



Principles of Track Geometry

Presented by:

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PRINCIPLES COURSE • MAY 3, 2016

WRI 2016

Individual Geometry Topics

- Gage
- Curves and Curve Alignment
- Superelevation
- Crosslevel Variance and Deviation
- Vertical Profile
- Runoff from a raise



Gage, Alignment, Profile, and Crosslevel Variations



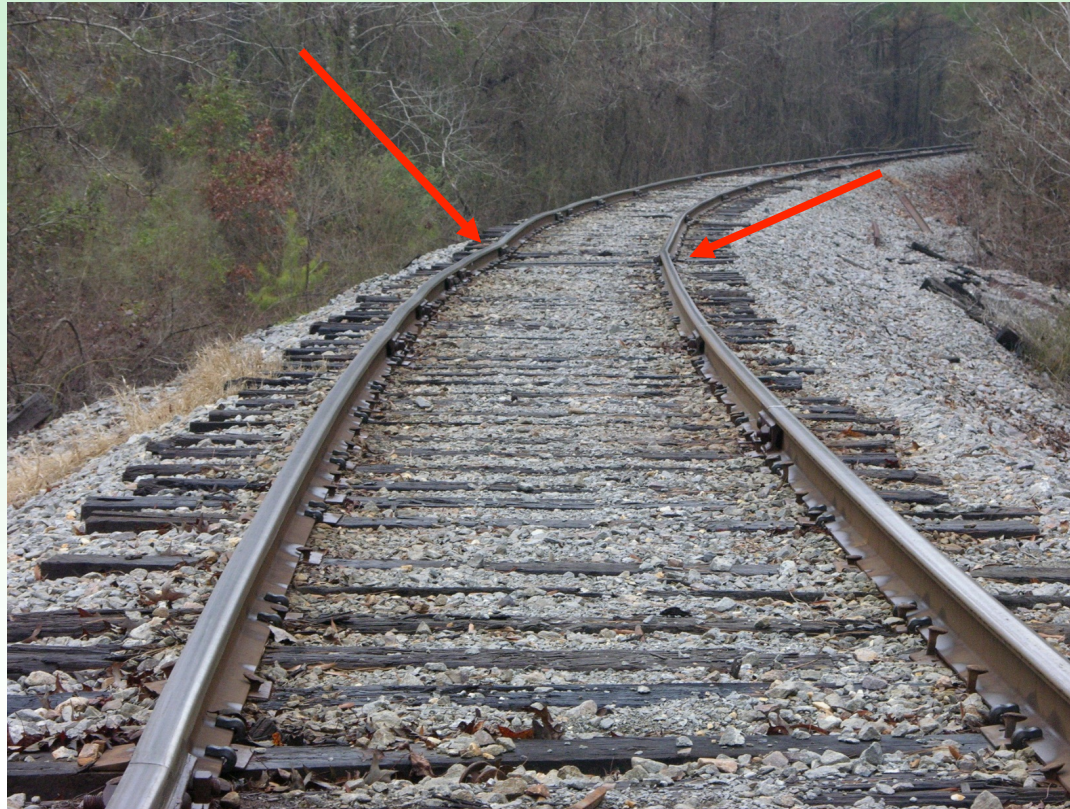
Gage and Alignment Variations



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Crosslevel and Alignment Variations



Surface and Profile Deviations



For North American Freight Operations

CLASSES OF TRACK

CLASS	OPERATING SPEEDS (MPH)			
	1. FREIGHT		2. PASSENGER	
	FROM	TO	FROM	TO
1	1	10	1	15
2	11	25	16	30
3	26	40	31	60
4	41	60	61	80
5	61	80	81	90





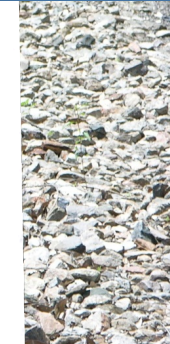
§213.53 Gage.

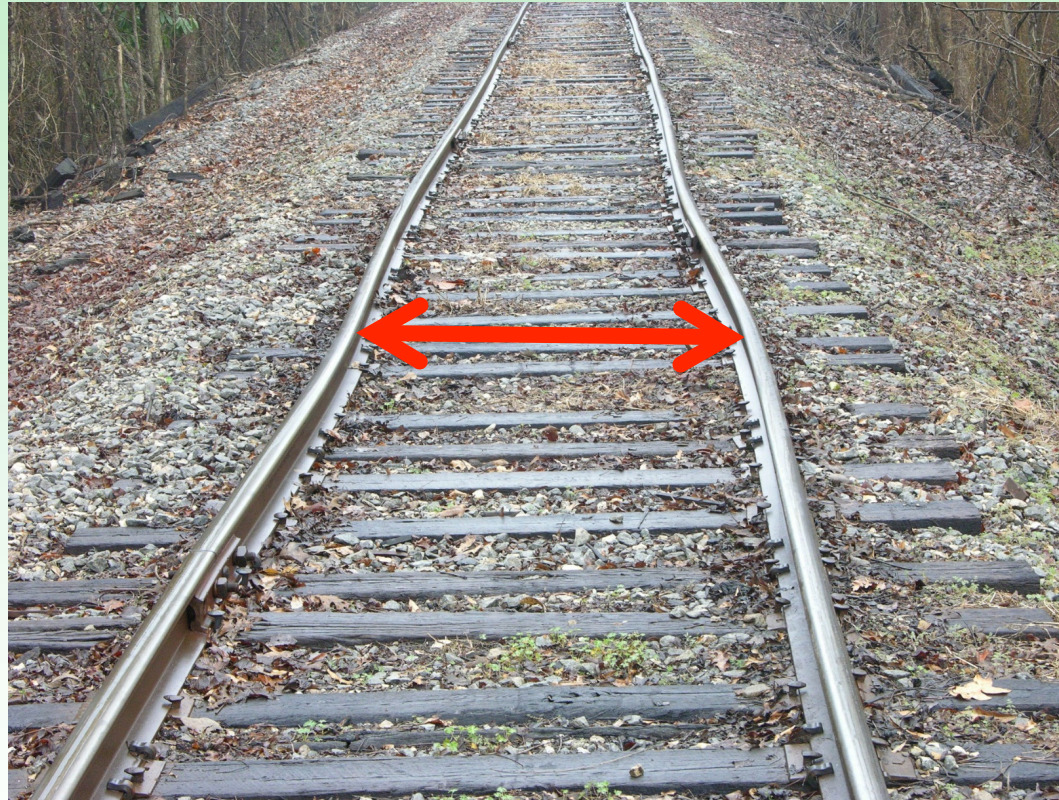
(a) Gage is measured between the heads of the rails at right-angles to the rails in a plane five-eighths of an inch below the top of the rail head.

(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—
Excepted track.	N/A	4'10 ¹ / ₄ "
Class 1 track	4'8"	4'10"
Class 2 and 3 track	4'8"	4'9 ³ / ₄ "
Class 4 and 5 track	4'8"	4'9 ¹ / ₂ "





Gage Deviations





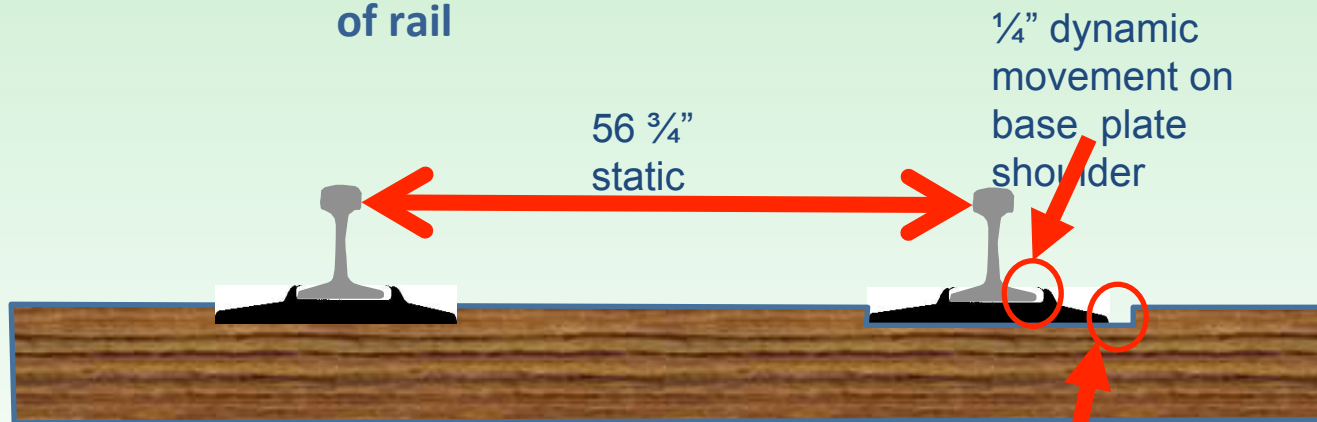
Gage Deviations



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Gage – Distance between the rail heads measured 5/8" below top of rail



56 3/4" static

1/4" dynamic movement on base plate shoulder

56 3/4" static gage
 1/4" dynamic base movement
 1/2" dynamic plate movement

1/2" dynamic lateral movement of plate on tie surface

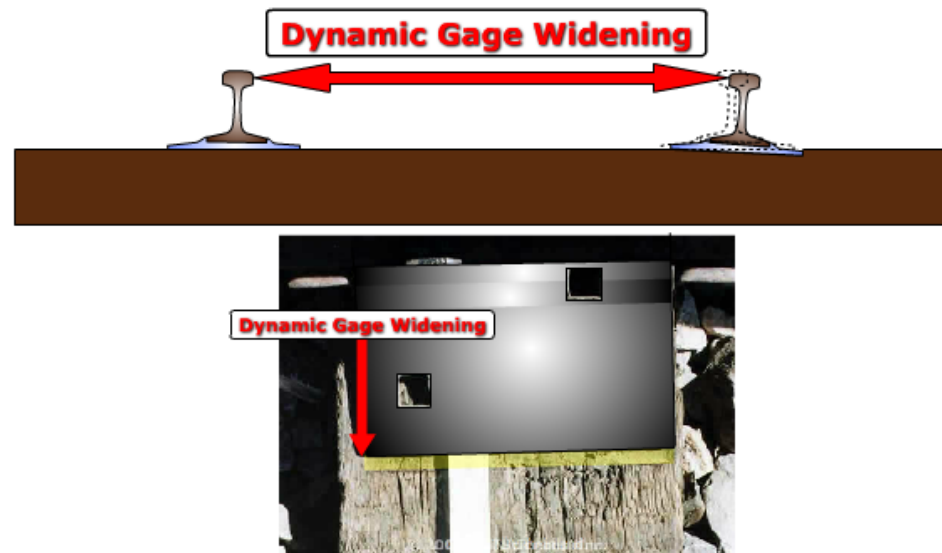
57 1/2" total gage for FRA Compliance

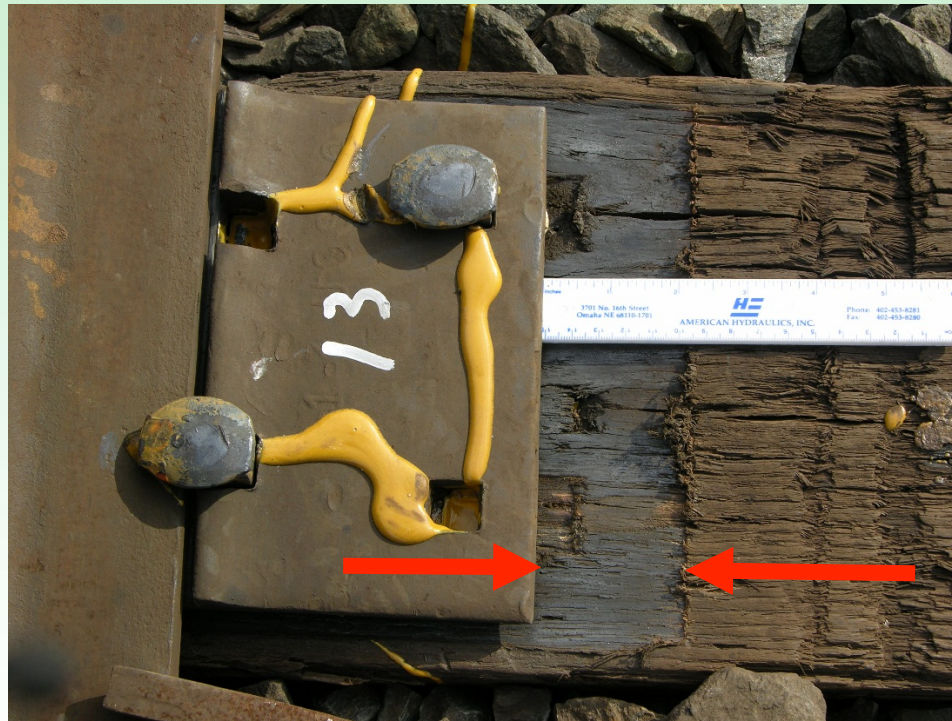
§ 213.13 Measuring track not under load.
 When unloaded track is measured to determine compliance with requirements of this part, the amount of rail movement, if any, that occurs while the track is loaded must be added to the measurements of the unloaded track.



Subpart C - Track Geometry §213.53 Gage

Remember to look for evidence of lateral rail movement as required in §213.13.





Dynamic Gage Widening





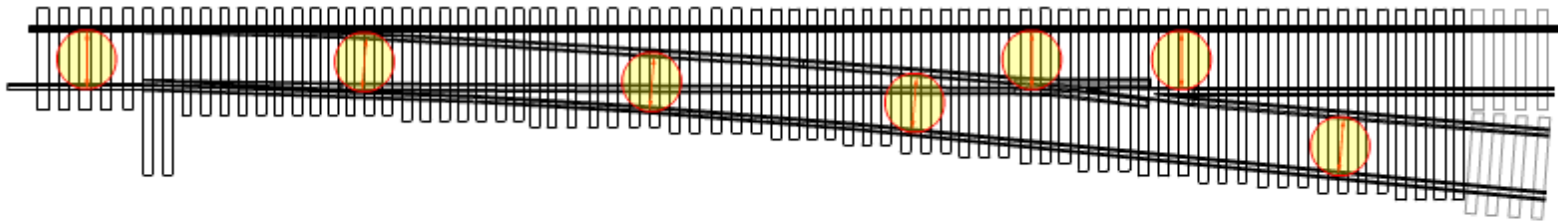
Measuring gage 5/8" below head of rail

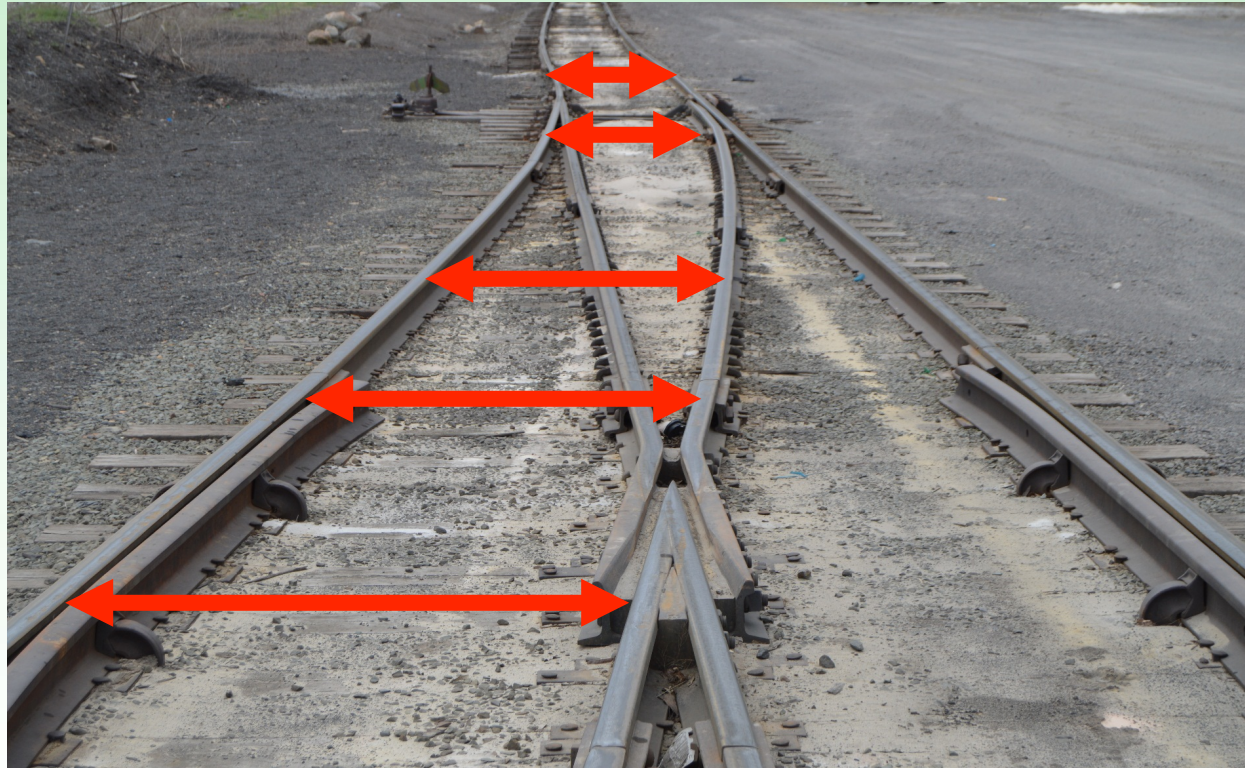


Subpart C - Track Geometry §213.53 Gage

Particular attention should be given to track gage in turnouts or locations where high lateral train forces are expected or evident.

These areas include the curved closure rails, the toe and heel of frogs, the curved track behind the frog and several feet ahead of the switch points.





