RSAC Vehicle-Track Interaction Task Force

Final Report

Volume 1 – Proposed Rule Text

Recommendations for High Speed, High Cant Deficiency Track Geometry Standards and Track-Vehicle Interaction Safety Limits to the Passenger Safety Working Group, Rail Safety Advisory Committee

December 3, 2007

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1. Introduction

This report volume documents the proposed changes and revisions to the Federal Railroad Administration (FRA) Track Safety Standards, *49 CFR 213*, as developed by the Track-Vehicle Interaction (TVI) Task Force and recommended to the Passenger Safety Working Group, Rail Safety Advisory Committee (RSAC). To ensure consistency with these recommendations, this report volume also includes proposed changes to the FRA Passenger Equipment Safety Standards, *49 CFR 238*. This document provides an outline of the changes to the existing text and a description of the rationale for the proposed revisions. A complete discussion of the technical justification for the recommended changes can be found in Volume 2.

1.1 Background

The Passenger Safety Working Group which was established by the RSAC, formed the TVI Task Force to review, update and recommend rule changes to the FRA Safety Standards *49 CFR 213, Subpart G*, issued in 1998 to reflect experience gained in qualifying several vehicles for high speed and high cant deficiency operation, including Amtrak's Acela high speed trainset, Maryland Transportation Authority's MARC-III bi-level car, New Jersey Transit's ALP-46 locomotive and Comet 5 car. The Track Standards for Class 6 and above currently cover the speed range of qualified passenger equipment at 91 miles per hour to 200 miles per hour and qualified freight equipment in the range of 81 miles per hour to 200 miles per hour.

The TVI Task Force recognized that the high speed standards were built on the principle that, to ensure safety, the interaction of the track and the vehicles must be considered within a system safety approach that provides for specific limits for vehicle response to track perturbations. This report Volume 1 and the companion Volume 2 reflect the approach taken by the Task Force, the supporting information and description of the development process, and the results, recommendations and conclusions reached by the Task Force.

1.2 Purpose

The purpose of this report volume is to document the proposed changes and revisions to the Track Safety Standards, *49 CFR 213* and the Passenger Equipment Safety Standards, *49 CFR 238*, as developed and recommended by the TVI Task Force.

1.3 Scope and Methodology

From the outset, the Task Force strove to develop practical standards that were based on a sound physical and mathematical basis, accounted for a range of vehicle types that are currently used and may likely be used on future high speed and/or high cant deficiency rail operations, provide safety assurance for train operations in all classes of track, would not present an undue burden on operators, and that were verifiable by field measurements.

The Task Force first identified the key issues requiring attention based on the past six years experience with the application of the current track safety standards, and defined work efforts to:

1. Consolidate inconsistencies between the track and equipment rules, low and high speed track safety standards, and requirements within the track safety standards

2. Establish necessary safety limits on wheel profile and truck equalization

3. Revise qualification requirements for high speed/high cant deficiency operation

4. Revise safety criteria (acceleration and wheel force limits)

5. Revise inspection, monitoring and maintenance requirements

6. Revise track geometry limits for high speed

7. Establish consistent requirements for high cant deficiency operations

Through the close examination of each of the above issues, the Task Force developed the proposed revisions contained in this report volume, which are intended to result in improved public safety and reduced burden to the railroad industry. These revisions were arrived at through dynamic simulation studies, consideration of international practices, and a thorough review of qualification and revenue service test data.

1.4 TVI Task Force

The TVI Task Force was composed of a number of FRA officials, railroad representatives, railroad engineering experts, consultants, labor representatives, and Volpe National Transportation Systems Center (VNTSC) engineers. Table 1-2 lists the Task Force participants and their respective organizations.

Table 1-2. List of Participants

Name	Organization
John Mardente	**Chair, FRA Office of Safety**
Cynthia Gross	Facilitator, FRA
Dan Alpert	FRA/RCC
Tom Blankenship	FRA Office of Safety
Magdy El-Sibaie	FRA Office of R&D
Gary Fairbanks	FRA Office of Safety
Al MacDowell	FRA Office of Safety (now retired)
Ron Newman	FRA Office of Safety
Frank Roskind	FRA/RRS
Satya Singh	FRA Office of Safety
Ali Tajaddini	FRA Office of R&D
Louis Cerny	Representing AAR
Greg Gagarin	Amtrak
James Howe	Amtrak
Pat Malin	Amtrak
Dave Staplin	Amtrak
Michael Trosino	Amtrak
Tom Peacock	APTA
Rick Inclima	BMWE
Nicolas Lessard	Bombardier Transportation
Timothy DePaepe	BRS
Peter Klauser	Consultant/FRA
Phil Olekszyk	Consultant/APTA
Jason Heineman	ENSCO/FRA
Kevin Kesler	ENSCO/FRA
Tim Martin	ENSCO/FRA
Amit Singh	ENSCO/FRA (formerly)
Brian Whitten	ENSCO/FRA
Larry Kelterborn	Interfleet Technology/APTA
Mark Stewart	Interfleet Technology/APTA
Steve Chrismer	LTK
Eric Magel	NRC-CSTT
Phil Strong	PS Consulting
Mike Coltman	VNTSC
Eric Curtis	VNTSC
Jon LeBlanc	VNTSC
Brian Marquis	VNTSC

2. Proposed Rule Text: 49 CFR 213 Subpart A – General

2.1 § 213.7 – Designation of qualified persons to supervise certain renewals and inspect track.

Changes to this section involved eliminating the need for qualified persons to be familiar with Subpart G requirements. The wording "that apply to the restoration and renewal of the track for which he or she is responsible" was added to the end of § 213.7(a)(2)(i). Three (3) other sentences in this section were similarly modified.

The original wording of the paragraph required that the person designated under 213.7 "knows and understands the requirements of this part". This required the person to have knowledge and understanding of everything in the book regardless of whether that person needed it to perform their duties. The addition of vehicle qualification and testing for high cant deficiency operations has added a level of complexity and requirements that are outside of the purview of the track foremen and inspectors. This change in language was made to relieve the qualified person from having to know and understand things not germane to that person's qualifications, or position.

§ 213.7 – Designation of qualified persons to supervise certain renewals and inspect track.

(a) Each track owner to which this part applies shall designate qualified persons to supervise restorations and renewals of track under traffic conditions. Each person designated shall have--

- (1) At least--
  - (i) 1 year of supervisory experience in railroad track maintenance; or
  - (ii) A combination of supervisory experience in track maintenance and training from a course in track maintenance or from a college level educational program related to track maintenance;
- (2) Demonstrated to the owner that he or she--
  - (i) Knows and understands the requirements of this part that apply to the restoration and renewal of the track for which he or she is responsible;
  - (ii) Can detect deviations from those requirements; and
  - (iii) Can prescribe appropriate remedial action to correct or safely compensate for those deviations; and
- (3) Written authorization from the track owner to prescribe remedial actions to correct or safely compensate for deviations from the requirements in this part that apply to the track for which he or she is responsible.

§ 213.7 – Designation of qualified persons to supervise certain renewals and inspect track.

(b) Each track owner to which this part applies shall designate qualified persons to inspect track for defects. Each person designated shall have--

(1) At least--

(i) 1 year of experience in railroad track inspection; or

(ii) A combination of experience in track inspection and training from a course in track inspection or from a college level educational program related to track inspection;

(2) Demonstrated to the owner that he or she--

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

(ii) Can detect deviations from those requirements; and

(iii) Can prescribe appropriate remedial action to correct or safely compensate for those deviations; and

(3) Written authorization from the track owner to prescribe remedial actions to correct or safely compensate for deviations from the requirements of this part that apply to the track for which he or she is responsible, pending review by a qualified person designated under paragraph (a) of this section.

[NOTE: Paragraphs (c) and (d) remain unchanged.]

3. Proposed Rule Text: 49 CFR 213 Subpart C – Track Geometry

3.1 § 213.55 – Track Alinement

Changes to this section primarily involved the addition of tighter single deviation geometry limits for operations above five inches of cant deficiency on track Classes 1-5. These include 31-foot and 62-foot mid chord offset limits.

Simulation studies have been performed using computer models of the AEM7 Locomotive, Acela Powercar, Acela Coach, and Amfleet Coach to determine the amplitude of alinement track geometry anomalies that result in undesirable response as defined by the VTI limits. These simulations were performed using two coefficients of friction (0.1 and 0.5), two anomaly shapes (bump and ramp), and combinations of speed, curvature and superelevation to cover a range of cant deficiency. The simulation results were used to determine the safe amplitudes of alinement track geometry variations. Results show that these proposed track geometry limits are necessary in order to provide an equivalent margin of safety for operations at higher cant deficiency.

Also, footnote 4 is new and the section title has been modified to better align with other sections.

§ 213.55 – Track Alinement

(a) Except as provided in paragraph (b), alinement may not deviate from uniformity more than the amount prescribed in the following table:

Class of Track	Tangent Track	Curved Track	
	The deviation of the mid-offset from a 62-foot line[1] may not be more than – (inches)	The deviation of the mid-ordinate from a 31-foot chord [2] may not be more than – (inches)	The deviation of the mid-ordinate from a 62-foot chord [2] may not be more than – (inches)
Class 1 Track	5	[3]N/A	5
Class 2 Track	3	[3]N/A	3
Class 3 Track	1¾	1¼	1¾
Class 4 Track	1½	1	1½
Class 5 Track	¾	½	⅝

§ 213.55 – Track Alinement

(b) On the outside rail in curves with Eu more than 5 inches, the alinement in the curve may not deviate from uniformity more than the amount prescribed in the following table:

Class of Track	Curved Track	
	The deviation of the mid-ordinate from a 31-foot chord [2] may not be more than – (inches)	The deviation of the mid-ordinate from a 62-foot chord [2] may not be more than – (inches)
Class 1 Track[4]	[3]N/A	1¼
Class 2 Track[4]	[3]N/A	1¼
Class 3 Track	¾	1¼
Class 4 Track	¾	⅞
Class 5 Track	½	⅝

[1] The ends of the line shall be at points on the gage side of the line rail, five-eighths of an inch below the top of the railhead. 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.

[2] The ends of the chord shall be at points on the gage side of the outer rail, five-eighths below the top of the railhead.

[3] N/A – Not Applicable

[4] Restraining rails or other systems may be required for derailment prevention.

3.2 § 213.57 – Curves, Elevation and Speed Limitations

The extensive changes proposed to this section, include modification and clarification of the qualification requirements and approval process for vehicles intended to operate at more than three inches of cant deficiency. For consistency with the High Speed Track Safety Standards, cant deficiency would no longer be limited to a maximum of four inches on track Classes 1 through 5, provided qualification requirements are met. For reference, cant deficiency is defined as the amount of superelevation, in inches, that would need to be added to the track in order to balance the centrifugal force when curving with a component of the gravitational force to realize no net lateral force measured in the plane of the rails.

In the existing rule, vehicle qualification requirements are only stipulated for vehicles intended to operate at up to four inches of cant deficiency and for vehicles intended to operate at greater than four inches of cant deficiency on track that is contiguous to a high speed corridor. Vehicles intended to operate at more than four inches of cant deficiency on routes not contiguous to a high speed corridor must presently file and obtain a waiver in accordance with part 211 of this chapter.

In paragraph (a) the 2nd sentence was removed, “Except as provided in § 213.63, the outside rail of a curve may not be lower than the inside rail.” This change was made since the statement in this paragraph is in conflict with § 213.63, which provides actual limits for the reverse elevation on a curve.

