on-track, instrumented vehicle performance testing using accelerometers, or other instrumentation, or both. Validation must also demonstrate that the model is sufficiently robust to capture fundamental responses observed during field testing. Once validated, the computer model can be used for MCAT or assessing a range of operating conditions or even to examine modifications to current designs.

Paragraph 2 concerns the application of MCAT for vehicle/track system qualification in § 213.345 and was developed in accordance with the changes made to § 213.345.

(a) Validation. To validate the vehicle model used for simulations under this part, the track owner or railroad shall obtain vehicle simulation predictions using measured track geometry data, chosen from the same track section over which testing shall be performed as specified in § 213.345(c)(2)(ii). These predictions shall be submitted to FRA in support of the request for approval of the qualification testing plan. Full validation of the vehicle model used for simulations under this part shall be determined when the results of the simulations demonstrate that they replicate all key responses observed during qualification testing.

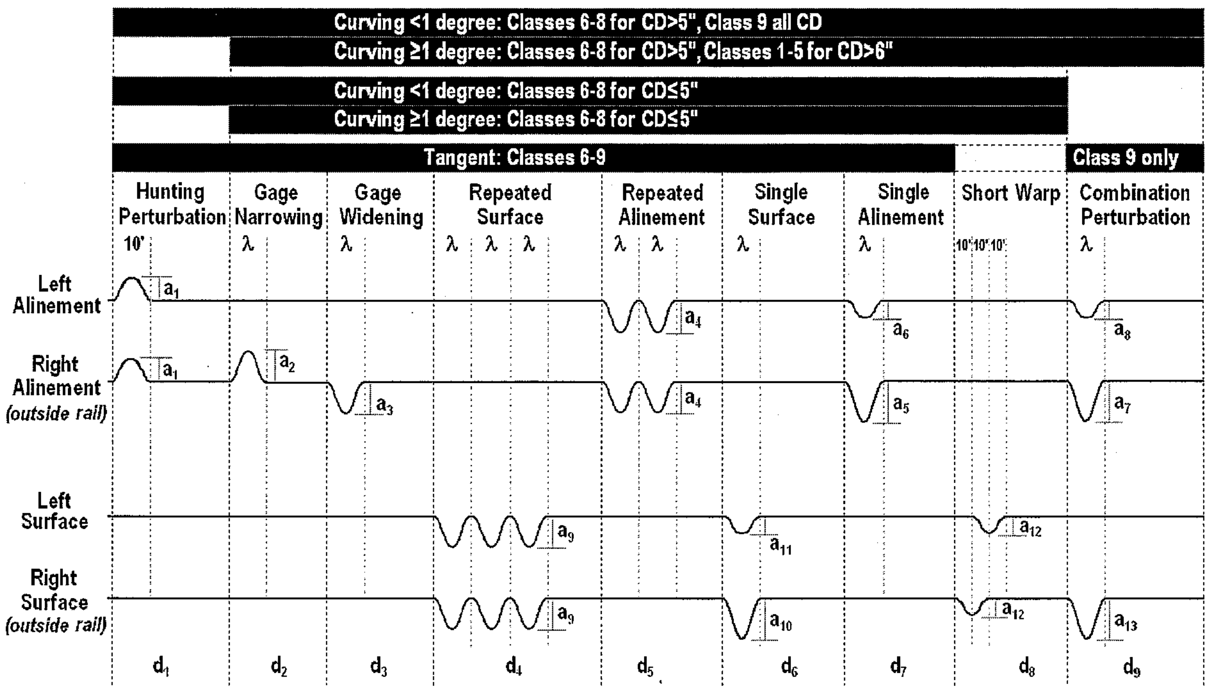
Guidance: Paragraph (a) addresses the validation of the vehicle model used for simulations. As discussed in § 213.345(g). FRA has sponsored research to establish a set of procedures for validating models used in simulating vehicle/track dynamic interaction. FRA intends to publish this research. The results are not conclusive. FRA is working to set up procedures and, when complete, and make it part of FRA's formal guidance on compliance with the Track Safety Standards. Again, in the interim, FRA encourages parties to approach FRA early in the qualification process should they have any questions or concerns about correlating simulation predictions with measured track geometry data.

(b) MCAT layout. MCAT consists of nine segments, each designed to test a vehicle's performance in response to a specific type of track perturbation. The basic layout of MCAT is shown in figure 1 of this appendix, by type of track (curving or tangent), class of track, and cant deficiency (CD). The values for wavelength, λ, amplitude of perturbation, a, and segment length, d, are specified in this appendix. The bars at the top of figure 1 show which segments are required depending on the speed and degree of curvature. For example, the hunting perturbation section is not required for simulation of curves greater than or equal to 1 degree.

Guidance: Paragraph (b) specifies the layout of the MCAT segments. The MCAT layout in figure 1 clarifies which segments are required depending on the speed and the degree of curvature involved. In particular, the hunting perturbation segment is not required for simulations of curves greater than or equal to 1 degree; the short warp segment is not required for tangent track simulations; and the combined perturbation segment is required on tangent track only for Class 9 track, and is not required for simulations of no more than 5 inches of cant deficiency other than for Class 9 track, where it is required for all cant deficiency values.

Figure 1 of Appendix D to Part 213

Basic MCAT Layout



(1) MCAT segments. MCAT's nine segments contain different types of track deviations in which the shape of each deviation is a versine having wavelength and amplitude varied for each simulation speed as further specified. The nine MCAT segments are defined as follows:

(i) Hunting perturbation (a_1): This segment contains an alinement deviation having a wavelength, λ, of 10 feet and amplitude of 0.25 inch on both rails to test vehicle stability on tangent track and on track that is curved less than 1 degree.

(ii) Gage narrowing (a2): This segment contains an alinement deviation on one rail to reduce the gage from the nominal value to the minimum permissible gage or maximum alinement (whichever comes first).

(iii) Gage widening (a3): This segment contains an alinement deviation on one rail to increase the gage from the nominal value to the maximum permissible gage or maximum alinement (whichever comes first).

