Principles of Track, Track Components, & Geometry

Presented by:
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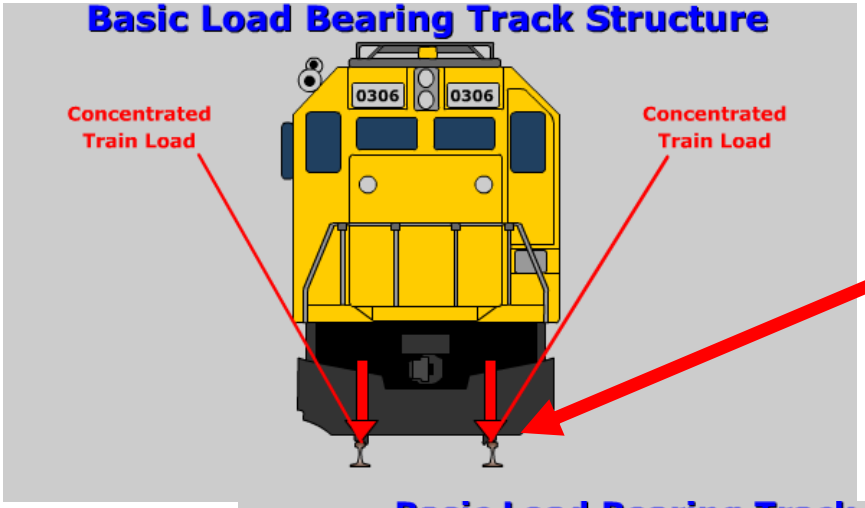
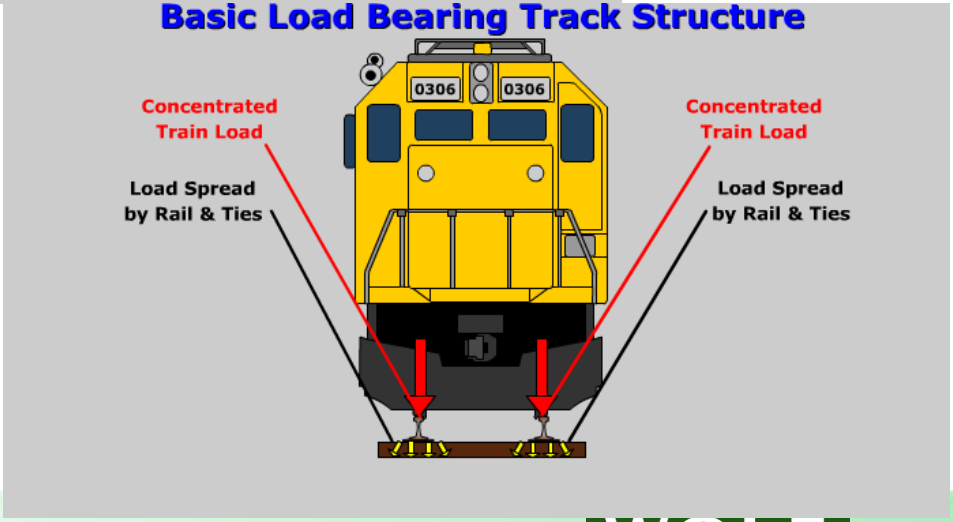
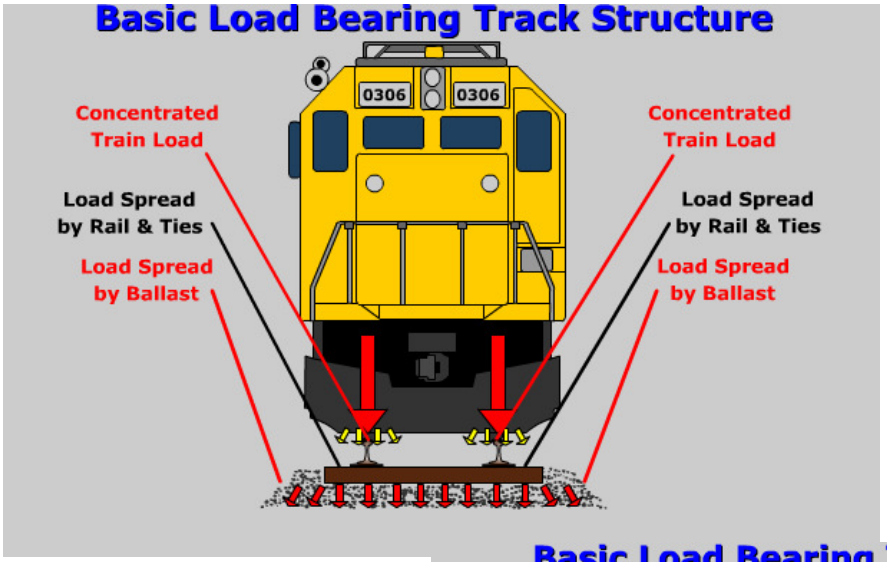
Topics

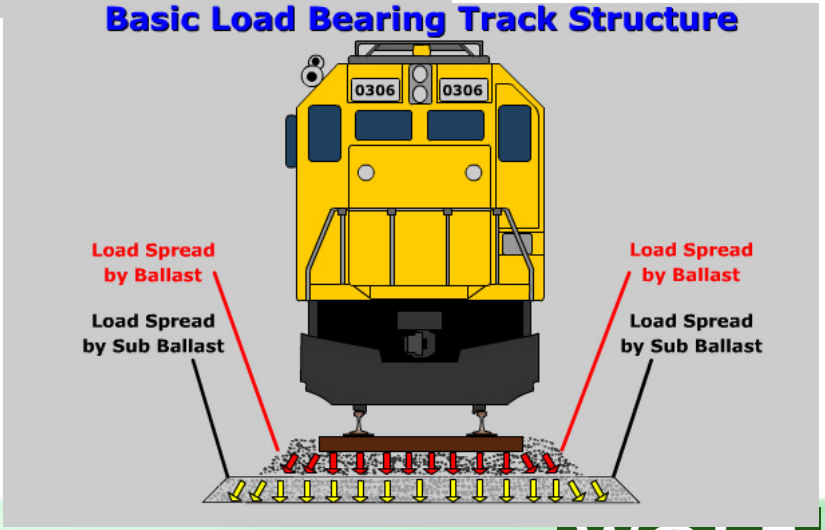
- Track Structure as a System
- Curves and Curve Geometry
- Turnouts and components
- Derails
- OWLS and Jump Frogs
- Track Geometry

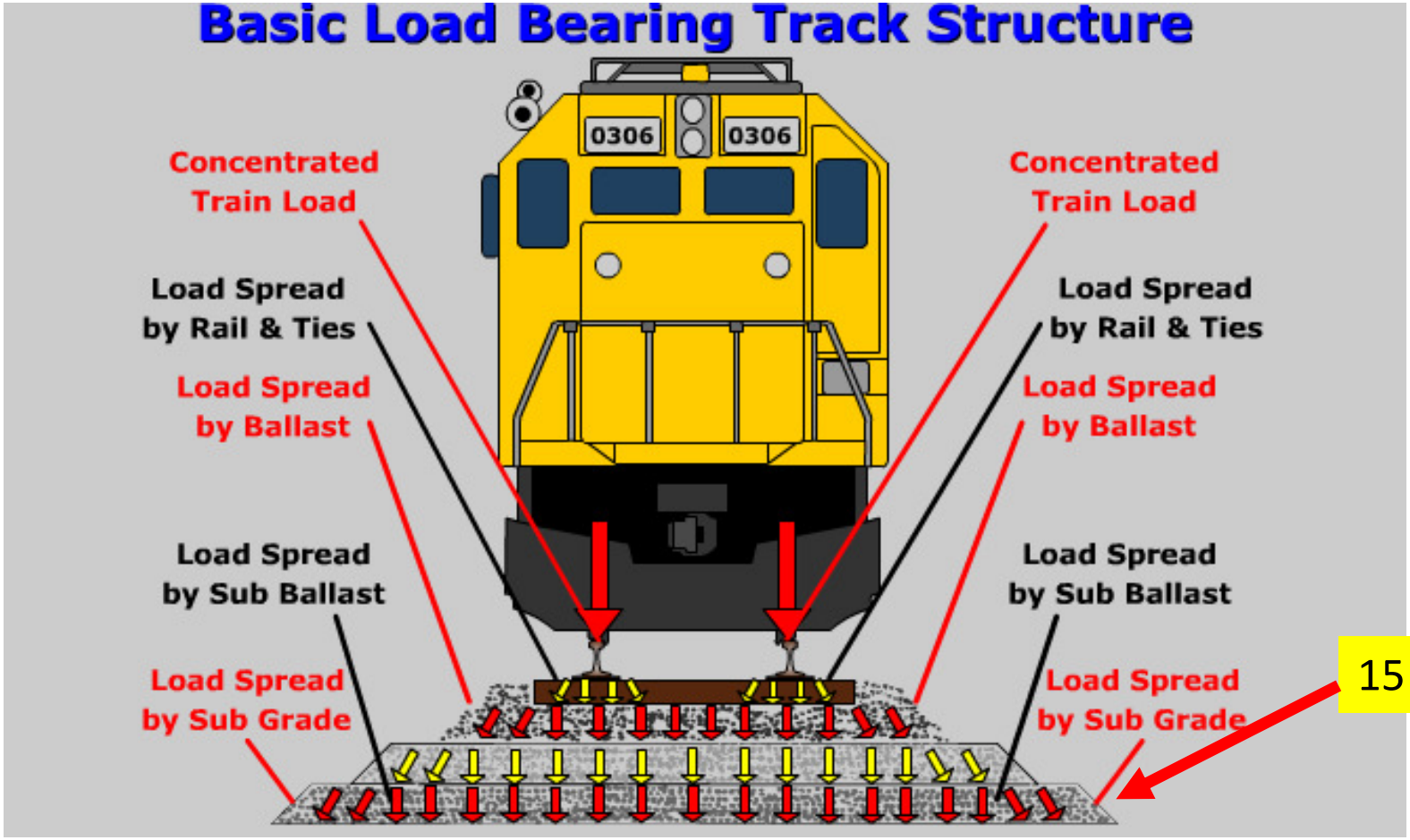


50,000 -100,000 PSI




Basic Load Bearing Track Structure
0306
0306
Concentrated Train Load
Concentrated Train Load
Load Spread by Rail & Ties
Load Spread by Rail & Ties
Load Spread by Ballast
Load Spread by Ballast


Basic Load Bearing Track Structure
0306
0306
Load Spread by Ballast
Load Spread by Ballast
Load Spread by Sub Ballast
Load Spread by Sub Ballast


Basic Load Bearing Track Structure
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Concentrated Train Load
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Load Spread by Rail & Ties
Load Spread by Rail & Ties
Load Spread by Ballast
Load Spread by Ballast
Load Spread by Sub Ballast
Load Spread by Sub Ballast
Load Spread by Sub Grade
Load Spread by Sub Grade
15 - 20 PSI