The Vmax equation sets the “maximum posted timetable operating speed” based on Eu, which is defined as the “qualifying cant deficiency of the vehicle type”. A footnote related to the Eu term, defines the “maximum allowable cant deficiency” which allows the vehicle to operate at the Eu for which it is approved, plus one inch. This one-inch margin provides a tolerance to account for the effects of local crosslevel or curvature conditions on Vmax that may result in the operating cant deficiency exceeding that approved for the equipment. Presently, this situation generates a limiting speed exception and some railroads have adopted the approach of penalizing the operating cant deficiency of the vehicle in order to avoid these exceptions. A footnote to the Vmax equation also provides guidance for defining the term “vehicle type.”

As in the existing rule, all vehicle types are considered qualified for three inches of cant deficiency.

Paragraph (d) now outlines the requirements for vehicle qualification for more than three inches of cant deficiency. The existing static lean requirements for four inches of cant deficiency limit the carbody roll to 5.7° with respect to the horizontal when the vehicle is standing on four-inch superelevation, and limit the vertical wheel load remaining on the raised wheels to 60% of their static level values and carbody roll to 8.6° with respect to the horizontal when the vehicle is standing on six-inch superelevation.

The new requirements do not limit the cant deficiency to four inches, and do not impose the six-inch superelevation static lean requirement specifically for four-inch cant deficiency qualification. The latter requirement addressed potential roll-over and passenger safety issues, should a vehicle be stopped or traveling at very low speed on highly superelevated track. Since these issues relate to all vehicle types operating at any cant deficiency and are not specific to operation above three inches of cant deficiency, this requirement specific to four-inch cant deficiency qualification is no longer imposed.

The new requirements can be met by either, static or dynamic testing. The static lean test limits the vertical wheel load remaining on the raised wheels to 60% of their static level values and the roll of a passenger carbody to 8.6° with respect to the horizontal when the vehicle is standing on superelevation equal to the proposed cant deficiency. The dynamic test limits the steady state vertical wheel load remaining on the low rail wheels to 60% of their static level values and the lateral acceleration in a passenger car to 0.15 g steady state when the vehicle operates through a curve at the proposed cant deficiency. Research indicates that the acceleration value of 0.15 g, which corresponds to the lateral acceleration a passenger would experience in a standing vehicle whose carbody is at a roll angle of 8.6° with respect to the horizontal, is considered to be the maximum steady state lateral acceleration at which additional jolts from vehicle dynamic response to track deviations can present a hazard to passenger safety. The limiting steady-state acceleration value of 0.15 g has also been accepted as common practice in European countries. The 0.15 g steady state lateral acceleration limit in the dynamic test provides consistency with the 8.6° roll requirement in the static lean test and eliminates the 5.7° roll requirement from the existing rule.

The proposed changes also separate and clarify the submittal requirements to FRA to obtain approval for the qualifying cant deficiency of a vehicle type (paragraph (e)) and to notify FRA prior to the implementation of the approved higher curving speeds (paragraph (f)). Additional clarification has been added regarding the submission of suspension maintenance information. The requirement now applies to vehicle types not subject to Part 238 or Part 229, and only to safety-critical components.

The proposed rule text also references pertinent sections of Subpart G, §§ 213.333 and 213.345, that contain requirements related to operations above five inches of cant deficiency. These sections include periodic track geometry measurements, the monitoring of carbody acceleration and requirements for vehicle/track system qualification.

Clarification was also added to the grandfathering statement to indicate that the equipment will be considered qualified to operate over previously operated track segment(s).

§ 213.57 – Curves, Elevation and Speed Limitations

(a) The maximum elevation of the outside rail of a curve may not be more than 8 inches on track Classes 1 and 2 and 7 inches on Classes 3 through 5.

(b) Vmax formula.

The maximum posted timetable operating speed for each curve is determined by the following formula—

$$V_{\max} = \sqrt{\frac{Ea + Eu}{0.0007D}}$$

Where--

V_{max} = Maximum posted timetable operating speed (miles per hour).

E_a = Actual elevation of the outside rail (inches).[1]

E_u = Qualifying cant deficiency [2] (inches) of the vehicle type. [3]

D = Degree of curvature (degrees).[4]

(c) 3 inch Cant Deficiency Operation.

All vehicle types are considered qualified for an Eu equal to 3 inches.

Table 1 of Appendix A is a table of speeds computed in accordance with the formula in paragraph (b) of this section, when Eu equals 3 inches, for various elevations and degrees of curvature.

[1] Actual elevation for each 155 foot track segment in the body of the curve is determined by averaging the elevation for 10 points through the segment at 15.5 foot spacing. If the curve length is less than 155 feet, average the points through the full length of the body of the curve.

[2] The maximum allowable cant deficiency for each curve may not exceed Eu plus 1 inch.

[3] Vehicle type or Vehicle of a type means 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 are considered the same type.

[4] Degree of curvature is determined by averaging the degree of curvature over the same track segment as the elevation.

§ 213.57 – Curves, Elevation and Speed Limitations

(d) Eu Greater Than 3 inches.

For Eu greater than 3 inches, each vehicle type must be approved by the Federal Railroad Administration. Each vehicle type must demonstrate compliance with the requirements of either paragraph (d)(1) or (d)(2) of this section:

(1) When positioned on a track with a uniform superelevation equal to the proposed Eu [5]:

(i) No wheel of the vehicle [6] 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 Eu:

(i) For the purposes of conducting this test, a plan must be submitted and approved by FRA in accordance with § 213.345 (e) and (f).

(ii) The steady-state (average) load on any wheel, throughout the body of the curve shall not be less than 60 percent of its static value on perfectly level track, and,

(iii) For passenger cars, the steady-state (average) lateral acceleration measured on the floor of the carbody shall not exceed 0.15g.

(e) The results of the testing specified in paragraph (d) of this section shall be transmitted to the Federal Railroad Administration requesting approval of the vehicle type at the desired speeds allowed under the formula in paragraph (b) of this section. The request shall be in writing and shall 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 and description of the instrumentation used to qualify the vehicle and the maximum values for wheel unloading and roll angles or accelerations which were observed during testing;

(3) For vehicle types not subject to Part 238 or Part 229, procedures or standards in effect which relate to the maintenance of all safety-critical components of the suspension system 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 weights on the wheels.

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

[6] Vehicle means a locomotive, as defined in § 229.5 of this part; a freight car, as defined in § 215.5 of this part; a passenger car, as defined in § 238.5 of this part; and any rail rolling equipment used in a train with either a freight car or a passenger car.

§ 213.57 – Curves, Elevation and Speed Limitations

(f) Upon FRA approval of the request in paragraph (e) of this section, the Federal Railroad Administrator shall be given written notification 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 request shall be in writing and shall contain, at a minimum, identification of the track segment(s) on which the higher curving speeds are to be implemented.

(g) For vehicles intended to operate at any curving speed producing more than 5 inches of cant deficiency, the following provisions of subpart G shall apply: §§. 213.333 (a) through (g), (j)(1), (k) and (m), 213.345, and 213.369(f).

(h) Vehicle types that have been permitted by FRA to operate at cant deficiencies greater than 3 inches, prior to **[insert date of publication of final rule]**, shall be considered qualified under this section to operate at those permitted cant deficiencies over the previously operated track segment(s).

(i) The documents required by the provisions of this section must be provided to the Federal Railroad Administrator by:

(1) The track owner, or

(2) An operating entity that provides service with the vehicle type, over trackage of one or more track owners, with the written consent of all of the affected track owners.

3.3 § 213.63 – Track Surface

Changes to this section involved the addition of tighter single deviation geometry limits for operations above five inches of cant deficiency on track Classes 1-5. These include 31-foot and 62-foot mid chord offset limits and a new limit for the difference in crosslevel within 10-feet (short warp).

Simulation studies have been performed using computer models of the AEM7 Locomotive, Acela Powercar, Acela Coach, and Amfleet Coach to determine the amplitude of surface track geometry anomalies that result in undesirable response as defined by the VTI limits. These simulations were performed using two coefficients of friction (0.1 and 0.5), two anomaly shapes (bump and ramp), and combinations of speed, curvature and superelevation to cover a range of cant deficiency. The simulation results were used to determine the safe amplitudes of surface track geometry variations. Results show that these proposed track geometry limits are necessary in order to provide an equivalent margin of safety for operations at higher cant deficiency.

§ 213.63 – Track Surface

(a) Except as provided in paragraph (b), each owner of the track to which this part applies shall maintain the surface of its track within the limits prescribed in the following table:

Track Surface	Class of Track				
	1 (inches)	2 (inches)	3 (inches)	4 (inches)	5 (inches)
The runoff in any 31 feet of rail at the end or a raise may not be more than…	3½	3	2	1½	1
The deviation from uniform profile on either rail at the mid-ordinate of a 62-foot chord may not be more than	3	2¾	2¼	2	1¼
The deviation from zero crosslevel at any point on tangent or reverse crosslevel elevation on curves may not be more than …	3	2	1¾	1¼	1
The difference in crosslevel between any two points less than 62 feet apart may not be more than[*1, 2]	3	2¼	2	1¾	1½
*Where determined by engineering decision prior to the promulgation of this rule, due to physical restrictions on spiral length and operating practices and experience, the variation in crosslevel on spirals per 31 feet may not be more than…	2	1¾	1¼	1	¾

[1] Except as limited by § 213.57(a), where the elevation at any point in a curve equals or exceeds 6 inches, the difference in crosslevel within 62 feet between that point and a point with greater elevation may not be more the 1½ inches.

[2] However, to control harmonics on Class 2 through 5 jointed track with staggered joints, the crosslevel differences shall not exceed 1¼ inches in all of six consecutive pairs of joints, as created by 7 low joints. Track with joints staggered less than 10 feet shall not be considered as having staggered joints. Joints within the 7 low joints outside of the regular joint spacing shall not be considered as joints for purposes of this footnote

§ 213.63 – Track Surface

(b) On curves with Eu more than 5 inches, each owner of the track to which this part applies shall maintain the surface of the curve within the limits prescribed in the following table:

Track Surface	Class of Track				
	1 (inches)	2 (inches)	3 (inches)	4 (inches)	5 (inches)
The deviation from uniform profile on either rail at the mid-ordinate of a 31-foot chord may not be more than	[3]N/A	[3]N/A	1	1	1
The deviation from uniform profile on either rail at the mid-ordinate of a 62-foot chord may not be more than.	2¼	2¼	1¾	1¼	1
The difference in crosslevel between any two points less than 10 feet apart (short warp) shall not be more than..	2	2	1¾	1¾	1½

[3] N/A – Not Applicable

3.4 § 213.65 – Combined Alinement and Surface Deviations

This is a new section that only applies to operations above five inches of cant deficiency on track Classes 1-5. An equation based limit for combined defects is presented. It is noted that this limit is only to be used with a track geometry measurement system and applied on the outside rail in curves. This new defect type involves a set of reduced alinement and surface deviations occurring within a single chord length of one another.

Although the current track standards prescribe limits on geometry variations existing in isolation, the FRA recognizes that a combination of alinement and surface variations, none of which individually amounts to a deviation from the requirements in this part, may result in undesirable response as defined by the VTI limits. Trains operating at high cant deficiency will increase the lateral force exerted on track during curving and, in many cases, correspondingly reduce the margin of safety associated with vehicle response to combination track variations. To address these issues, simulation studies have been performed using computer models of the AEM7 Locomotive, Acela Powercar, Acela Coach, and Amfleet Coach to determine the amplitude of combined surface and alinement track geometry anomalies that result in undesirable response as defined by the VTI limits. These simulations were performed using two coefficients of friction (0.1 and 0.5), two anomaly shapes (bump and ramp), and combinations of speed, curvature and superelevation to cover a range of cant deficiency. The simulation results were used to determine the safe amplitudes of combined track geometry variations. Results show that these track geometry limits are necessary in order to provide an equivalent margin of safety for operations at higher cant deficiency.