(iv) Repeated surface (a9): This segment contains three consecutive maximum permissible profile variations on each rail.

(v) Repeated alinement (a4): This segment contains two consecutive maximum permissible alinement variations on each rail.

(vi) Single surface (a10, a11): This segment contains a maximum permissible profile variation on one rail. If the maximum permissible profile variation alone produces a condition which exceeds the maximum allowed warp condition, a second profile variation is also placed on the opposite rail to limit the warp to the maximum permissible value.

(vii) Single alinement (a5, a6): This segment contains a maximum permissible alinement variation on one rail. If the maximum permissible alinement variation alone produces a condition which exceeds the maximum allowed gage condition, a second alinement variation is also placed on the opposite rail to limit the gage to the maximum permissible value.

(viii) Short warp (a12): This segment contains a pair of profile deviations to produce a maximum permissible 10-foot warp perturbation. The first is on the outside rail, and the second follows 10 feet farther on the inside rail. Each deviation has a wavelength, λ, of 20 feet and variable amplitude for each simulation speed as described below. This segment is to be used only on curved track simulations.

(ix) Combined perturbation (a7, a8, a13): This segment contains a maximum permissible down and out combined geometry condition on the outside rail in the body of the curve. If the maximum permissible variations produce a condition which exceeds the maximum allowed gage condition, a second variation is also placed on the opposite rail as for the MCAT segments described in paragraphs (b)(1)(vi) and (vii) of this appendix. This segment is to be used for all simulations on Class 9 track, and only for curved track simulations at speeds producing more than 5 inches of cant deficiency on track Classes 6 through 8, and at speeds producing more than 6 inches of cant deficiency on track Classes 1 through 5.

Guidance: Paragraph (b)(1) describes characteristics of each MCAT segment. Attention needs to be paid when using track geometry data from various measurement systems. The data format may have different sign designations for surface and alignment deviations. For example, in FRA's TGMS system, the alignment perturbation that reduces the gage has negative value for the left rail and positive value for the right rail, referencing the traveling direction of the track inspection car.

Paragraph (b)(1)(i) makes clear that the hunting perturbation segment applies both to tangent track and to track that is curved less than 1 degree. Figure 1 and the text in paragraph (b)(1)(i) reference curvature conditions under which the hunting segment is to be used. Since the curvature value is calculated using a combination of speed and cant deficiency, there is no need to specify which track classes need to include this section in curving simulations.

The amplitude of 0.25 inch of hunting perturbation *a1* will ensure vehicle stability on tangent track. At this limit, wheel contact should stay on the tread, and the ability of the vehicle to remain stable and resist hunting can appropriately be examined.

Paragraph (b)(1)(ix) makes clear that the combined perturbation segment is to be used for all simulations on Class 9 track. Figure 1 also reflects application of the combined perturbations segment to tangent cases on Class 9 track. These provisions make this appendix consistent with § 213.332.

(2) Segment lengths: Each MCAT segment shall be long enough to allow the vehicle's response to the track deviation(s) to damp out. Each segment shall also have a minimum length as specified in table 1 of this appendix, which references the distances in figure 1 of this appendix. For curved track segments, the perturbations shall be placed far enough in the body of the curve to allow for any spiral effects to damp out.

Table 1 of Appendix D to Part 213

Minimum Lengths of MCAT Segments

Distances (ft)								
d_1	d_2	d_3	d_4	d_5	d_6	d_7	d_8	d_9
1000	*1000*	*1000*	*1500*	*1000*	*1000*	*1000*	*1000*	*1000*

Guidance: Paragraph (b)(2) specifies the required length of MCAT segments. Table 1 lists the minimum lengths of each MCAT segment.

Longer segment lengths can be used at higher speeds to allow for transient response to dissipate and to ensure that the filtering window does not extend to the next MCAT segment.

(3) Degree of curvature.

(i) For each simulation involving assessment of curving performance, the degree of curvature, D, which generates a particular level of cant deficiency, E_u, for a given speed, V, shall be calculated using the following equation, which assumes a curve with 6 inches of superelevation:

$$D = \frac{6 + E_u}{0.0007 \times V^2}$$

Where—

D = Degree of curvature (degrees).

V = Simulation speed (m.p.h.).

E_u = Cant deficiency (inches).

(ii) Table 2 of this appendix depicts the degree of curvature for use in MCAT simulations of both passenger and freight equipment performance on Class 2 through 9 track, based on the equation in paragraph (b)(3)(i) of this appendix. The degree of curvature for use in MCAT simulations of equipment performance on Class 1 track is not depicted; it would be based on the same equation using an appropriate superelevation. The degree of curvature for use in MCAT simulations of freight equipment performance on Class 6 (freight) track is shown in italics for cant deficiencies not exceeding 6 inches, to emphasize that the values apply to freight equipment only.

Guidance: Paragraph (b)(3) concerns degree of curvature for use in MCAT simulations of both passenger and freight equipment performance on Class 2 through 9 track by speed and cant deficiency. Paragraph (b)(3)(i) gives the equation to compute curvature, which is a different form of the V_{max} equation in §§ 213.57 and 213.329.

Paragraph (b)(3)(i) contains the newly added Table 2 that gives the applicable curvature for different track classes and cant deficiency, based on the equation in paragraph (b)(3)(i) of this appendix.

For track Classes 2 through 5, degrees of curvature are identified only where the cant deficiencies are more than 6 inches, since those are the only cant deficiencies that require simulations for such track classes. Degrees of curvature for use in MCAT simulations of equipment performance on Class 1 track are not specified because extraordinarily high values of curvature would correspond to such cant deficiencies, which are not physically practical to allow any rail vehicle to traverse. The highest curvature exiting in the U.S. rail system is approximately 20 degrees. Nonetheless, FRA intends that degrees of curvature for Class 1 track be based on the same equation in paragraph (b)(3)(i) using an appropriate superelevation. FRA also notes that the degrees of curvature for use in MCAT simulations of freight equipment performance on Class 6 (freight) track for speeds of 85 and 90 m.p.h. is shown in italics for cant deficiencies not exceeding 6 inches, to emphasize that these values apply to freight equipment only. MCAT simulations are required for both passenger and freight equipment performance where track Class 6 speeds coincide, i.e., speeds exceeding 90 m.p.h.