Checking Gage in a Turnout at Multiple Locations



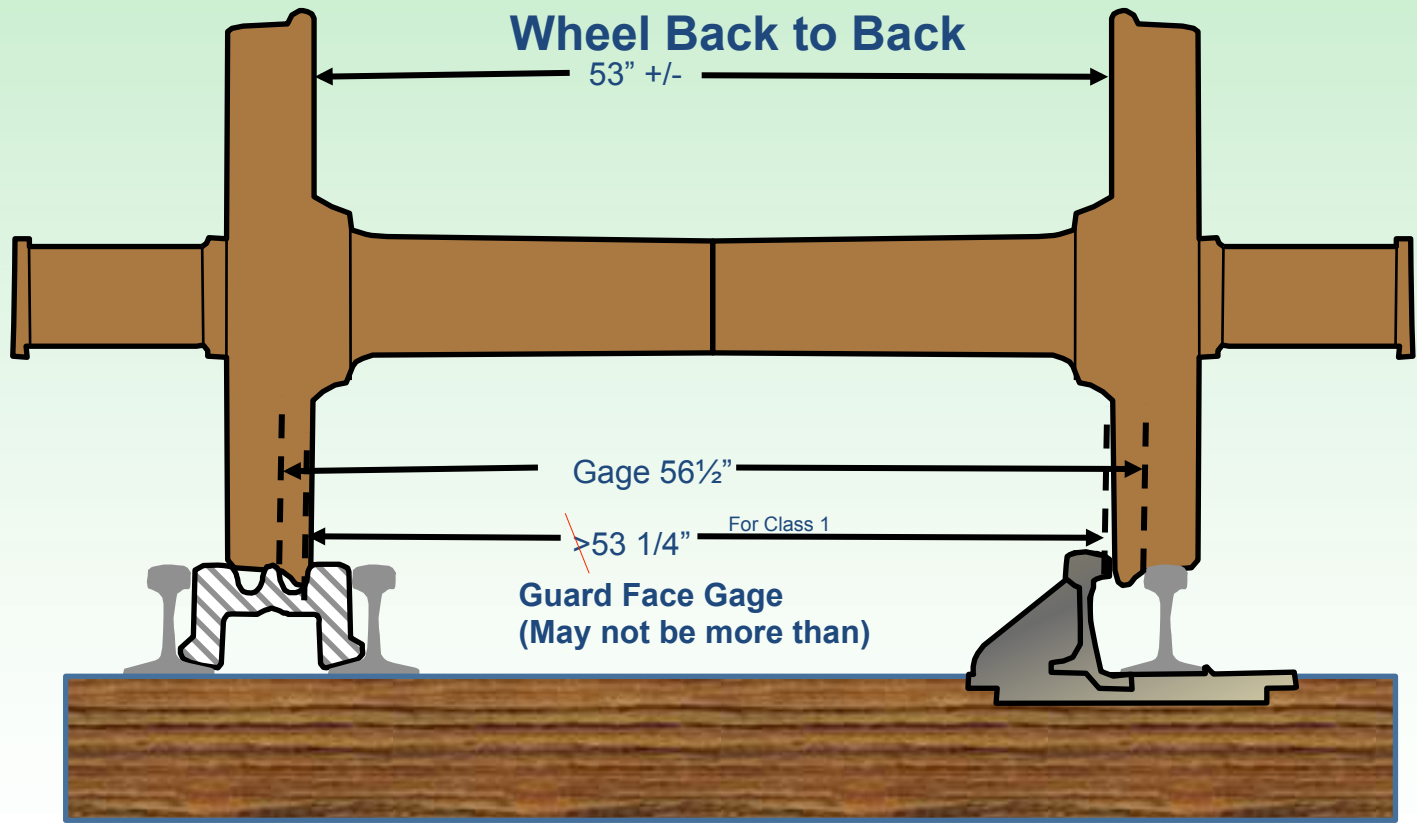


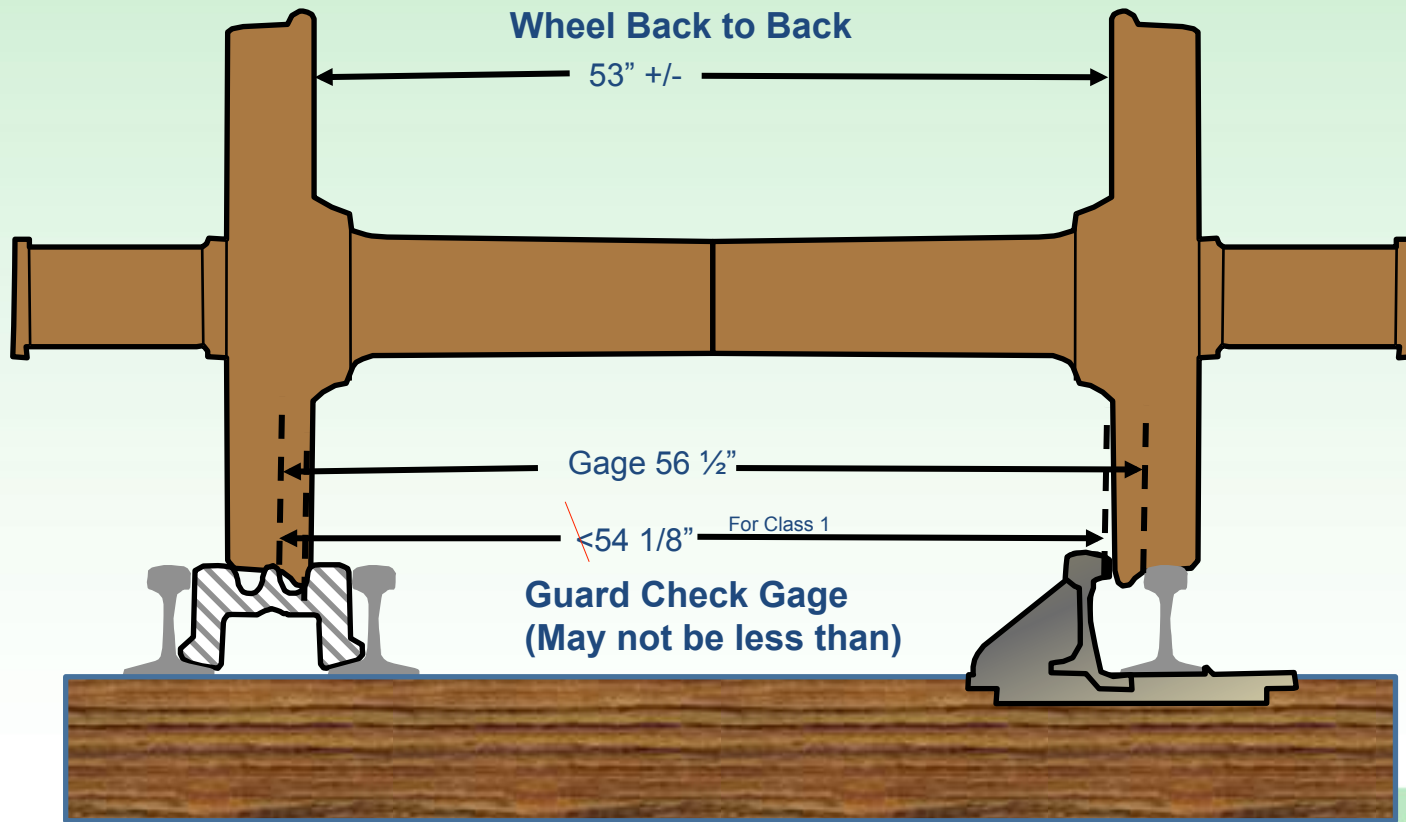
213.143 Guard Check and Face Gage

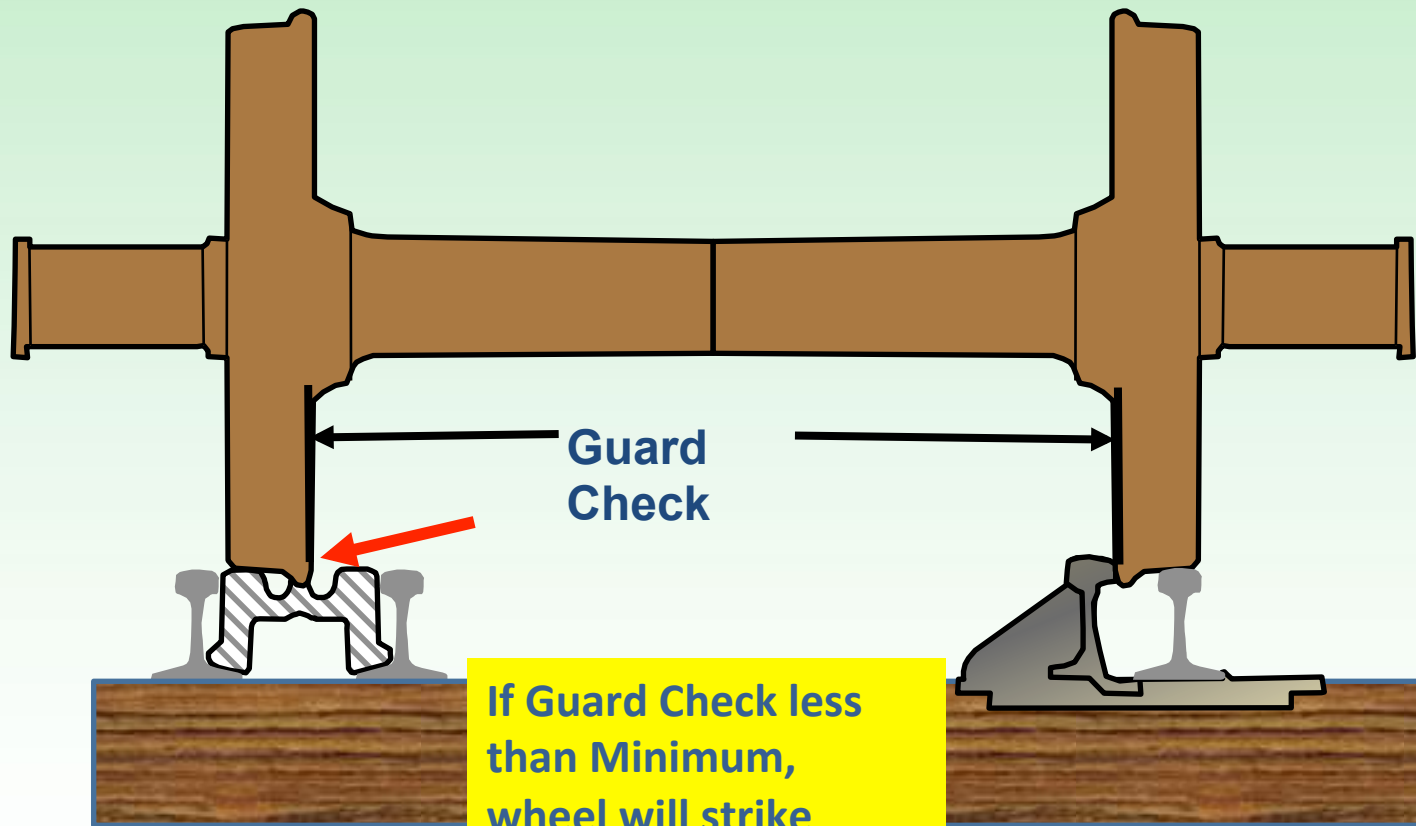
The guard check and guard face gages in frogs shall be within the limits prescribed by the following table

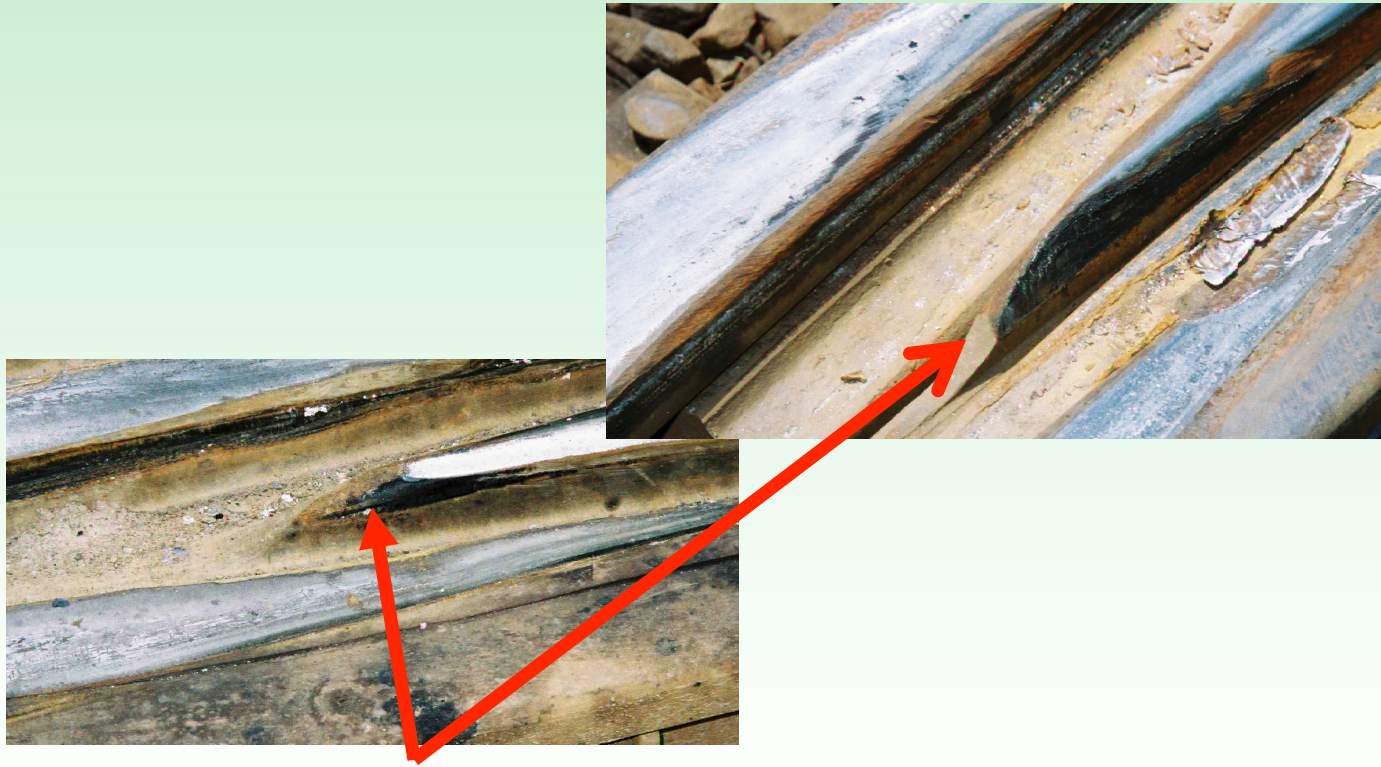
Class of Track	Guard Check gage may not be <u>less</u> than	Guard Face gage may not be <u>more</u> than
Class 1	4' 6 1/8"	4' 5 1/4"
Class 2	4' 6 1/4"	4' 5 1/8"
Class 3 & 4	4' 6 3/8"	4' 5 1/8"
Class 5	4' 6 1/2"	4' 5"





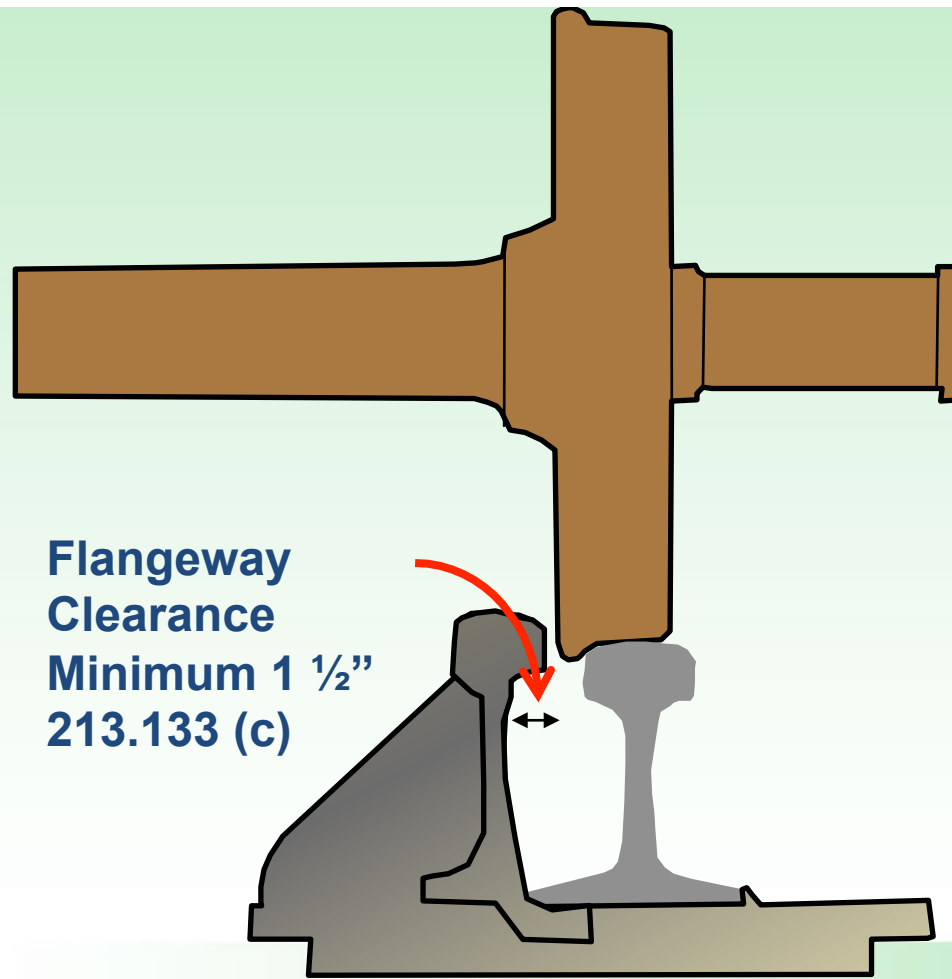






**Wheel Striking point of Frog;
Guard check less than minimum**





**Flangeway
Clearance
Minimum 1 1/2"
213.133 (c)**



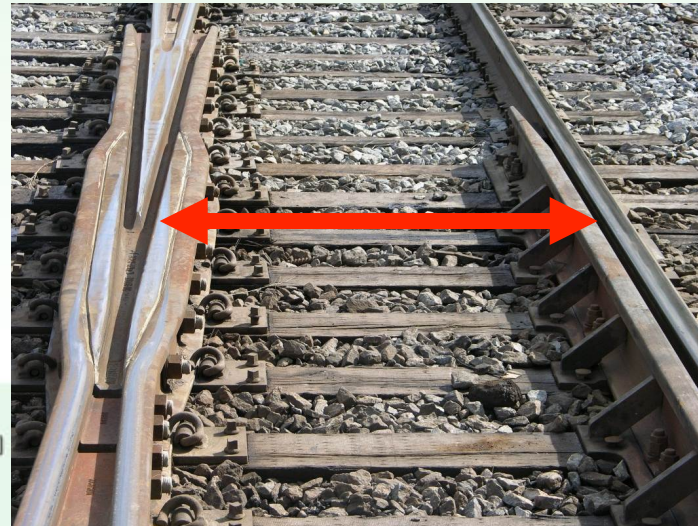
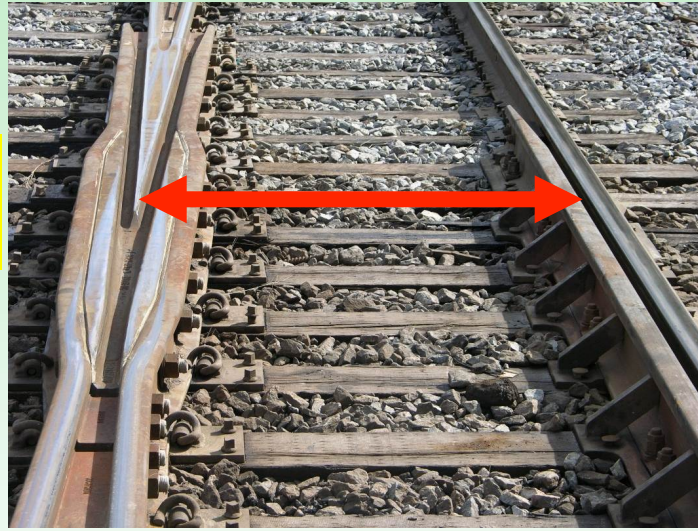
Class 5 Track

**Guard Check- Gage
Line of frog to Guard Line**

Minimum = 54 1/2"

**Guard Face -
Distance
Between Wing
Rail and Guard
Line**

Maximum = 53 "