§ 213.65 – Combined Alinement and Surface Deviations

Combined Defects.

This section applies only to operations with Eu greater than 5 inches when the track is measured using a qualified Track Geometry Measurement System (TGMS) as defined in § 213.333. The combination of alinement and surface deviations for the same chord length on the outside rail in curves, as measured by the TGMS, shall comply with the following formula:

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

Where--

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

A_L – allowable alinement limit as per § 213.55(b) (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 § 213.63(b) (always positive) for the class of track

4. Proposed Rule Text: 49 CFR 213 Subpart G – Train Operations at Track Classes 6 and Higher

4.1 § 213.305 – Designation of Qualified Individuals; General Qualifications

Changes to this section involved eliminating the need for qualified persons to be familiar with all of the Subpart G requirements. The wording "that are necessary to supervise the restoration and renewal of the track" was added to the end of § 213.305(a)(2)(i). In addition, the wording "that are necessary to perform inspections in accordance with §§ 213.365 and 213.367 of this subpart" was added to the end of § 213.305(b)(2)(i).

The original wording of the paragraph required that the person designated under 213.305 "knows and understands the requirements of this part". This required the person to have knowledge and understanding of everything in the book regardless of whether that person needed it to perform their duties. The addition of vehicle qualification and testing for high cant deficiency operations has added a level of complexity and requirements that are outside of the purview of the track foremen and inspectors. This change in language was made to relieve the qualified person from having to know and understand things not germane to that person's qualifications, or position.

§ 213.305 – Designation of Qualified Individuals; General Qualifications

[NOTE: Introductory paragraph and paragraph (a)(1) remain unchanged.]

(a)(2) Demonstrate to the track owner that the individual:

(i) Knows and understands the requirements of this subpart that are necessary to supervise the restoration and renewal of track;

(ii) Can detect deviations from those requirements; and

(iii) Can prescribe appropriate remedial action to correct or safely compensate for those deviations; and

[NOTE: Paragraphs (a)(3) and (b)(1) remain unchanged.]

(b)(2) Demonstrate to the track owner that the individual:

(i) Knows and understands the requirements of this subpart that are necessary to perform inspections in accordance with §§ 213.365 and 213.367 of this subpart;

(ii) Can detect deviations from those requirements; and

(iii) Can prescribe appropriate remedial action to correct or safely compensate for those deviations; and

[NOTE: Paragraphs (b)(3), (c), (d) and (e) remain unchanged.]

4.2 § 213.307 – Class of Track: Operating Speed Limits

Changes to this section involved the removal of Class 9 track as well as reducing the maximum allowable speed for Class 8 track from 160 to 150 mph. The Task Force recommends the removal of track Class 9 and the lowering of the maximum speed on Class 8 track since all operations in excess of 150 mph can only be authorized by FRA in conjunction with a Rule of Particular Applicability (RPA) which considers and regulates overall system safety (as per footnote 2).

The track/vehicle interaction, track structure and inspection requirements in a RPA are specific to the operation and system components used. At speeds above 150 mph the track safety standards will be based on unique equipment characteristics that are required to operate at high speed. Track geometry measurement systems, criteria and safety limits might be quite different than currently defined. In consideration of the above the Task Force recommends that all aspects of operation above 150 mph be developed using a system safety approach and regulated through a RPA specific to the high speed operation envisaged.

§ 213.307 – Class of Track: Operating Speed Limits

(a) Except as provided in paragraph (b) of this section and §§ 213.329, 213.337(a) and 213.345(a), 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	150 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 Sections 213.345 and 213.329(d) of this subpart.

(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 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 150 m.p.h. are authorized by this part only in conjunction with a rule of particular applicability addressing other safety issues presented by the system.

[NOTE: Paragraph (b) remains unchanged.]

4.3 § 213.323 – Track Gage

Modifications recommended to this section include the removal of track Class 9 and increasing the limit for the change of gage within 31 feet from ½-inch to ¾-inch for track Class 6. The latter change was requested by Amtrak due to difficulties with maintaining wood tie track (with cut spikes) especially at higher rail temperatures.

For track constructed with wood ties and cut spikes the ½-inch variation in gage is difficult to maintain. The tolerances of the rail base, tie plate shoulders and spikes are sufficient to permit a ½-inch variation particularly if the rail is in compression due to heat stress. Modeling of the variation up to ¾-inch in 31 feet has shown no safety concerns; in addition modeling of 20 miles of actual measured track geometry including gage variations has shown no safety concerns up to 115 mph.

§ 213.323 – Track Gage

(a) Gage is measured between the heads of the rails at right-angles to the rails in a plane five-eighths of an inch below the top of the rail head.

(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 –
6	4′8″	4′9¼″	¾″
7	4′8″	4′9¼″	½″
8	4′8″	4′9¼″	½″

4.4 § 213.327 – Track Alinement

Changes to this section primarily involved the addition of tighter single deviation geometry limits for operations above five inches of cant deficiency. These include 31-foot, 62-foot, and 124-foot mid chord offset (MCO) limits and are being included in paragraph (c), with the existing paragraph text moving to (d).

Simulation studies have been performed using computer models of the AEM7 Locomotive, Acela Powercar, Acela Coach, and Amfleet Coach to determine the amplitude of alinement track geometry anomalies that result in undesirable response as defined by the VTI limits. These simulations were performed using two coefficients of friction (0.1 and 0.5), two anomaly shapes (bump and ramp), and combinations of speed, curvature and superelevation to cover a range of cant deficiency. The simulation results were used to determine the safe amplitudes of alinement track geometry variations. Results show that these proposed track geometry limits are necessary in order to provide an equivalent margin of safety for operations at higher cant deficiency.

In addition, the existing single deviation limits in paragraph (b) have been expanded for applicability to either tangent or curved track. Specifically, the 62-foot MCO limit for Class 6 curved track has been tightened to ⅝-inch, whereas the tangent track limit remains at the existing value of ¾-inch. This change was made to resolve inconsistencies between limits in Class 5 and 6. In addition, the 62-foot MCO limits for Class 7 and Class 8 tangent track has been increased to ¾-inch, whereas the curved track limit remains at the existing value of ½-inch. The 124-foot MCO limits for Class 8 tangent track has been increased to 1-inch, whereas the curved track limit remains at the existing value of ¾-inch. These changes are based on results of simulations studies that were performed using computer models of the AEM7 Locomotive, Acela Powercar, Acela Coach, Amfleet Coach and P42 Locomotive.

Other changes include; removing reference to Class 9 track, adding footnote 1 to paragraph (d), which is an adaptation of footnotes 1 and 2 from § 213.55 describing the line rail, and modifying the section title to better align with other sections.

§ 213.327 – Track Alinement

[NOTE: Paragraph (a) remains unchanged.]

(b) Except as provided in paragraph (c), for a single deviation, alinement may not deviate from uniformity 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[1] may not be more than – (inches)	The deviation from uniformity of the mid-chord offset for a 62-foot chord[1] may not be more than – (inches)	The deviation from uniformity of the mid-chord offset for a 124-foot chord[1] may not be more than – (inches)
6	Tangent	½	¾	1½
	Curve		⅝	
7	Tangent	½	¾	1¼
	Curve		½	
8	Tangent	½	¾	1
	Curve		½	¾

(c) On the outside rail in curves with Eu more than 5 inches, a single deviation in alinement in the curve may not deviate from uniformity more than the amount prescribed in the following table:

Class of Track	Curved Track	The deviation from uniformity of the mid-chord offset for a 31-foot chord[1] may not be more than – (inches)	The deviation from uniformity of the mid-chord offset for a 62-foot chord[1] may not be more than – (inches)	The deviation from uniformity of the mid-chord offset for a 124-foot chord[1] may not be more than – (inches)
6	Curve	½	⅝	1¼
7	Curve	½	½	1
8	Curve	½	½	¾

§ 213.327 – Track Alinement

(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 owner of the track to which this subpart applies 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[1] may not be more than – (inches)	The deviation from uniformity of the mid-chord offset for a 62-foot chord[1] may not be more than – (inches)	The deviation from uniformity of the mid-chord offset for a 124-foot chord[1] may not be more than – (inches)
6	⅜	½	1
7	⅜	⅜	⅞
8	⅜	⅜	½

[1] The ends of the chord shall be at points on the gage side of the outer rail, five-eighths below the top of the railhead. 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.

4.5 § 213.329 – Curves, Elevation and Speed Limitations

The changes proposed to this section, include modification and clarification of the qualification requirements and approval process for vehicles intended to operate at more than three inches of cant deficiency.

In paragraph (a), the 2nd sentence, “The outside rail of a curve may not be more than ½ inch lower than the inside rail”, was moved to the surface table in § 213.331(a).

The Vmax equation sets the “maximum posted timetable operating speed” based on Eu, which is defined as the “qualifying cant deficiency of the vehicle type”. A footnote related to the Eu term, defines the “maximum allowable cant deficiency” which allows the vehicle to operate at the Eu for which it is approved, plus one-half inch. The one-half inch margin provides a tolerance to account for the effects of local crosslevel or curvature conditions on Vmax that may result in the operating cant deficiency exceeding that approved for the equipment. Presently, this situation generates a limiting speed exception and some railroads have adopted the approach of penalizing the operating cant deficiency of the vehicle in order to avoid these exceptions. A footnote to the Vmax equation also provides guidance for defining the term “vehicle type.”

As in the existing rule, all vehicle types are considered qualified for three inches of cant deficiency.

Paragraph (d) now outlines the requirements for vehicle qualification for more than three inches of cant deficiency. The existing rule contains two static lean requirements. The first, limits the vertical wheel load remaining on the raised wheels to 60% of their static level values and the roll of a passenger carbody to 5.7° with respect to the horizontal when the vehicle is standing on superelevation equal to the proposed cant deficiency. The second requirement, which limited vertical wheel load remaining on the raised wheels to 60% of their static level values and the roll of a passenger carbody to 8.6° with respect to the horizontal when the vehicle is standing on seven-inch superelevation, addressed potential roll-over and passenger safety issues, should a vehicle be stopped or traveling at very low speed on highly superelevated track. Since these issues relate to all vehicle types operating at any cant deficiency and are not specific to operation above three inches of cant deficiency, this second qualification requirement has been eliminated from this section, and should be addressed by industry standards.

The new requirements can be met by either, static or dynamic testing. The static lean test limits the vertical wheel load remaining on the raised wheels to 60% of their static level values and the roll of a passenger carbody to 8.6° with respect to the horizontal when the vehicle is standing on superelevation equal to the proposed cant deficiency. The dynamic test limits the steady state vertical wheel load remaining on the low rail wheels to 60% of their static level values and the lateral acceleration in a passenger car to 0.15 g steady state when the vehicle operates through a curve at the proposed cant deficiency. Research indicates that the acceleration value of 0.15 g, which corresponds to the lateral acceleration a passenger would experience in a standing vehicle whose carbody is at a roll angle of 8.6° with respect to the horizontal, is considered to be the maximum steady state lateral acceleration at which additional jolts from vehicle dynamic response to track deviations can present a hazard to passenger safety. The limiting steady-state acceleration value of 0.15 g has also been accepted as common practice in European countries. The 0.15 g steady state lateral acceleration limit in the dynamic test provides consistency with the 8.6° roll requirement in the static lean test and eliminates the 5.7° roll requirement from the existing rule.