Table 2 of Appendix D to Part 213
Degree of Curvature for Use in MCAT Simulations (Track Classes 2 through 9)

		Tangent	Cant Deficiency (inches)								
			3	**4**	**5**	**6**	**7**	**8**	**9**		
Passenger	m.p.h.	Degree of curvature used in simulations								m.p.h.	Freight
Class 2	20						46.4	50.0	53.6	20	**Class 2**
	25						29.7	32.0	34.3	25	
	30						20.6	22.2	23.8	30	**Class 3**
Class 3	35						15.2	16.3	17.5	35	
	40						11.6	12.5	13.4	40	
	45						9.17	9.88	10.6	45	**Class 4**
	50						7.43	8.00	8.57	50	
	55						6.14	6.61	7.08	55	
	60						5.16	5.56	5.95	60	
Class 4	65						4.40	4.73	5.07	65	**Class 5**
	70						3.79	4.08	4.37	70	
	75						3.30	3.56	3.81	75	
	80						2.90	3.13	3.35	80	
Class 5	85	0.00	1.78	1.98	2.18	2.37	2.57	2.77	2.97	85	**Class 6**
	90	0.00	1.59	1.76	1.94	2.12	2.29	2.47	2.65	90	
Class 6	95	0.00	1.42	1.58	1.74	1.90	2.06	2.22	2.37	95	
	100	0.00	1.29	1.43	1.57	1.71	1.86	2.00	2.14	100	
	105	0.00	1.17	1.30	1.43	1.55	1.68	1.81	1.94	105	
	110	0.00	1.06	1.18	1.30	1.42	1.53	1.65	1.77	110	
Class 7	115	0.00	0.97	1.08	1.19	1.30	1.40	1.51	1.62	115	**Class 7**
	120	0.00	0.89	0.99	1.09	1.19	1.29	1.39	1.49	120	
	125	0.00	0.82	0.91	1.01	1.10	1.19	1.28	1.37	125	
Class 8	130	0.00	0.76	0.85	0.93	1.01	1.10	1.18	1.27	130	**Class 8**
	135	0.00	0.71	0.78	0.86	0.94	1.02	1.10	1.18	135	
	140	0.00	0.66	0.73	0.80	0.87	0.95	1.02	1.09	140	
	145	0.00	0.61	0.68	0.75	0.82	0.88	0.95	1.02	145	
	150	0.00	0.57	0.63	0.70	0.76	0.83	0.89	0.95	150	
	155	0.00	0.54	0.59	0.65	0.71	0.77	0.83	0.89	155	
	160	0.00	0.50	0.56	0.61	0.67	0.73	0.78	0.84	160	
Class 9	165	0.00	0.47	0.52	0.58	0.63	0.68	0.73	0.79	165	**Class**
	170	0.00	0.44	0.49	0.54	0.59	0.64	0.69	0.74	170	

	175	0.00	0.42	0.47	0.51	0.56	0.61	0.65	0.70	175	9
	180	0.00	0.40	0.44	0.49	0.53	0.57	0.62	0.66	180	
	185	0.00	0.38	0.42	0.46	0.50	0.54	0.58	0.63	185	
	190	0.00	0.36	0.40	0.44	0.47	0.51	0.55	0.59	190	
	195	0.00	0.34	0.38	0.41	0.45	0.49	0.53	0.56	195	
	200	0.00	0.32	0.36	0.39	0.43	0.46	0.50	0.54	200	
	205	0.00	0.31	0.34	0.37	0.41	0.44	0.48	0.51	205	
	210	0.00	0.29	0.32	0.36	0.39	0.42	0.45	0.49	210	
	215	0.00	0.28	0.31	0.34	0.37	0.40	0.43	0.46	215	
	220	0.00	0.27	0.30	0.32	0.35	0.38	0.41	0.44	220	

(c) Required simulations.

(1) To develop a comprehensive assessment of vehicle performance, simulations shall be performed for a variety of scenarios using MCAT. These simulations shall be performed on tangent or curved track, or both, depending on the level of cant deficiency and speed (track class) as summarized in table 3 of this appendix.

Table 3 of Appendix D to Part 213

Summary of Required Vehicle Performance Assessment Using Simulations

	New vehicle types	*Previously qualified vehicle types*
Curved track: cant deficiency ≤ 6 inches	*Curving performance simulation: not required for track Classes 1 through 5; optional for track Class 6; required for track Classes 7 through 9*	*Curving performance simulation: not required for track Classes 1 through 6; optional for track Classes 7 through 9 for cant deficiency > 5 inches*
Curved track: cant deficiency > 6 inches	*Curving performance simulation required for all track classes*	*Curving performance simulation optional for all track classes*
Tangent track	*Tangent performance simulation: not required for track Classes 1 through 5; optional for track Class 6; required for track Classes 7 through 9*	*Tangent performance simulation not required for any track class*

(i) All simulations shall be performed using the design wheel profile and a nominal track gage of 56.5 inches, using tables 4, 5, 6, or 7 of this appendix, as appropriate. In addition, all simulations involving the assessment of curving performance shall be repeated using a nominal track gage of 57.0 inches, using tables 5, 6, or 7 of this appendix, as appropriate.