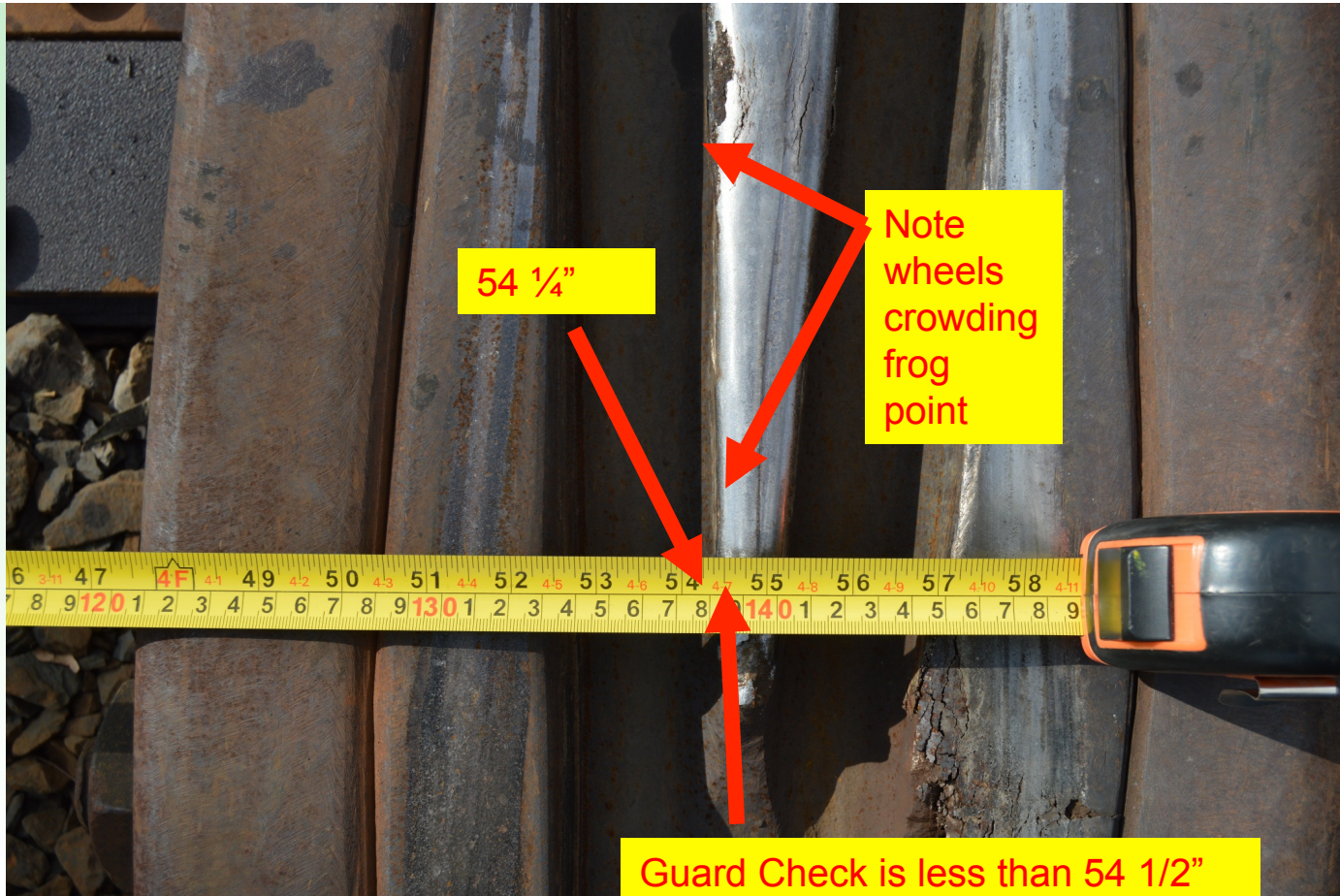


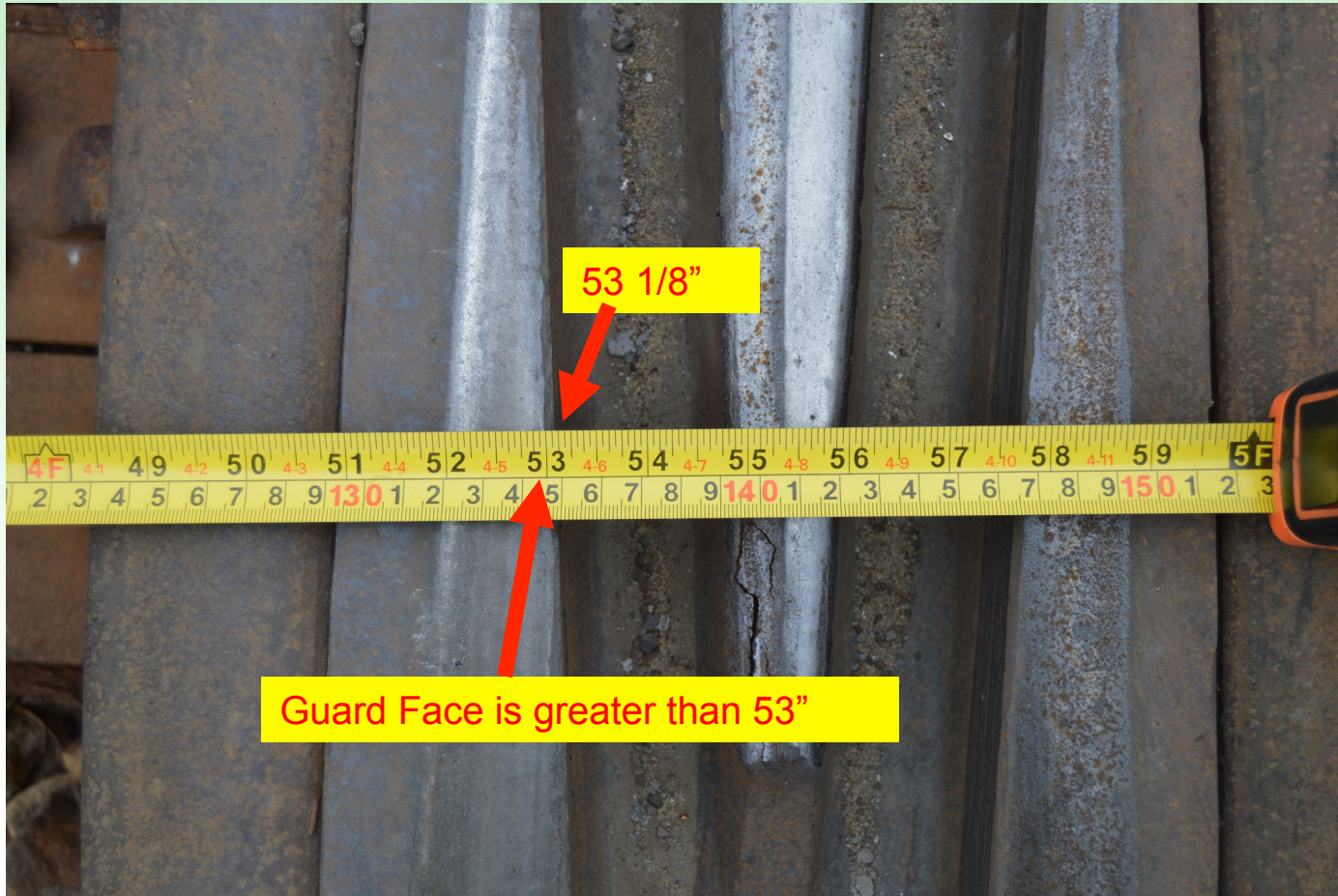


Guard Face may not be more than 53" for Class 5.

Guard Check may not be less than 54 1/2" for Class 5.









Checking minimum Flange
way
Clearance of 1 ½"



Issues with Gage

- Tight Gage
 - Can induce hunting at lower speed ranges
 - Wears wheels and rail at accelerated rate
- Wide Gage
 - Indication of weak ties and fasteners
 - Can allow greater wheelset angles of attack
 - Reduces safety margin for rail roll and wheel drop in



Curves and Curve Geometry

A high percentage of all derailments occur on curved track, including turnouts! It is important to understand curve geometry and how it affects car performance.



Curves and Curve Geometry

2 Characteristics of curves



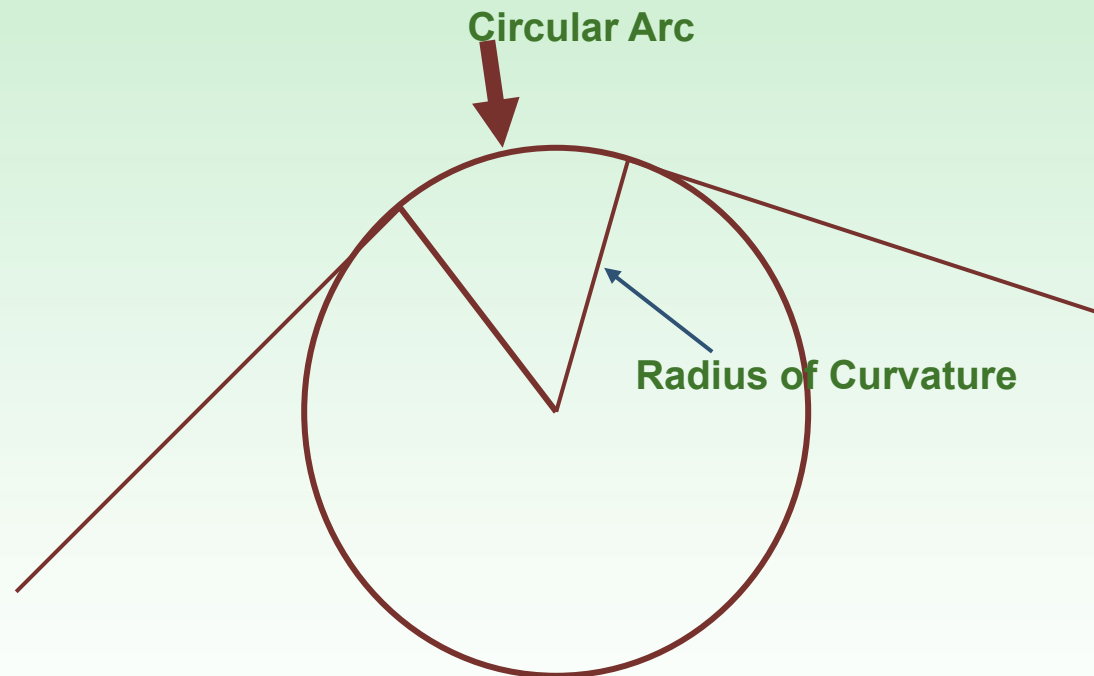
Elevation



Alignment



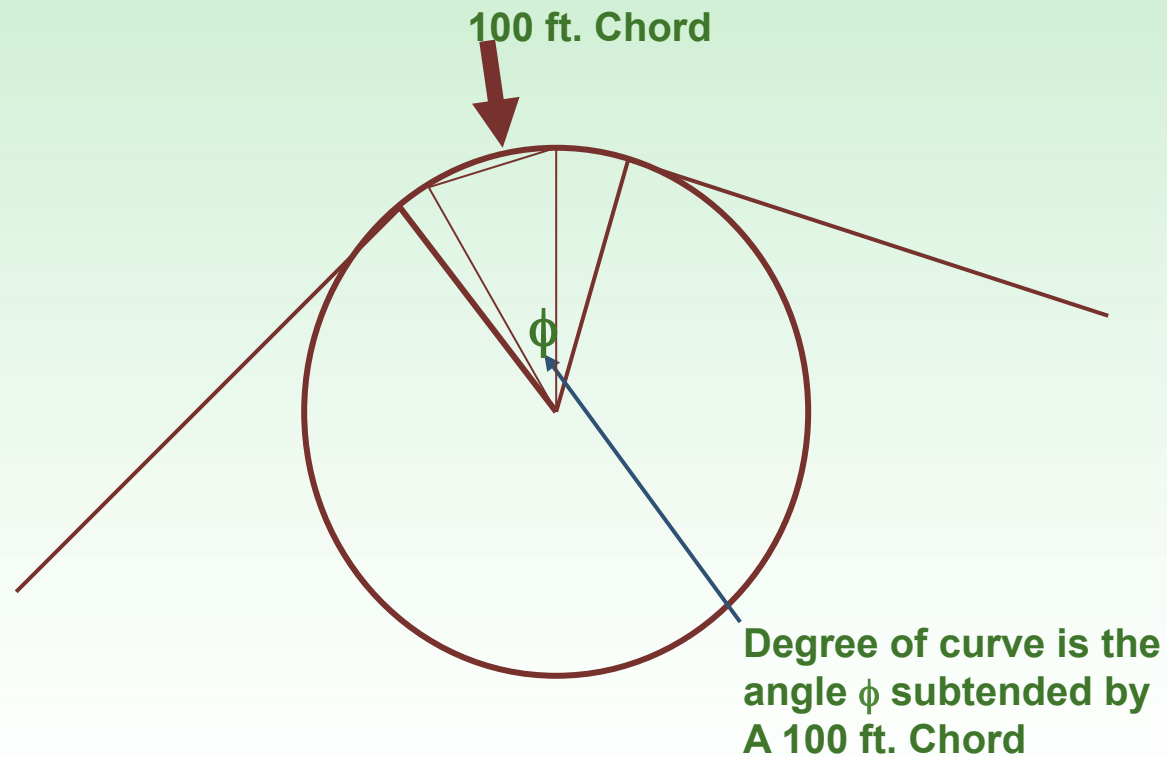
Definition of a Curve



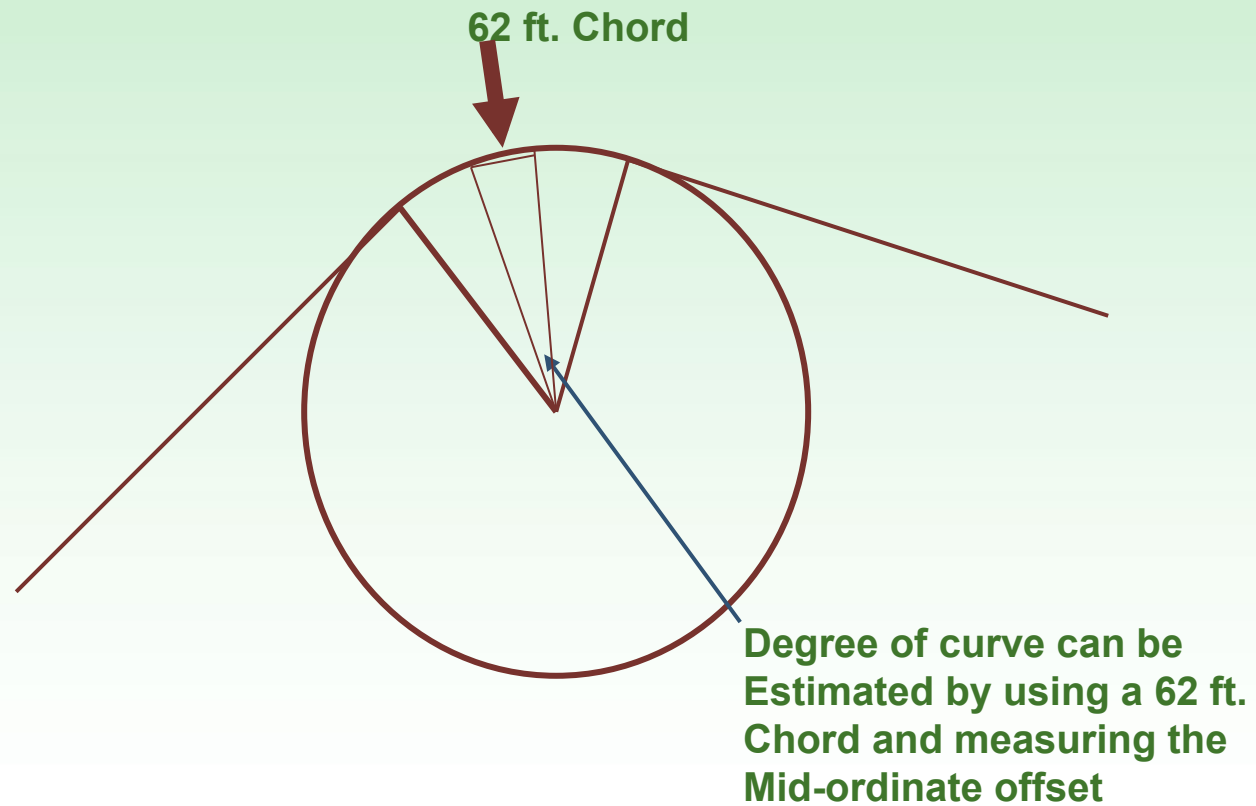
A curve is defined as a path along the edge of a circular arc defined by a circle of with a given radius



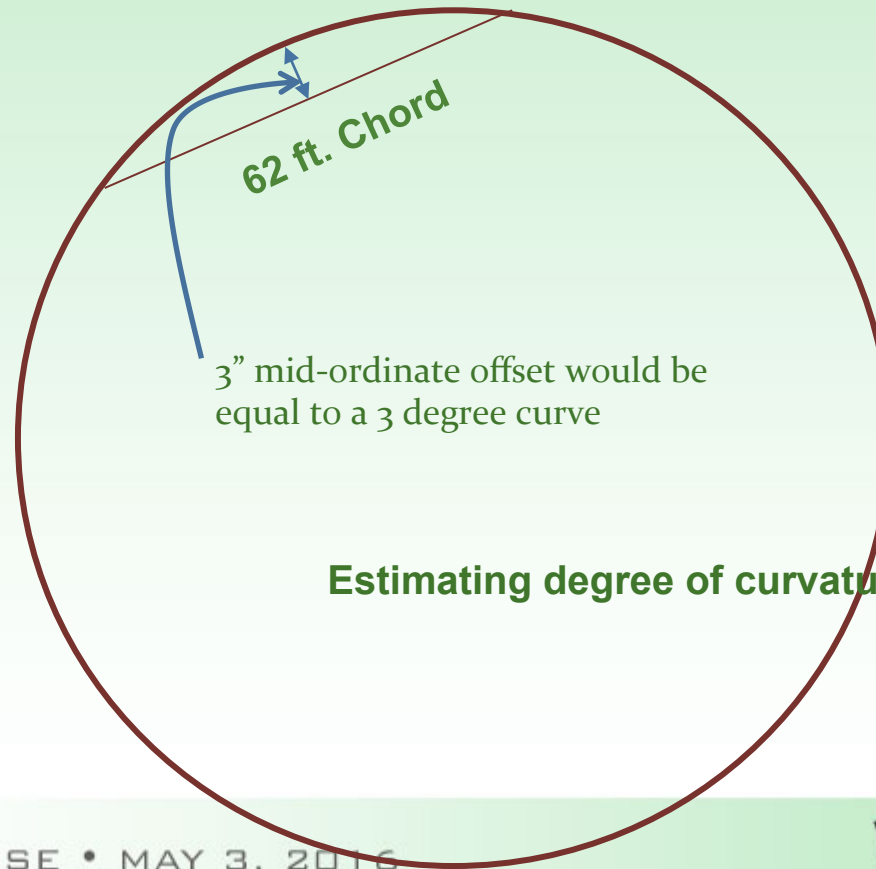
Railroad Definition of a Curve



Estimating degree of curvature using a 62 ft. chord



Midordinate offset in inches is approximately equal to the degree of curve



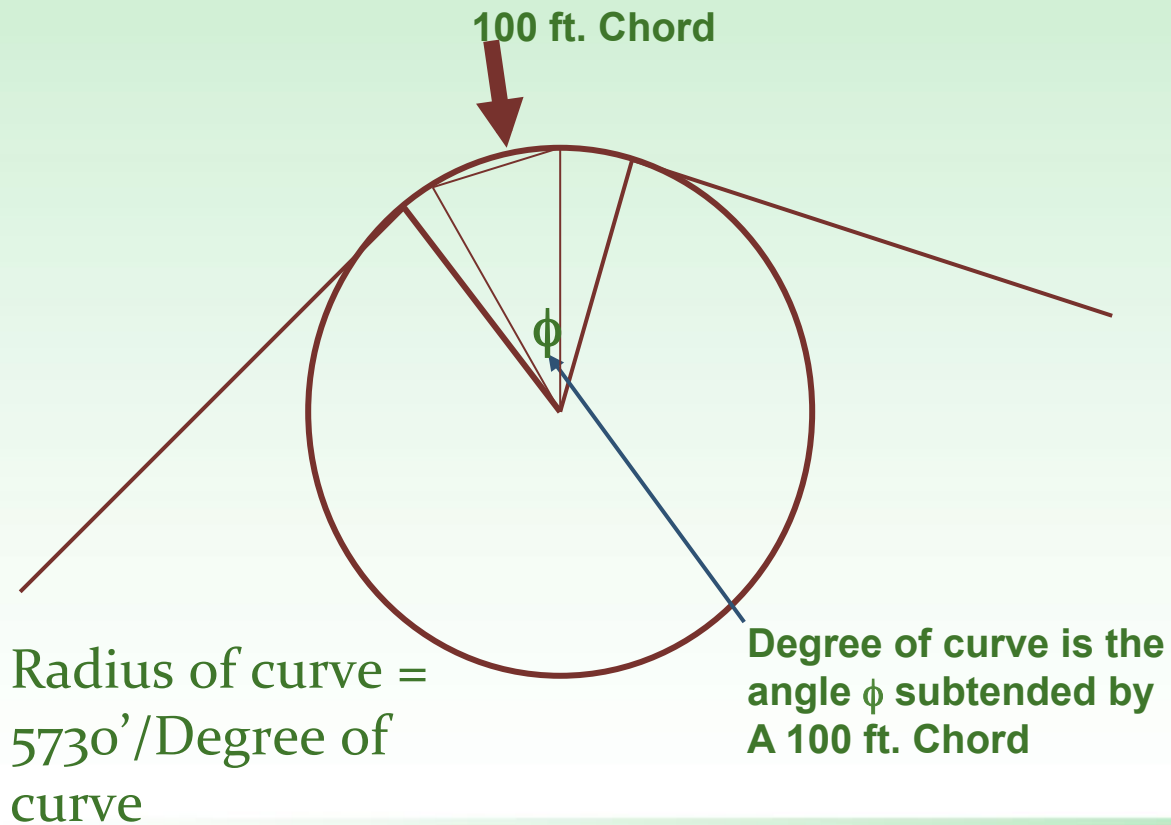
Estimating degree of curvature using a 62 ft. chord