The proposed changes also separate and clarify the submittal requirements to FRA to obtain approval for the qualifying cant deficiency of a vehicle type (paragraph (e)) and to notify FRA prior to the implementation of the approved higher curving speeds (paragraph (f)). Additional clarification has been added regarding the submission of suspension maintenance information. The requirement now applies to vehicle types not subject to Part 238 or Part 229, and only to safety-critical components.

Clarification was also added to the grandfathering statement to indicate that the equipment will be considered qualified to operate over previously operated track segment(s).

§ 213.329 – Curves, Elevation and Speed Limitations

(a) The maximum elevation of the outside rail of a curve may not be more than 7 inches.

(b) Vmax formula.

The maximum posted timetable operating speed for each curve is determined by the following formula:

$$V_{\max} = \sqrt{\frac{Ea + Eu}{0.0007D}}$$

Where--

Vmax = Maximum posted timetable operating speed (miles per hour).

Ea = Actual elevation of the outside rail (inches) [7].

Eu = Qualifying cant deficiency [8] (inches) of the vehicle type [9].

D = Degree of curvature (degrees) [10].

(c) 3 inch Cant Deficiency Operation.

All vehicle types are considered qualified for an Eu equal to 3 inches.

Table 1 of Appendix A is a table of speeds computed in accordance with the formula in paragraph (b) of this section, when Eu equals 3 inches, for various elevations and degrees of curvature for track speeds up to 150 mph.

[7] Actual elevation for each 155 foot track segment in the body of the curve is determined by averaging the elevation for 10 points through the segment at 15.5 foot spacing. If the curve length is less than 155 feet, average the points through the full length of the body of the curve.

[8] The maximum allowable cant deficiency for each curve may not exceed Eu plus ½ inch.

[9] Vehicle type or Vehicle of a type means 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 are considered the same type.

[10] Degree of curvature is determined by averaging the degree of curvature over the same track segment as the elevation.

§ 213.329 – Curves, Elevation and Speed Limitations

(d) Eu Greater Than 3 inches.

For Eu greater than 3 inches, each vehicle type must be approved by the Federal Railroad Administration. Each vehicle type must demonstrate compliance with the requirements of either paragraph (d)(1) or (d)(2) of this section:

(1) When positioned on a track with a uniform superelevation equal to the proposed Eu [11]:

(i) No wheel of the vehicle [12] 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 Eu:

(i) For the purposes of conducting this test, a plan must be submitted and approved by FRA in accordance with § 213.345 (e) and (f).

(ii) The steady-state (average) load on any wheel, throughout the body of the curve shall not be less than 60 percent of its static value on perfectly level track, and,

(iii) For passenger cars, the steady-state (average) lateral acceleration measured on the floor of the carbody shall not exceed 0.15g.

(e) The results of the testing specified in paragraph (d) of this section shall be transmitted to the Federal Railroad Administration requesting approval of the vehicle type at the desired speeds allowed under the formula in paragraph (b) of this section. The request shall be in writing and shall 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 and description of the instrumentation used to qualify the vehicle and the maximum values for wheel unloading and roll angles or accelerations which were observed during testing;

(3) For vehicle types not subject to Part 238 or Part 229, procedures or standards in effect which relate to the maintenance of all safety-critical components of the suspension system 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 weights on the wheels.

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

[12] Vehicle means a locomotive, as defined in § 229.5 of this part; a freight car, as defined in § 215.5 of this part; a passenger car, as defined in § 238.5 of this part; and any rail rolling equipment used in a train with either a freight car or a passenger car.

§ 213.329 – Curves, Elevation and Speed Limitations

(f) Upon FRA approval of the request in paragraph (e) of this section, the Federal Railroad Administrator shall be given written notification 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 request shall be in writing and shall contain, at a minimum, identification of the track segment(s) on which the higher curving speeds are to be implemented.

(g) Vehicle types that have been permitted by FRA to operate at cant deficiencies greater than 3 inches, prior to **[insert date of publication of final rule]**, shall be considered qualified under this section to operate at those permitted cant deficiencies over the previously operated track segment(s).

(h) The documents required by the provisions of this section must be provided to the Federal Railroad Administrator by:

(1) The track owner, or

(2) An operating entity that provides service with the vehicle type over trackage of one or more track owners, with the written consent of all of the affected track owners.

4.6 § 213.331 – Track Surface

Changes to this section primarily involved the addition of tighter geometry limits for operations above five inches of cant deficiency. These include 124-foot mid chord offset limits and a new limit for the difference in crosslevel within 10-feet (short warp), which are both being included in paragraph (b), with the existing paragraph text moving to (c).

Simulation studies have been performed using computer models of the AEM7 Locomotive, Acela Powercar, Acela Coach, and Amfleet Coach to determine the amplitude of surface track geometry anomalies that result in undesirable response as defined by the VTI limits. These simulations were performed using two coefficients of friction (0.1 and 0.5), two anomaly shapes (bump and ramp), and combinations of speed, curvature and superelevation to cover a range of cant deficiency. The simulation results were used to determine the safe amplitudes of surface track geometry variations. Results show that these proposed track geometry limits are necessary in order to provide an equivalent margin of safety for operations at higher cant deficiency.

In addition, the reference to Class 9 track has been removed and four (4) new limits have been added to the existing single deviation limits in paragraph (a). The existing 1-inch runoff limit for Class 5 track, as listed in § 213.63, has been added for track Classes 6-8. The existing 1-inch limit for deviation from zero crosslevel on tangent Class 5 track, as listed in § 213.63, has been added for track Classes 6-8. The ½-inch reverse elevation limit for curved track, as currently listed in § 213.329(a), has been moved to this section. Finally, new limits for the difference in crosslevel within 10-feet (short warp) on curved track have been added. The first three limits (runoff, deviation from zero crosslevel on tangent, and reverse elevation limit for curved track), although not explicitly stated in the current table, have always been applicable since it is necessary for Class 6 through 8 track to also meet all the geometry requirements of Class 1 through 5. These three limits have been added to make the table comprehensive. The fourth limit, short warp, was added based on results of simulation studies that were performed using computer models of the AEM7 Locomotive, Acela Powercar, Acela Coach, and Amfleet Coach.

§ 213.331 – Track Surface

(a) For a single deviation in track surface, each owner of the track to which this subpart applies shall maintain the surface of its track within the limits prescribed in the following table:

Track Surface	Class of Track		
	6 (inches)	7 (inches)	8 (inches)
The runoff in any 31 feet of rail at the end or a raise may not be more than…	1	1	1
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
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
Except as provided in paragraph (b), 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
The deviation from zero crosslevel at any point on tangent may not be more than …	1	1	1
Reverse elevation on curves may not be more than …	½	½	½
The difference in crosslevel between any two points less than 62 feet apart may not be more than [2]	1½	1½	1½
On curved track, the difference in crosslevel between any two points less than 10 feet apart (short warp) shall not be more than..	1¼	1⅛	1

[1] Uniformity for profile is established by placing the midpoint of the specified chord at the point of maximum measurement.

[2] However, to control harmonics on jointed track with staggered joints, the crosslevel differences shall not exceed 1¼ inches in all of six consecutive pairs of joints, as created by 7 low joints. Track with joints staggered less than 10 feet shall not be considered as having staggered joints. Joints within the 7 low joints outside of the regular joint spacing shall not be considered as joints for purposes of this footnote.

(b) On curves with Eu more than 5 inches, for a single deviation in track surface in a curve, each owner of the track to which this subpart applies shall maintain the surface of the curve within the limits prescribed in the following table:

Track Surface	Class of Track		
	6 (inches)	7 (inches)	8 (inches)
The difference in crosslevel between any two points less than 10 feet apart (short warp) shall not be more than..	1¼	1	[3]1
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

[3] On curves with Eu more than 7 inches, the difference in crosslevel between any two points less than 10 feet apart (short warp) shall not be more than ¾ inch.

§ 213.331 – Track Surface

(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 owner of the track to which this subpart applies shall maintain the surface of the track within the limits prescribed for each deviation:

Track Surface	Class of Track		
	6 (inches)	7 (inches)	8 (inches)
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
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
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

4.7 § 213.332 – Combined Alinement and Surface Deviations

This is a new section that only applies to operations above five inches of cant deficiency. An equation based limit for combined defects is presented. It is noted that this limit is only to be used with a track geometry measurement system and applied on the outside rail in curves. This new defect type involves a set of reduced alinement and surface deviations occurring within a single chord length of one another.

Although the current track standards prescribe limits on geometry variations existing in isolation, the FRA recognizes that a combination of alinement and surface variations, none of which individually amounts to a deviation from the requirements in this part, may result in undesirable response as defined by the VTI limits. Trains operating at high cant deficiency will increase the lateral force exerted on track during curving and, in many cases, correspondingly reduce the margin of safety associated with vehicle response to combination track variations. To address these issues, simulation studies have been performed using computer models of the AEM7 Locomotive, Acela Powercar, Acela Coach, and Amfleet Coach to determine the amplitude of combined surface and alinement track geometry anomalies that result in undesirable response as defined by the VTI limits. These simulations were performed using two coefficients of friction (0.1 and 0.5), two anomaly shapes (bump and ramp), and combinations of speed, curvature and superelevation to cover a range of cant deficiency. The simulation results were used to determine the safe amplitudes of combined track geometry variations. Results show that these track geometry limits are necessary in order to provide an equivalent margin of safety for operations at higher cant deficiency.

§ 213.332 – Combined Alinement and Surface Deviations

Combined Defects.

This section applies only to operations with Eu greater than 5 inches when the track is measured using a qualified Track Geometry Measurement System (TGMS) as defined in § 213.333. The combination of alinement and surface deviations for the same chord length on the outside rail in curves, as measured by the TGMS, shall comply with the following formula:

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

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

4.8 § 213.333 – Automated Vehicle Inspection Systems

Many significant changes were made to this section including, the addition of; TGMS inspection requirements for Class 6 track and also for low speed, high cant deficiency operations, as referenced by § 213.57(g), and a reference was added for § 213.332, which is the newly proposed section for combined defects. In addition, the references for Class 9 track have been removed and clarification has been added such that the documents required by this section must be provided to the FRA by either the track owner or an operating entity. Other major changes to this section are as follows.

The minimum time between TGMS inspections has been slightly reduced in some cases. For inspection frequencies of twice per 60 days, the minimum number of days between inspections has been reduced from 15 to 12 days to allow for inspections to occur every two weeks. For inspection frequencies of twice per 120 days, the minimum number of days between inspections has been reduced from 30 to 25 days to allow for inspections to occur monthly. For inspection frequencies of once per year, the minimum number of days between inspections has been reduced from 180 to 170 days to allow for inspections to occur every six months.

Changes were made to the GRMS testing requirements, in part to reflect recommendations made in DOT/FRA/ORD-06/13, *Development of Gage Widening Projection Parameter for the Deployable Gage Restraint Measurement System*. These changes include replacing the GWR equation (and all references to GWR) with a GWP equation, which now compensates for the weight of the testing vehicle. This correction results in more uniform strength measurements across the variety of testing vehicles that are in operation. The GWP equation recommended in the section must be consistent with the formula developed for use in § 213.110.