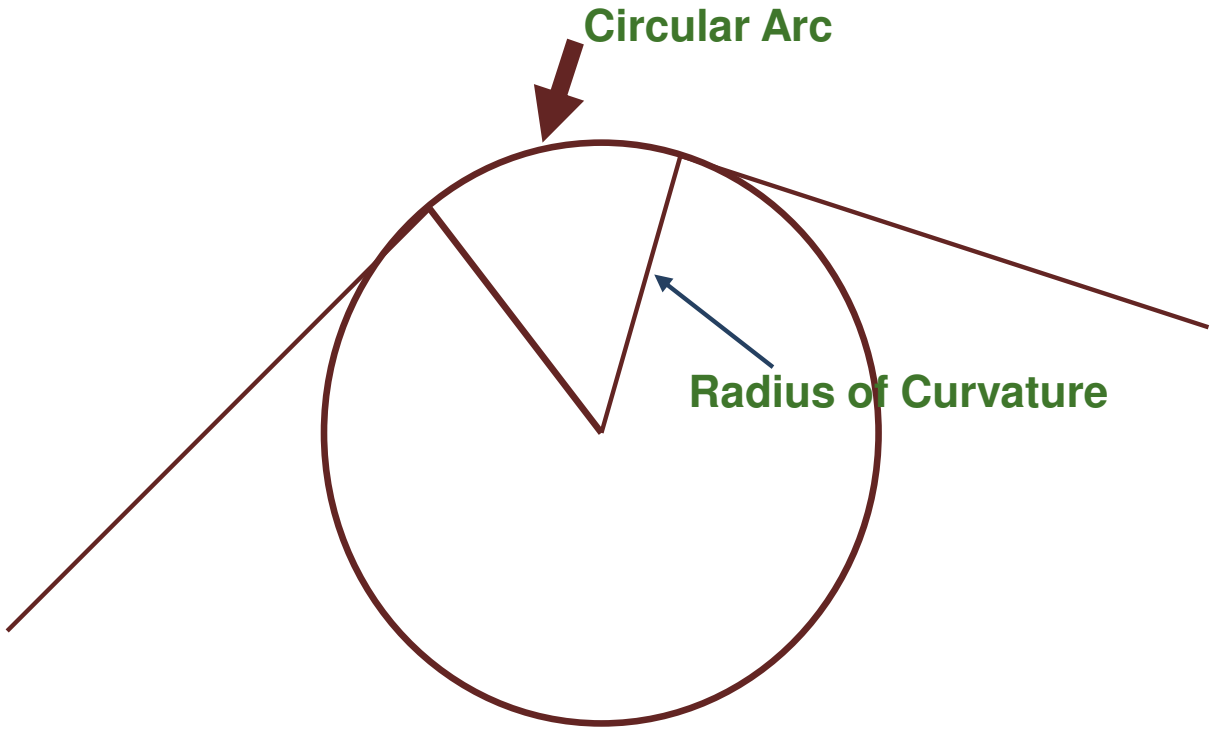
Curves and Curve Geometry

2 characteristics of curves

Elevation

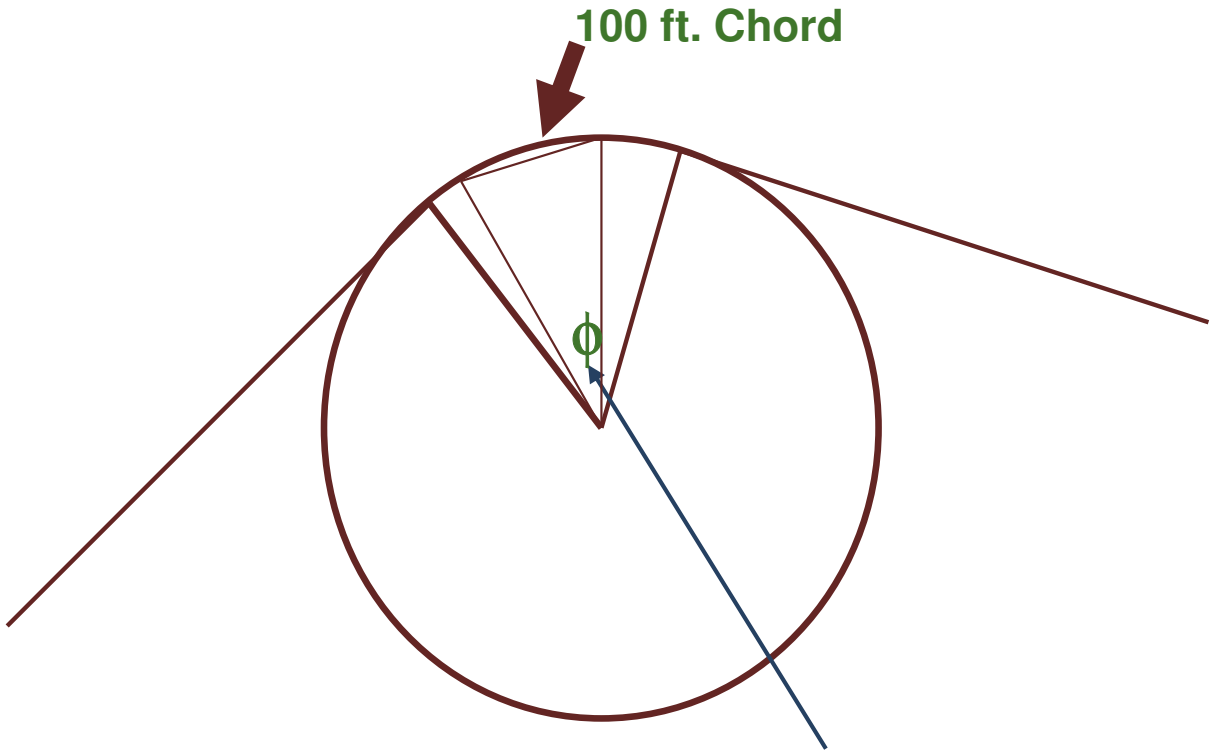
Alignment

Definition of a Curve



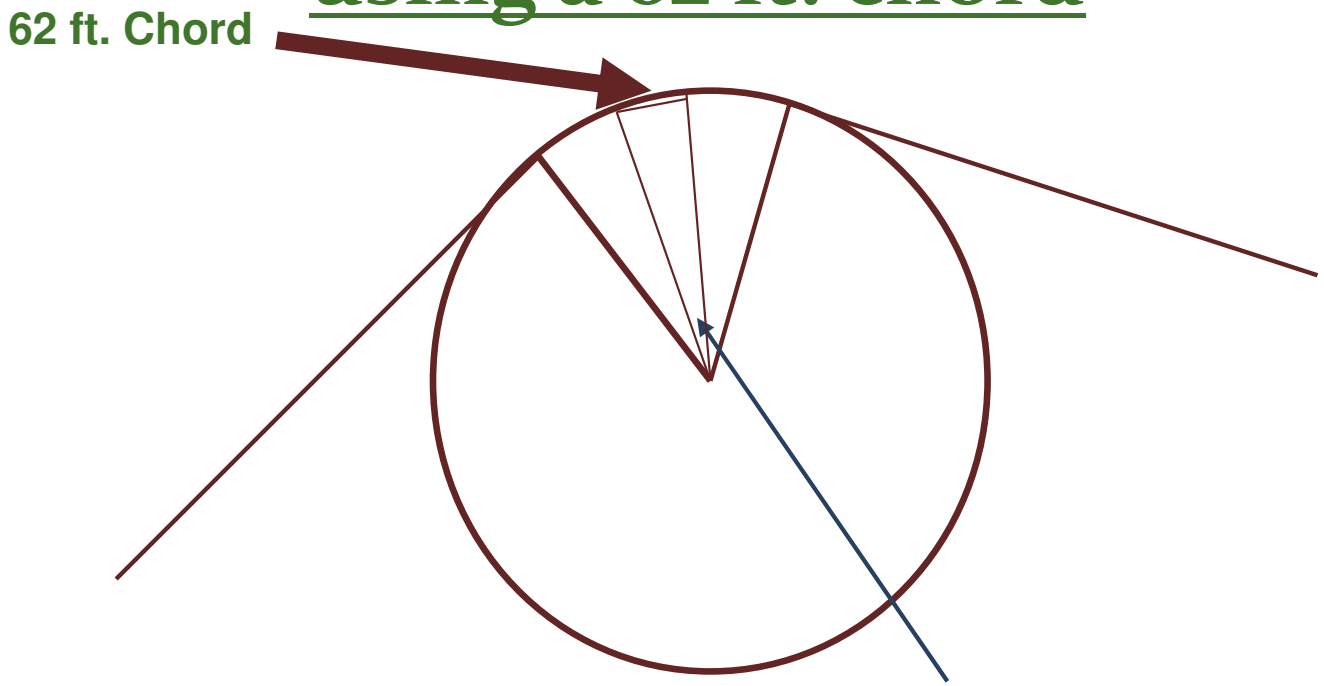
A curve is defined as a path along the edge of a circular arc defined by a circle of with a given radius

Railroad Definition of a Curve



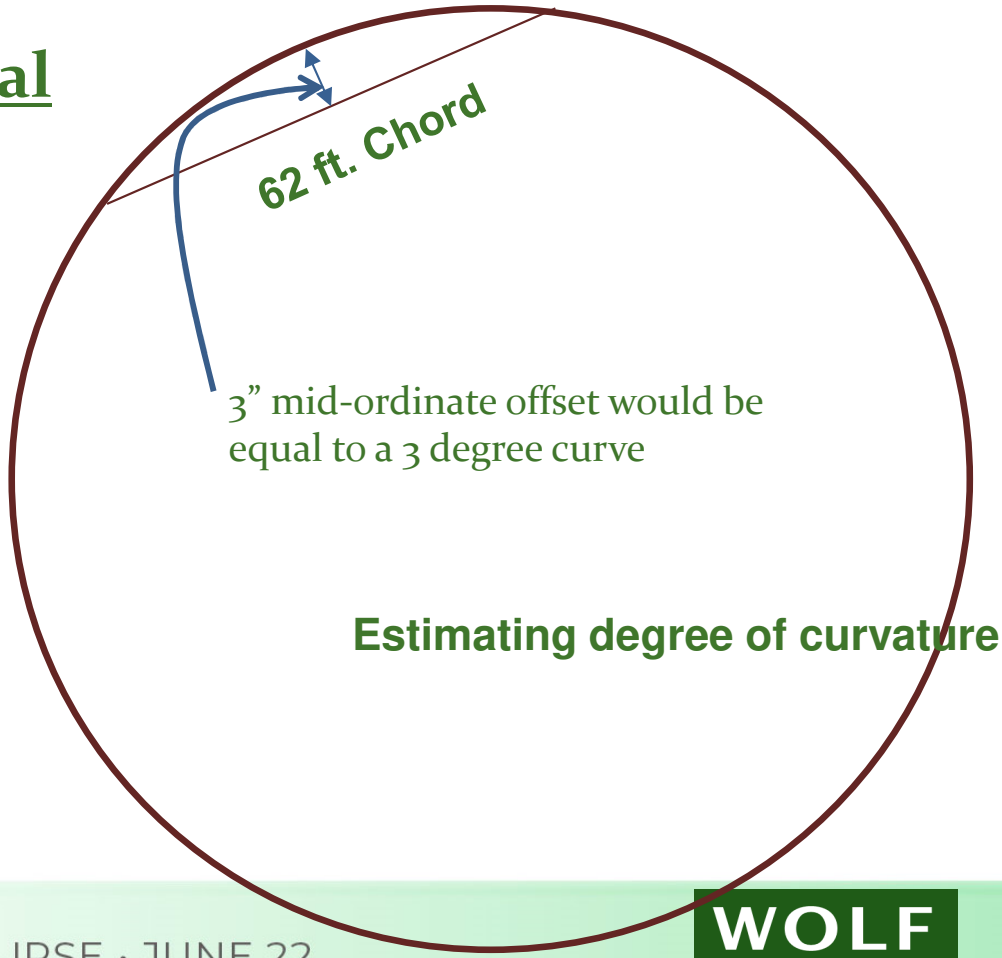
Degree of curve is the angle ϕ subtended by a 100 ft. chord

Estimating degree of curvature using a 62 ft. chord



Degree of curve can be estimated by using a 62 ft. chord and measuring the mid-ordinate offset

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



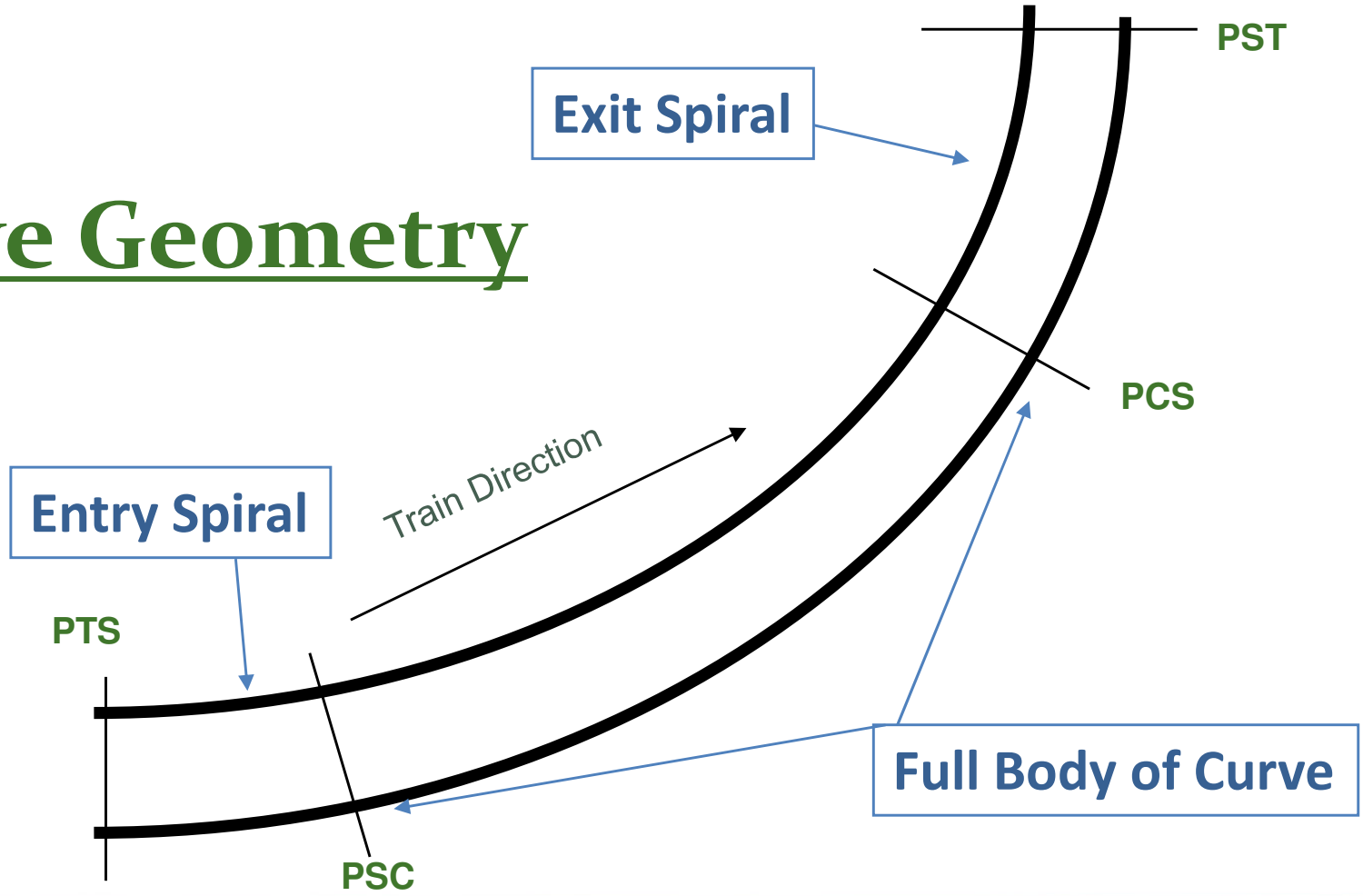
Estimating degree of curvature using a 62 ft. chord