Stringlining using 62 ft. Chord



Radius of a Curve

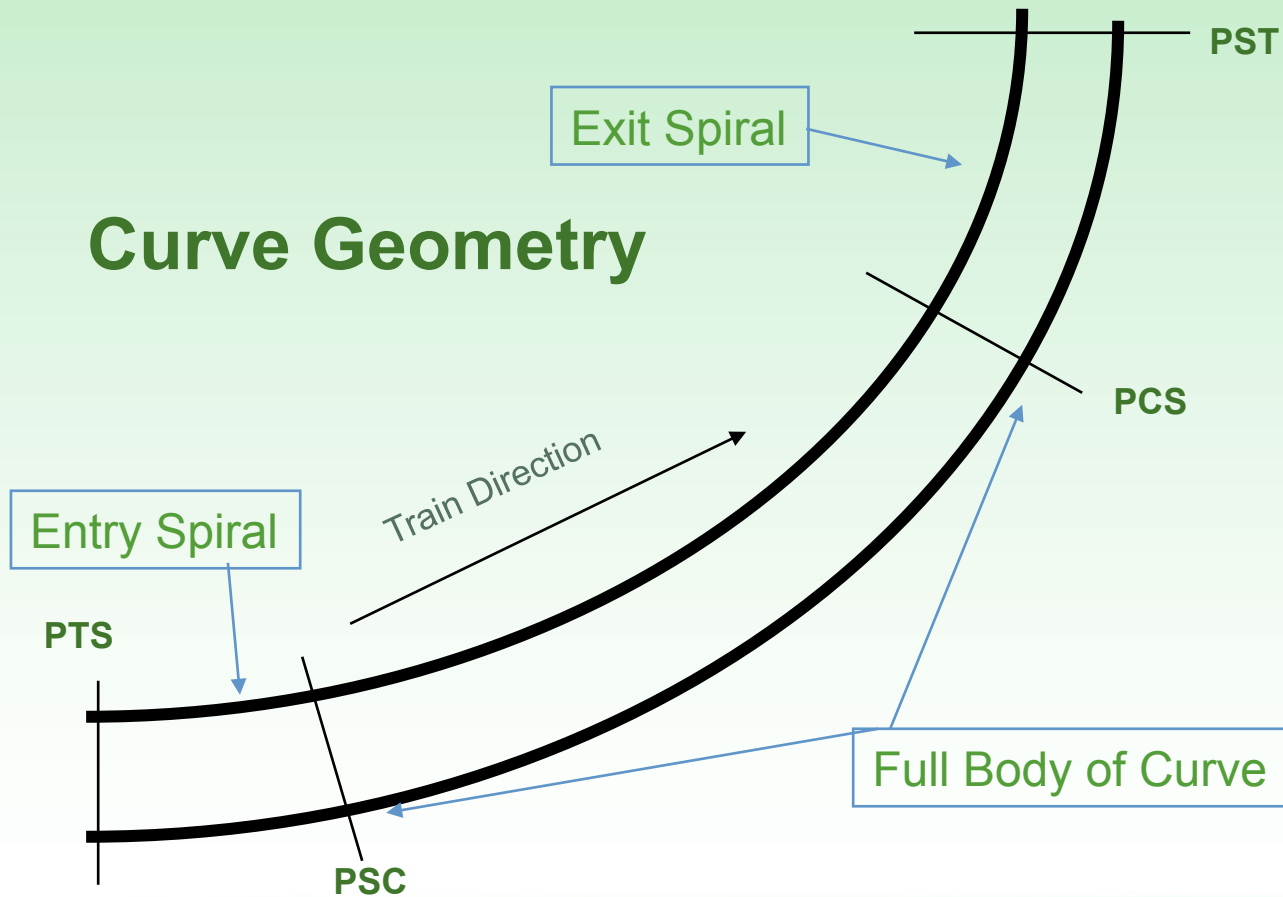


Degree of Curve & Radius

Degree of Curve	Mid-Ordinate of a 62' Chord	Radius of Curve
1	1"	5730'
2	2"	2865'
3	3"	1910'
5	5"	1146'
10	10"	573'



Curve Geometry

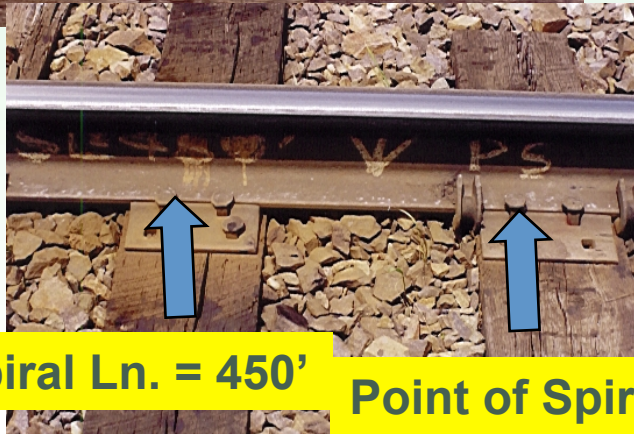




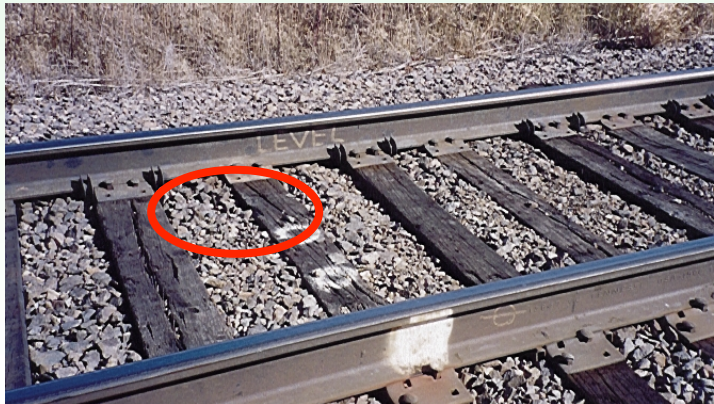
Full - PSC or PCS



Level - PST or PTS



Spiral Ln. = 450' **Point of Spiral**





**PSC
5°01'46"
3 1/2" Elevation**

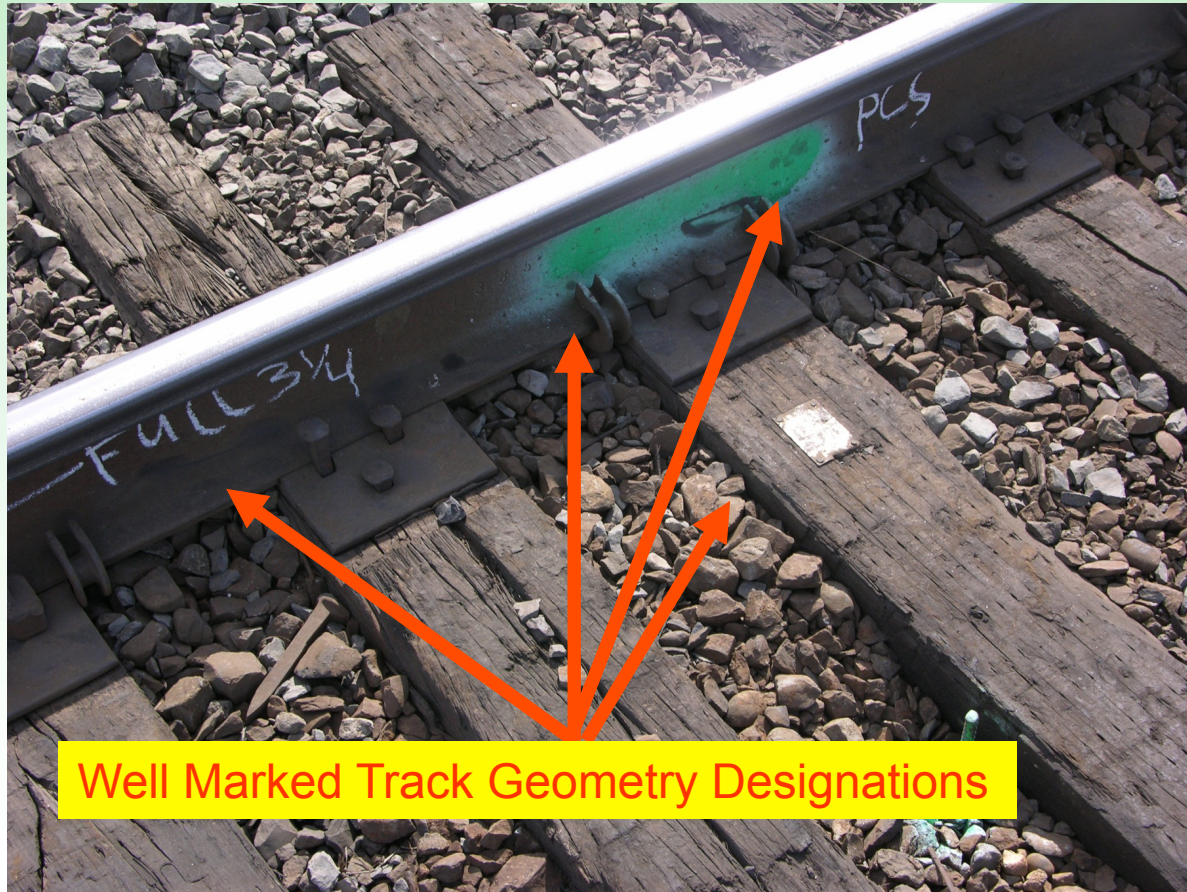


1/2" Elevation



1" Elevation





Well Marked Track Geometry Designations

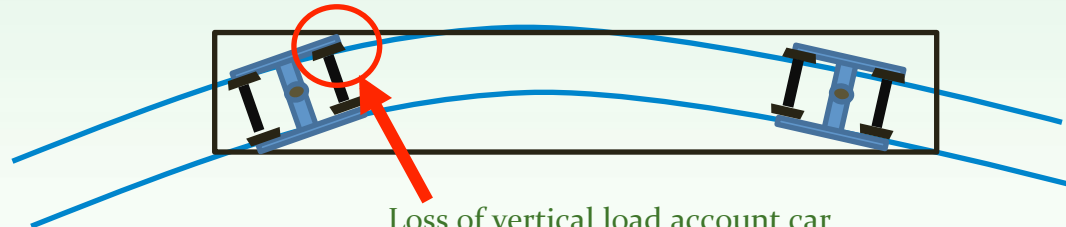


Train direction



High Rail

Low Rail

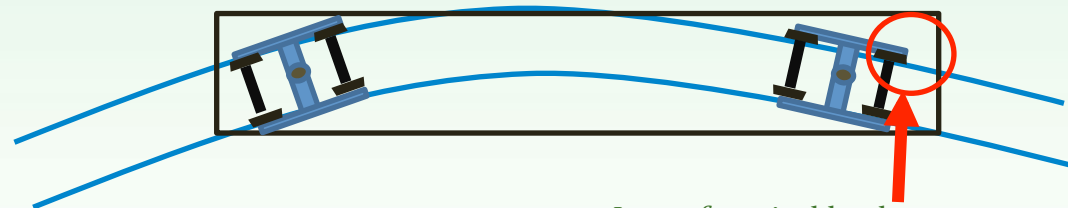


Loss of vertical load account car twist at outer rail, trail truck, third axle. This is most frequently derailing wheel.

Most Likely Derailing Wheel in Entrance Spiral



Train direction

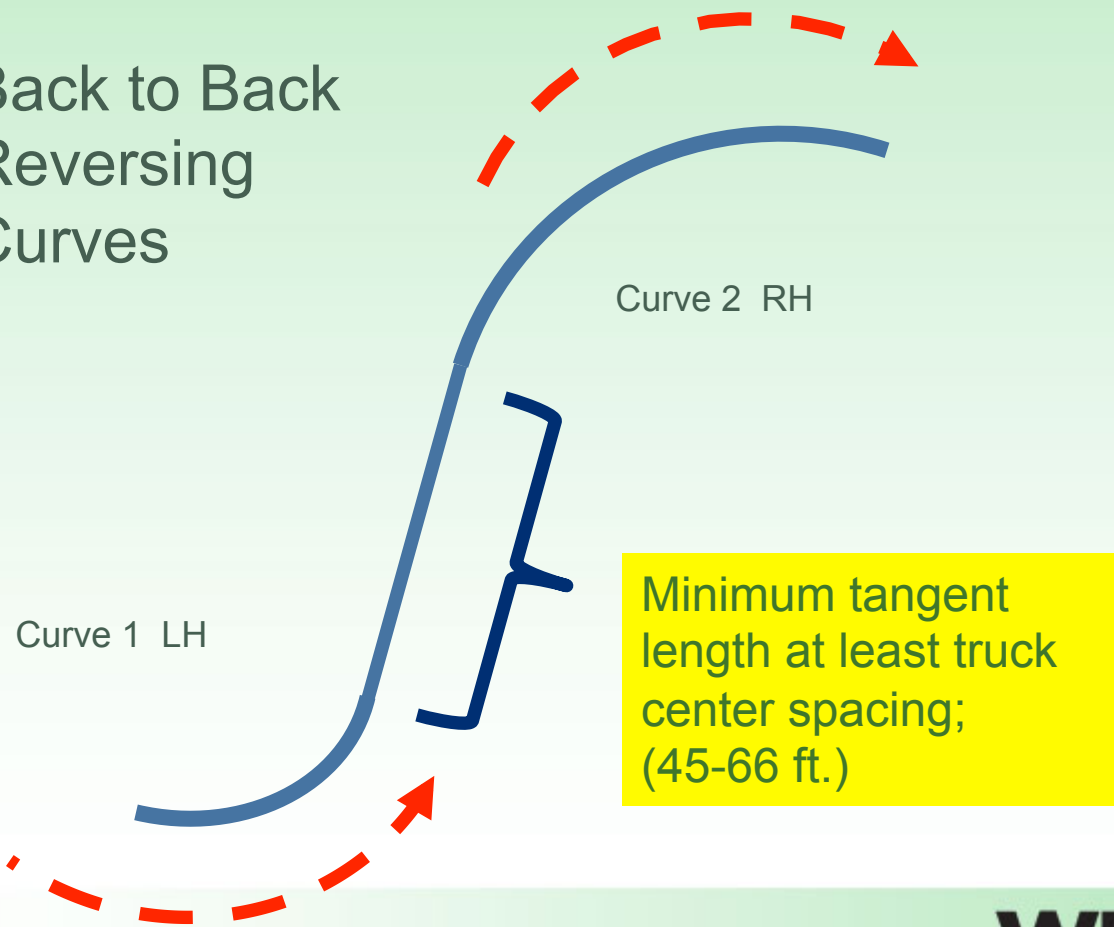


Loss of vertical load account car twist at outer rail, lead truck, first axle. This is most frequently derailing wheel. Also, lateral forces are highest on lead truck.

Most Likely Derailing Wheel in Exit Spiral



Back to Back Reversing Curves



Lack of sufficient intervening tangent between back to back reverse curves



Summary of Curve

Derailment Issues

- Most frequent type of derailment in body of curve is rail rollover; wheel climb due to crosslevel and alignment defects
- Most frequent type of derailment in entry spiral is wheel climb of wheel on trail truck, third axle, on high rail.
- Most frequent type of derailment in exit spiral is wheel climb of wheel on lead truck, first axle, on high rail.
- Insufficient tangent between reversing curves can cause trucks to bind, resulting in wheel climb or gage spreading.



§213.55 Track alinement.

(a) Except as provided in paragraph (b) of this section, 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 --	The deviation of the mid-ordinate from a 31-foot chord [2] may not be more than --	The deviation of the mid-ordinate from a 62-foot chord [2] may not be more than --
1	5"	N/A^3	5"
2	3"	N/A^3	3"
3	1¾"	1¼"	1¾"
4	1½"	1"	1½"
5	¾"	½"	¾"

[1] The ends of the line must 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 must be used for the full length of that tangential segment of track.

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

[3] N/A - Not Applicable





31 ft.
Class 3-5

62
ft.

In Classes 3 through 5, both the 31-foot and 62-foot chords must be used, and corresponding measurements must be calculated to determine compliance with the required alignment thresholds. If alignment defects are found using both the 31-foot and the 62-foot chord, the inspector should report the item as one defect and note that the defect does not comply with the requirements for the second chord, e.g., “1¾ inches alignment deviation on curved track for 62-foot chord. Note: 1¾ inches alignment deviation for 31-foot chord at this location.”





Horizontal Alignment



§213.55 Alinement - Stringlining

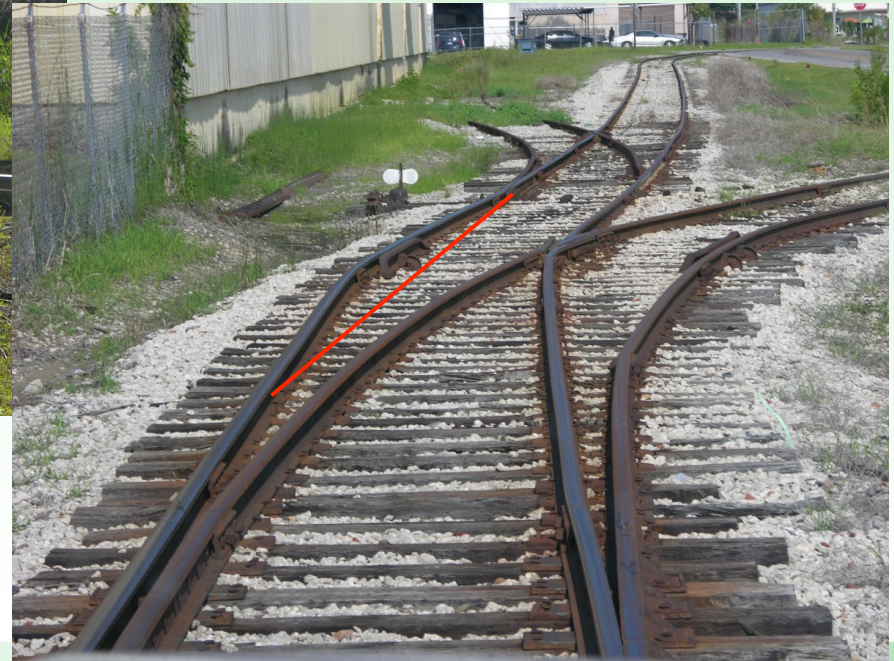
The chord (string) is stretched and held tight between two points on the rail, $\frac{5}{8}$ inch below the top running surface of the rail. Measure the MCO between the rail and the string with a graduated ruler, using blocks to compensate for shallow curvature and special trackwork, if necessary.



Alignment Deviations





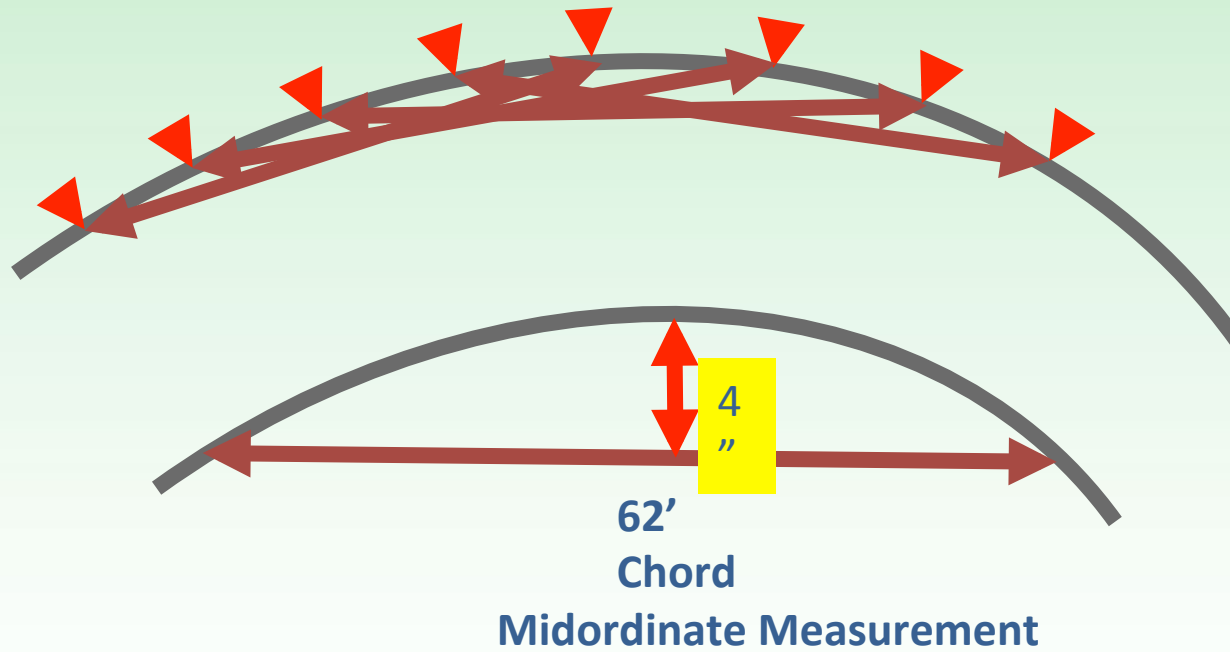


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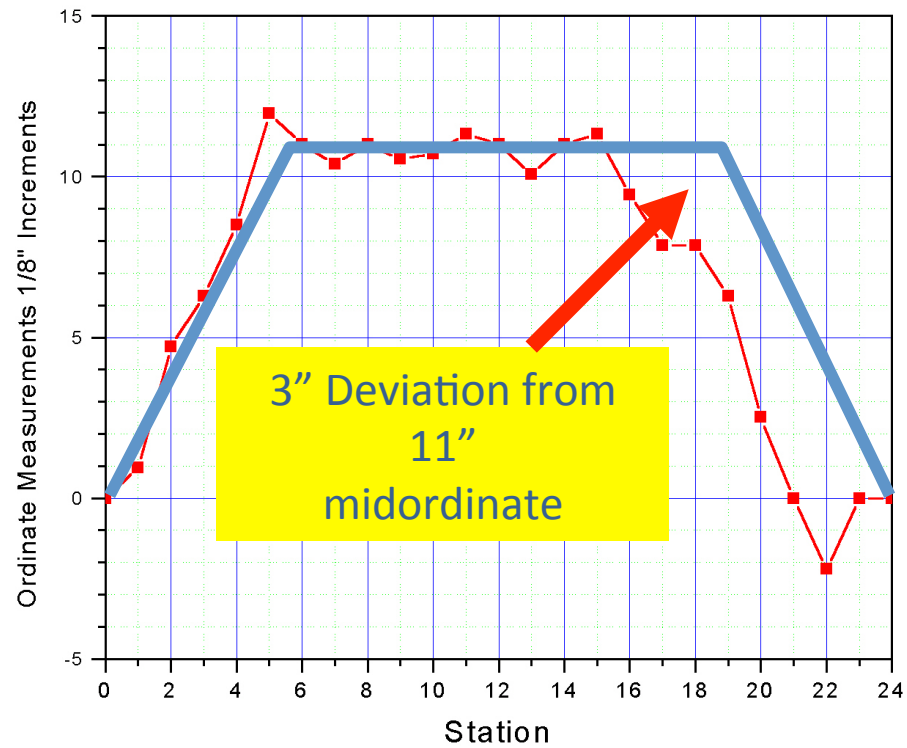
Measuring Alignment with 62' Chord - Stringlining