(ii) If the wheel profile is different than American Public Transportation Administration (APTA) wheel profiles 320 or 340, then for tangent track segments all simulations shall be repeated using either APTA wheel profile 320 or 340, depending on the established conicity that is common for the operation, as specified in APTA SS-M-015-06, Standard for Wheel Flange Angle of Passenger Equipment (2007). This APTA standard is incorporated by reference into this appendix with the approval of the Director of the Federal Register under 5 U.S.C. 552(a) and 1 CFR part 51. To enforce any edition other than that specified in this appendix, FRA must publish notice of change in the Federal Register and the material must be made available to the public. All approved material is available for inspection at the Federal Railroad Administration, Docket Clerk, 1200 New Jersey Avenue, SE., Washington, DC 20590 (telephone 202-493-6030), and is available from the American Public Transportation Association, 1666 K Street NW., Suite 1100, Washington, DC 20006 (telephone 202-496-4800; www.apta.com). It is also available for inspection at the National Archives and Records Administration (NARA). For information on the availability of this material at NARA, call 202-741-6030 or go to http://www.archives.gov/federal_register/code_of_federal_regulations/ibr_locations.html

An alternative worn wheel profile may be used in lieu of either APTA wheel profile, if approved by FRA.

(iii) All simulations shall be performed using a wheel/rail coefficient of friction of 0.5.

Guidance: Paragraph (c) identifies and describes the simulations that are required using MCAT. Table 3 summarizes the requirements by vehicle type, cant deficiency, and class of track when assessing vehicle performance using MCAT.

FRA makes explicit when simulations are required, including identifying when simulations are an option for demonstrating compliance with the rule.

Paragraph (c)(1)(ii) addresses the use of worn wheel profiles in simulations.

Simulations using worn wheels will be conducted only for tangent track segments. Worn wheel profiles can both present a problem for stability on tangent track and affect response during curving. However, the effect of wheel wear on stability on tangent track is of paramount concern. For all other vehicle and rail parameters that might equally or more significantly affect response during curving, only nominal values for such parameters are required to be used in MCAT simulations. Therefore, it is not required that simulations be conducted with worn wheel profiles in curves.

(2) Vehicle performance on tangent track Classes 6 through 9. For maximum vehicle speeds corresponding to track Class 6 and higher, the MCAT segments described in paragraphs (b)(1)(i) through (vii) of this appendix shall be used to assess vehicle performance on tangent track. For track Class 9, simulations must also include the

combined perturbation segment described in paragraph (b)(1)(ix) of this appendix. A parametric matrix of MCAT simulations shall be performed using the following range of conditions:

(i) *Vehicle speed. Simulations shall demonstrate that at up to 5 m.p.h. above the proposed maximum operating speed, the vehicle type shall not exceed the wheel/rail force and acceleration criteria defined in the Vehicle/Track Interaction Safety Limits table in § 213.333. Simulations shall also demonstrate acceptable vehicle dynamic response by incrementally increasing speed from 95 m.p.h. (115 m.p.h. if a previously qualified vehicle type on an untested route) to 5 m.p.h. above the proposed maximum operating speed (in 5 m.p.h. increments).*

(ii) *Perturbation wavelength. For each speed, a set of three separate MCAT simulations shall be performed. In each MCAT simulation for the perturbation segments described in paragraphs (b)(1)(ii) through (vii) and (b)(1)(ix) of this appendix, every perturbation shall have the same wavelength. The following three wavelengths, λ, shall be used: 31, 62, and 124 feet. The hunting perturbation segment described in paragraph (b)(1)(i) of this appendix has a fixed wavelength, λ, of 10 feet.*

(iii) *Amplitude parameters. Table 4 of this appendix provides the amplitude values for the MCAT segments described in paragraphs (b)(1)(i) through (vii) and (b)(1)(ix) of this appendix for each speed of the required parametric MCAT simulations. The last set of simulations shall be performed at 5 m.p.h. above the proposed maximum operating speed using the amplitude values in table 4 that correspond to the proposed maximum operating speed. For qualification of vehicle types at speeds greater than track Class 6 speeds, the following additional simulations shall be performed:*

(A) *For vehicle types being qualified for track Class 7 speeds, one additional set of simulations shall be performed at 115 m.p.h. using the track Class 6 amplitude values in table 4 (i.e., a 5 m.p.h. overspeed on Class 6 track).*

(B) *For vehicle types being qualified for track Class 8 speeds, two additional sets of simulations shall be performed. The first set at 115 m.p.h. using the track Class 6 amplitude values in table 4 (i.e., a 5 m.p.h. overspeed on Class 6 track), and a second set at 130 m.p.h. using the track Class 7 amplitude values in table 4 (i.e., a 5 m.p.h. overspeed on Class 7 track).*

(C) *For vehicle types being qualified for track Class 9 speeds, three additional sets of simulations shall be performed. The first set at 115 m.p.h. using the track Class 6 amplitude values in table 4 (i.e., a 5 m.p.h. overspeed on Class 6 track), a second set at 130 m.p.h. using the track Class 7 amplitude values in table 4 (i.e., a 5 m.p.h. overspeed on Class 7 track), and a third set at 165 m.p.h. using the track Class 8 amplitude values in table 4 (i.e., a 5 m.p.h. overspeed on Class 8 track).*

Table 4 of Appendix D to Part 213
Track Class 6 through 9 Amplitude Parameters (in inches) for MCAT Simulations on Tangent Track