Stringlining using 62 ft. Chord

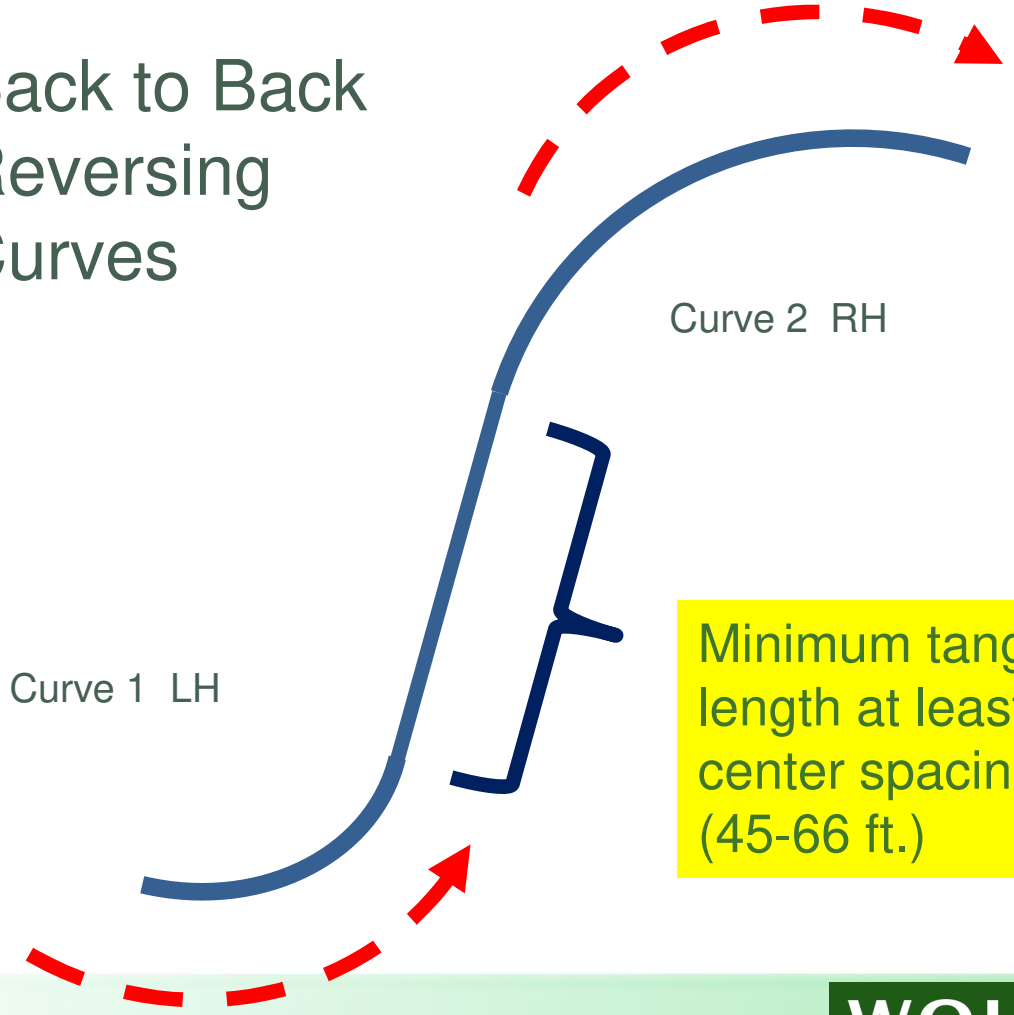
Degree of Curve & Radius

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

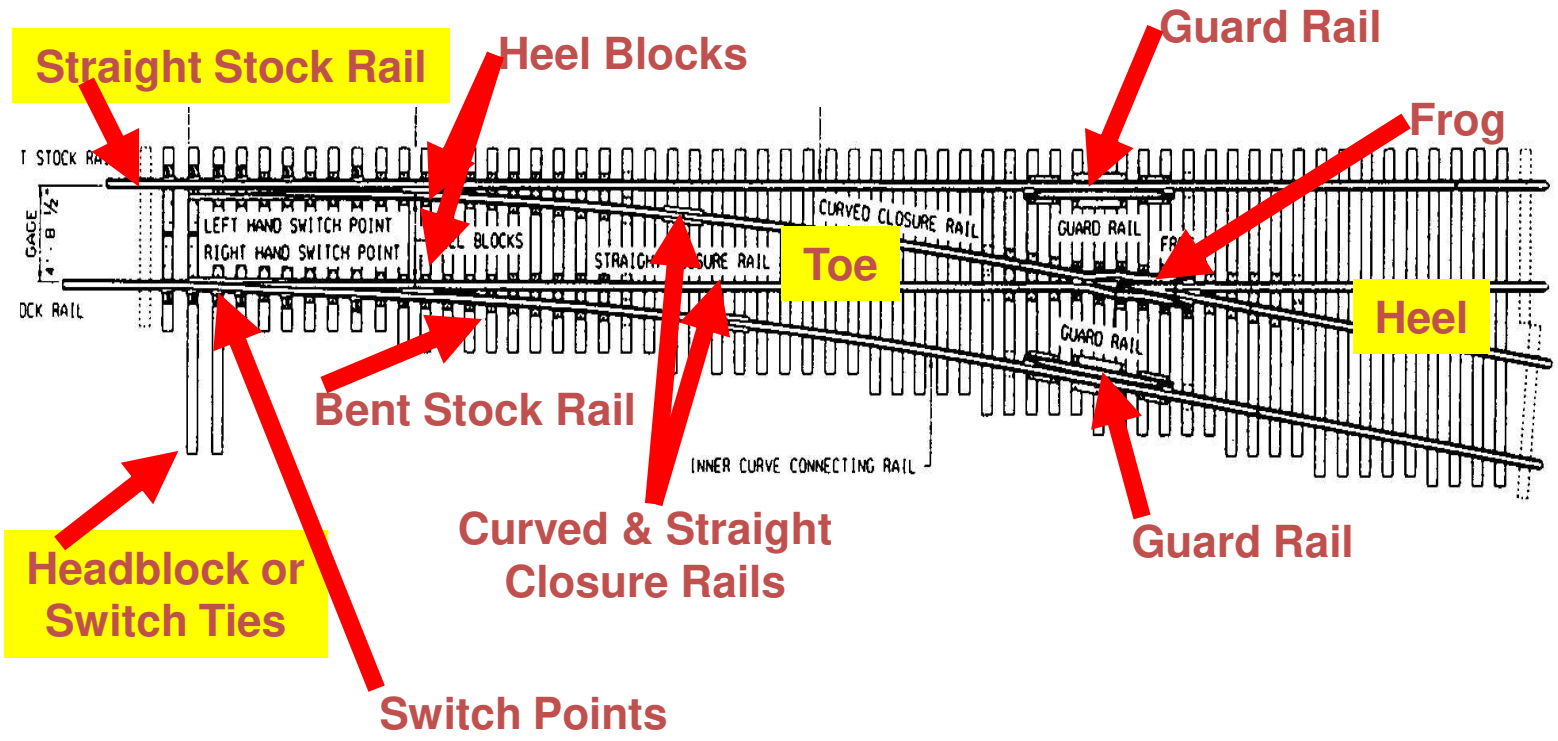


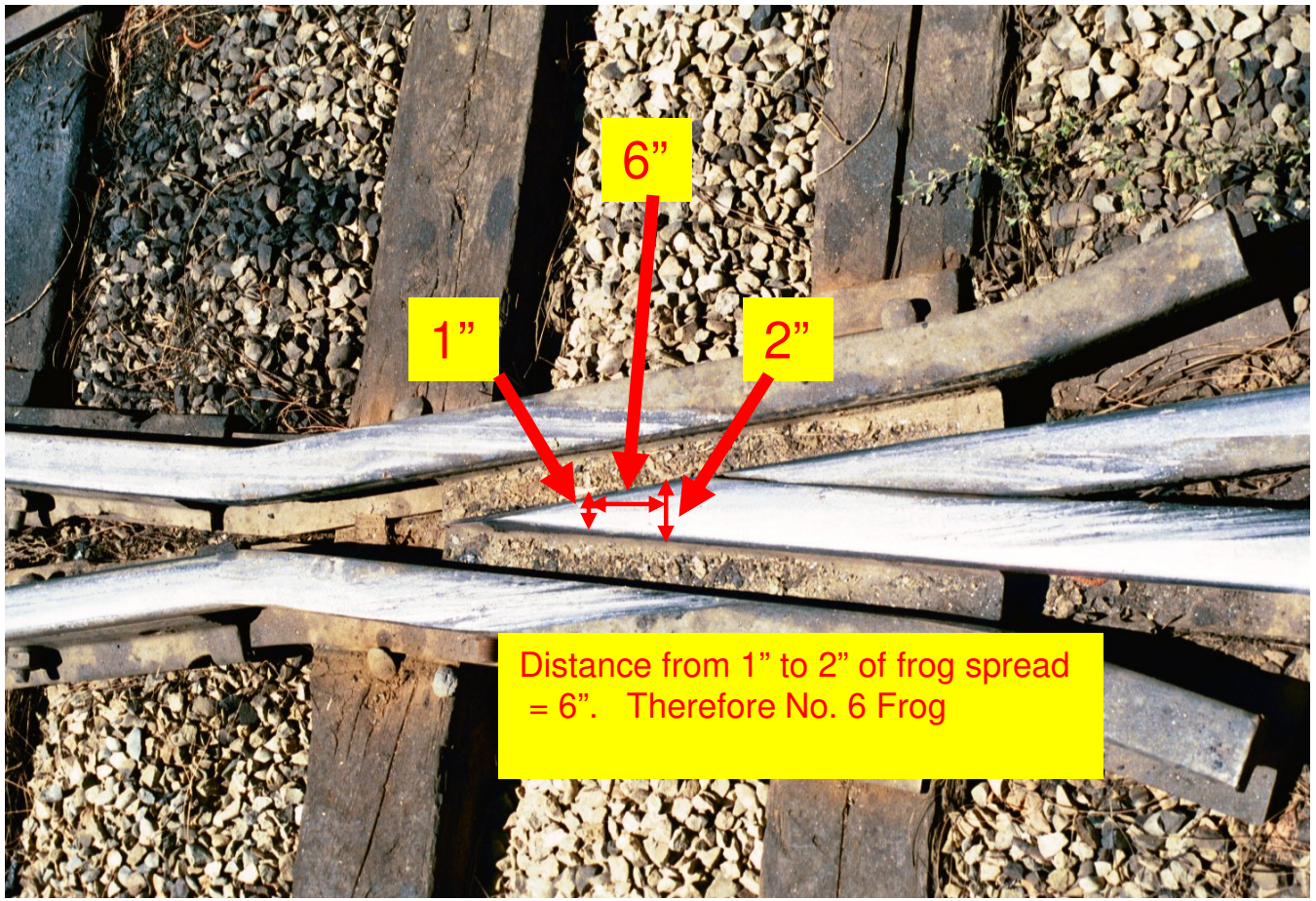
Back to Back Reversing Curves



Minimum tangent length at least truck center spacing; (45-66 ft.)