4" = 4 Degree Curve

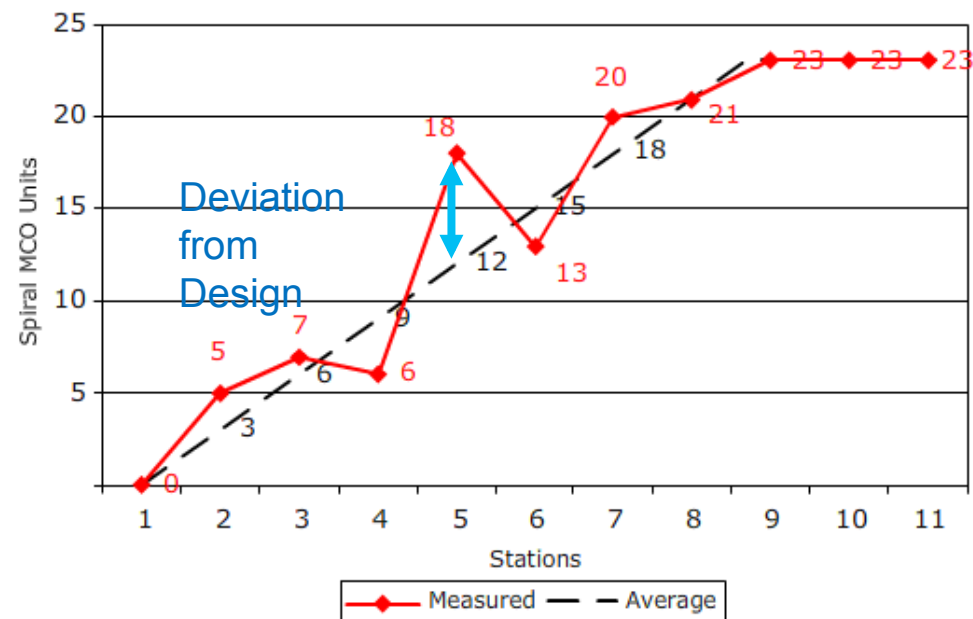


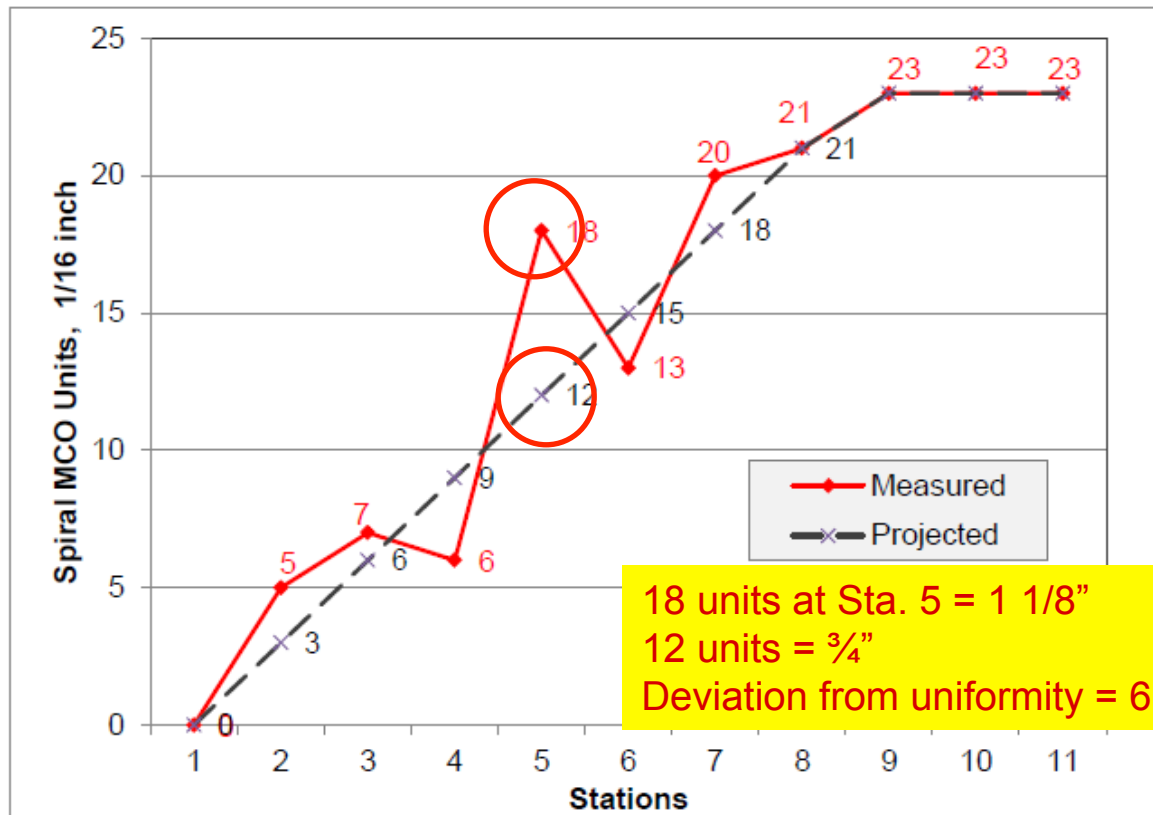
Curve Alignment Geometry



Checking Alignment Deviations in Spirals

Place the measured values in a graph and plot the spiral.





18 units at Sta. 5 = 1 1/8"
 12 units = 3/4"
 Deviation from uniformity = 6 units (3/8")



Stringlining in the field using 62' Chord





**Using Spring clamps to Stringline when
no help available**



FRA Alignment Table

§ 213.55 Alinement.

Alinement may not deviate from uniformity more than the amount prescribed in the following table:

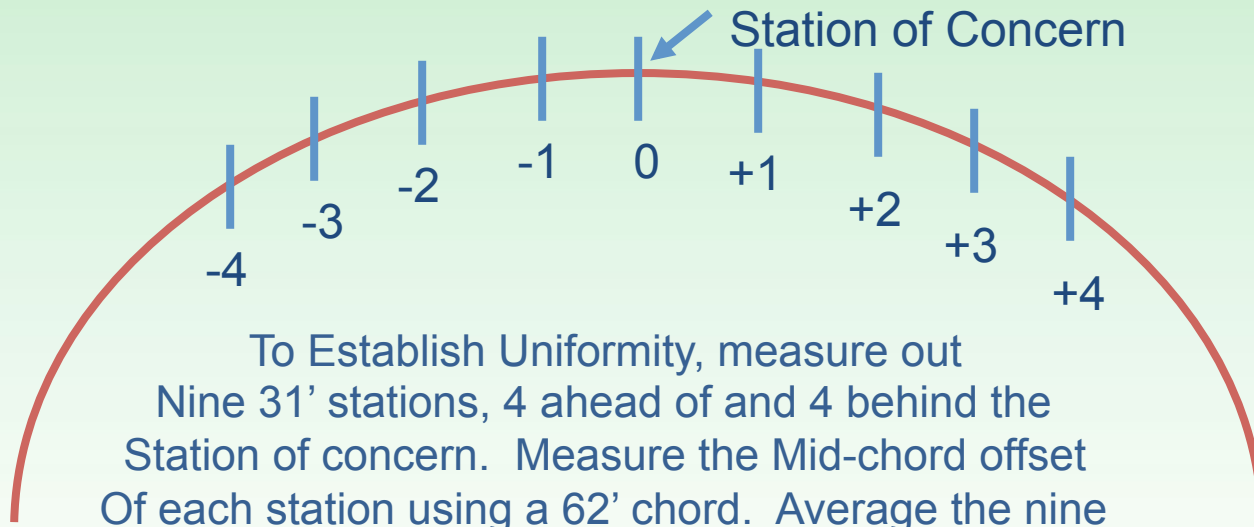
Class of track	Tangent track	Curved track	
	The deviation of the mid-offset from a 62-foot line ¹ may not be more than— (inches)	The deviation of the mid-ordinate from a 31-foot chord ² may not be more than— (inches)	The deviation of the mid-ordinate from a 62-foot chord ² may not be more than— (inches)
Class 1 track	5	³ N/A	5
Class 2 track	3	³ N/A	3
Class 3 track	1 ³ / ₄	1 ¹ / ₄	1 ³ / ₄
Class 4 track	1 ¹ / ₂	1	1 ¹ / ₂
Class 5 track	³ / ₄	¹ / ₂	⁵ / ₈

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 track.

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

³ N/A—Not Applicable.





To Establish Uniformity, measure out Nine 31' stations, 4 ahead of and 4 behind the Station of concern. Measure the Mid-chord offset Of each station using a 62' chord. Average the nine Stations and this determines Uniformity. The difference Between the MCO at the station of concern, and the Average uniformity is the "deviation from Uniformity".

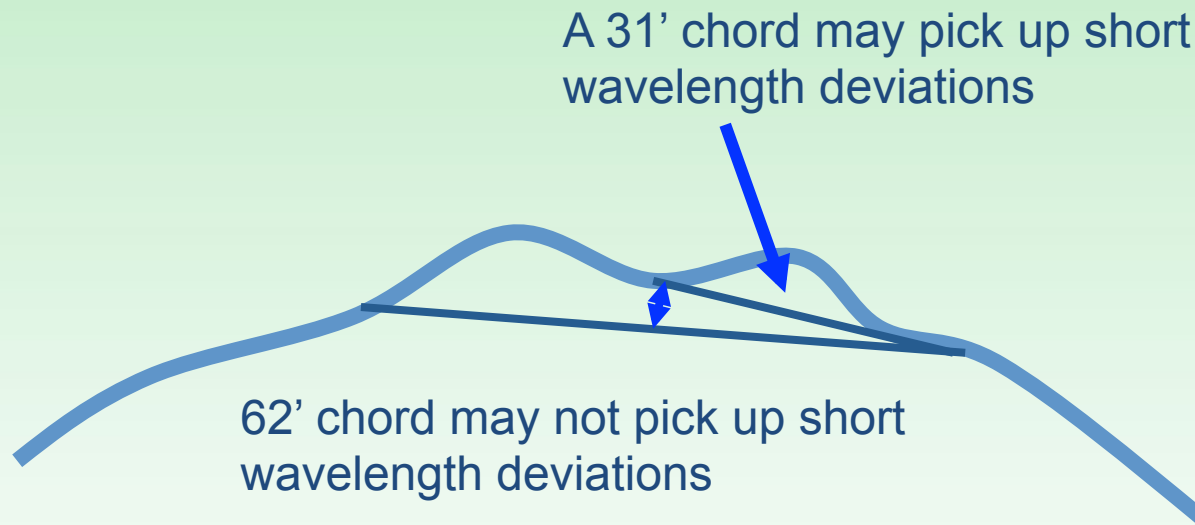
Determining compliance with FRA Alignment Standard using 9 point averaging method



As a reference, the following table summarizes the acceptable proper chords, station spacing, and number of stations to determine alignment compliance.

Alignment Stations					
Geometry	Class	Chord (feet)	Total No. Stations	Station Spacing (feet)	Curve Length (feet)
Curve	1-2	62	9 or	31	248
		62	17	15½	248
	3-5	31	17	15½	248
		62	9 or	31	248
		62	17	15½	248
Tangent	1 - 5	62	1	n/a	n/a





Why use a 31 ft. chord in certain situations?

1. Short wavelength deviations
2. Higher degree curves, easier to measure
3. Must use 31' chord for Class 3-5
4. Easier to measure in high winds



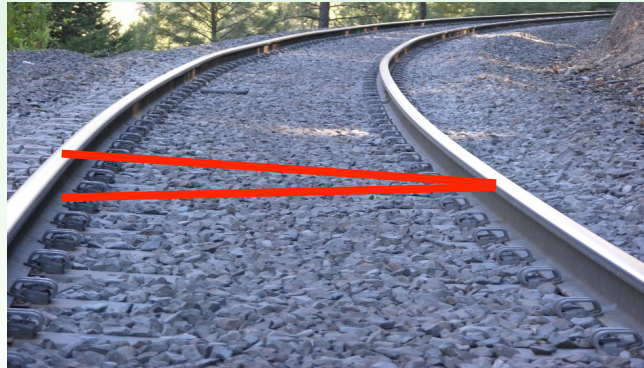


Curve elevation



Superelevation in a curve

Normally, between 0.0 to 6.0 inches of elevation is added to outer rail to counterbalance effects of centrifugal forces based on normal train speeds.



A balanced (equilibrium) condition implies the vertical forces on each rail are equal.

Figure 8 illustrates the three types of balance conditions.

4° Curve - 5" Superelevation

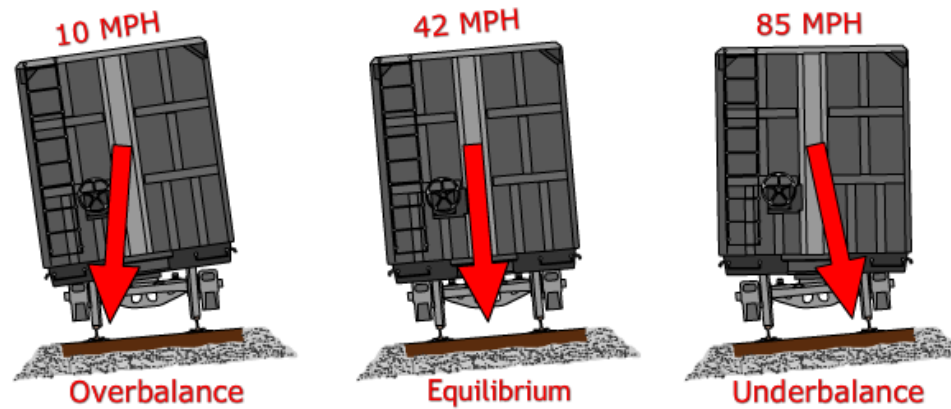
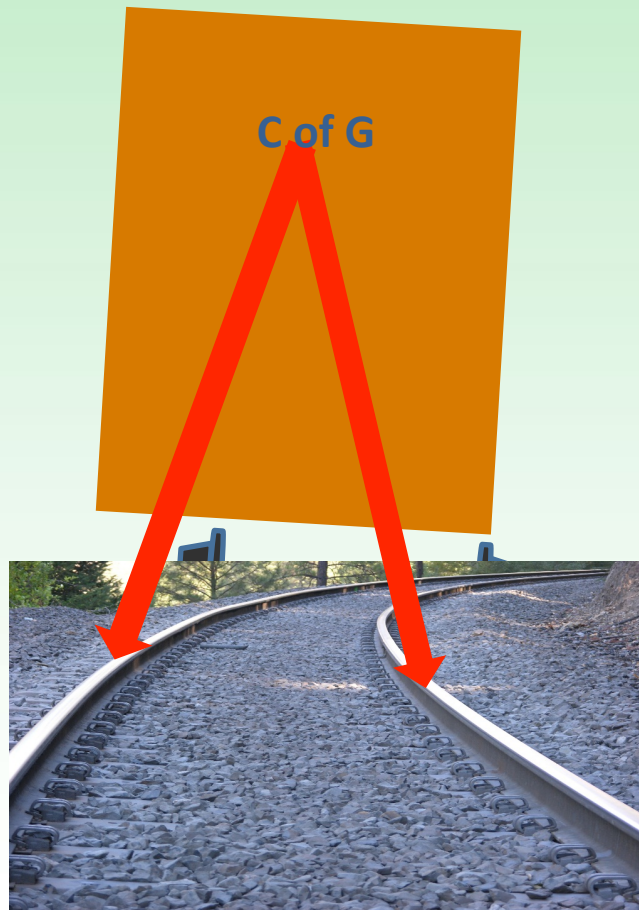


Figure 8





At equilibrium,
There are equal
vertical weights on
both high and low
rail.



$$\text{Eq. Elevation} = .0007 (D) (V^2)$$

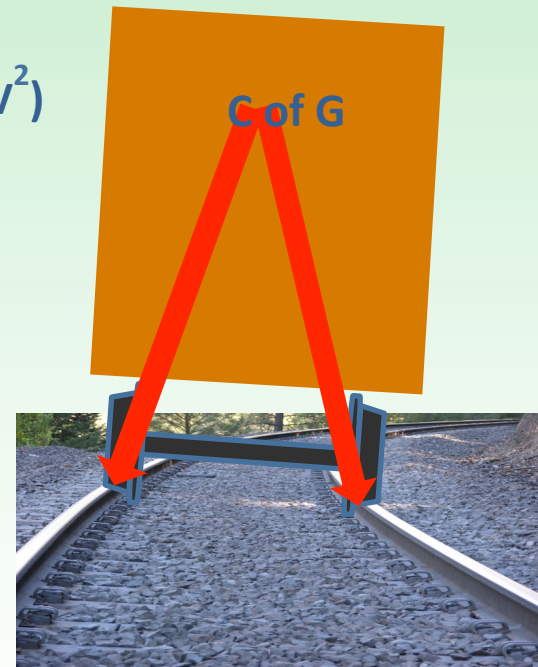
For 5 degree curve; 30
MPH

$$\text{Eq. El.} = .0007 (5) (30^2)$$

$$\text{Eq. El.} = .0007 (5) (900)$$

$$\text{Eq. El.} \sim 3.00''$$

$$1'' \text{ Unbalance} = 3.00 - 1.00 = 2.00''$$



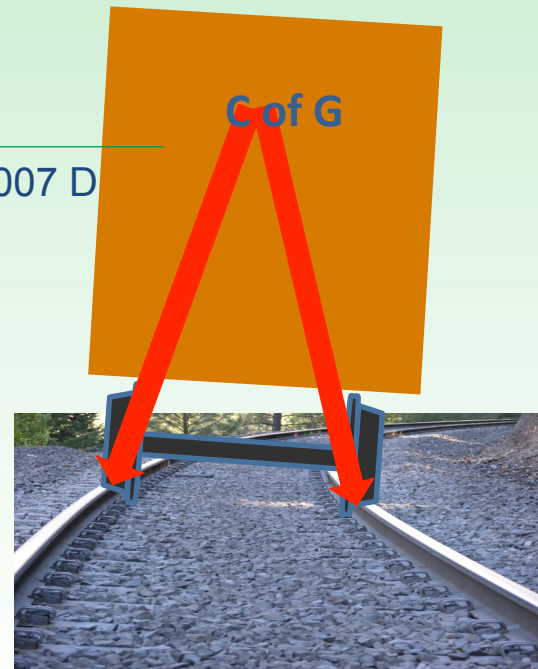
To determine Equilibrium Speed for Curve



For 5 degree curve; 3"
Elevation

3" cant deficiency

$$\begin{aligned} V_{\max} &= \sqrt{\text{Elevation} + \text{Cant Deficiency} / .0007 D} \\ &= \sqrt{6" / .0007 (5)} \\ &= 41 \text{ MPH} \end{aligned}$$



To determine FRA Maximum Speed for Curve



Typical Scenarios to Watch For:

- 1) Elevation for once a day Amtrak/VIA/Commuter
- 2) Elevations on ruling grades
- 3) Elevations close to speed restrictions