		Gage 56.5"			
		Class 6	Class 7	Class 8	Class 9
Max. Operating Speed (m.p.h.)		110	125	160	220
Max. Simulation Speed (m.p.h.)		115	130	165	225
MCAT Segments	**Parameter**	**Segment Description**			
Hunting	a_1	(b)(1)(i)			
Gage Narrowing	a_2	(b)(1)(ii)			
Gage Widening	a_3	(b)(1)(iii)			
Repeated Surface	a_9	(b)(1)(iv)			
Repeated Alinement	a_4	(b)(1)(v)			
Single Surface	a_{10}, a_{11}	(b)(1)(vi)			
Single Alinement	a_5, a_6	(b)(1)(vii)			
Short Warp	a_{12}				
Combined Perturbation	a_7, a_8, a_{13}				(b)(1)(ix)
		Amplitude Parameters (inches)			
Wavelength λ = 10ft	a_1	0.250	0.250	0.250	0.250
Wavelength λ = 20ft	a_{12}				
Wavelength λ = 31ft	a_2	0.500	0.500	0.500	0.250
	a_3	0.750	0.500	0.500	0.500
	a_4	0.375	0.375	0.375	0.375
	a_5	0.500	0.500	0.500	0.500
	a_6	0.000	0.000	0.000	0.000
	a_7				0.333
	a_8				0.000
	a_9	0.750	0.750	0.500	0.375
	a_{10}	1.000	1.000	0.750	0.500
	a_{11}	0.000	0.000	0.000	0.000
	a_{13}				0.333
Wavelength λ = 62ft	a_2	0.500	0.500	0.500	0.250
	a_3	0.750	0.500	0.500	0.500
	a_4	0.500	0.375	0.375	0.375
	a_5	0.750	0.750	0.750	0.500
	a_6	0.000	0.250	0.250	0.000
	a_7				0.333
	a_8				0.000
	a_9	0.750	0.750	0.750	0.500
	a_{10}	1.000	1.000	1.000	0.750
	a_{11}	0.000	0.000	0.000	0.000
	a_{13}				0.500
Wavelength λ = 124ft	a_2	0.500	0.500	0.500	0.250
	a_3	0.750	0.750	0.750	0.750
	a_4	1.000	0.875	0.500	0.500
	a_5	1.500	1.250	1.000	0.750
	a_6	0.750	0.500	0.250	0.000
	a_7				0.500
	a_8				0.000
	a_9	1.250	1.000	0.875	0.625
	a_{10}	1.750	1.500	1.250	1.000
	a_{11}	0.250	0.000	0.000	0.000
	a_{13}				0.667

Guidance: Paragraph (c)(2) addresses vehicle performance on tangent track Classes 6 through 9. The text in paragraphs (c)(2)(ii) and (iii) describes the simulation parameters, i.e., wavelength and amplitude listed in Table 4.

Table 4 in the paragraph provides the amplitude values for the MCAT segments described in paragraphs (b)(1)(i) through (vii) and, for track Class 9, (b)(1)(ix), for each speed of the required parametric MCAT simulations.

The header table contains the maximum operating and simulation speeds for each track class, along with a list of all of the amplitude parameters identifying each MCAT segment to which they correspond, where each segment description can be found, and to which class(es) of track they are applicable.

(3) Vehicle performance on curved track Classes 6 through 9. For maximum vehicle speeds corresponding to track Class 6 and higher, the MCAT segments described in paragraphs (b)(1)(ii) through (viii) of this appendix shall be used to assess vehicle performance on curved track. For curves less than 1 degree, simulations must also include the hunting perturbation segment described in paragraph (b)(1)(i) of this appendix. For track Class 9 and for cant deficiencies greater than 5 inches, simulations must also include the combined perturbation segment described in paragraph (b)(1)(ix) of this appendix. A parametric matrix of MCAT simulations shall be performed using the following range of conditions:

(i) Vehicle speed. Simulations shall demonstrate that at up to 5 m.p.h. above the proposed maximum operating speed, the vehicle type shall not exceed the wheel/rail force and acceleration criteria defined in the Vehicle/Track Interaction Safety Limits table in § 213.333. Simulations shall also demonstrate acceptable vehicle dynamic response by incrementally increasing speed from 95 m.p.h. (115 m.p.h. if a previously qualified vehicle type on an untested route) to 5 m.p.h. above the proposed maximum operating speed (in 5 m.p.h. increments).

(ii) Perturbation wavelength. For each speed, a set of three separate MCAT simulations shall be performed. In each MCAT simulation for the perturbation segments described in paragraphs (b)(1)(ii) through (vii) and paragraph (b)(1)(ix) of this appendix, every perturbation shall have the same wavelength. The following three wavelengths, λ, shall be used: 31, 62, and 124 feet. The hunting perturbation segment described in paragraph (b)(1)(i) of this appendix has a fixed wavelength, λ, of 10 feet, and the short warp perturbation segment described in paragraph (b)(1)(viii) of this appendix has a fixed wavelength, λ, of 20 feet.

(iii) Track curvature. For each speed, a range of curvatures shall be used to produce cant deficiency conditions ranging from greater than 3 inches up to the maximum intended for qualification (in 1 inch increments). The value of curvature, D, shall be determined using the equation defined in paragraph (b)(3) of this appendix. Each curve shall include representations of the MCAT segments described in paragraphs (b)(1)(i) through (ix) of this appendix, as appropriate, and have a fixed superelevation of 6 inches.

(iv) Amplitude parameters. Table 5 of this appendix provides the amplitude values for each speed of the required parametric MCAT simulations for cant deficiencies greater than 3 inches and not more than 5 inches. Table 6 of this appendix provides the amplitude values for each speed of the required parametric MCAT simulations for cant deficiencies greater

than 5 inches. The last set of simulations at the maximum cant deficiency shall be performed at 5 m.p.h. above the proposed maximum operating speed using the amplitude values in table 5 or 6 of this appendix, as appropriate, that correspond to the proposed maximum operating speed and cant deficiency. For these simulations, the value of curvature, D, shall correspond to the proposed maximum operating speed and cant deficiency. For qualification of vehicle types at speeds greater than track Class 6 speeds, the following additional simulations shall be performed:

(A) For vehicle types being qualified for track Class 7 speeds, one additional set of simulations shall be performed at 115 m.p.h. using the track Class 6 amplitude values in table 5 or 6 of this appendix, as appropriate (i.e., a 5 m.p.h. overspeed on Class 6 track) and a value of curvature, D, that corresponds to 110 m.p.h. and the proposed maximum cant deficiency.

(B) For vehicle types being qualified for track Class 8 speeds, two additional set of simulations shall be performed. The first set of simulations shall be performed at 115 m.p.h. using the track Class 6 amplitude values in table 5 or 6 of this appendix, as appropriate (i.e., a 5 m.p.h. overspeed on Class 6 track) and a value of curvature, D, that corresponds to 110 m.p.h. and the proposed maximum cant deficiency. The second set of simulations shall be performed at 130 m.p.h. using the track Class 7 amplitude values in table 5 or 6, as appropriate (i.e., a 5 m.p.h. overspeed on Class 7 track) and a value of curvature, D, that corresponds to 125 m.p.h. and the proposed maximum cant deficiency.