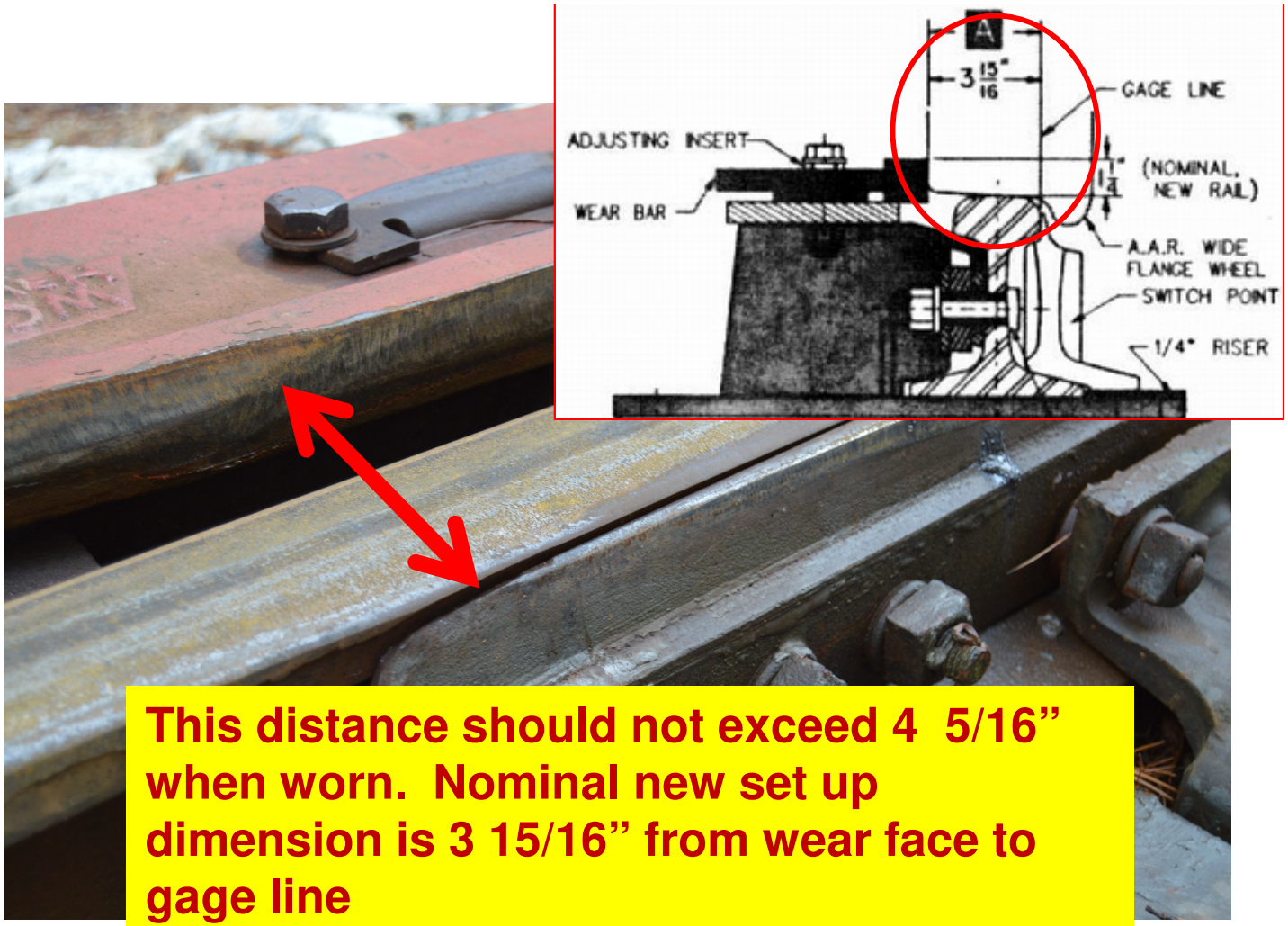
Lack of sufficient intervening tangent between back to back reverse curves


Straight Stock Rail
Heel Blocks
Guard Rail
Frog
Toe
Heel
Bent Stock Rail
Curved & Straight
Closure Rails
Guard Rail
Headblock or
Switch Ties
Switch Points
LEFT HAND SWITCH POINT
RIGHT HAND SWITCH POINT
CURVED CLOSURE RAIL
GUARD RAIL
INNER CURVE CONNECTING RAIL



How to determine frog number

Heavy wear on switch point protector



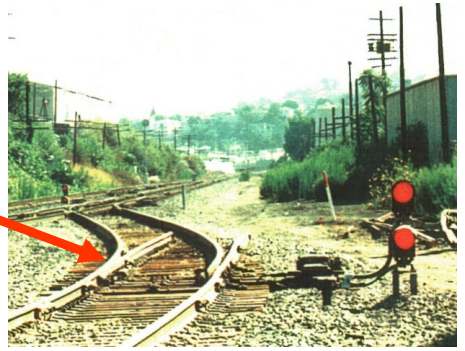
This distance should not exceed 4 5/16" when worn. Nominal new set up dimension is 3 15/16" from wear face to gage line

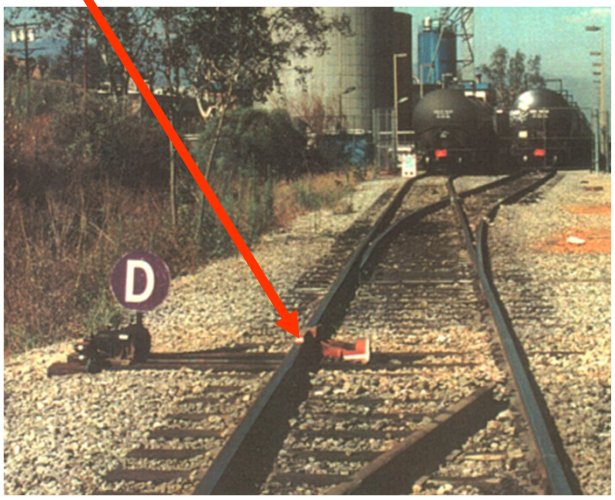
§ 213.205 Derails.

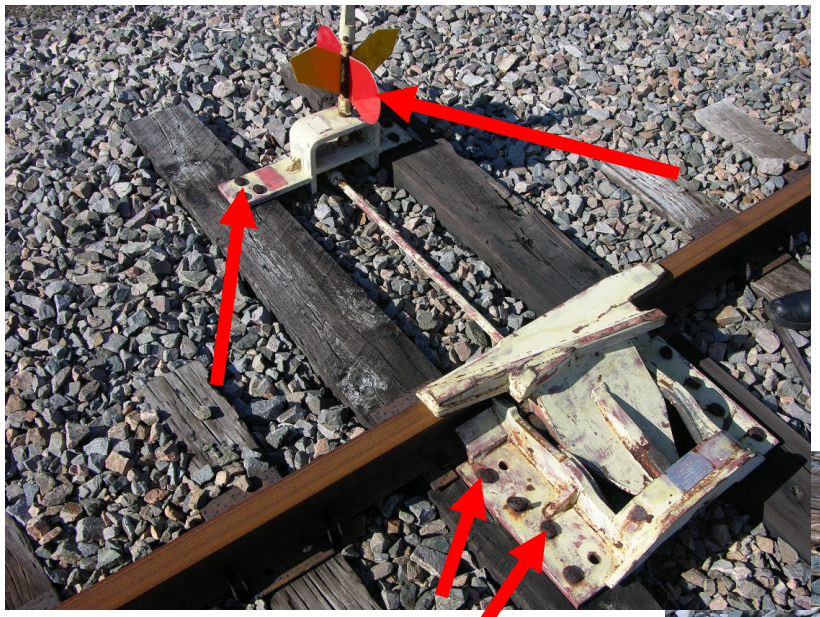
DERAILS

(a) Each derail shall be clearly visible.
(b) When in a locked position, a derail shall be free of lost motion which would prevent it from performing its intended function.
(c) Each derail shall be maintained to function as intended.

(d) Each derail shall be properly installed for the rail to which it is applied. (This paragraph (d) is applicable September 21, 1999.)

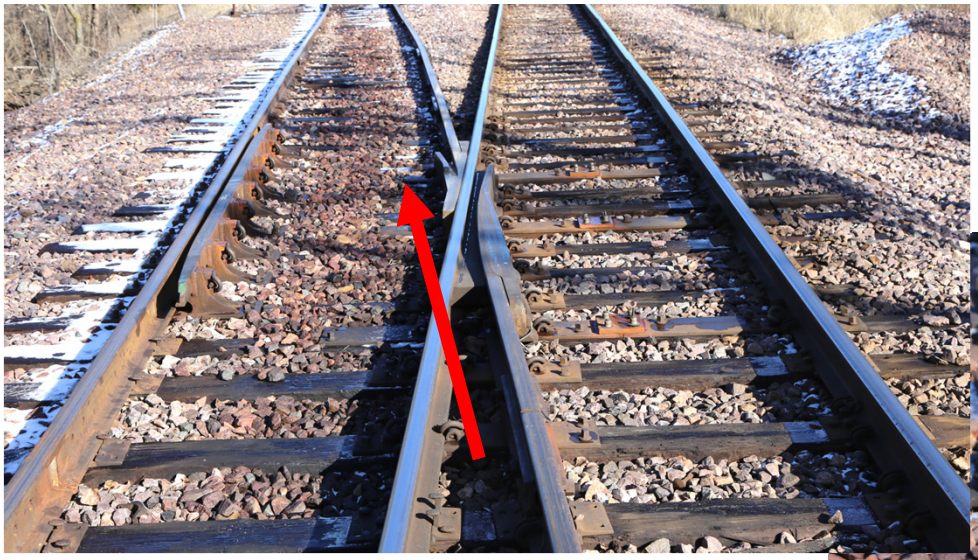






Hayes HB style

OWLS – One Way Low Speed Diamond



Jump Frogs

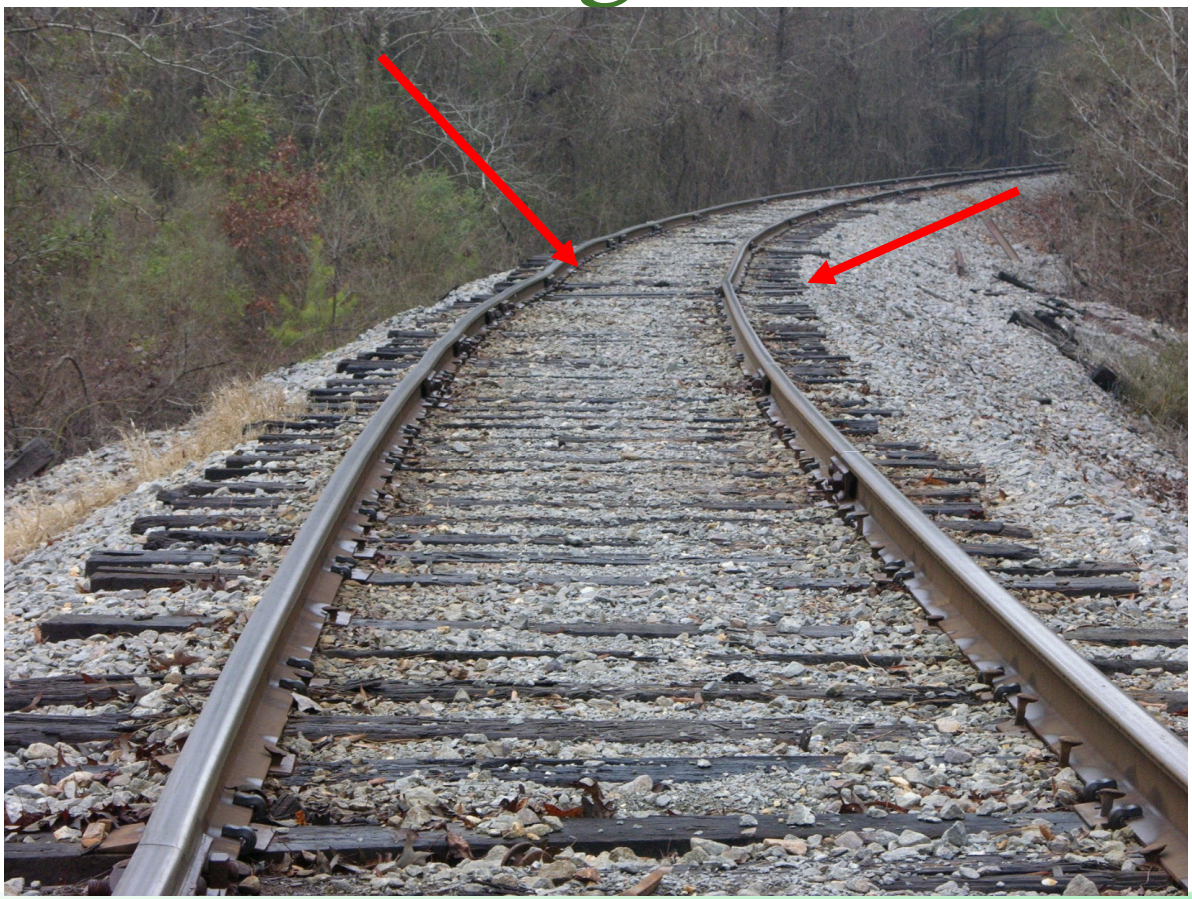
Individual Geometry Topics

- 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

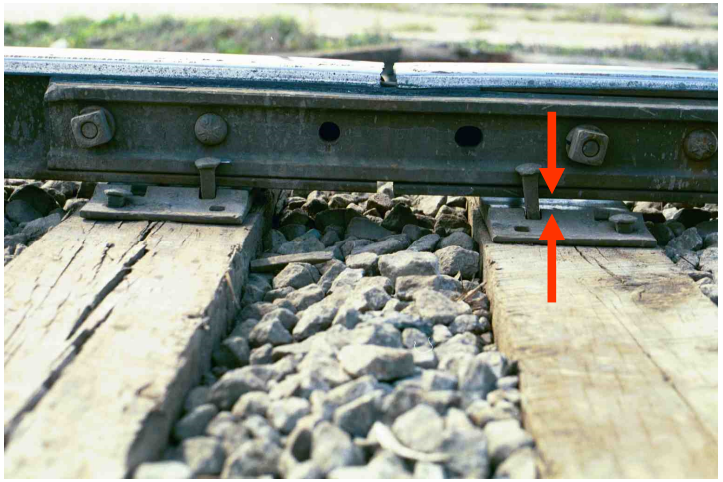
Crosslevel and Alignment Variations

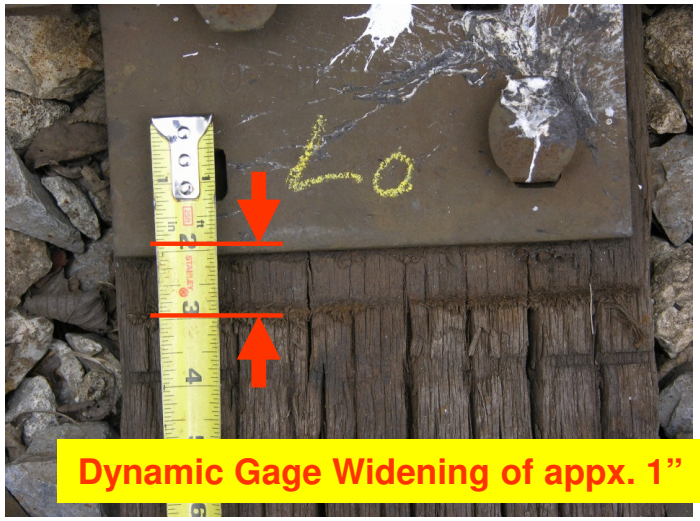


Surface and Profile Deviations

§ 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.