Elevation for Amtrak vs. Freight

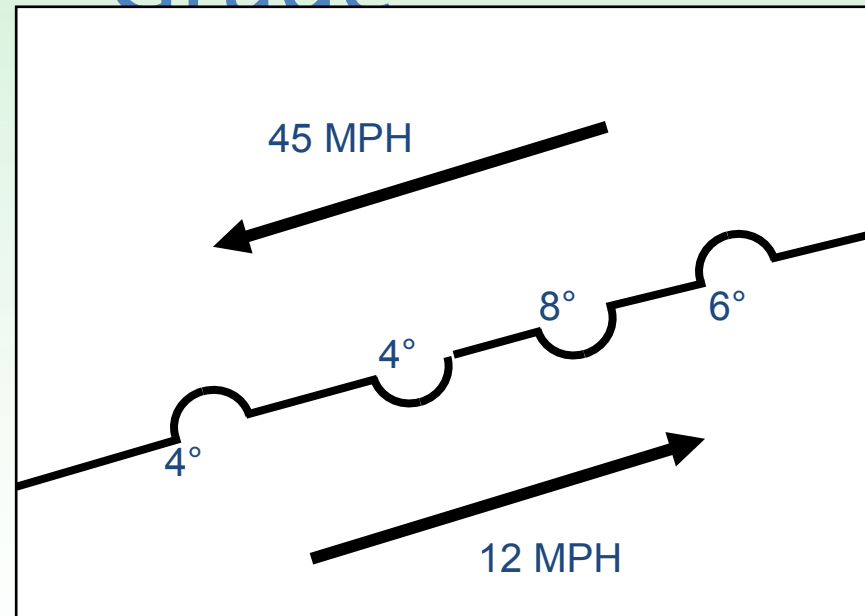
For a 2 Degree Curve:

Amtrak 79 MPH = 6" SE

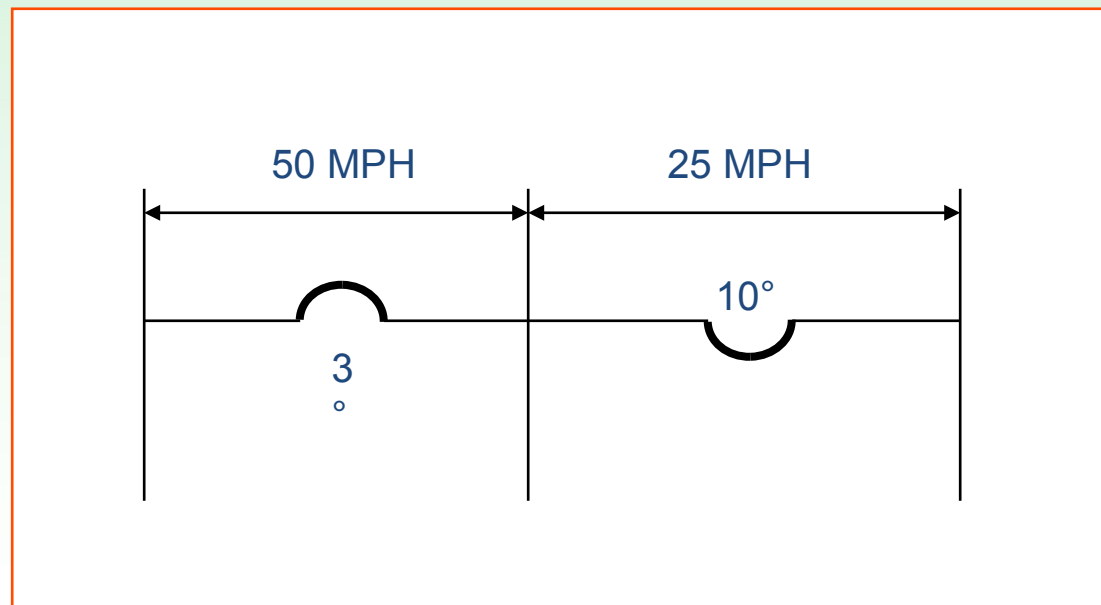
Freight 50 MPH = 2 1/2" SE



Elevation vs. Ruling Grade



Elevations Close to Speed Restrictions



Optimized Superelevation

An amount of superelevation that will minimize centrifugal force influence for a predominance of train tonnage for Normal operating speeds.

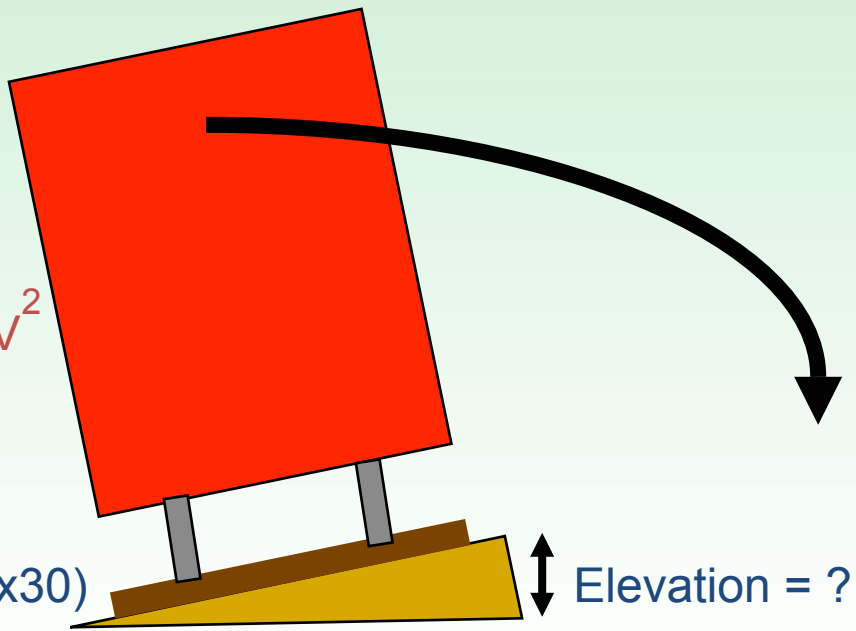


The Key Question...

What speed do you use to adjust
superelevation?



Correct Superelevation for Curve & Velocity



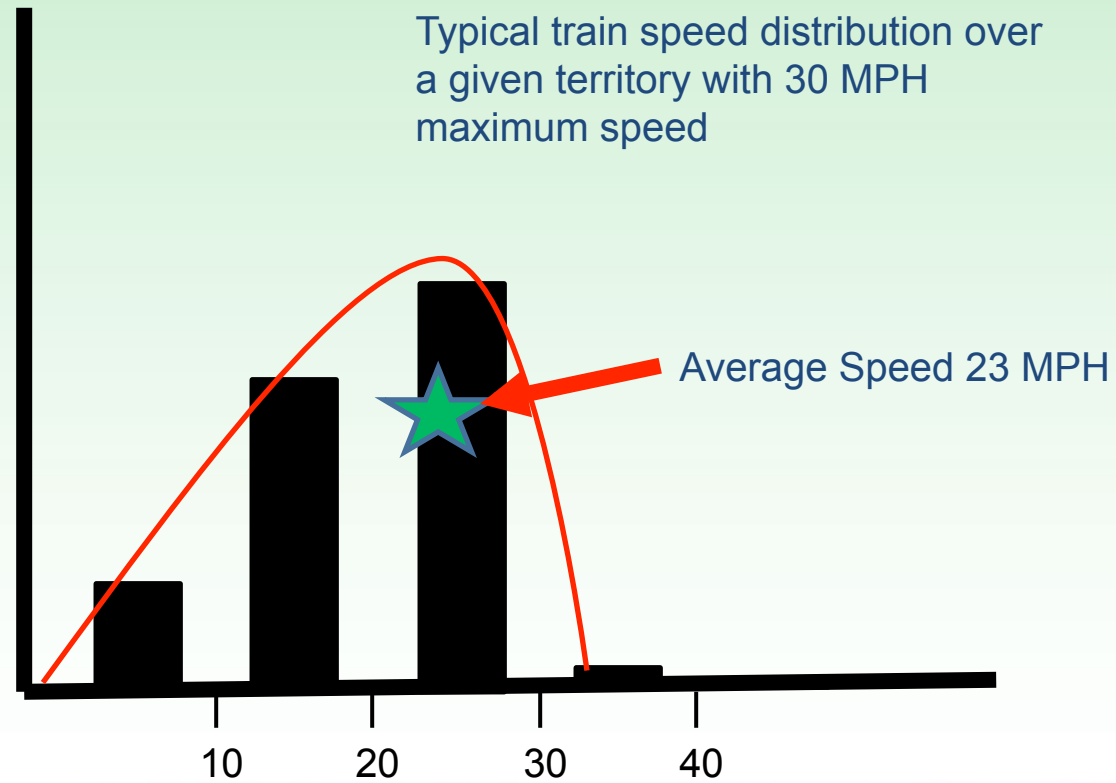
The diagram shows a red rectangular vehicle on a yellow ramp that is tilted to the right. A curved arrow points from the vehicle towards the right, indicating the direction of travel. A vertical double-headed arrow on the right side of the ramp is labeled "Elevation = ?".

$EL_{EQ.} = .00067 DV^2$
4 D. Curve
 $V = 30 \text{ MPH}$
 $EL = .00067 (4) (30 \times 30)$
 $EL_{EQ.} = 2.4 \text{ "}$



Number of trains

Typical train speed distribution over a given territory with 30 MPH maximum speed

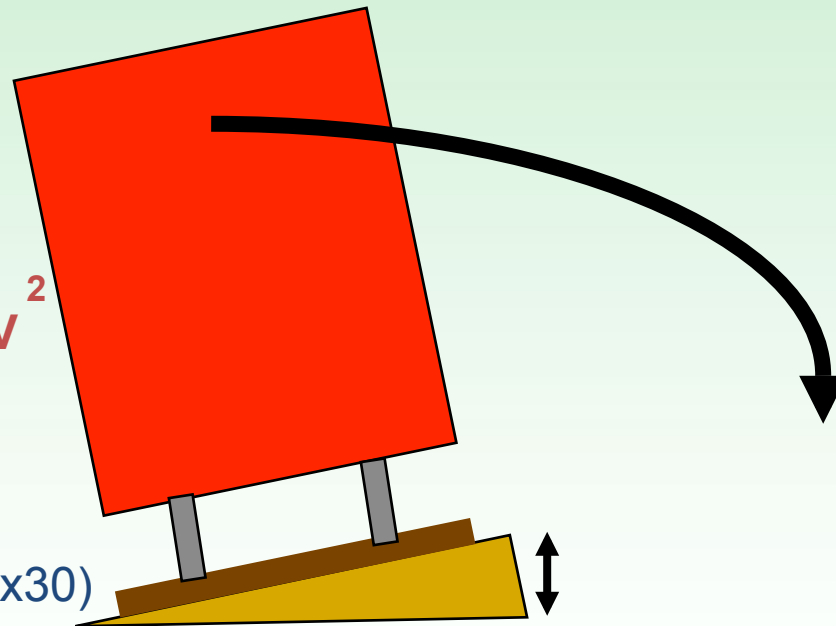


Correct Superelevation for Curve & Velocity

$$\text{EL EQ.} = .00067 DV^2$$

4 D. Curve
V = 30 MPH

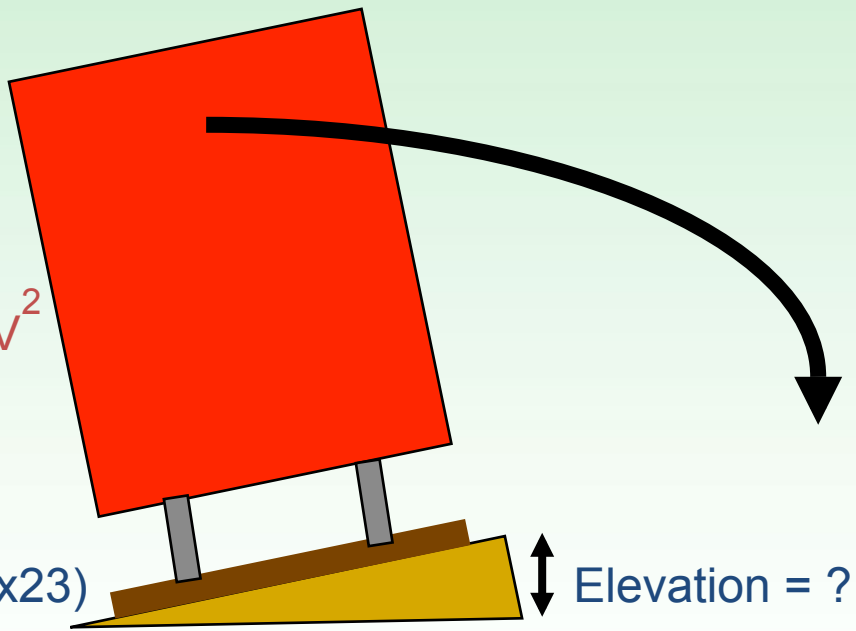
$$\text{EL} = .00067 (4) (30 \times 30)$$
$$\text{EL EQ.} = 2.4 \text{ "}$$



→ 1 " Unbalance 2.4" - 1.0" = 1.4"



Correct Superelevation for Average Train Speed On track with 30 MPH Timetable Speed



$EL_{EQ.} = .00067 DV^2$
4 D. Curve
 $V = 23 \text{ MPH}$
 $EL = .00067 (4) (23 \times 23)$
 $EL_{EQ.} = 1.4 \text{ ''}$

Elevation = ?



Railroad Practice

- Because not all trains make timetable speed, many railroads underbalance curves 1" to 2" depending on the statistical spread of train speeds.
- If you consistently run 0-5 MPH under timetable speed, then ~1" underbalance may be appropriate.
- If you consistently run 5-10 MPH under timetable speed, then ~1.5" underbalance may be appropriate.



Appendix A to Part 213—Maximum Allowable Curving Speeds

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

Table 1—Three Inches Unbalance

Degree of curvature	Elevation of outer rail (inches)												
	0	1/2	1	1 1/2	2	2 1/2	3	3 1/2	4	4 1/2	5	5 1/2	6
	Maximum allowable operating speed (m.p.h.)												
0°30'	93	100	107	113	120	125	131	136	141	146	151	156	160
0°40'	80	87	93	98	104	109	113	118	122	127	131	135	139
0°50'	72	77	83	88	93	97	101	106	110	113	117	121	124
1°00'	65	71	76	80	85	89	93	96	100	104	107	110	113
1°15'	59	63	68	72	76	79	83	86	89	93	96	99	101
1°30'	53	58	62	65	69	72	76	79	82	85	87	90	93
1°45'	49	53	57	61	64	67	70	73	76	78	81	83	86
2°00'	46	50	53	57	60	63	65	68	71	73	76	78	80
2°15'	44	47	50	53	56	59	62	64	67	69	71	73	76
2°30'	41	45	48	51	53	56	59	61	63	65	68	70	72
2°45'	39	43	46	48	51	53	56	58	60	62	64	66	68
3°00'	38	41	44	46	49	51	53	56	58	60	62	64	65
3°15'	36	39	42	44	47	49	51	53	55	57	59	61	63
3°30'	35	38	40	43	45	47	49	52	53	55	57	59	61
3°45'	34	37	39	41	44	46	48	50	52	53	55	57	59
4°00'	33	35	38	40	42	44	46	48	50	52	53	55	57
4°30'	31	33	36	38	40	42	44	45	47	49	50	52	53
5°00'	29	32	34	36	38	40	41	43	45	46	48	49	51
5°30'	28	30	32	34	36	38	39	41	43	44	46	47	48
6°00'	27	29	31	33	35	36	38	39	41	42	44	45	46
6°30'	26	28	30	31	33	35	36	38	39	41	42	43	44
7°00'	25	27	29	30	32	34	35	36	38	39	40	42	43
8°00'	23	25	27	28	30	31	33	34	35	37	38	39	40
9°00'	22	24	25	27	28	30	31	32	33	35	36	37	38
10°00'	21	22	24	25	27	28	29	30	32	33	34	35	36
11°00'	20	21	23	24	25	27	28	29	30	31	32	33	34
12°00'	19	20	22	23	24	26	27	28	29	30	31	32	33



§213.63 Track surface.

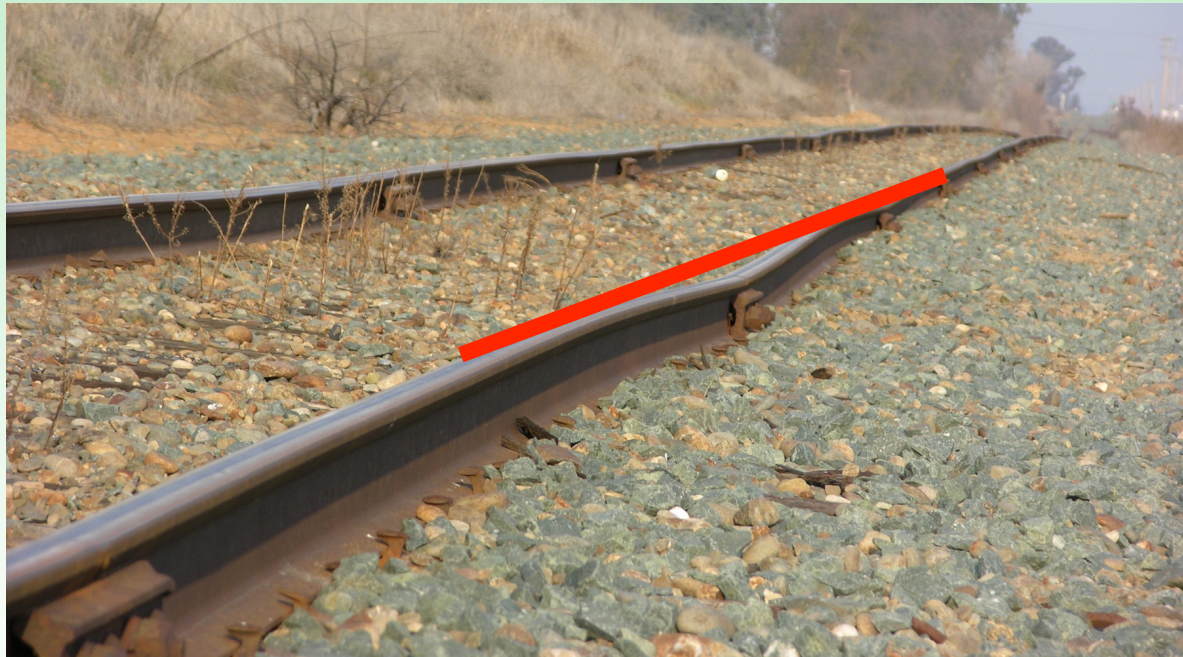
(a) Except as provided in paragraph (b) of this section, each track owner shall maintain the surface of its track within the limits prescribed in the following table:

Track surface (inches)	Class of track				
	1	2	3	4	5
The runoff in any 31 feet of rail at the end of a raise may not be more than	3 1/2	3	2	1 1/2	1
The deviation from uniform profile on either rail at the mid-ordinate of a 62-foot chord may not be more than	3	2 3/4	2 1/4	2	1 1/4
The deviation from zero crosslevel at any point on tangent or reverse crosslevel elevation on curves may not be more than	3	2	1 3/4	1 1/4	1
The difference in crosslevel between any two points less than 62 feet apart may not be more than* ^{1 2}	3	2 1/4	2	1 3/4	1 1/2
*Where determined by engineering decision prior to June 22, 1998, 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	1 3/4	1 1/4	1	3/4

¹Except 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 than 1 1/2 inches.

²However, to control harmonics on Class 2 through 5 jointed track with staggered joints, the crosslevel differences shall not exceed 1 1/4 inches in all of six consecutive pairs of joints, as created by seven low joints. Track with joints staggered less than 10 feet apart shall not be considered as having staggered joints. Joints within the seven low joints outside of the regular joint spacing shall not be considered as joints for purposes of this footnote.