(C) For vehicle types being qualified for track Class 9 speeds, three additional sets of simulations shall be performed. The first set of simulations shall be performed at 115 m.p.h. using the track Class 6 amplitude values in table 5 or 6 of this appendix, as appropriate (i.e., a 5 m.p.h. overspeed on Class 6 track) and a value of curvature, D, that corresponds to 110 m.p.h. and the proposed maximum cant deficiency. The second set of simulations shall be performed at 130 m.p.h. using the track Class 7 amplitude values in table 5 or 6, as appropriate (i.e., a 5 m.p.h. overspeed on Class 7 track) and a value of curvature, D, that corresponds to 125 m.p.h. and the proposed maximum cant deficiency. The third set of simulations shall be performed at 165 m.p.h. using the track Class 8 amplitude values in table 5 or 6, as appropriate (i.e., a 5 m.p.h. overspeed on Class 8 track) and a value of curvature, D, that corresponds to 160 m.p.h. and the proposed maximum cant deficiency.

Table 5 of Appendix D to Part 213
Track Classes 6 through 9 Amplitude Parameters (in inches)
for MCAT Simulations on Curved Track with Cant Deficiency > 3 and ≤ 5 Inches

		Gage 56.5"				Gage 57.0"			
		Class 6	**Class 7**	**Class 8**	**Class 9**	**Class 6**	**Class 7**	**Class 8**	**Class 9**
Max. Operating Speed (m.p.h.)		110	125	160	220	110	125	160	220
Max. Simulation Speed (m.p.h.)		115	130	165	225	115	130	165	225
MCAT Segments	**Parameter**	**Segment Description**				**Segment Description**			
Hunting	a_1	(b)(1)(i) [1]				(b)(1)(i) [1]			
Gage Narrowing	a_2	(b)(1)(ii)				(b)(1)(ii)			
Gage Widening	a_3	(b)(1)(iii)				(b)(1)(iii)			
Repeated Surface	a_9	(b)(1)(iv)				(b)(1)(iv)			
Repeated Alinement	a_4	(b)(1)(v)				(b)(1)(v)			
Single Surface	a_{10}, a_{11}	(b)(1)(vi)				(b)(1)(vi)			
Single Alinement	a_5, a_6	(b)(1)(vii)				(b)(1)(vii)			
Short Warp	a_{12}	(b)(1)(viii)				(b)(1)(viii)			
Combined Perturbation	a_7, a_8,				(b)(1)(ix)				(b)(1)(ix)
		Amplitude Parameters				**Amplitude Parameters (inches)**			
Wavelength λ = 10ft	a_1	0.250	0.250[1]	0.250[1]	0.250[1]	0.250	0.250[1]	0.250[1]	0.250[1]
Wavelength λ = 20ft	a_{12}	0.625	0.563	0.500	0.375	0.625	0.563	0.500	0.375
Wavelength λ = 31ft	a_2	0.500	0.500	0.500	0.250	0.500	0.500	0.500	0.500
	a_3	0.750	0.500	0.500	0.500	0.250	0.250	0.250	0.500
	a_4	0.375	0.375	0.375	0.375	0.375	0.375	0.375	0.375
	a_5	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500
	a_6	0.000	0.000	0.000	0.000	0.250	0.250	0.250	0.250
	a_7				0.333				0.333
	a_8				0.000				0.083
	a_9	0.750	0.750	0.500	0.375	0.750	0.750	0.500	0.375
	a_{10}	1.000	1.000	0.750	0.500	1.000	1.000	0.750	0.500
	a_{11}	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	a_{13}				0.333				0.333
Wavelength λ = 62ft	a_2	0.500	0.500	0.500	0.250	0.500	0.500	0.500	0.500
	a_3	0.750	0.500	0.500	0.500	0.250	0.250	0.250	0.250
	a_4	0.500	0.375	0.375	0.375	0.500	0.375	0.375	0.375
	a_5	0.625	0.500	0.500	0.500	0.625	0.500	0.500	0.500
	a_6	0.000	0.000	0.000	0.000	0.375	0.250	0.250	0.250
	a_7				0.333				0.333
	a_8				0.000				0.083
	a_9	0.750	0.750	0.750	0.500	0.750	0.750	0.750	0.500
	a_{10}	1.000	1.000	1.000	0.750	1.000	1.000	1.000	0.750
	a_{11}	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	a_{13}				0.500				0.500
Wavelength λ = 124ft		0.500	0.500	0.500	0.250	1.000	1.000	1.000	0.750
	a_3	0.750	0.750	0.750	0.750	0.250	0.250	0.250	0.250
	a_4	1.000	0.875	0.500	0.500	1.000	0.875	0.500	0.500
	a_2	1.500	1.250	0.750	0.750	1.500	1.250	0.750	0.750
	a_6	0.750	0.500	0.000	0.000	1.250	1.000	0.500	0.500
	a_7				0.500				0.500
	a_8				0.000				0.250
	a_9	1.250	1.000	0.875	0.625	1.250	1.000	0.875	0.625
	a_{10}	1.750	1.500	1.250	1.000	1.750	1.500	1.250	1.000
	a_{11}	0.250	0.000	0.000	0.000	0.250	0.000	0.000	0.000
	a_{13}				0.667				0.667

[1] For curves <1 degree

Table 6 of Appendix D to Part 213
Track Class 6 through 9 Amplitude Parameters (in inches) for MCAT Simulations on Curved Track with Cant Deficiency > 5 Inches