For North American Freight Operations

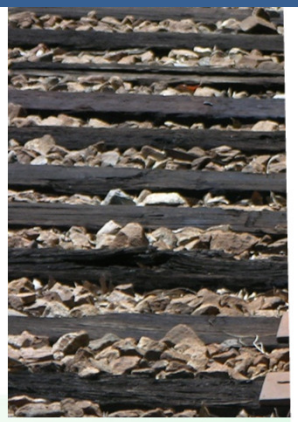
CLASSES OF TRACK

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

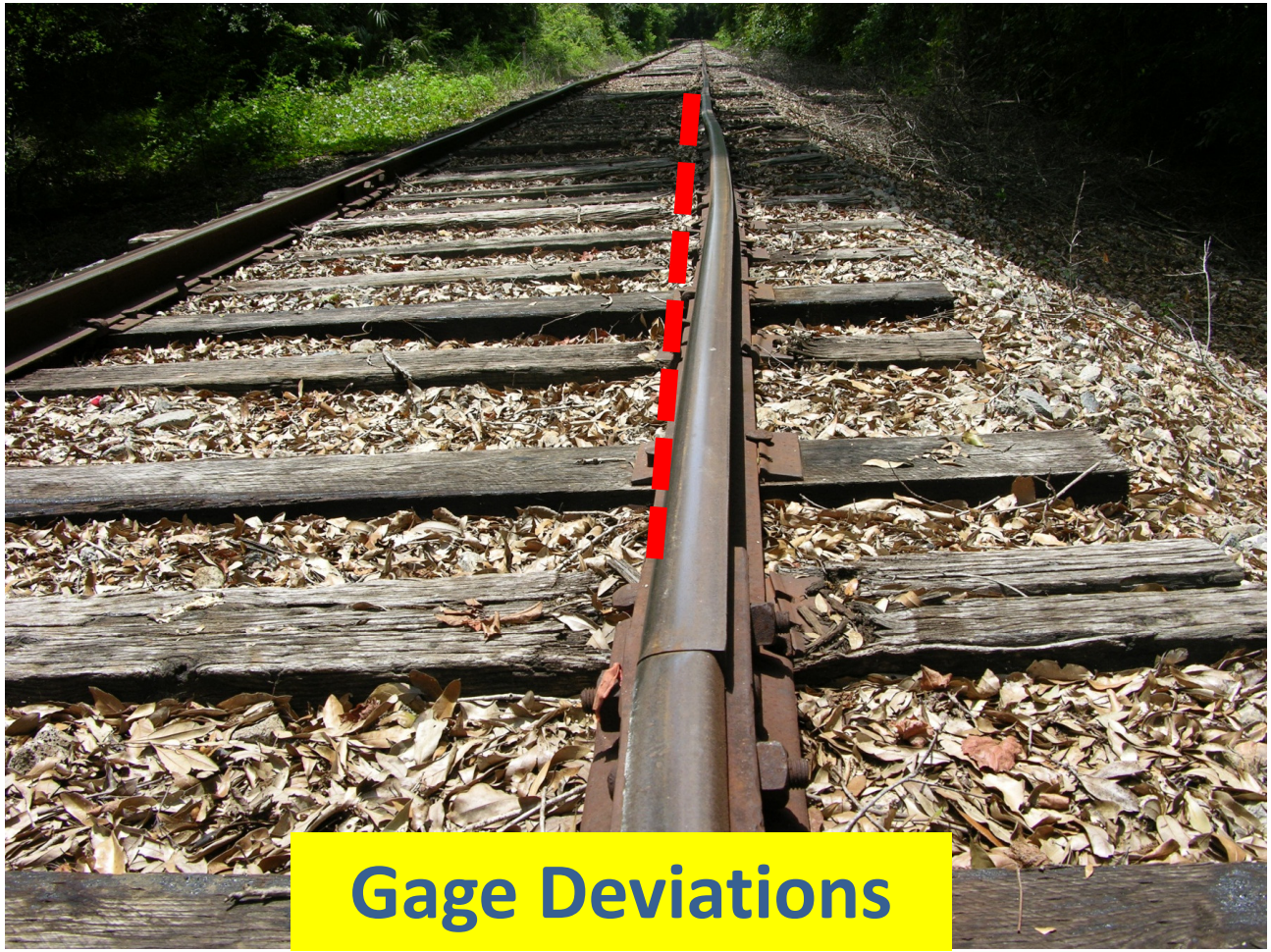
§ 213.53 Gage.

(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.

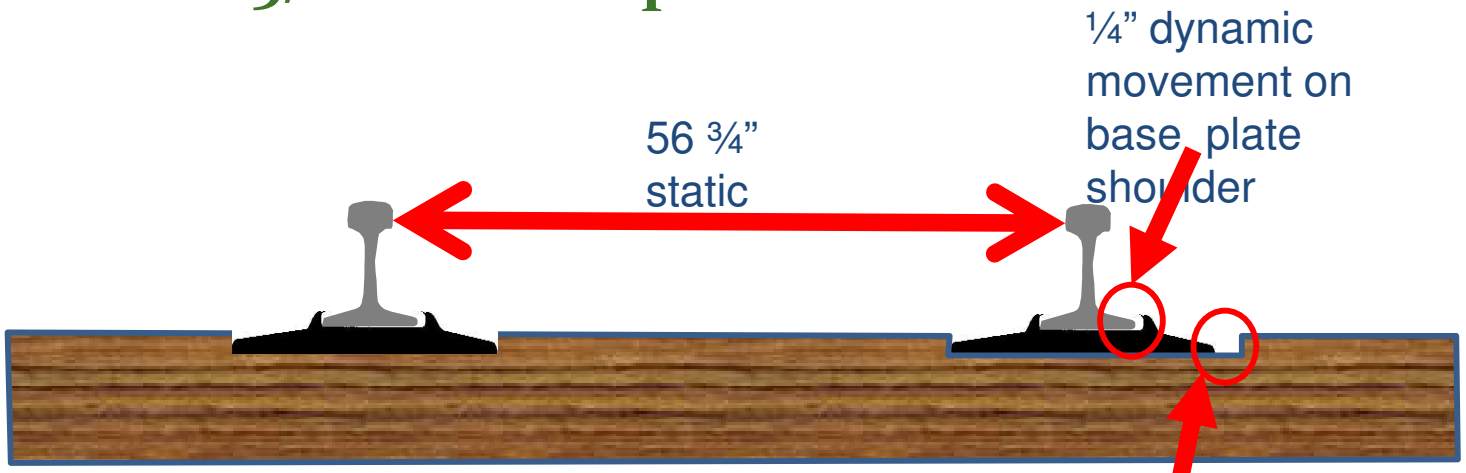
(b) Gage shall be within the limits prescribed in the following table —



Class of track	The gage must be at least—	But not more than—
Excepted track.	N/A	4'10¼"
Class 1 track	4'8"	4'10"
Class 2 and 3 track	4'8"	4'9¾"
Class 4 and 5 track	4'8"	4'9½"


Gage Deviations

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

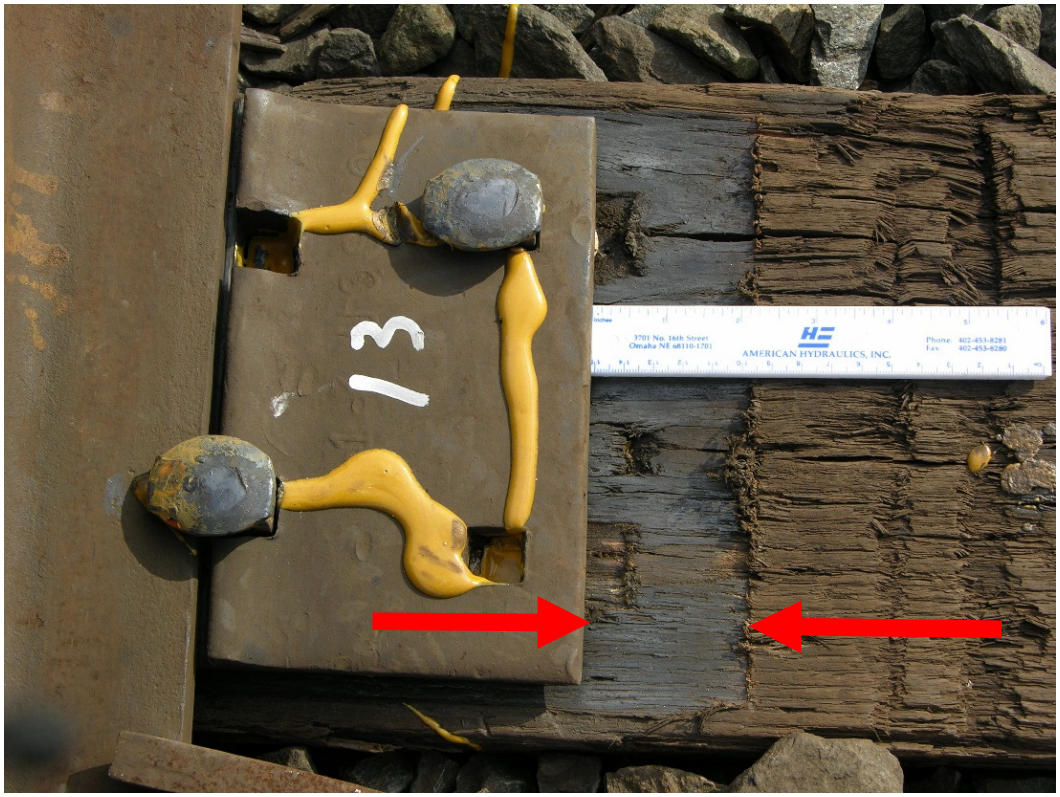


56 ¾” static gage
¼” dynamic base movement
½” dynamic plate movement

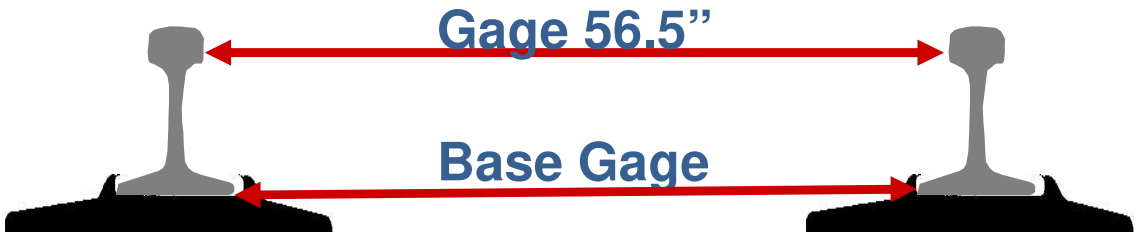
57 ½” total gage for FRA Compliance

§ 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.