Revisions were made to the wording and requirements in § 213.333(j) and (k), which relate to carbody and truck accelerometer monitoring. Changes included adding the option to use a portable device when performing the acceleration monitoring and clarifying where the carbody and truck accelerometers shall be located. Monitoring requirements have been included for operations above five inches of cant deficiency on track Classes 1 through 6. Based on data collected to date and to reduce the unnecessary burden on the track owner the monitoring frequency for operations at track Class 8 speeds has been reduced from once per day to; four times per week for carbody accelerations and twice within 60 days for truck accelerations. In addition, a clause has been added to allow the operating entity to petition the FRA, after a specified amount of time or mileage, to eliminate the truck accelerometer monitoring requirement.

The requirement in § 213.333(l) for measuring wheel-rail forces during testing on Class 8 track was modified to be optional. The necessity to perform this testing will be determined by FRA on a case-by-case basis, after performing a review of an annually submitted report detailing the accelerometer monitoring data that was collected per § 213.333 (j) and (k). A thorough review of the Acela trainset IWS data, as well as the economics associated with those tests, revealed that, in this case, there was significant cost and little apparent safety benefit to justify conducting additional annual IWS tests. It was concluded that the other testing and monitoring requirements in effect are adequate to maintain the necessary oversight during revenue operations.

Substantial changes have been made to the content of the Vehicle-Track Interaction Safety Limits table. In general, the "Requirements" text for most of the limits has been clarified or updated. Specifically, 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 Net Axle Lateral L/V Ratio limit has been modified from 0.5 to '$0.4 + 5.0/V_a$', which now takes into account the weight of the vehicle.

Due to variations in vehicle design requirements and passenger ride safety, the carbody acceleration limits have been divided to include separate limits for passenger cars and other vehicles (such as locomotives). In addition, the carbody transient acceleration limits have been relaxed from 0.5 g lateral and 0.6 g vertical to; 0.65 g for passenger cars and 0.75 g for other vehicles in the lateral direction and 1.0 g in the vertical direction. These changes were made after considerable research into the performance of existing vehicles during qualification testing and revenue operations. Overall, it was found that the existing acceleration limits were too conservative for the protection of events leading to vehicle or passenger safety issues.

Based on the small energy content associated with high frequency acceleration events of the carbody, a clause has been added to exclude any transient acceleration peaks lasting less than 50 milliseconds. Other changes to this table include the addition of new limits for carbody lateral and vertical sustained oscillatory acceleration events, as well as adding minimum requirements for sampling and filtering of the acceleration data. The sustained acceleration limits were included in response to a review of data that was obtained during qualification testing for the MARC-III Bi-level car.

The truck lateral acceleration limit, used for the detection of truck hunting, has been tightened from 0.4 g to 0.3 g and now includes a requirement that the value must exceed that limit for more than 2 seconds. This update was made in response to measured examples of truck hunting that were not being identified with the existing limit. In addition, the limit now requires that the RMS_t (root mean squared with linear trend removed) value be used rather than the RMS_m (root mean squared with mean removed) value. This change will increase the data quality while the vehicle is negotiating spiral track segments.

§ 213.333 – Automated Vehicle Inspection Systems

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

(1) For operations at a cant deficiency 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 cant deficiency 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 Class 8, at least twice within any 60 day period with not less than 12 days between inspections.

[NOTE: Paragraph (b) remains unchanged.]

(c) A qualifying TGMS shall be capable of measuring and processing the necessary track geometry parameters, at an interval of no more than every 2 feet, which enables the system to determine compliance with:

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

(2) For track Classes 6 through 8: § 213.323, Track gage; § 213.327, Alinement; § 213.329, Curves; elevation and speed limitations; § 213.331, Track surface; and for operation at a cant deficiency of more than 5 inches §213.332, Combined alinement and surface deviations.

[NOTE: Paragraphs (d), (e), (f) and (g) remain unchanged.]

§ 213.333 – Automated Vehicle Inspection Systems

(h) For track Class 8, a qualifying Gage Restraint Measuring 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 inches.

(i) A GRMS shall meet or exceed minimum design requirements which specify 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;

(iii) Under an applied lateral load which provides for lateral/vertical load ratio of between 0.5 and 1.25[13], 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 Gage Widening Projection (GWP) as follows:

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

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.

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

§ 213.333 – Automated Vehicle Inspection Systems

(j) A vehicle having dynamic response characteristics that are representative of other vehicle types[14] 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. The tests shall be conducted at the following frequency, unless otherwise determined by FRA after reviewing the test data required by this subpart:

(1) For operations at a cant deficiency 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 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 car of each type that is assigned to the service; and

(3) For operations at track Class 8 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. 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.

(k) (1) The instrumented vehicle or the portable device, as required in paragraph (j) of this section, shall monitor vertical and lateral acceleration. The accelerometers shall be placed on 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 entity operating the vehicle type assigned to the service may petition the FRA for exemption from this requirement.

(3) If the carbody lateral, carbody vertical, or truck frame lateral acceleration safety limits in this section's table of vehicle/track interaction safety limits are exceeded, appropriate speed restrictions shall be applied until corrective action is taken.

[14] Vehicle type or Vehicle of a type means 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 are considered the same type.

§ 213.333 – Automated Vehicle Inspection Systems

(l) For track Class 8, the entity operating the vehicle type assigned to the service 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 service be operated over the track at the revenue speed profile. The instrumented vehicle shall be equipped to measure wheel/rail forces. If the wheel/rail force limits in this section's table of vehicle/track interaction safety limits are exceeded, appropriate speed restrictions shall be applied until corrective action is taken.

(m) Unless otherwise specified, the documents required by the provisions of this section must be provided to the Federal Railroad Administrator by:

(1) The track owner, or

(2) An operating entity that provides service with the vehicle type over trackage of one or more track owners, with the written consent of all of the affected track owners.

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% of the static vertical wheel load for five 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	$\leq \dfrac{\tan(\delta) - 0.5}{1 + 0.5\tan(\delta)}$	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 five or more continuous feet.
Net Axle Lateral L/V Ratio	$\leq 0.4 + \dfrac{5.0}{Va}$	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% of the static vertical load that the axle exerts on the track for five 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 five or more continuous feet.

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

Vehicle-Track Interaction Safety Limits

Carbody Accelerations [3]			
Parameter	**Passenger Cars**	**Other Vehicles**	**Requirements**
Carbody Lateral (Transient)	≤ 0.65 g peak-to-peak 1 sec window[2] excludes peaks < 50 msec	≤ 0.75 g peak-to-peak 1 sec window[2] 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 0.65 g and 0.75 g for passenger cars and other vehicles, respectively.
Carbody Lateral (Sustained Oscillatory)	≤ 0.10 g RMS_t[1] 4 sec window[2] 4 sec sustained	≤ 0.12 g RMS_t[1] 4 sec window[2] 4 sec sustained	Sustained oscillatory lateral acceleration of the carbody shall not exceed the prescribed (root mean squared) safety limits of 0.10 g and 0.12 g for passenger cars and other vehicles, respectively. Root mean squared values are to be determined over a sliding 4 second window with linear trend removed and shall be sustained for more than 4 seconds.
Carbody Vertical (Transient)	≤ 1.0 g peak-to-peak 1 sec window[2] excludes peaks < 50 msec	≤ 1.0 g peak-to-peak 1 sec window[2] 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 1.0 g.
Carbody Vertical (Sustained Oscillatory)	≤ 0.25 g RMS_t[1] 4 sec window[2] 4 sec sustained	≤ 0.25 g RMS_t[1] 4 sec window[2] 4 sec sustained	Sustained oscillatory vertical acceleration of the carbody shall not exceed the prescribed (root mean squared) safety limit of 0.25 g. Root mean squared values are to be determined over a sliding 4 second window with linear trend removed and shall be sustained for more than 4 seconds.

1 RMS_t = RMS with linear trend removed.

2 Acceleration measurements shall be processed through a low pass filter (LPF) with a minimum cut-off frequency of 10 Hz. The sample rate for acceleration data shall be at least 100 samples per second.

3 Carbody accelerations in the vertical and lateral directions shall be measured by accelerometers oriented and located as per § 213.333(k).

Vehicle-Track Interaction Safety Limits

Truck Lateral Acceleration[3]			
Parameter	**Safety Limit**	**Filter/ Window**	**Requirements**
Truck Lateral Acceleration	≤ 0.30 g RMS_t[1]	2 sec window[2] 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 0.3 g root mean squared for more than 2 seconds. Root mean squared values are to be determined over a sliding 2 second window with linear trend removed.

1 RMS_t = RMS with linear trend removed.

2 Acceleration measurements shall be processed through a low pass filter (LPF) with a minimum cut-off frequency of 10 Hz. The sample rate for acceleration data shall be at least 100 samples per second.

3 Truck lateral acceleration shall be measured on the truck frame by accelerometers oriented and located as per § 213.333(k).

4.9 § 213.345 – Vehicle-Track System Qualification

Many significant changes were made to this section including wording and requirement modifications and clarifications, structure and layout of the requirements, and specific updates to the necessary qualification steps. In general, the section title was modified to address the vehicle and track system. Applicability was added for low speed, high cant deficiency operations, as referenced by § 213.57(g). The over-speed testing was modified from 10 mph above to 5 mph above the maximum proposed operating speed or at a speed that produces more than 3 inches above maximum proposed cant deficiency, whichever is less. It was felt that the existing 10 mph over-speed testing was too conservative in consideration of the existing speed regulation standards. Clarification was also added to the grandfathering statement to indicate that the equipment will be considered qualified to operate over previously operated track segment(s).

The additional (and tighter) carbody acceleration limits of § 213.345(b) were removed and the section now refers to § 213.333 for the applicable VTI limits for accelerations and wheel/rail forces. This change was made after considerable research into the performance of existing vehicles during qualification testing and revenue operations. Overall, it was found that the existing acceleration limits were too conservative for the protection of events leading to vehicle or passenger safety issues.

A qualification regiment has been added for previously qualified vehicles that wish to operate on new track segments. This ensures that when qualified vehicles currently in operation are moved to a new route, the new vehicle/track system is adequately examined for deficiencies.

For new vehicles intending to operate above track Class 5 speeds, or at cant deficiencies above five inches, the qualification requirements include a combination of computer simulations, car body acceleration testing, truck acceleration testing, and wheel/rail force measurements. Computer simulations are required for all operations at track Class 6 through 8 speeds or for any operations above six inches of cant deficiency. Car body acceleration testing is required for all operations at track Class 6 through 8 speeds or for any operations above five inches of cant deficiency. Truck acceleration testing is required for all operations at track Class 6 through 8 speeds. Wheel/rail force measurements, through the use of instrumented wheelsets (or equivalent device), is required for all operations at track Class 7 and 8 speeds or for any operations above six inches of cant deficiency.

For previously qualified vehicles intending to operate on new routes above track Class 5 speeds or at cant deficiencies above five inches, the qualification requirements also include a combination of computer simulations, car body acceleration testing, truck acceleration testing, and wheel/rail force measurements. Either computer simulations or measurement of wheel-rail forces is required for all operations at track Class 7 and 8 speeds or for any operations above six inches of cant deficiency. Car body acceleration testing is required for all operations above four inches of cant deficiency and at track Class 6 through 8 speeds or for any operations above five inches of cant deficiency. Truck acceleration testing is required for all operations at track Class 7 and 8 speeds.