		Gage 56.5"				Gage 57.0"			
		Class 6	**Class 7**	**Class 8**	**Class 9**	**Class 6**	**Class 7**	**Class 8**	**Class 9**
Max. Operating Speed (m.p.h.)		110	125	160	220	110	125	160	220
Max. Simulation Speed (m.p.h.)		115	130	165	225	115	130	165	225
MCAT Segments	**Parameter**	**Segment Description**				**Segment Description**			
Hunting	a_1	(b)(1)(i) [1]				(b)(1)(i) [1]			
Gage Narrowing	a_2	(b)(1)(ii)				(b)(1)(ii)			
Gage Widening	a_3	(b)(1)(iii)				(b)(1)(iii)			
Repeated Surface	a_9	(b)(1)(iv)				(b)(1)(iv)			
Repeated Alinement	a_4	(b)(1)(v)				(b)(1)(v)			
Single Surface	a_{10}, a_{11}	(b)(1)(vi)				(b)(1)(vi)			
Single Alinement	a_5, a_6	(b)(1)(vii)				(b)(1)(vii)			
Short Warp	a_{12}	(b)(1)(viii)				(b)(1)(viii)			
Combined Perturbation	a_7, a_8, a_{13}				(b)(1)(ix)				(b)(1)(ix)
		Amplitude Parameters (inches)				**Amplitude Parameters (inches)**			
Wavelength λ = 10ft	a_1	0.250[1]	0.250[1]	0.250[1]	0.250[1]	0.250[1]	0.250[1]	0.250[1]	0.250[1]
Wavelength λ = 20ft	a_{12}	0.625	0.500	0.500[2]	0.375	0.625	0.500	0.500[2]	0.375
Wavelength λ = 31ft	a_2	0.500	0.500	0.500	0.250	0.500	0.500	0.500	0.500
	a_3	0.750	0.500	0.500	0.500	0.250	0.250	0.250	0.500
	a_4	0.375	0.375	0.375	0.375	0.375	0.375	0.375	0.375
	a_5	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500
	a_6	0.000	0.000	0.000	0.000	0.250	0.250	0.250	0.250
	a_7	0.333	0.333	0.333	0.333	0.333	0.333	0.333	0.333
	a_8	0.000	0.000	0.000	0.000	0.083	0.083	0.083	0.083
	a_9	0.750	0.750	0.500	0.375	0.750	0.750	0.500	0.375
	a_{10}	1.000	1.000	0.750	0.500	1.000	1.000	0.750	0.500
	a_{11}	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	a_{13}	0.667	0.667	0.500	0.333	0.667	0.667	0.500	0.333
Wavelength λ = 62ft	a_2	0.500	0.500	0.500	0.250	0.500	0.500	0.500	0.500
	a_3	0.750	0.500	0.500	0.500	0.250	0.250	0.250	0.250
	a_4	0.500	0.375	0.375	0.375	0.500	0.375	0.375	0.375
	a_5	0.625	0.500	0.500	0.500	0.625	0.500	0.500	0.500
	a_6	0.000	0.000	0.000	0.000	0.375	0.250	0.250	0.250
	a_7	0.417	0.333	0.333	0.333	0.417	0.333	0.333	0.333
	a_8	0.000	0.000	0.000	0.000	0.167	0.083	0.083	0.083
	a_9	0.750	0.750	0.750	0.500	0.750	0.750	0.750	0.500
	a_{10}	1.000	1.000	1.000	0.750	1.000	1.000	1.000	0.750
	a_{11}	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	a_{13}	0.667	0.667	0.667	0.500	0.667	0.667	0.667	0.500
Wavelength λ = 124ft	a_2	0.500	0.500	0.500	0.250	1.000	1.000	1.000	0.750
	a_3	0.750	0.750	0.750	0.750	0.250	0.250	0.250	0.250
	a_4	1.000	0.875	0.500	0.500	1.000	0.875	0.500	0.500
	a_5	1.250	1.000	0.750	0.750	1.250	1.000	0.750	0.750
	a_6	0.500	0.250	0.000	0.000	1.000	0.750	0.500	0.500
	a_7	0.833	0.667	0.500	0.500	0.833	0.667	0.500	0.500
	a_8	0.083	0.000	0.000	0.000	0.583	0.417	0.250	0.250
	a_9	1.250	1.000	0.875	0.625	1.250	1.000	0.875	0.625
	a_{10}	1.500	1.250	1.250	1.000	1.500	1.250	1.250	1.000
	a_{11}	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	a_{13}	1.000	0.833	0.833	0.667	1.000	0.833	0.833	0.667

[1] For curves <1 degree

[2] 0.375 for E_u>7"

Guidance: Paragraph (c)(3) addresses vehicle performance on curved track Classes 6 through 9. Paragraphs (c)(3)(ii) and (iv) contain the descriptive text regarding the information in Tables 5 and 6. Paragraph (c)(3)(ii) makes clear that running simulations using all three wavelengths is a requirement. Paragraph (c)(3)(iv) specifies the need to run the final simulations at 5 m.p.h. over the maximum proposed operating speed and cant deficiency. Paragraphs (c)(3)(iv)(A) through (C) specify that this 5 m.p.h. overspeed condition is required when transitioning between classes, e.g., 115 m.p.h. for Class 6 track when qualifying a vehicle for Class 7 track. In addition, the text in paragraphs (c)(3)(iv)(A) through (C) describes how the 5 m.p.h. overspeed cases at the end of a track class will be conducted at the maximum proposed cant deficiency, using the curvature value, D, calculated using the maximum track class speed and maximum proposed cant deficiency.

Table 5 applies to Class 6 through 9 curved track with cant deficiency greater than 3 inches but not greater than 5 inches; Table 6 applies to Class 6 through 9 curved track with cant deficiency greater than 5 inches. Both tables contain the maximum operating and simulation speeds for each track class, along with a list of all of the amplitude parameters identifying each MCAT segment to which they correspond, where each segment description can be found, and to which class(es) of track they are applicable.