Dynamic Gage Widening

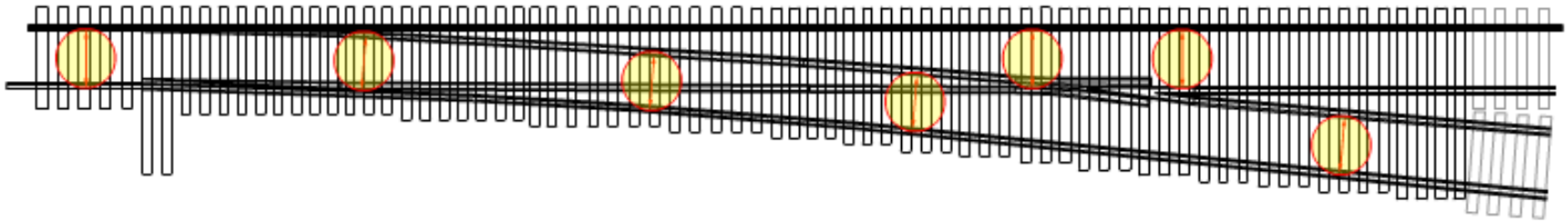


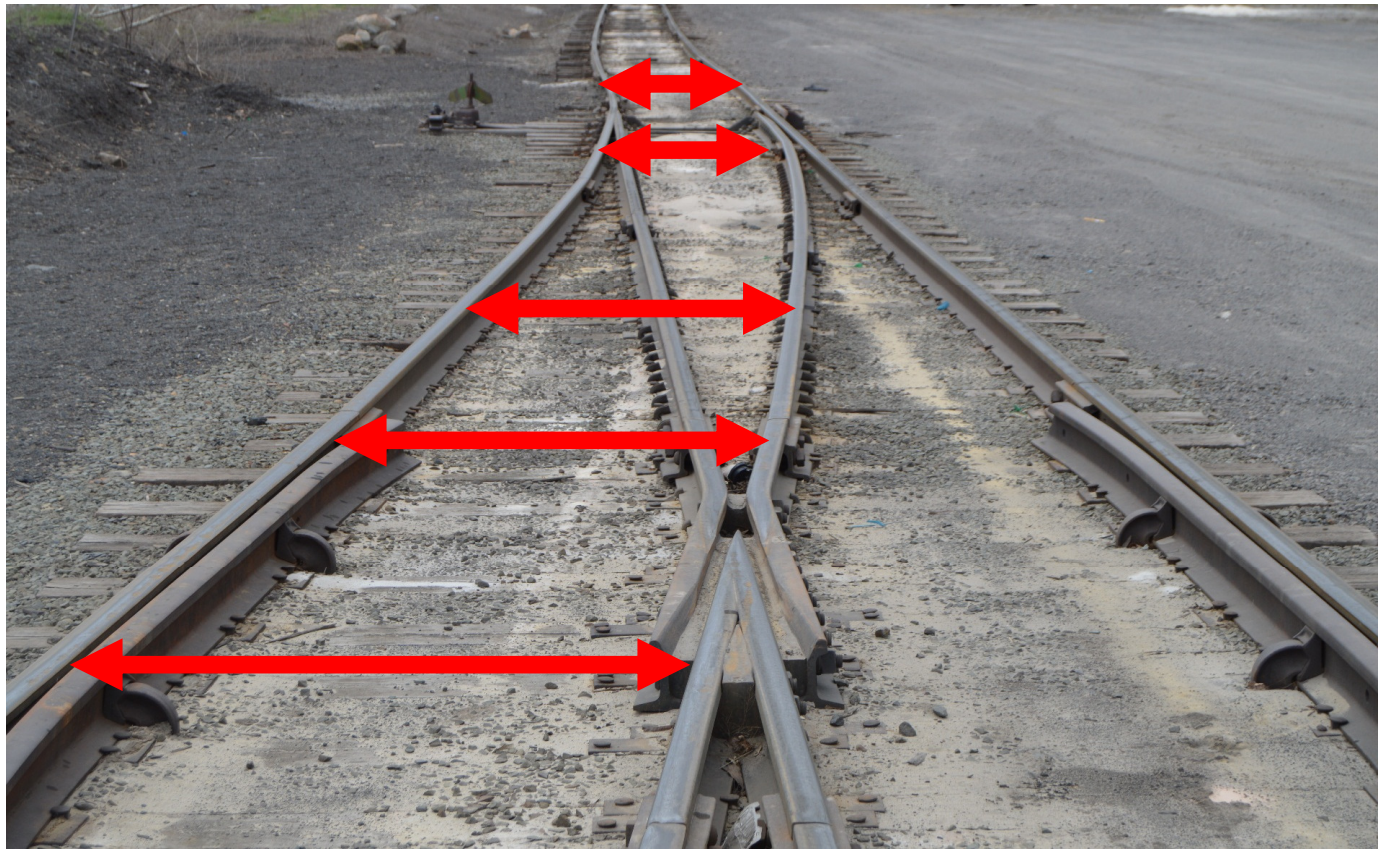
Rail Wt.	Base Gage Decimal(in.)	Base Gage Fraction(in.)
100	54.16	54 5/32
115	53.96	53 31/32
119	53.91	53 29/32
132	53.77	53 ¾
133	53.69	53 11/16
136	53.72	53 23/32
141	53.72	53 23/32

Subpart C - Track Geometry
§213.53 Gage

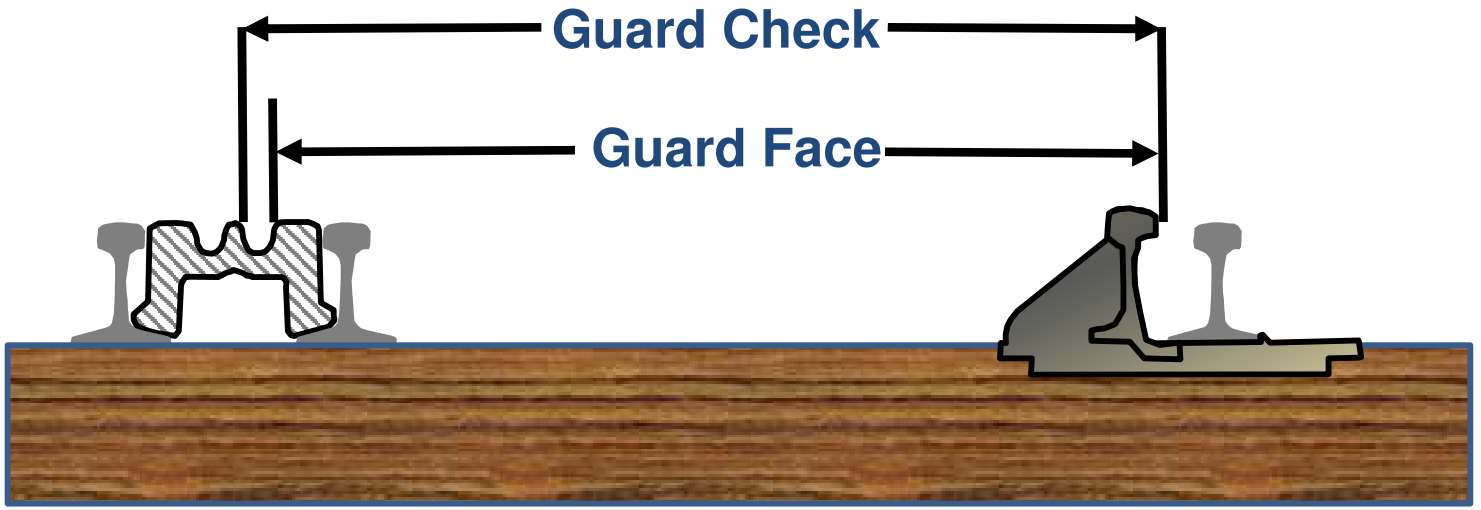
Particular attention should be given to track gage in turnouts or locations where high lateral train forces are expected or evident.

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.





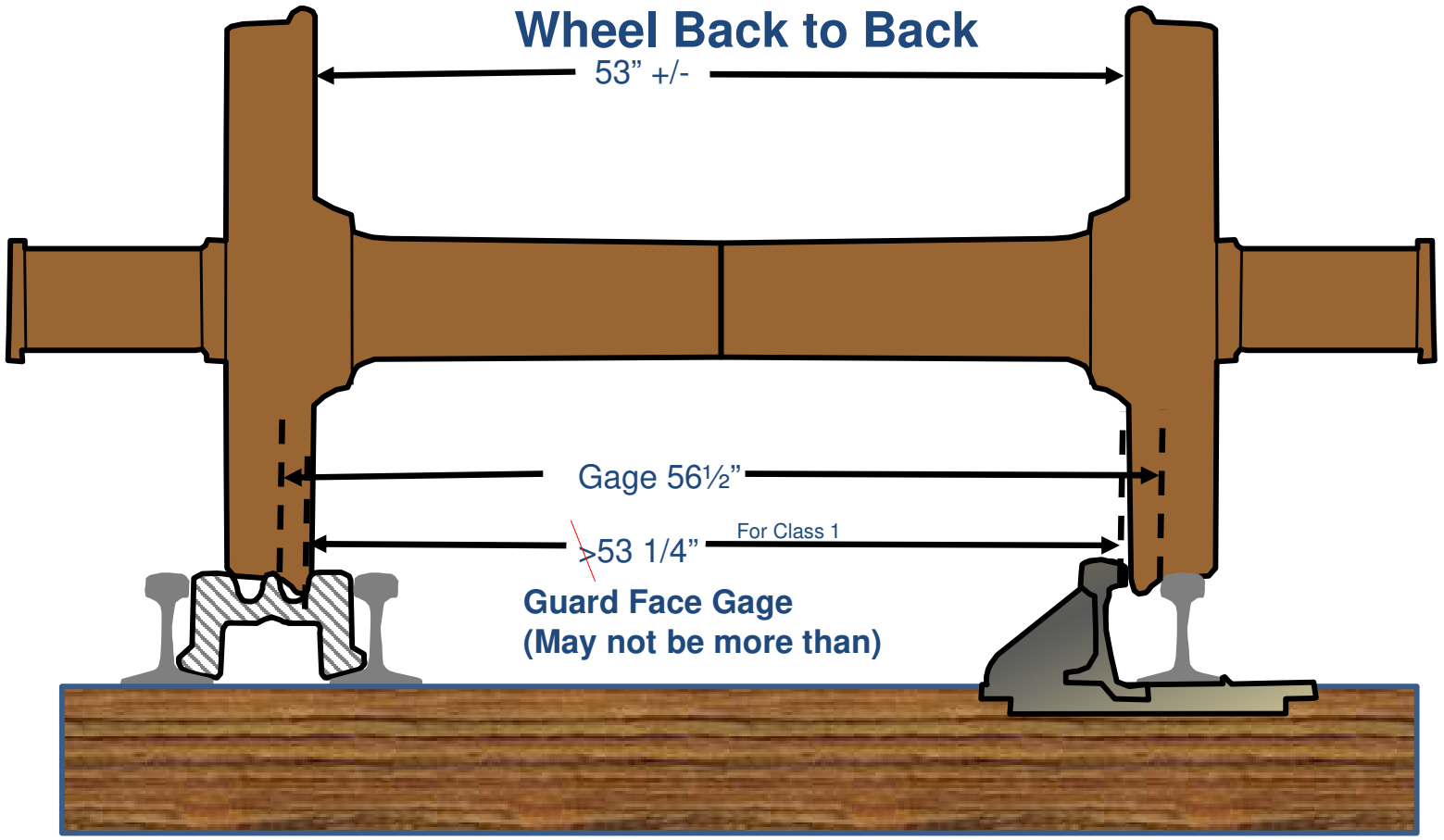
Checking Gage in a Turnout at Multiple locations