Vertical Profile





Crosslevel Variations/Deviation





Curve Superelevation and Crosslevel



PRINCIPLES COURSE • MAY 3, 2016

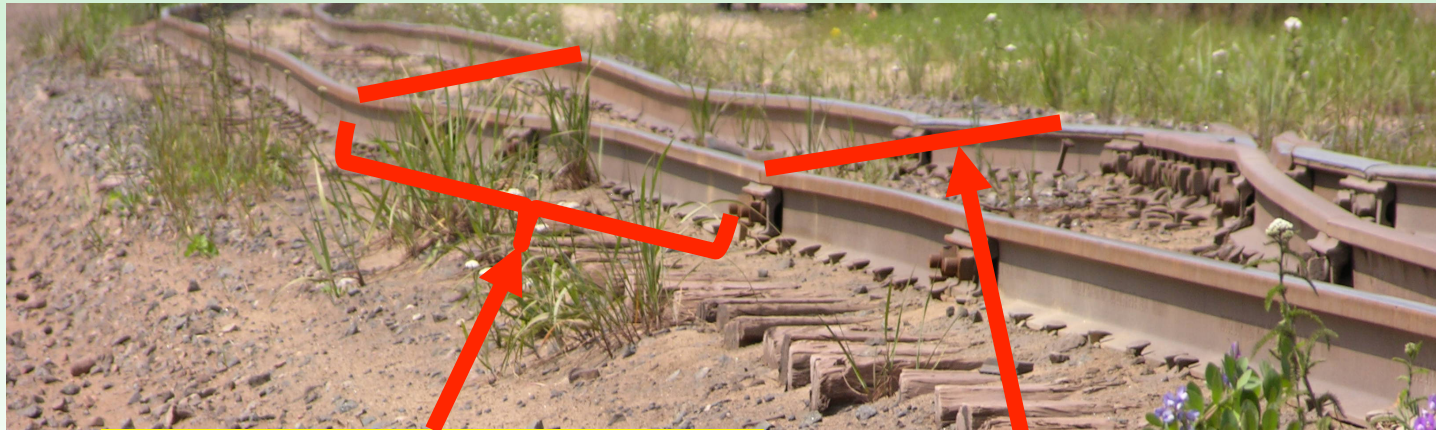
WRI 2016

2 Key Words used in the FRA Regulations

1. Variation or Difference
2. Deviation

**They sound similar, but have different;
yet, important, meanings.**





This is a variance or difference in two Crosslevel measurements over 62'. Variations are relative differences between any two measurements.

This is a deviation from zero Crosslevel; or a deviation from where the Crosslevel should be. Deviations are singular measurements.



§213.63 Track surface.

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

Track surface (inches)	Class of track				
	1	2	3	4	5
The runoff in any 31 feet of rail at the end of a raise may not be more than	3 1/2	3	2	1 1/2	1
The deviation from uniform profile on either rail at the mid-ordinate of a 62-foot chord may not be more than	3	2 3/4	2 1/4	2	1 1/4
The deviation from zero crosslevel at any point on tangent or reverse crosslevel elevation on curves may not be more than	3	2	1 3/4	1 1/4	1
The difference in crosslevel between any two points less than 62 feet apart may not be more than* ^{1 2}	3	2 1/4	2	1 3/4	1 1/2
*Where determined by engineering decision prior to June 22, 1998, 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	1 3/4	1 1/4	1	3/4

¹Except 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 than 11/2 inches.

²However, to control harmonics on Class 2 through 5 jointed track with staggered joints, the crosslevel differences shall not exceed 11/4 inches in all of six consecutive pairs of joints, as created by seven low joints. Track with joints staggered less than 10 feet apart shall not be considered as having staggered joints. Joints within the seven low joints outside of the regular joint spacing shall not be considered as joints for purposes of this footnote.



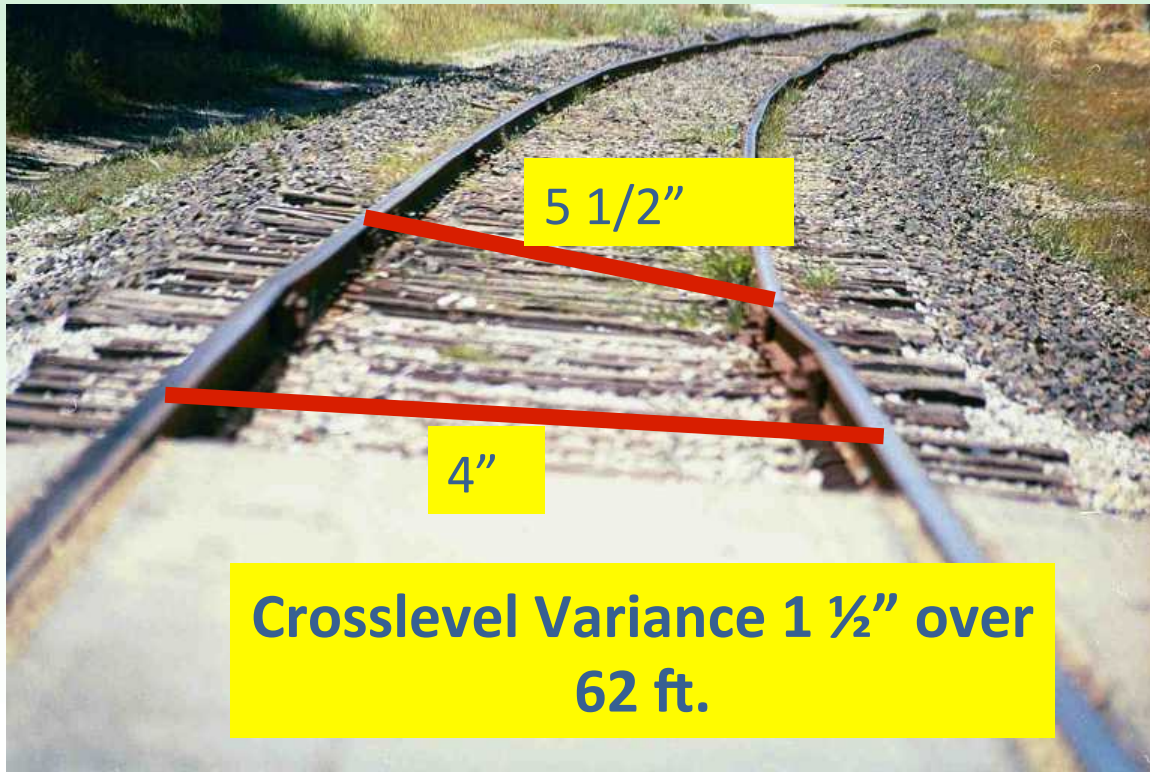
Crosslevel Variations



Any two Crosslevel measurements less than 62' apart



Crosslevel Variations



§213.63 Track surface.

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

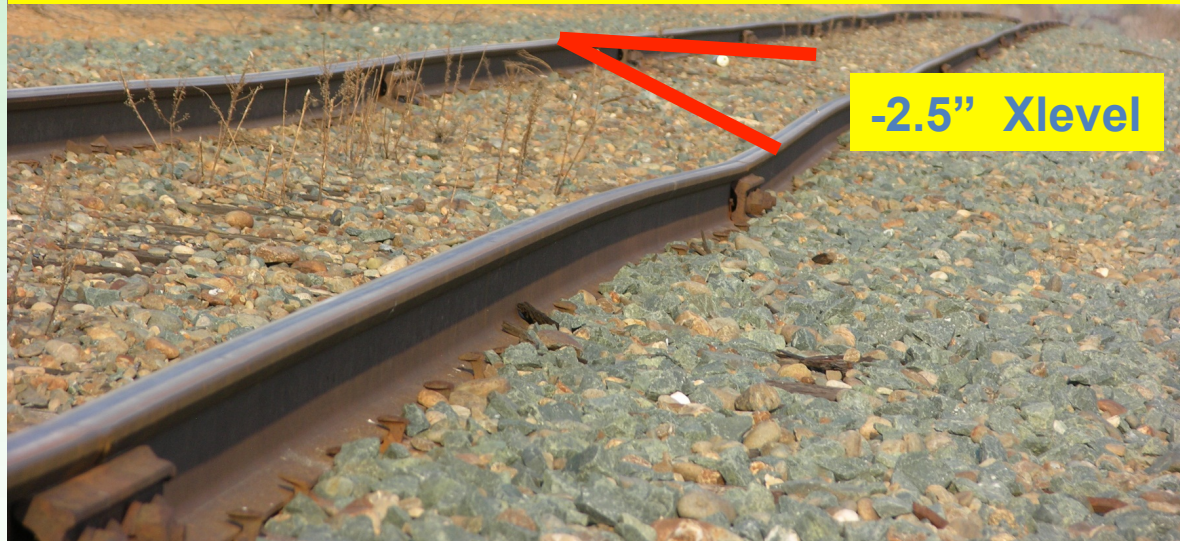
Track surface (inches)	Class of track				
	1	2	3	4	5
The runoff in any 31 feet of rail at the end of a raise may not be more than	3 1/2	3	2	1 1/2	1
The deviation from uniform profile on either rail at the mid-ordinate of a 62-foot chord may not be more than	3	2 3/4	2 1/4	2	1 1/4
The deviation from zero crosslevel at any point on tangent or reverse crosslevel elevation on curves may not be more than	3	2	1 3/4	1 1/4	1
The difference in crosslevel between any two points less than 62 feet apart may not be more than* ^{1 2}	3	2 1/4	2	1 3/4	1 1/2
*Where determined by engineering decision prior to June 22, 1998, 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	1 3/4	1 1/4	1	3/4

¹Except 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 than 1 1/2 inches.

²However, to control harmonics on Class 2 through 5 jointed track with staggered joints, the crosslevel differences shall not exceed 1 1/4 inches in all of six consecutive pairs of joints, as created by seven low joints. Track with joints staggered less than 10 feet apart shall not be considered as having staggered joints. Joints within the seven low joints outside of the regular joint spacing shall not be considered as joints for purposes of this footnote.



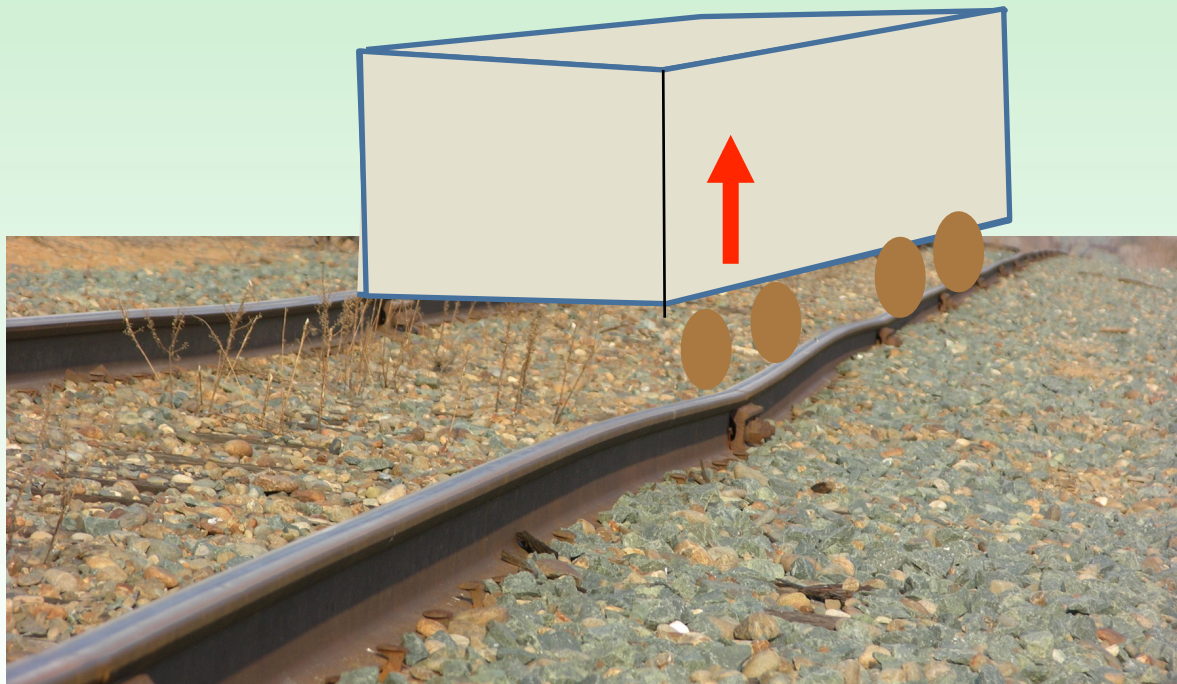
Crosslevel Deviations



Deviation from Zero Crosslevel at any point on tangent, or reverse crosslevel in curves may not be more than

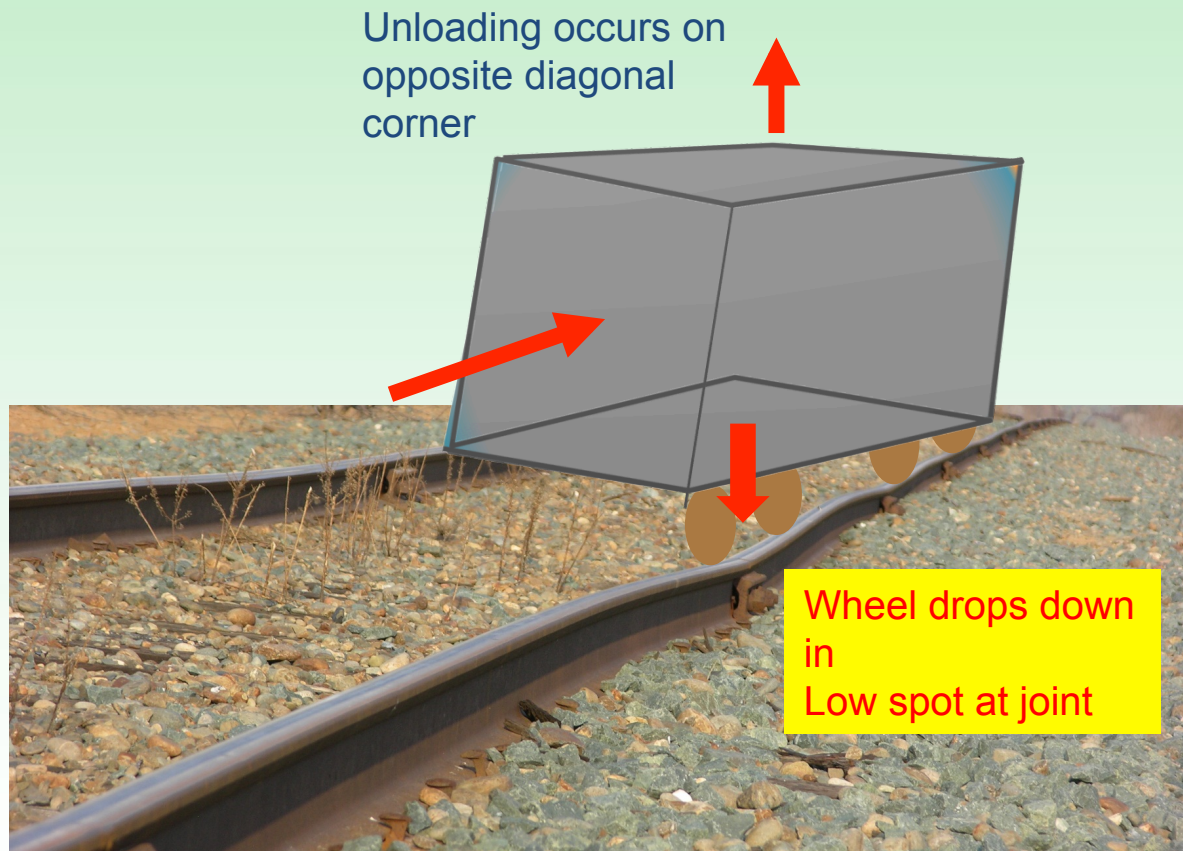
1	2	3	4	5	Class Deviation
3"	2"	1 3/4"	1 1/4"	1 "	





**Wheel Unloading/Lift due to Crosslevel Variation
Between rear and front trucks**





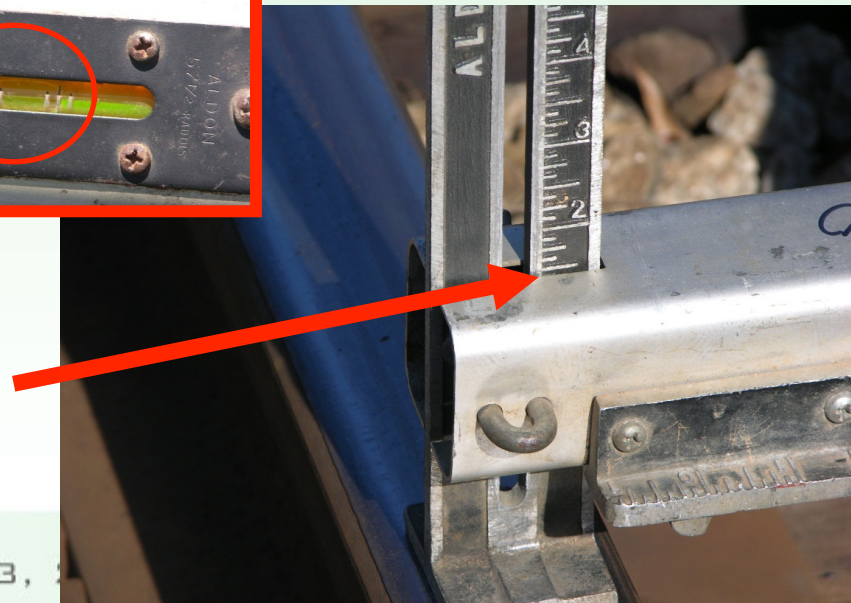
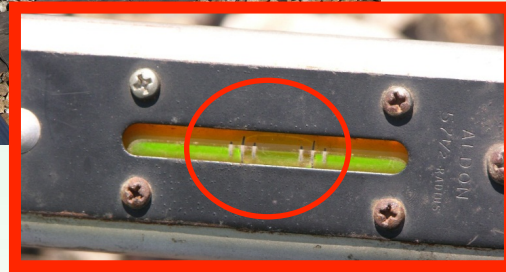
Wheel Unloading/Lift due to Crosslevel Variation

Between rear and front trucks





Measuring Crosslevel with level board





§213.63 Track surface.

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

Track surface (inches)	Class of track				
	1	2	3	4	5
The runoff in any 31 feet of rail at the end of a raise may not be more than	3 1/2	3	2	1 1/2	1
The deviation from uniform profile on either rail at the mid-ordinate of a 62-foot chord may not be more than	3	2 3/4	2 1/4	2	1 1/4
The deviation from zero crosslevel at any point on tangent or reverse crosslevel elevation on curves may not be more than	3	2	1 3/4	1 1/4	1
The difference in crosslevel between any two points less than 62 feet apart may not be more than* ^{1 2}	3	2 1/4	2	1 3/4	1 1/2
*Where determined by engineering decision prior to June 22, 1998, 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	1 3/4	1 1/4	1	3/4

¹Except 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 than 1 1/2 inches.

²However, to control harmonics on Class 2 through 5 jointed track with staggered joints, the crosslevel differences shall not exceed 1 1/4 inches in all of six consecutive pairs of joints, as created by seven low joints. Track with joints staggered less than 10 feet apart shall not be considered as having staggered joints. Joints within the seven low joints outside of the regular joint spacing shall not be considered as joints for purposes of this footnote.



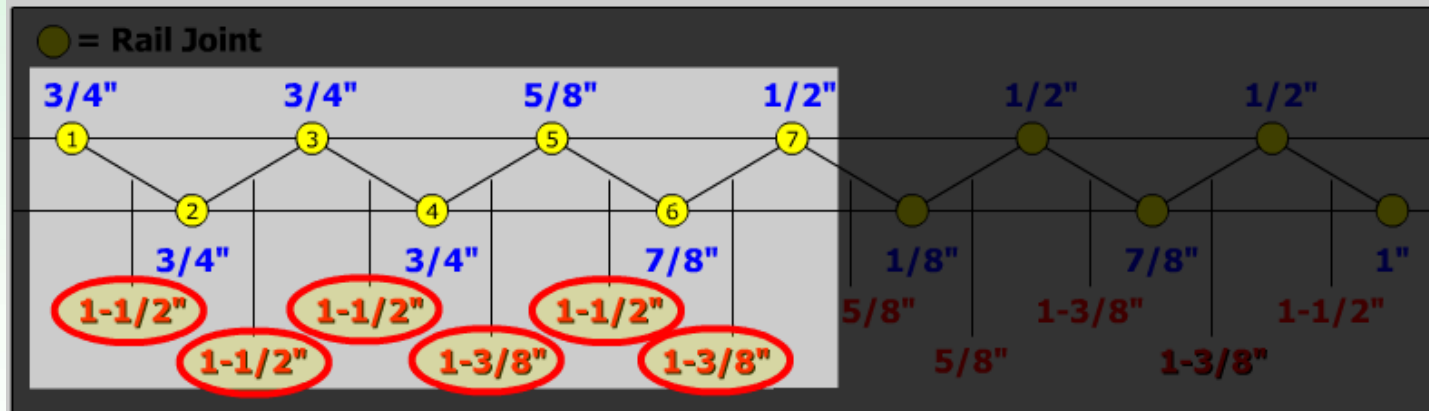


Staggered Jointed Rail



FRA - Harmonic Rock-Off II

In this case, **Deficient Track Crosslevel**, could be considered a potential **Primary Derailment Cause**.