Other changes include clarification of the qualification test plan content and the addition of a requirement for the plan to be submitted to the FRA at least 60 days prior to conducting the testing. A requirement has been added to explicitly state that a TGMS vehicle shall be operated over the intended test route within 30 days of the testing. Clarification has also been added stating that the documents required by this section must be provided to the FRA by either the track owner or an operating entity. A statement has been added that any exceptions to the safety limits which occur on track or at speeds that are not part of the test do not need to be reported. This statement reflects the system approach in that the proposed high-speed and/or high-cant deficiency track geometry and VTI limits are performance based and related to one another. As an example, any exception to the dynamic limits that occur at speeds below Class 6 speeds when the cant deficiency is below 5 inches do not need to be reported.

§ 213.345 – Vehicle-Track System Qualification

(a) All vehicle types intended to operate at 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 ensure 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, or at a speed that produces a cant deficiency greater than 3 inches above the proposed maximum cant deficiency, whichever is less; and

(2) On track meeting the requirements for the class of track associated with the proposed maximum operating speed. When conducting qualification testing, the class of track shall remain the same even if a speed up to 5 m.p.h. above the proposed maximum operating speed is otherwise associated with the next higher class of track. Speeds exceeding 150 m.p.h. on track Class 8 are permitted for the purposes of conducting the testing.

(b) Vehicles of a type[15] 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 [insert effective date of publication of final rule], 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).

(c) New vehicle type qualification. Vehicle types not previously qualified under this subpart shall demonstrate compliance with paragraph (a) of this section through the following:

(1) Simulations. For vehicles intended to operate at track Class 6 speeds or above, or at any curving speeds 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 classes as specified in Appendix D of this part; and

(ii) A track segment representative of the full route on which the vehicle 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.

[15] Vehicle type or Vehicle of a type means 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 are considered the same type.

§ 213.345 – Vehicle-Track System Qualification

(2) Carbody acceleration. For vehicles 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 ensure that the vehicle will not exceed the carbody lateral and vertical acceleration safety limits specified in § 213.333.

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

(4) Wheel/rail force measurement. For vehicles intended to operate at track Class 7 or 8 speeds, or at any curving speed producing more than 6 inches of cant deficiency, qualification testing conducted over a representative segment of the route shall ensure that the vehicle will not exceed the wheel/rail force safety limits specified in § 213.333.

(d) Previously qualified vehicles. 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 and testing to demonstrate compliance with paragraph (a) of this section in accordance with the following:

(1) Simulations or wheel/rail force measurement. For vehicles intended to operate at track Class 7 or 8 speeds or at any curving speed producing more than 6 inches of cant deficiency, simulations or measurement of wheel/rail forces during qualification testing shall ensure that the vehicle will not exceed the wheel/rail force safety limits specified in § 213.333. Simulations, if conducted, shall be in accordance with paragraph (c)(1) 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 vehicles intended to operate at any curving speeds producing more than 5 inches of cant deficiency, or at both track Class 6 speeds or above and at any curving speeds producing more than 4 inches of cant deficiency, qualification testing conducted over a representative segment of the new route shall ensure that the vehicle will not exceed the carbody lateral and vertical acceleration safety limits specified in § 213.333.

(3) Truck lateral acceleration. For vehicles intended to operate at track Class 7 speeds or above, simulations or measurement of truck lateral acceleration during qualification testing shall ensure that the vehicle 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.

(e) Qualification test plan. To obtain the data required to support the qualification program outlined in paragraphs (c) and (d) of this section, a qualification test plan shall be submitted to the Federal Railroad Administrator, at least 60 days prior to conducting the testing, requesting approval to operate the test 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) The results of vehicle/track performance simulations as required in this subpart.

§ 213.345 – Vehicle-Track System Qualification

(2) Identification of the representative segment of the route for qualification testing.

(3) 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;

(4) The design wheel flange angle that will be used for the determination of the Single Wheel L/V Ratio safety limit specified in§ 213.333.

(5) A target maximum testing speed and a target maximum cant deficiency in accordance with paragraph (a) of this section.

(6) As part of this submittal an analysis and description of the signal system and operating practices to govern operations in track Classes 7 and 8 must be provided, which shall include a statement of sufficiency in these areas for the class of operation.

(f) Qualification test. Upon FRA approval of the qualification test 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 Class 6 and above operations); and

(ii) On a segment of curved track, from the speeds corresponding to 3-inch cant deficiency to the target maximum cant deficiency (Eu).

(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)(2) 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 or at curving speeds producing no more than 3 inches of cant deficiency above the maximum safe cant deficiency, whichever is less.

(3) While conducting stage-one and stage-two testing, if any of the monitored safety limits are exceeded, on any segment of track intended for operation at track Class 6 speed or greater, or on any segment of track intended for operation at more than 5 inches of cant deficiency, testing may continue provided the track location(s) where the limits are exceeded are identified and test speeds are 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 test program, a qualifying Track Geometry Measuring System (TGMS) specified in § 213.333 shall be operated over the intended route within a period not exceeding 30 calendar days prior to the start of the test program.

§ 213.345 – Vehicle-Track System Qualification

(g) Qualification test results. A report shall be submitted to FRA detailing the results of the test procedures and qualification program upon the completion of the qualification testing. The report submittal shall be made at least 60 days prior to the intended operation of the equipment in revenue service over the route.

(h) Based on the test results and submissions, FRA will approve a maximum train speed and value of cant deficiency for revenue service.

(i) The documents required by the provisions of this section must be provided to the Federal Railroad Administrator by:

(1) The track owner, or

(2) An operating entity that provides service with the vehicle type over trackage of one or more track owners, with the written consent of all of the affected track owners.

4.10 Minimally Compliant Analytical Track (MCAT)

The Track Safety Standards require certain vehicles to be qualified per § 213.345 in order to demonstrate safe operation for various track conditions. As a result of advancements made over the last few decades, computational models have become practical and reliable tools for understanding the dynamic behavior of vehicles and trains. As such, some of the qualification requirements can be effectively met by simulation using a suitably validated vehicle model. These models can be used to assess the response of vehicle designs to a wide range of track conditions corresponding to the limiting conditions allowed for each class of track.

APPENDIX D to Part 213 - MCAT SIMULATIONS USED FOR QUALIFICATION OF HIGH SPEED AND HIGH CANT DEFICIENCY VEHICLES

1. PURPOSE AND SCOPE

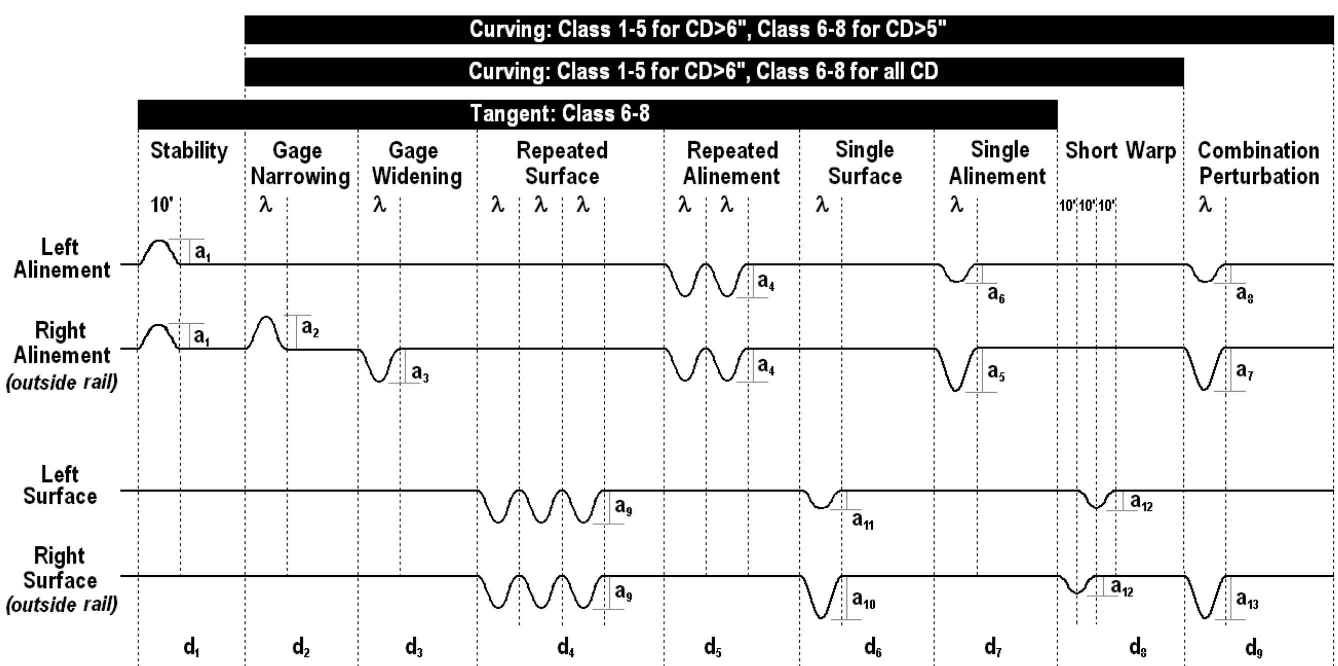
(a) As part of the qualification requirements defined in Subpart G of the FRA Track Safety Standards, simulations will be performed using a track containing defined geometry perturbations at the limits that are permitted for a class of track and level of cant deficiency. These simulations will be used to: 1) identify vehicle dynamic performance issues prior to service and 2) demonstrate that a vehicle is suitable for operation on a particular class of track.

As per § 213.345(c)(1), MCAT will be used for the qualification of a vehicle that operates at speeds corresponding to Class 6 through 8 or for a vehicle that operates at a cant deficiency greater than 6 inches. In addition, for qualified vehicles on an untested route, MCAT may be used for the qualification of a vehicle that operates at speeds corresponding to Class 7 through 8 or for a vehicle that operates at a cant deficiency greater than 6 inches, as per § 213.345(d)(1).

2. TRACK LAYOUT

(a) The minimally compliant analytical track, MCAT, consists of nine sections; 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.

Figure 1: Basic MCAT track layout



APPENDIX D to Part 213 - MCAT SIMULATIONS USED FOR QUALIFICATION OF HIGH SPEED AND HIGH CANT DEFICIENCY VEHICLES

(b) MCAT contains the following nine track sections:

(1) **STABILITY (a_1):** This section contains an alinement deviation on both rails to test vehicle stability on tangent track. The shape of each deviation is a versine having a wavelength of 10 feet and amplitude of 0.5 inches. This section is only to be used on tangent track simulations.

(2) **GAGE NARROWING (a_2)**: This section 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). The shape of the deviation is a versine having wavelength and amplitude varied for each simulation speed as described below.

(3) **GAGE WIDENING (a_3):** This section 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). The shape of the deviation is a versine having wavelength and amplitude varied for each simulation speed as described below.

(4) **REPEATED SURFACE (a_9):** This section contains three consecutive maximum permissible profile variations on each rail. The shape of each deviation is a versine having wavelength and amplitude varied for each simulation speed as described below.

(5) **REPEATED ALINEMENT (a_4):** This section contains two consecutive maximum permissible alinement variations on each rail. The shape of each deviation is a versine having wavelength and amplitude varied for each simulation speed as described below.

(6) **SINGLE SURFACE (a_{10}, a_{11}):** This section contains a maximum permissible profile variation on one rail. The shape of the deviation is a versine having wavelength and amplitude varied for each simulation speed as described below. 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.

(7) **SINGLE ALINEMENT (a_5, a_6):** This section contains a maximum permissible alinement variation on one rail. The shape of the deviation is a versine having wavelength and amplitude varied for each simulation speed as described below. 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.