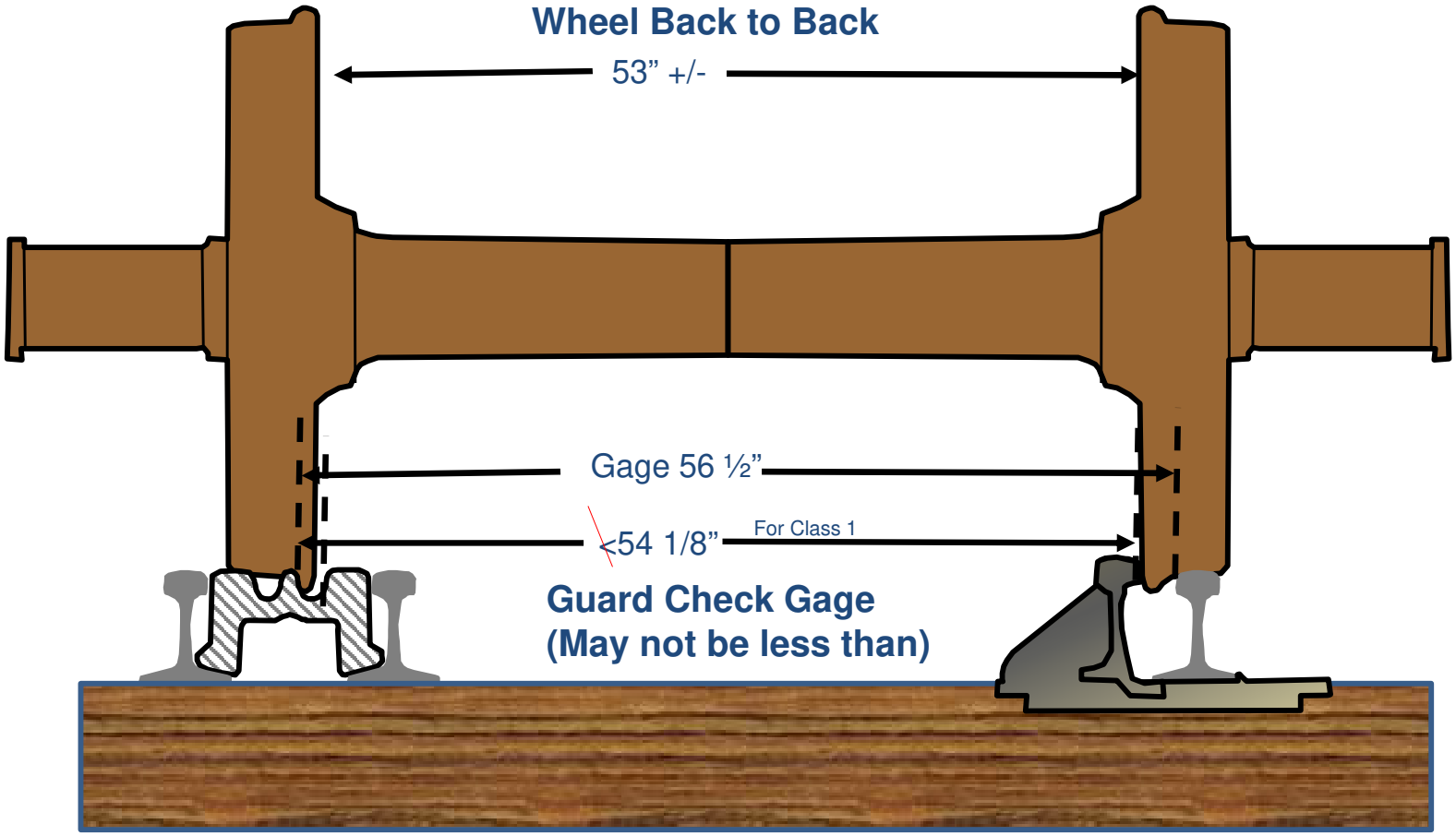

Guard Check
Guard Face

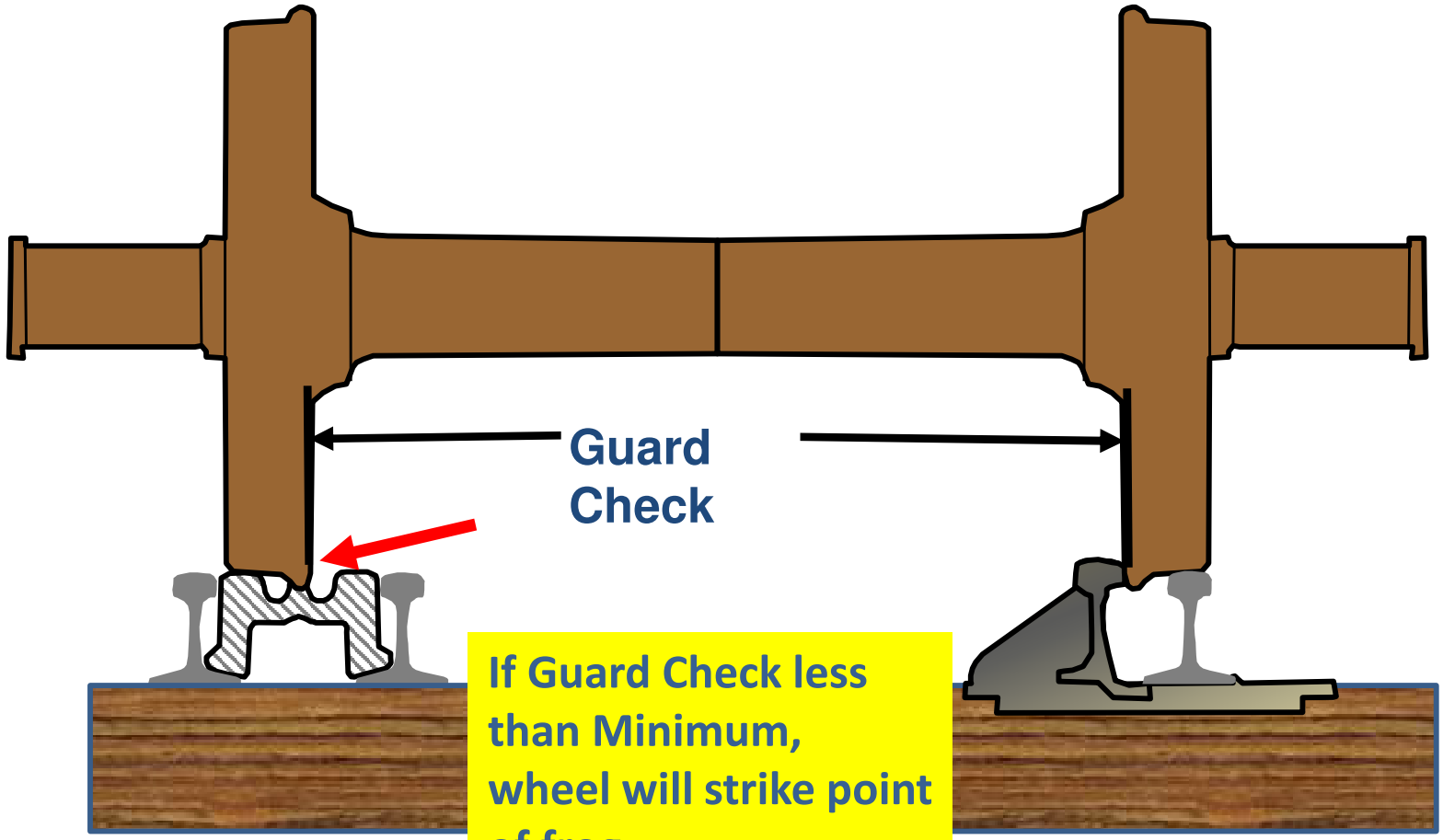
213.143 Guard Check and Face Gage

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 less than	Guard Face gage may not be more than
Class 1	4’ 6 1/8”	4’ 5 ¼”
Class 2	4’ 6 ¼”	4’ 5 1/8”
Class 3 & 4	4’ 6 3/8”	4’ 5 1/8”
Class 5	4’ 6 ½”	4’ 5”

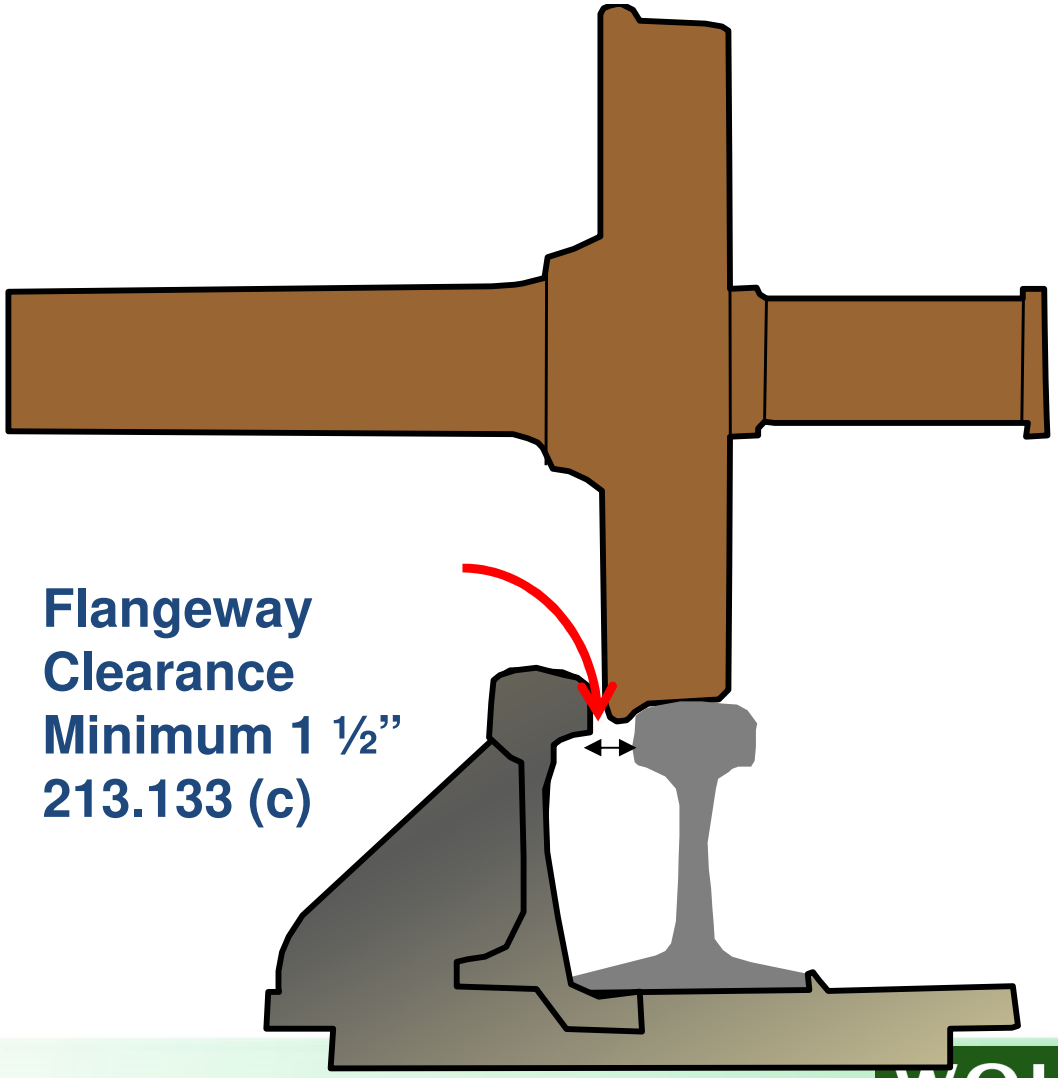

Wheel Back to Back
53” +/-
Gage 56½”
For Class 1
>53 1/4”
Guard Face Gage
(May not be more than)


Wheel Back to Back
53” +/-
Gage 56 ½”
<54 1/8”
For Class 1
Guard Check Gage
(May not be less than)



If Guard Check less than Minimum, wheel will strike point of frog

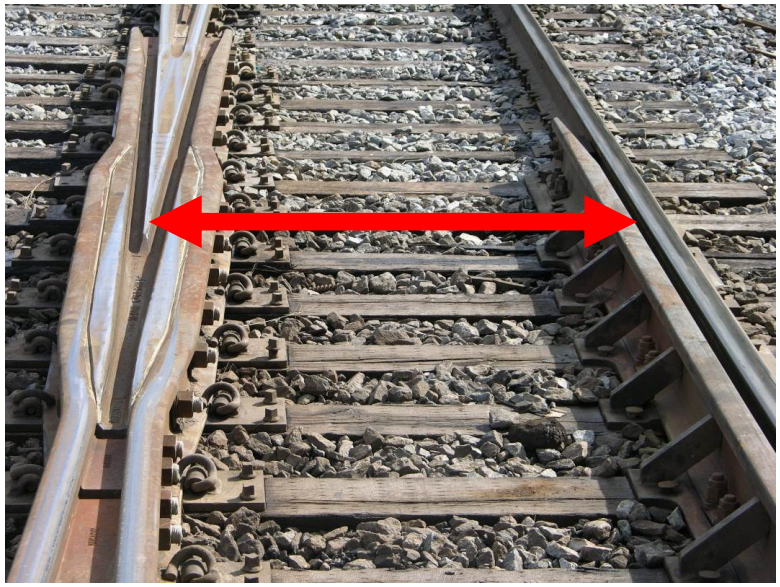
Wheel Striking point of Frog;
Guard check less than minimum


Flangeway
Clearance
Minimum 1 ½”
213.133 (c)

Class 5 Track

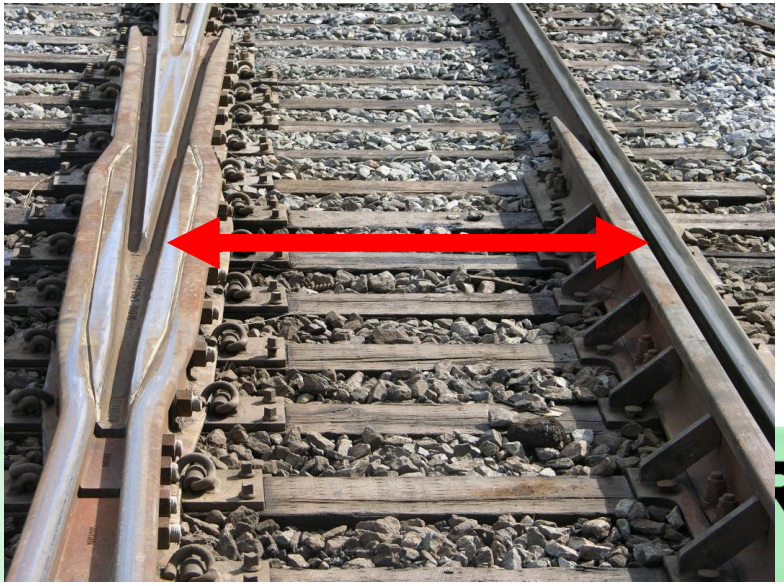
Guard Check- Gage
Line of frog to Guard Line

Minimum = 54 1/2”



Guard Face - Distance Between Wing Rail and Guard Line

Maximum = 53 ”



Alignment Deviations

§ 213.55 Track alinement.