(4) Vehicle performance on curved track Classes 1 through 5 at high cant deficiency. For maximum vehicle speeds corresponding to track Classes 1 through 5, the MCAT segments described in paragraphs (b)(1)(ii) through (ix) of this appendix shall be used to assess vehicle performance on curved track if the proposed maximum cant deficiency is greater than 6 inches. A parametric matrix of MCAT simulations shall be performed using the following range of conditions:

(i) Vehicle speed. Simulations shall demonstrate that at up to 5 m.p.h. above the proposed maximum operating speed, the vehicle shall not exceed the wheel/rail force and acceleration criteria defined in the Vehicle/Track Interaction Safety Limits table in § 213.333. Simulations shall also demonstrate acceptable vehicle dynamic response at 5 m.p.h. above the proposed maximum operating speed.

(ii) Perturbation wavelength. For each speed, a set of two separate MCAT simulations shall be performed. In each MCAT simulation for the perturbation segments described in paragraphs (b)(1)(ii) through (vii) and paragraph (b)(1)(ix) of this appendix, every perturbation shall have the same wavelength. The following two wavelengths, λ, shall be used: 31 and 62 feet. The short warp perturbation segment described in paragraph (b)(1)(viii) of this appendix has a fixed wavelength, λ, of 20 feet.

(iii) Track curvature. For a speed corresponding to 5 m.p.h. above the proposed maximum operating speed, a range of curvatures shall be used to produce cant deficiency conditions ranging from 6 inches up to the maximum intended for qualification (in 1 inch increments). The value of curvature, D, shall be determined using the equation in paragraph (b)(3) of this appendix. Each curve shall contain the MCAT segments described in paragraphs (b)(1)(ii) through (ix) of this appendix and have a fixed superelevation of 6 inches.

(iv) *Amplitude parameters. Table 7 of this appendix provides the amplitude values for the MCAT segments described in paragraphs (b)(1)(ii) through (ix) of this appendix for each speed of the required parametric MCAT simulations.*

Table 7 of Appendix D to Part 213
Track Class 1 through 5 Amplitude Parameters (in inches) for MCAT Simulations on Curved Track with Cant Deficiency > 6 Inches

		Gage 56.5"					Gage 57.0"				
		Class 1	**Class 2**	**Class 3**	**Class 4**	**Class 5**	**Class 1**	**Class 2**	**Class 3**	**Class 4**	**Class 5**
Max. Operating Speed (m.p.h.)		15	30	60	80	90	15	30	60	80	90
Max. Simulation Speed (m.p.h.)		20	35	65	85	95	20	35	65	85	95
MCAT Segments	**Parameter**	**Segment Description**					**Segment Description**				
Hunting	a_1										
Gage Narrowing	a_2	(b)(1)(ii)					(b)(1)(ii)				
Gage Widening	a_3	(b)(1)(iii)					(b)(1)(iii)				
Repeated Surface	a_9	(b)(1)(iv)					(b)(1)(iv)				
Repeated Alinement	a_4	(b)(1)(v)					(b)(1)(v)				
Single Surface	a_{10}, a_{11}	(b)(1)(vi)					(b)(1)(vi)				
Single Alinement	a_5, a_6	(b)(1)(vii)					(b)(1)(vii)				
Short Warp	a_{12}	(b)(1)(viii)					(b)(1)(viii)				
Combined Perturbation	a_7, a_8,	(b)(1)(ix)					(b)(1)(ix)				
		Amplitude Parameters (inches)					**Amplitude Parameters (inches)**				
Wavelength λ = 10ft	a_1										
Wavelength λ = 20ft	a_{12}	1.000	1.000	0.875	0.875	0.750	1.000	1.000	0.875	0.875	0.750
Wavelength λ = 31ft	a_2	0.500	0.500	0.500	0.500	0.500	1.250	1.250	1.250	0.500	0.500
	a_3	1.250	1.250	1.250	0.500	0.500	0.750	0.750	0.750	0.500	0.500
	a_4	0.750	0.750	0.750	0.750	0.500	0.750	0.750	0.750	0.750	0.500
	a_5	0.750	0.750	0.750	0.750	0.500	0.750	0.750	0.750	0.750	0.500
	a_6	0.000	0.000	0.000	0.250	0.000	0.000	0.000	0.000	0.250	0.000
	a_7	0.500	0.500	0.500	0.500	0.333	0.500	0.500	0.500	0.500	0.333
	a_8	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	a_9	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	a_{10}	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	a_{11}	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	a_{13}	0.667	0.667	0.667	0.667	0.667	0.667	0.667	0.667	0.667	0.667
Wavelength λ = 62ft	a_2	0.500	0.500	0.500	0.500	0.500	1.250	1.250	1.250	0.500	0.500
	a_3	1.250	1.250	1.250	0.500	0.500	0.750	0.750	0.750	0.500	0.500
	a_4	1.250	1.250	1.250	0.875	0.625	1.250	1.250	1.250	0.875	0.625
	a_5	1.250	1.250	1.250	0.875	0.625	1.250	1.250	1.250	0.875	0.625
	a_6	0.000	0.000	0.000	0.375	0.125	0.500	0.500	0.500	0.375	0.125
	a_7	0.833	0.833	0.833	0.583	0.417	0.833	0.833	0.833	0.583	0.417
	a_8	0.000	0.000	0.000	0.083	0.000	0.083	0.083	0.083	0.083	0.000
	a_9	1.750	1.750	1.750	1.250	1.000	1.750	1.750	1.750	1.250	1.000
	a_{10}	1.750	1.750	1.750	1.250	1.000	1.750	1.750	1.750	1.250	1.000
	a_{11}	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	a_{13}	1.167	1.167	1.167	0.833	0.667	1.167	1.167	1.167	0.833	0.667

Guidance: Paragraph (c)(4) addresses vehicle performance on curved track Classes 1 through 5 at high cant deficiency.

Paragraph (c)(4)(ii) makes clear that running simulations using both the 31-foot and 62-foot wavelengths is required for assessing vehicle performance on curved track Classes 1 through 5 at high cant deficiency.

Table 7 contains information for Classes 1 through 5 track similar to that in Tables 5 and 6 for curved track Classes 6 through 9.