² However, to control harmonics on Class 2 through 5 jointed track with staggered joints, the crosslevel differences shall not exceed 1-1/4 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. (Footnote 2 is applicable September 21, 1999.)



§213.63 Track surface.

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

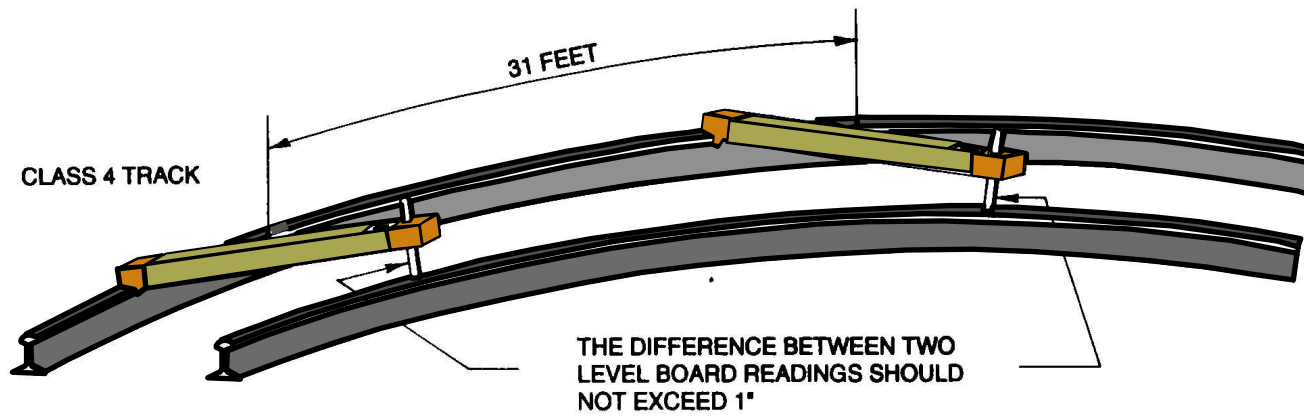
Track surface (inches)	Class of track				
	1	2	3	4	5
The runoff in any 31 feet of rail at the end of a raise may not be more than	3 1/2	3	2	1 1/2	1
The deviation from uniform profile on either rail at the mid-ordinate of a 62-foot chord may not be more than	3	2 3/4	2 1/4	2	1 1/4
The deviation from zero crosslevel at any point on tangent or reverse crosslevel elevation on curves may not be more than	3	2	1 3/4	1 1/4	1
The difference in crosslevel between any two points less than 62 feet apart may not be more than ^{*1 2}	3	2 1/4	2	1 3/4	1 1/2
*Where determined by engineering decision prior to June 22, 1998, 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	1 3/4	1 1/4	1	3/4

¹Except 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 than 1 1/2 inches.

²However, to control harmonics on Class 2 through 5 jointed track with staggered joints, the crosslevel differences shall not exceed 1 1/4 inches in all of six consecutive pairs of joints, as created by seven low joints. Track with joints staggered less than 10 feet apart shall not be considered as having staggered joints. Joints within the seven low joints outside of the regular joint spacing shall not be considered as joints for purposes of this footnote.



VARIATION IN CROSSLEVEL ON SPIRALS



VARIATION IN CROSSLEVEL ON SPIRALS IN ANY 31' MAY NOT BE ANY MORE THAN	CLASS OF TRACK				
	1	2	3	4	5
	2"	1 3/4"	1 1/4"	1"	3/4"



Class 5 Spiral - PTS to PSC

Station (31 ft.)	Design Elevation	Level Board Reading	Elevation Variation
1	0	0	None Exceed 3/4"
2	1/2"	3/8"	3/8"
3	1"	3/4"	3/8"
4	1 1/2"	1"	1/4"
5	2"	1 1/8"	1/8"
6	2 1/2"	1 7/8"	3/4"



§213.63 Track surface.

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

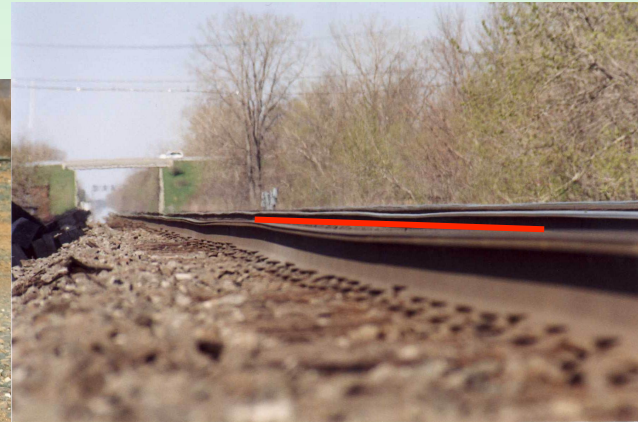
Track surface (inches)	Class of track				
	1	2	3	4	5
The runoff in any 31 feet of rail at the end of a raise may not be more than	3 1/2	3	2	1 1/2	1
The deviation from uniform profile on either rail at the mid-ordinate of a 62-foot chord may not be more than	3	2 3/4	2 1/4	2	1 1/4
The deviation from zero crosslevel at any point on tangent or reverse crosslevel elevation on curves may not be more than	3	2	1 3/4	1 1/4	1
The difference in crosslevel between any two points less than 62 feet apart may not be more than* ^{1 2}	3	2 1/4	2	1 3/4	1 1/2
*Where determined by engineering decision prior to June 22, 1998, 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	1 3/4	1 1/4	1	3/4

¹Except 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 than 1 1/2 inches.

²However, to control harmonics on Class 2 through 5 jointed track with staggered joints, the crosslevel differences shall not exceed 1 1/4 inches in all of six consecutive pairs of joints, as created by seven low joints. Track with joints staggered less than 10 feet apart shall not be considered as having staggered joints. Joints within the seven low joints outside of the regular joint spacing shall not be considered as joints for purposes of this footnote.



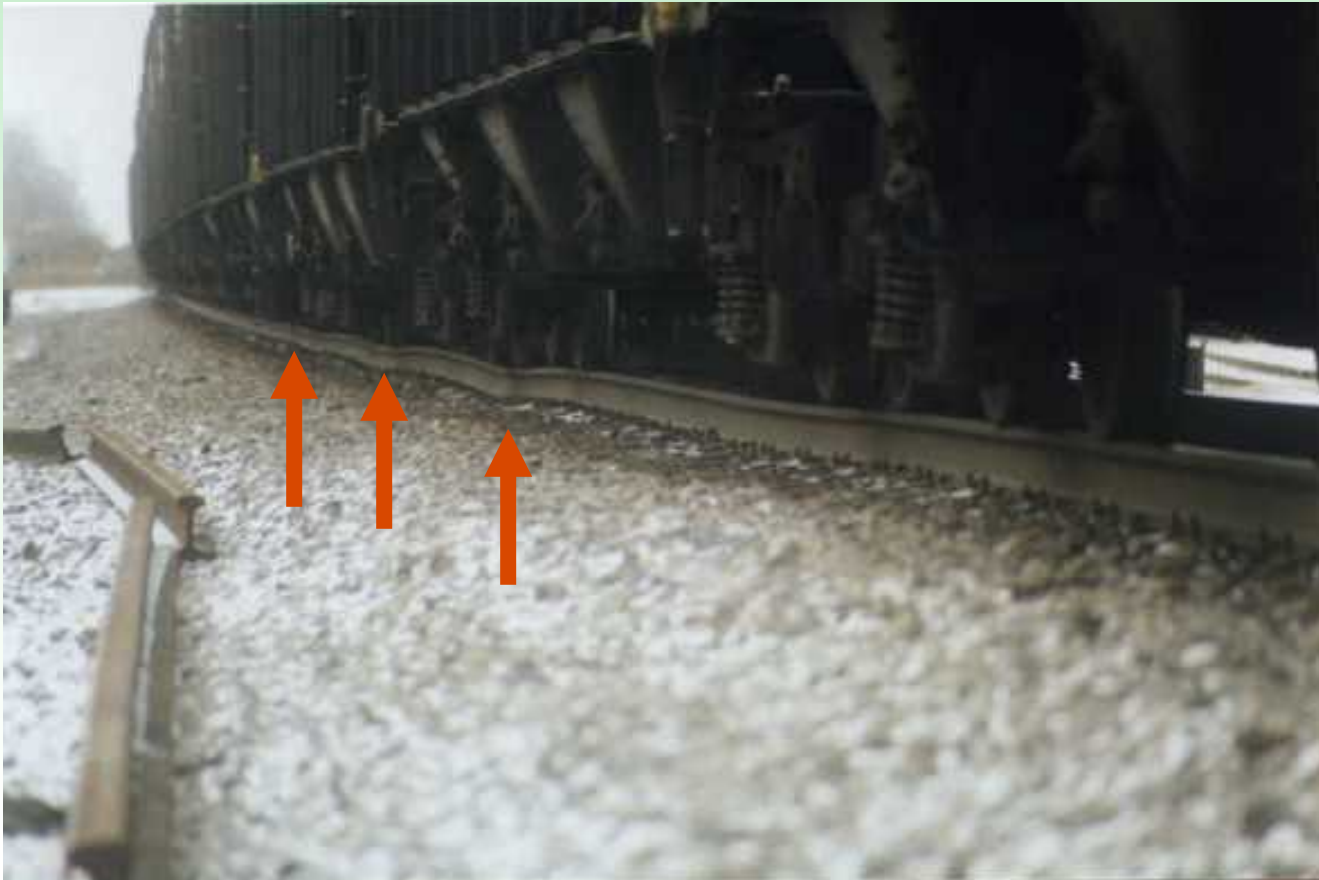
Vertical Profile Deviations





Vertical Bounce Derailments are most often due to combinations of vertical track profile variations acting in concert with vehicles possessing poor vertical damping characteristics





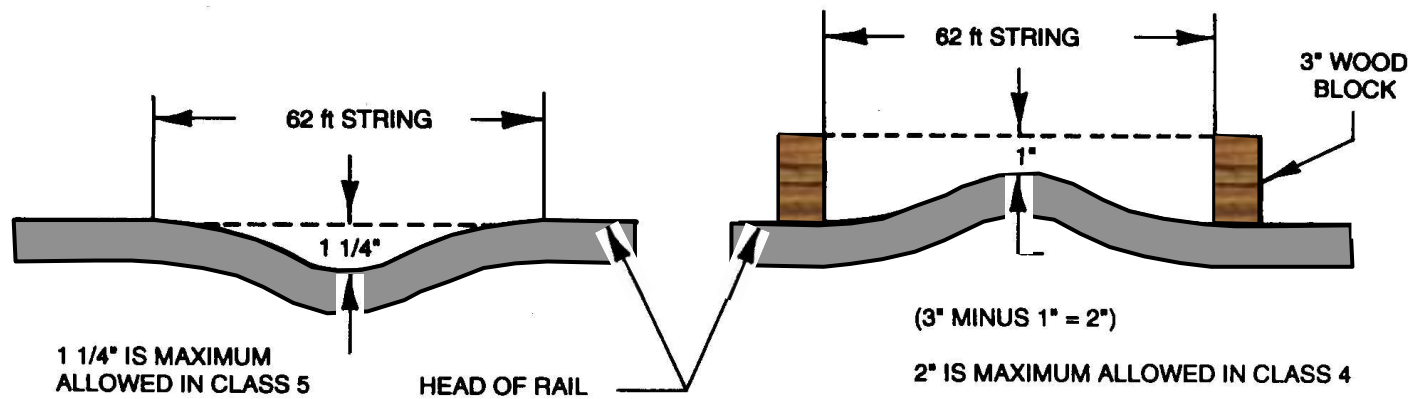
Vertical profile deviation caused by poor subgrade



Stretch 62 ft. chord/string; measure vertical offset at center of chord



DEVIATION FROM UNIFORM PROFILE



	CLASS OF TRACK				
	1	2	3	4	5
THE DEVIATION FROM UNIFORM PROFILE ON EITHER RAIL AT THE MID-ORDINATE OF A 62' CHORD MAY NOT BE MORE THAN	3"	2 3/4"	2 1/4"	2"	1 1/4"





Checking Vertical Profile with 62' Chord



§213.63 Track surface.

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

Track surface (inches)	Class of track				
	1	2	3	4	5
The runoff in any 31 feet of rail at the end of a raise may not be more than	3 1/2	3	2	1 1/2	1
The deviation from uniform profile on either rail at the mid-ordinate of a 62-foot chord may not be more than	3	2 3/4	2 1/4	2	1 1/4
The deviation from zero crosslevel at any point on tangent or reverse crosslevel elevation on curves may not be more than	3	2	1 3/4	1 1/4	1
The difference in crosslevel between any two points less than 62 feet apart may not be more than ^{*12}	3	2 1/4	2	1 3/4	1 1/2
*Where determined by engineering decision prior to June 22, 1998, 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	1 3/4	1 1/4	1	3/4

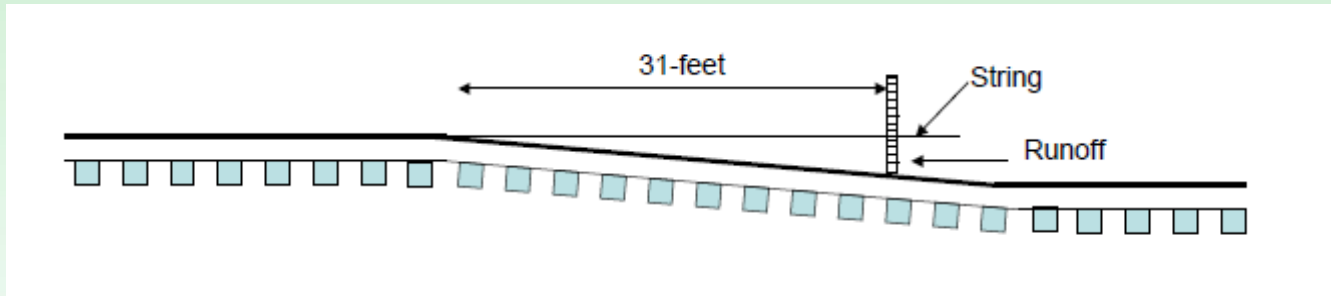
¹Except as limited by §213.57(a), where the elevation at any point in a curve equals or exceeds 6 inches, the difference in crosslevel within 62 feet between that point and a point with greater elevation may not be more than 1 1/2 inches.

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Frost Heaves Causing a raise in the track due to track degradation

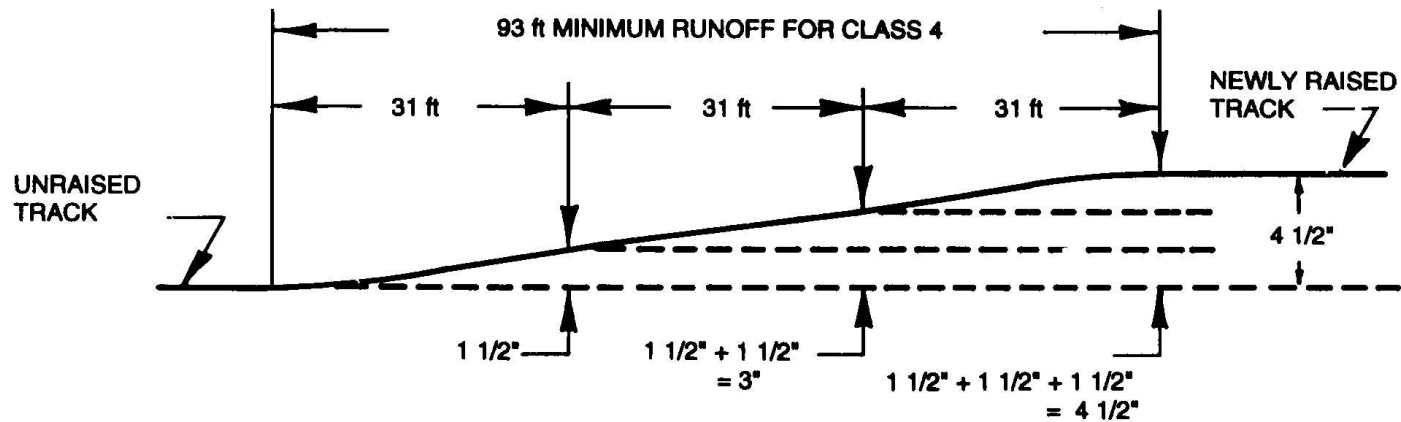




Rate of Runoff over 31 feet



YOU NEED A 4 1/2" RUNOFF FROM A RAISE



THE RUNOFF IN ANY 31' OF TRACK AT THE END OF A RAISE MAY BE NO MORE THAN	CLASS OF TRACK				
	1	2	3	4	5
	3 1/2"	3"	2"	1 1/2"	1"



Multiple Defects in Succession

§ 213.1 Scope of part.

- (a) This part prescribes minimum safety requirements for railroad track that is part of the general railroad system of transportation. The requirements prescribed in this part apply to specific track conditions existing in isolation. Therefore, a combination of track conditions, none of which individually amounts to a deviation from the requirements in this part, may require remedial action to provide for safe operations over that track. This part does not restrict a railroad from adopting and enforcing additional or more stringent requirements not inconsistent with this part.

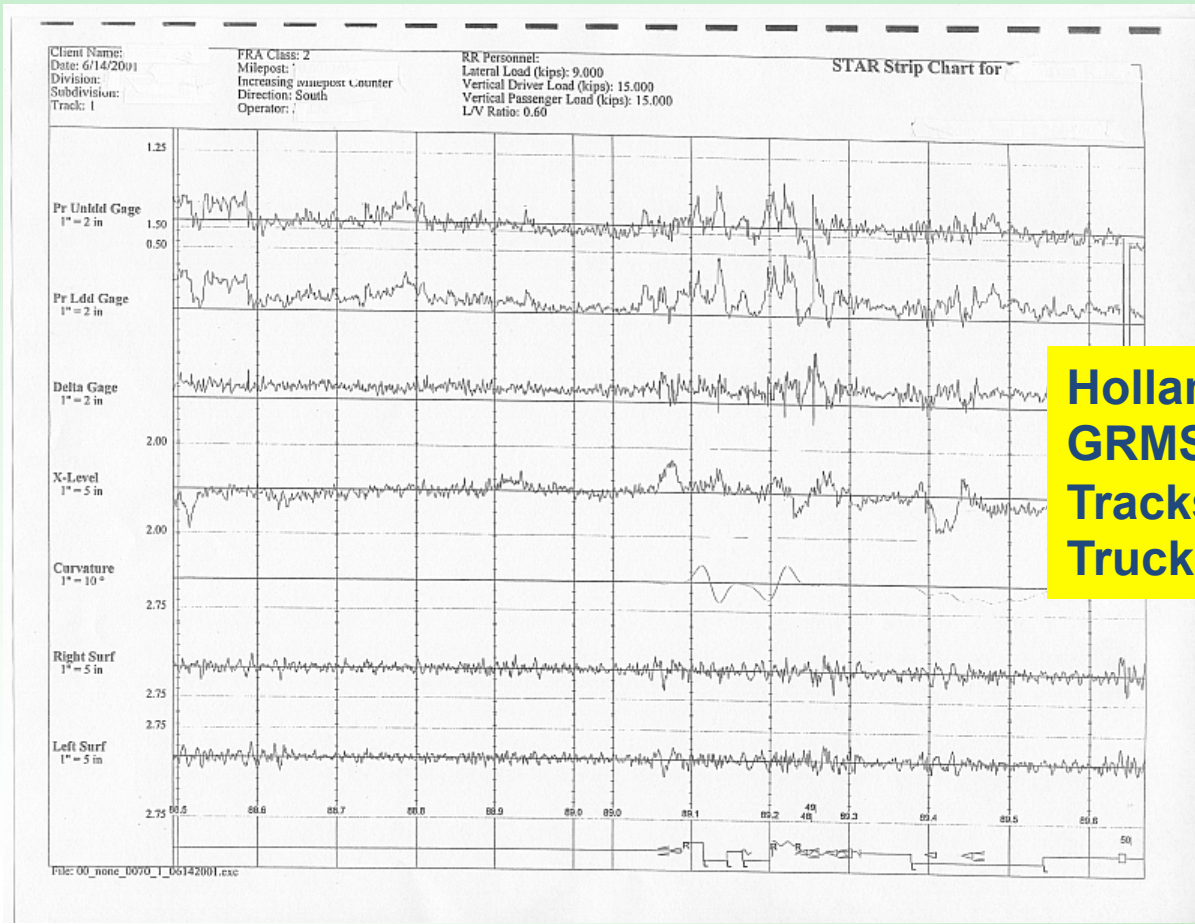


Track Geometry

Recording Cars

TGC





Holland
GRMS
Trackstar
Truck





The End



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