(8) **SHORT WARP (a_{12}):** This section contains a pair of profile deviations to produce a maximum permissible 10 foot warp perturbation. The first is on the outside rail, while the second follows 10 feet later on the inside rail. The shape of each deviation is a versine having a 20 foot wavelength and amplitude varied for each simulation speed as described below. This section is only to be used on curved track simulations.

(9) **COMBINATION PERTURBATION (a_7, a_8, a_{13}):** This section contains a maximum permissible down and out combined geometry on the outside rail in the body of the curve. The shape of each deviation is a versine having wavelength and amplitude varied for each simulation speed as described below. 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 in sections 6 and 7 above. This section is only to be used on curved track simulations for cant deficiency more than 5 inches on track Classes 6 to 8 and for cant deficiency more than 6 inches on track Classes 1 to 5.

APPENDIX D to Part 213 - MCAT SIMULATIONS USED FOR QUALIFICATION OF HIGH SPEED AND HIGH CANT DEFICIENCY VEHICLES

(c) **SECTION LENGTHS:** The length of each section should be long enough to allow the vehicle response in a given section to damp out. For reference, Table 1 provides the length of each segment defined in Figure 1 that was used in the modeling of several representative high speed vehicles. The perturbations shall be placed far enough in the body of the curve to allow for any spiral effects to damp out.

Table 1: 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

(d) **DEGREE OF CURVATURE:** For each of the simulations 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 Equation 1 below. This equation assumes a curve with 6 inches of superelevation.

$$D = \frac{6 + Eu}{0.0007 \bullet V^2} \qquad \textbf{Equation 1.}$$

Where—

D = Degree of curvature (degrees).
V = Simulation speed (miles per hour).
E_u = Cant deficiency (inches).

3. REQUIRED SIMULATIONS

(a) To develop a comprehensive assessment of vehicle performance, simulations shall be performed for a variety of scenarios using the MCAT track defined above. These simulations will be performed to assess performance on tangent and/or curved track depending on the level of cant deficiency and speed (track class) as shown in Table 2.

Table 2: Vehicle performance assessment using MCAT

	NE Class 1 - 5 **QE Class 1 - 6**	**NE Class 6 - 8** **QE Class 7 - 8**
Cant Deficiency ≤ 6 inches	No Simulation	MCAT – performance on curve
Cant Deficiency > 6 inches	MCAT – performance on curve	MCAT – performance on curve
Tangent Track	No Simulation	MCAT – performance on tangent

NE: New Equipment, **QE**: Qualified Equipment

All MCAT simulations shall be performed using the design wheel profile and a nominal track gage of 56.5 inches, using Tables 3, 4, 5, and 6. In addition, all simulations involving the assessment of curving performance shall be repeated using a nominal track gage of 57.0 inches, using Tables 4, 5, and 6.

All simulations shall be repeated using either the APTA 340 or the APTA 320 wheel profile, depending on the established conicity that is common for the operation. In lieu of these profiles, an alternative worn wheel profile may be used if approved by the FRA.

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

APPENDIX D to Part 213 - MCAT SIMULATIONS USED FOR QUALIFICATION OF HIGH SPEED AND HIGH CANT DEFICIENCY VEHICLES

(b) **TRACK CLASS 6 THROUGH 8, VEHICLE PERFORMANCE ON TANGENT TRACK:**

For maximum vehicle speeds corresponding to Track Class 6 and higher, MCAT sections 1 through 7 shall be used to assess vehicle performance on tangent track. A parametric matrix of MCAT simulations shall be performed using the following range of conditions:

(1) **VEHICLE SPEED:** Simulations shall ensure that, any speed less than 5 mph above the proposed maximum operating speed, the equipment shall not exceed the wheel/rail force and acceleration criteria defined in the Vehicle/Track Interaction Safety Limits table in section § 213.333. Simulations shall be performed to demonstrate acceptable vehicle dynamic response by incrementally increasing speed from 95 mph (115 mph if qualified equipment on untested route) to 5 mph above the proposed maximum operating speed (in 5 mph increments).

(2) **PERTURBATION WAVELENGTH:** For each speed, a set of three separate MCAT simulations shall be performed. In each MCAT simulation, every perturbation shall have the same wavelength. The following three wavelengths, λ, are to be used: 31, 62 and 124 feet.

(3) **AMPLITUDE PARAMETERS:** Table 3 below provides the amplitude values for MCAT sections 1 through 7 for each speed in the parametric MCAT simulations described above.

The last set of simulations shall be performed at 5 mph above the proposed maximum operating speed using the amplitude values in Table 3 that correspond to the proposed maximum operating speed.

For qualification of vehicles involving speeds greater than Track Class 6, the following additional simulations shall be performed:

- For vehicles that are qualified for Track Class 7 speeds, one additional set of simulations shall be performed at 115 mph using the Track Class 6 amplitude values in Table 3 (i.e. a 5 mph overspeed on Class 6 track).
- For vehicles that are qualified for Track Class 8 speeds, two additional set of simulations shall be performed. The first set at 115 mph using the Track Class 6 amplitude values in Table 3 (i.e. a 5 mph overspeed on Class 6 track) and a second set at 130 mph using the Track Class 7 amplitude values in Table 3 (i.e. a 5 mph overspeed on Class 7 track).

APPENDIX D to Part 213 - MCAT SIMULATIONS USED FOR QUALIFICATION OF HIGH SPEED AND HIGH CANT DEFICIENCY VEHICLES

Table 3: Track Class 6 through 8 Amplitude Parameters in inches for MCAT Simulations on Tangent Track

		Standard Gage (56.5")		
		Class 6	Class 7	Class 8
λ = 31 ft	a_1	0.500	0.500	0.500
	a_2	0.500	0.500	0.500
	a_3	0.500	0.500	0.500
	a_4	0.375	0.375	0.375
	a_5	0.500	0.500	0.500
	a_6	0.000	0.000	0.000
	a_9	0.750	0.750	0.500
	a_{10}	1.000	1.000	0.750
	a_{11}	0.000	0.000	0.000
λ = 62 ft	a_1	0.500	0.500	0.500
	a_2	0.500	0.500	0.500
	a_3	0.500	0.500	0.500
	a_4	0.500	0.375	0.375
	a_5	0.750	0.750	0.750
	a_6	0.250	0.250	0.250
	a_9	0.750	0.750	0.750
	a_{10}	1.000	1.000	1.000
	a_{11}	0.000	0.000	0.000
λ = 124 ft	a_1	0.500	0.500	0.500
	a_2	0.500	0.500	0.500
	a_3	0.750	0.750	0.750
	a_4	1.000	0.875	0.500
	a_5	1.500	1.250	1.000
	a_6	0.750	0.500	0.250
	a_9	1.250	1.000	0.875
	a_{10}	1.750	1.500	1.250
	a_{11}	0.250	0.000	0.000

APPENDIX D to Part 213 - MCAT SIMULATIONS USED FOR QUALIFICATION OF HIGH SPEED AND HIGH CANT DEFICIENCY VEHICLES

(c) TRACK CLASS 6 THROUGH 8, VEHICLE PERFORMANCE ON CURVED TRACK:

For maximum vehicle speeds corresponding to Track Class 6 and higher, MCAT sections 2 through 9 shall be used to assess vehicle performance on curved track. A parametric matrix of MCAT simulations shall be performed using the following range of conditions:

(1) **VEHICLE SPEED:** Simulations shall ensure that, any speed less than 5 mph above the proposed maximum operating speed, the equipment shall not exceed the wheel/rail force and acceleration criteria defined in the Vehicle/Track Interaction Safety Limits table in section § 213.333. Simulations shall be performed to demonstrate acceptable vehicle dynamic response by incrementally increasing speed from 95 mph (115 mph if qualified equipment on untested route) to 5 mph above the proposed maximum operating speed (in 5 mph increments).

(2) **PERTURBATION WAVELENGTH:** For each speed, a set of three separate MCAT simulations shall be performed. In each MCAT simulation, every perturbation shall have the same wavelength. The following three wavelengths, λ, are to be used: 31, 62, and 124 feet.

(3) **TRACK CURVATURE:** For each speed a range of curvatures will be used to produce cant deficiency conditions ranging from 3 inches up to the maximum intended for qualification (in 1 inch increments). The value of curvature, D, shall be determined using Equation 1 defined above in section 2(d). Each curve shall contain MCAT sections 2 through 9 and have a fixed superelevation of 6 inches.

(4) **AMPLITUDE PARAMETERS:** Table 4 below provides the amplitude values for each speed in the parametric MCAT simulations described above for cant deficiencies 3 through 5. Table 5 below provides the amplitude values for each speed in the parametric MCAT simulations described above for cant deficiencies greater than 5 inches.

The last set of simulations at the maximum cant deficiency shall be performed at 5 mph above the proposed maximum operating speed using the amplitude values in Tables 4 or 5 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 vehicles involving speeds greater than Track Class 6, the following additional simulations shall be performed:

- For vehicles that are qualified for Track Class 7 speeds, one additional set of simulations shall be performed at 115 mph using the Track Class 6 amplitude values in Tables 4 and 5 (i.e. a 5 mph overspeed on Class 6 track) and a value of curvature, D, that corresponds to 110 mph and the proposed maximum cant deficiency.
- For vehicles that are qualified for Track Class 8 speeds, two additional set of simulations shall be performed. The first set of simulations shall be performed at 115 mph using the Track Class 6 amplitude values in Tables 4 and 5 (i.e. a 5 mph overspeed on Class 6 track) and a value of curvature, D, that corresponds to 110 mph and the proposed maximum cant deficiency. The second set of simulations shall be performed at 130 mph using the Track Class 7 amplitude values in Tables 4 and 5 (i.e. a 5 mph overspeed on Class 7 track) and a value of curvature, D, that corresponds to 125 mph and the proposed maximum cant deficiency.

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Table 4: Track Class 6 through 8 Amplitude Parameters in inches for MCAT Simulations on Curved Track (3 through 5 inch Cant Deficiency)

		Standard Gage (56.5")			Wider Gage (57.0")		
		Class 6	Class 7	Class 8	Class 6	Class 7	Class 8
λ = 31 ft	a_2	0.500	0.500	0.500	0.500	0.500	0.500
	a_3	0.500	0.500	0.500	0.250	0.250	0.250
	a_4	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
	a_6	0.000	0.000	0.000	0.250	0.250	0.250
	a_9	0.750	0.750	0.500	0.750	0.750	0.500
	a_{10}	1.000	1.000	0.750	1.000	1.000	0.750
	a_{11}	0.000	0.000	0.000	0.000	0.000	0.000
	a_{12}	0.625	0.563	0.500	0.625	0.563	0.500
λ = 62 ft	a_2	0.500	0.500	0.500	0.500	0.500	0.500
	a_3	0.500	0.500	0.500	0.250	0.250	0.250
	a_4	0.500	0.375	0.375	0.500	0.375	0.375
	a_5	0.625	0.500	0.500	0.625	0.500	0.500
	a_6	0.125	0.000	0.000	0.375	0.250	0.250
	a_9	0.750	0.750	0.750	0.750	0.750	0.750
	a_{10}	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
	a_{12}	0.625	0.563	0.500	0.625	0.563	0.500
λ = 124 ft	a_2	0.500	0.500	0.500	1.000	1.000	1.000
	a_3	0.750	0.750	0.750	0.250	0.250	0.250
	a_4	1.000	0.875	0.500	1.000	0.875	0.500
	a_5	1.500	1.250	0.750	1.500	1.250	0.750
	a_6	0.750	0.500	0.000	1.250	1.000	0.500
	a_9	1.250	1.000	0.875	1.250	1.000	0.875
	a_{10}	1.750	1.500	1.250	1.750	1.500	1.250
	a_{11}	0.250	0.000	0.000	0.250	0.000	0.000
	a_{12}	0.625	0.563	0.500	0.625	0.563	0.500

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Table 5: Track Class 6 through 8 Amplitude Parameters in inches for MCAT Simulations on Curved Track (Cant Deficiency greater than 5 inches)

		Standard Gage (56.5")			Wider Gage (57.0")		
		Class 6	Class 7	Class 8	Class 6	Class 7	Class 8
λ = 31 ft	a_2	0.500	0.500	0.500	0.500	0.500	0.500
	a_3	0.500	0.500	0.500	0.250	0.250	0.250
	a_4	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
	a_6	0.000	0.000	0.000	0.250	0.250	0.250
	a_7	0.333	0.333	0.333	0.333	0.333	0.333
	a_8	0.000	0.000	0.000	0.083	0.083	0.083
	a_9	0.750	0.750	0.500	0.750	0.750	0.500
	a_{10}	1.000	1.000	0.750	1.000	1.000	0.750
	a_{11}	0.000	0.000	0.000	0.000	0.000	0.000
	a_{12}	0.625	0.500	0.500[1]	0.625	0.500	0.500[1]
	a_{13}	0.667	0.667	0.500	0.667	0.667	0.500
λ = 62 ft	a_2	0.500	0.500	0.500	0.500	0.500	0.500
	a_3	0.500	0.500	0.500	0.250	0.250	0.250
	a_4	0.500	0.375	0.375	0.500	0.375	0.375
	a_5	0.625	0.500	0.500	0.625	0.500	0.500
	a_6	0.125	0.000	0.000	0.375	0.250	0.250
	a_7	0.417	0.333	0.333	0.417	0.333	0.333
	a_8	0.000	0.000	0.000	0.167	0.083	0.083
	a_9	0.750	0.750	0.750	0.750	0.750	0.750
	a_{10}	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
	a_{12}	0.625	0.500	0.500[1]	0.625	0.500	0.500[1]
	a_{13}	0.667	0.667	0.667	0.667	0.667	0.667
λ = 124 ft	a_2	0.500	0.500	0.500	1.000	1.000	1.000
	a_3	0.750	0.750	0.750	0.250	0.250	0.250
	a_4	1.000	0.875	0.500	1.000	0.875	0.500
	a_5	1.250	1.000	0.750	1.250	1.000	0.750
	a_6	0.500	0.250	0.000	1.000	0.750	0.500
	a_7	0.833	0.667	0.500	0.833	0.667	0.500
	a_8	0.083	0.000	0.000	0.583	0.417	0.250
	a_9	1.250	1.000	0.875	1.250	1.000	0.875
	a_{10}	1.500	1.250	1.250	1.500	1.250	1.250
	a_{11}	0.000	0.000	0.000	0.000	0.000	0.000
	a_{12}	0.625	0.500	0.500[1]	0.625	0.500	0.500[1]
	a_{13}	1.000	0.833	0.833	1.000	0.833	0.833

[1] 0.375 for CD>7"

APPENDIX D to Part 213 - MCAT SIMULATIONS USED FOR QUALIFICATION OF HIGH SPEED AND HIGH CANT DEFICIENCY VEHICLES

(d) **TRACK CLASS 1 THROUGH 5, VEHICLE PERFORMANCE ON CURVED TRACK AT HIGH CANT DEFICIENCY:**

For maximum vehicle speeds corresponding to track Class 1 through 5, MCAT sections 2 through 9 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:

(1) **VEHICLE SPEED**: Simulations shall ensure that at 5 mph above the proposed maximum operating speed, the equipment shall not exceed the wheel/rail force and acceleration criteria defined in the Vehicle/Track Interaction Safety Limits table in section § 213.333. Simulations shall be performed to demonstrate acceptable vehicle dynamic response at 5 mph above the proposed maximum operating speed.

(2) **PERTURBATION WAVLENGTH**: For each speed, a set of two separate MCAT simulations shall be performed. In each MCAT simulation, every perturbation shall have the same wavelength. The following two wavelengths, λ, are to be used: 31 and 62 feet.

(3) **TRACK CURVATURE**: For a speed corresponding to 5 mph above the proposed maximum operating speed, a range of curvatures will 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 Equation 1 defined above in section 2(d). Each curve shall contain MCAT sections 2 through 9 and have a fixed superelevation of 6 inches.

(4) **AMPLITUDE PARAMETERS:** Table 6 below provides the amplitude values for each case in the parametric MCAT simulations described above.

Table 6: Track Class 1 through 5 Amplitude Parameters in inches for MCAT Simulations on Curved Track (Cant Deficiency greater than 6 inches)

		Standard Gage (56.5")					Wider Gage (57.0")				
		Class 1	Class 2	Class 3	Class 4	Class 5	Class 1	Class 2	Class 3	Class 4	Class 5
λ = 31 ft	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_{12}	1.000	1.000	0.875	0.875	0.750	1.000	1.000	0.875	0.875	0.750
	a_{13}	0.667	0.667	0.667	0.667	0.667	0.667	0.667	0.667	0.667	0.667
λ = 62 ft	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_{12}	1.000	1.000	0.875	0.875	0.750	1.000	1.000	0.875	0.875	0.750
	a_{13}	1.167	1.167	1.167	0.833	0.667	1.167	1.167	1.167	0.833	0.667

APPENDIX D to Part 213 - MCAT SIMULATIONS USED FOR QUALIFICATION OF HIGH SPEED AND HIGH CANT DEFICIENCY VEHICLES

4. MODEL COMPARISON

(a) A comparison of the vehicle simulation model predictions and measured wheel/rail forces and accelerations shall be made and submitted with the MCAT results using measured track data. The segment of measured track geometry shall be chosen from the same track section over which testing is performed as per §213.345(c)(1)(ii).

4.11 Removal of References to Class 9

References to Class 9 track have been removed in the text developed for the rule. Some sections must still be edited to remove this reference as follows:

Remove References to Class 9
§ 213.335 Crossties, paragraphs (c), (d), (e) and (g)
§ 213.347 Automotive or Railroad Crossings at Grade, paragraph (a)
§ 213.349 Rail End Mismatch, table
§ 213.355 Frog Guard Rails and Guard Faces: Gage, table
§ 213.357 Derails, paragraphs (a) and (g)
§ 213.361 Right of Way
§ 213.365 Visual Inspections, table in paragraph (c) and paragraph (f)
Appendix A, Table 1 – remove speeds greater than 150 mph

5. Proposed Rule Text: 49 CFR 238 Subpart C – Specific Requirements for Tier I Passenger Equipment

This section was updated to align with the changes being proposed in part 213 of this chapter and also to provide reference pointers to relevant sections of part 213. The existing pre-revenue service qualification requirement was consolidated with a pointer to the qualification requirements of § 213.345. For consistency throughout parts 213 and 238, the term "hunting oscillations" was replaced with "truck hunting" and the definition of hunting oscillations was replaced with a pointer to § 213.333 for the existing definition of truck hunting.

5.1 § 238.227 – Suspension System

§ 238.227 – Suspension System

On or after November 8, 1999—

(a) All passenger equipment shall exhibit freedom from truck hunting at all operating speeds. If truck hunting does occur, a railroad shall immediately take appropriate action to prevent derailment. Truck hunting is defined in § 213.333 of this chapter.

(b) Nothing in this section shall affect the requirements of the Track Safety Standards in part 213 of this chapter as they apply to passenger equipment as provided in that part. In particular—

(1) <u>Pre-revenue service qualification.</u> All passenger equipment intended for service at speeds greater than 90 mph or at any curving speed producing more than 5 inches of cant deficiency shall demonstrate safe operation during pre-revenue service qualification in accordance with § 213.345 of this chapter and is subject to the requirements of either § 213.57 or § 213.329 of this chapter.

(2) <u>Revenue service operation:</u> All passenger equipment intended for service at speeds greater than 90 mph or at any curving speed producing more than 5 inches of cant deficiency is subject to the requirements of § 213.333 of this chapter and either § 213.57 or § 213.329 of this chapter.

6. Proposed Rule Text: 49 CFR 238 Subpart E – Specific Requirements for Tier II Passenger Equipment

This section was updated to align with the changes being proposed in part 213 of this chapter and also to provide reference pointers to relevant sections of part 213. The steady state lateral car body acceleration limit of 0.12 g was changed to 0.15 g, to align with the proposed requirements in § 213.329. The remaining acceleration requirements were consolidated with a pointer to the requirements of § 213.333. For consistency throughout parts 213 and 238, the term "hunting oscillations" was replaced with "truck hunting" and the definition of hunting oscillations was replaced with a pointer to § 213.333 for the existing definition of truck hunting. The overheat sensor requirement in § 238.427(d) was felt to be unrelated to suspension systems and as such, was moved to § 238.428, a new section.

6.1 § 238.427 – Suspension System

§ 238.427 – Suspension System

(a) General requirements.

(1) Suspension systems shall be designed to reasonably prevent wheel climb, wheel unloading, rail rollover, rail shift, and a vehicle from overturning to ensure safe, stable performance and ride quality. These requirements shall be met:

(i) In all operating environments, and under all track conditions and loading conditions as determined by the operating railroad; and

(ii) At all track speeds and over all track qualities consistent with the Track Safety Standards in part 213 of this chapter, up to the maximum operating speed and maximum cant deficiency of the equipment.

(2) All passenger equipment shall meet the safety performance standards for suspension systems contained in part 213 of this chapter, or alternative standards providing at least equivalent safety if approved by FRA under the provisions of § 238.21. In particular–

(i) Pre-revenue service qualification. All passenger equipment shall demonstrate safe operation during pre-revenue service qualification in accordance with § 213.345 of this chapter and is subject to the requirements of § 213.329 of this chapter.

(ii) Revenue service operation. All passenger equipment in service is subject to the requirements of § 213.329 and § 213.333 of this chapter.

(b) Car body accelerations. A passenger car shall not operate under conditions that result in a steady-state lateral acceleration greater than 0.15 g, as measured parallel to the car floor inside the passenger compartment. Additional car body acceleration limits are specified in § 213.333 of this chapter.

(c) Truck (hunting) acceleration. Each truck shall be equipped with a permanently installed lateral accelerometer mounted on the truck frame. If truck hunting is detected, the train monitoring system shall provide an alarm to the operator and the train shall be slowed to a speed at least 5 mph less than the speed at which the truck hunting stopped. Truck hunting is defined in § 213.333 of this chapter.

6.2 § 238.428 – Overheat Sensors

This is a new section and contains the requirement wording (no change) as currently contained in § 238.427(d) of this chapter. It was determined that a requirement for overheat sensors should not be included with those for suspension systems (§ 238.427).

§ 238.428 – Overheat Sensors
Overheat sensors for each wheelset journal bearing shall be provided. The sensors may be placed either onboard the equipment or at reasonable intervals along the railroad's right-of-way.

6.3 Appendix C to Part 238 – Suspension System Safety Performance Standards

The entirety of Appendix C, which includes the minimum suspension system safety performance standards for Tier II passenger equipment, was removed from part 238. These performance standards were consolidated with a pointer to the wheel/rail force requirements currently included in § 213.333 of this chapter and referenced in § 238.427(a)(2).

Appendix C to Part 238 – Suspension System Safety Performance Standards
Remove entire Appendix.