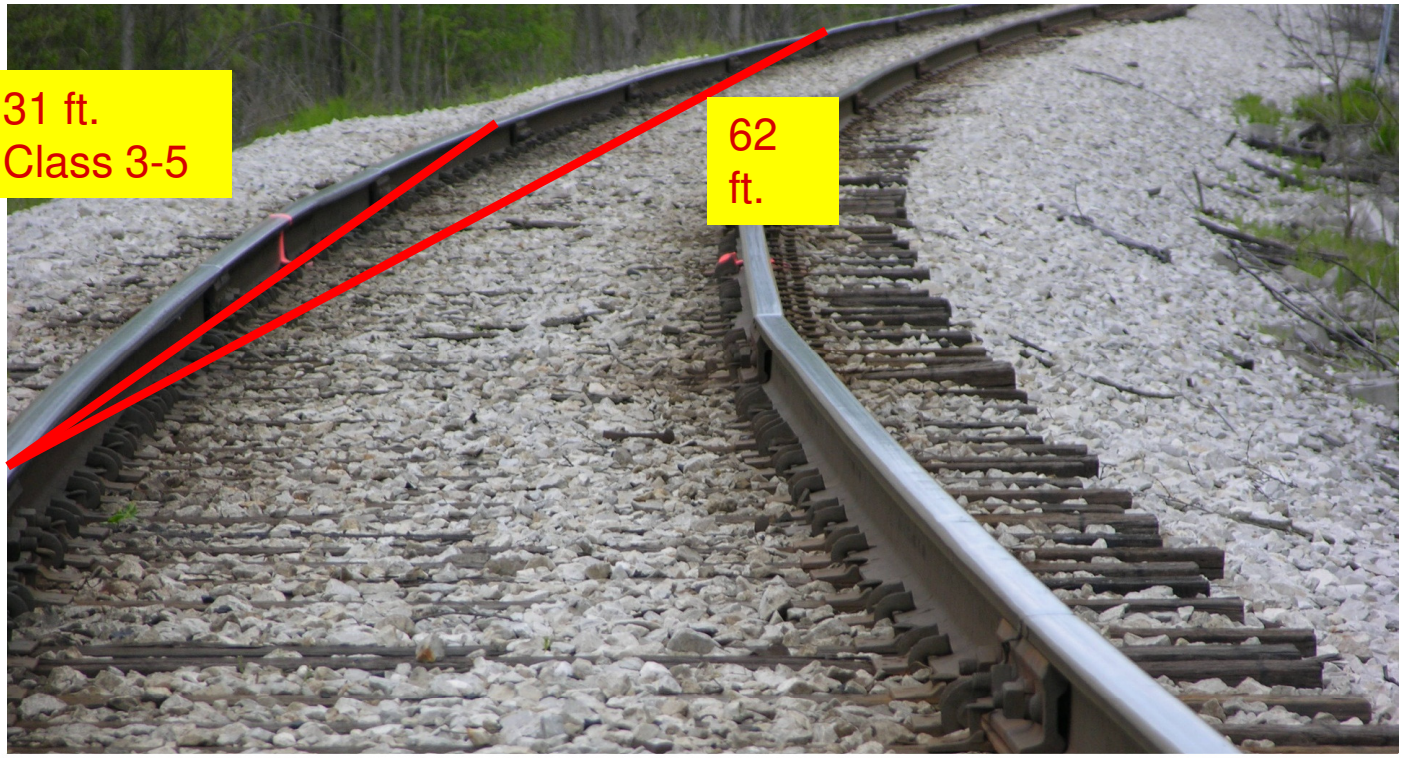
(a) Except as provided in paragraph (b) of this section, alinement may not deviate from uniformity more than the amount prescribed in the following table:

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"	⅜"

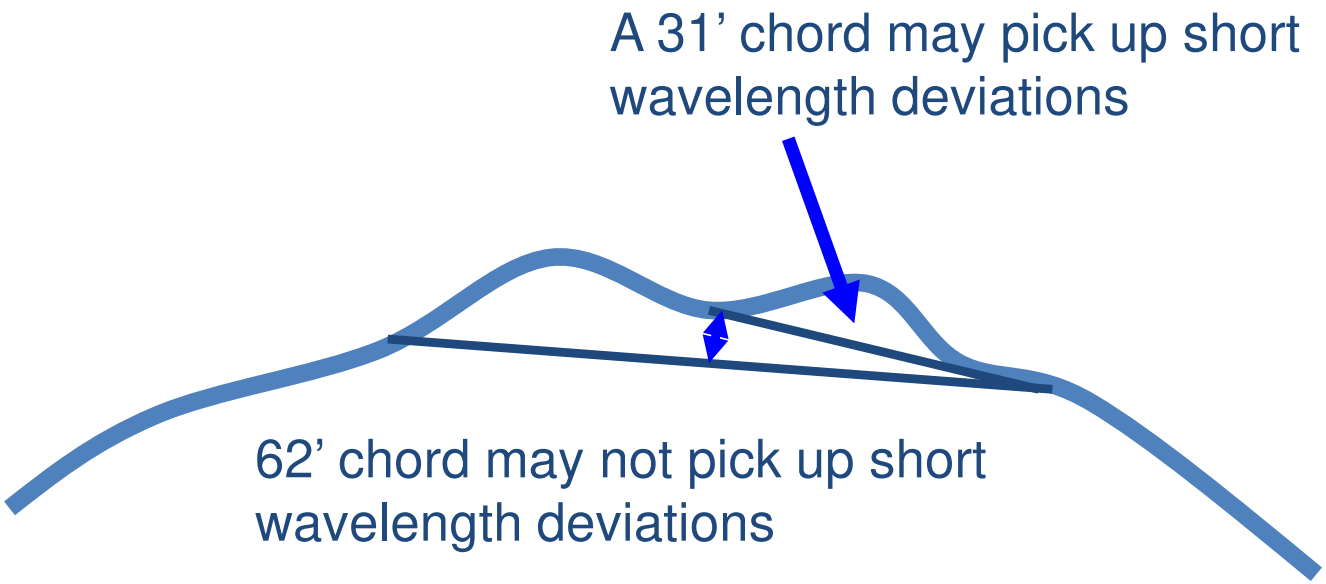
[1] The ends of the line must be at points on the gage side of the line rail, five-eights of an inch below the top of the railhead. Either rail may be used as the line rail, however, the same rail must be used for the full length of that tangential segment of track.

[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



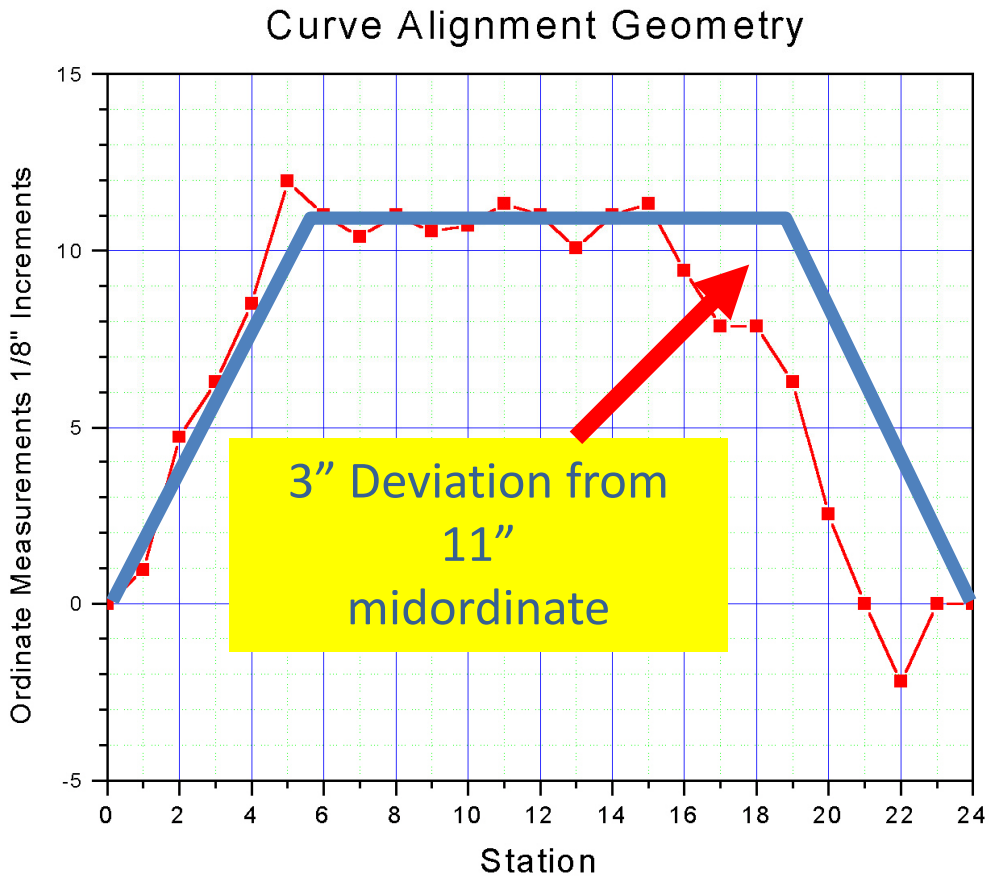
In Classes 3 through 5, both the 31-foot and 62-foot chords must be used, and corresponding measurements must be calculated to determine compliance with the required alinement thresholds. If alinement defects are found using both the 31-foot and the 62-foot chord, the inspector should report the item as one defect and note that the defect does not comply with the requirements for the second chord, e.g., "1¾ inches alinement deviation on curved track for 62-foot chord. Note: 1⅜ inches alinement deviation for 31-foot chord at this location."

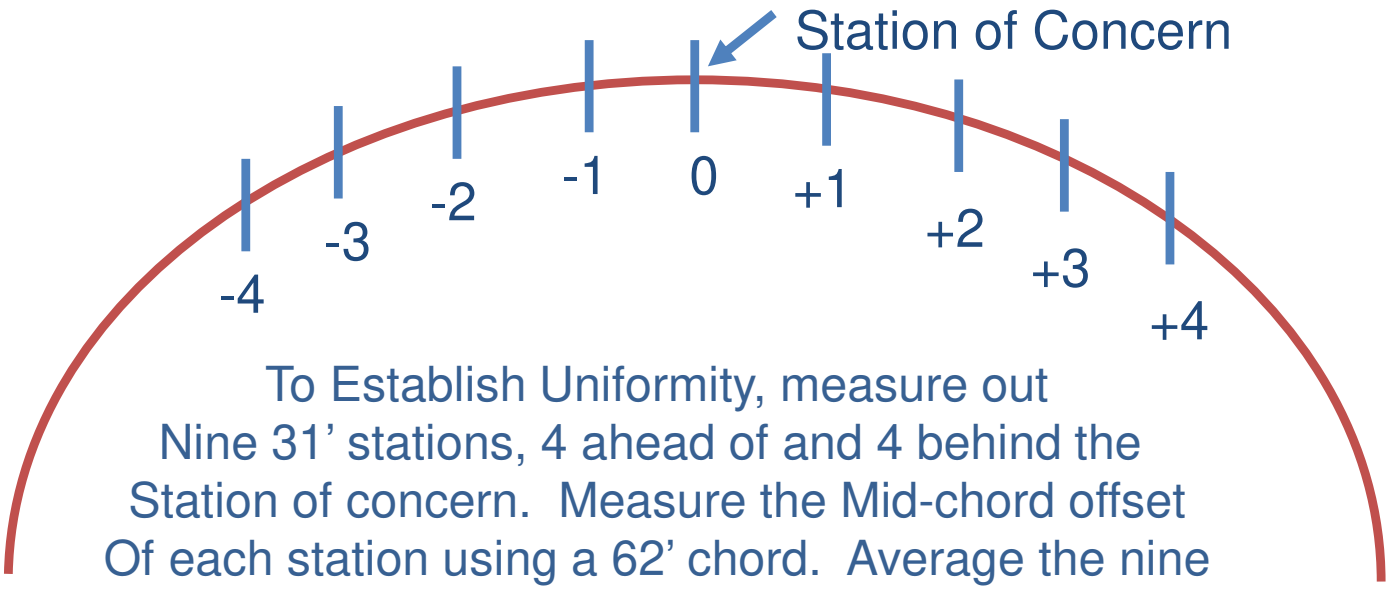


Why use a 31 ft. chord in certain situations?

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

Horizontal Alignment


Curve Alignment Geometry
Ordinate Measurements 1/8" Increments
15
10
5
0
-5
0
2
4
6
8
10
12
14
16
18
20
22
24
Station
3” Deviation from 11” midordinate



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

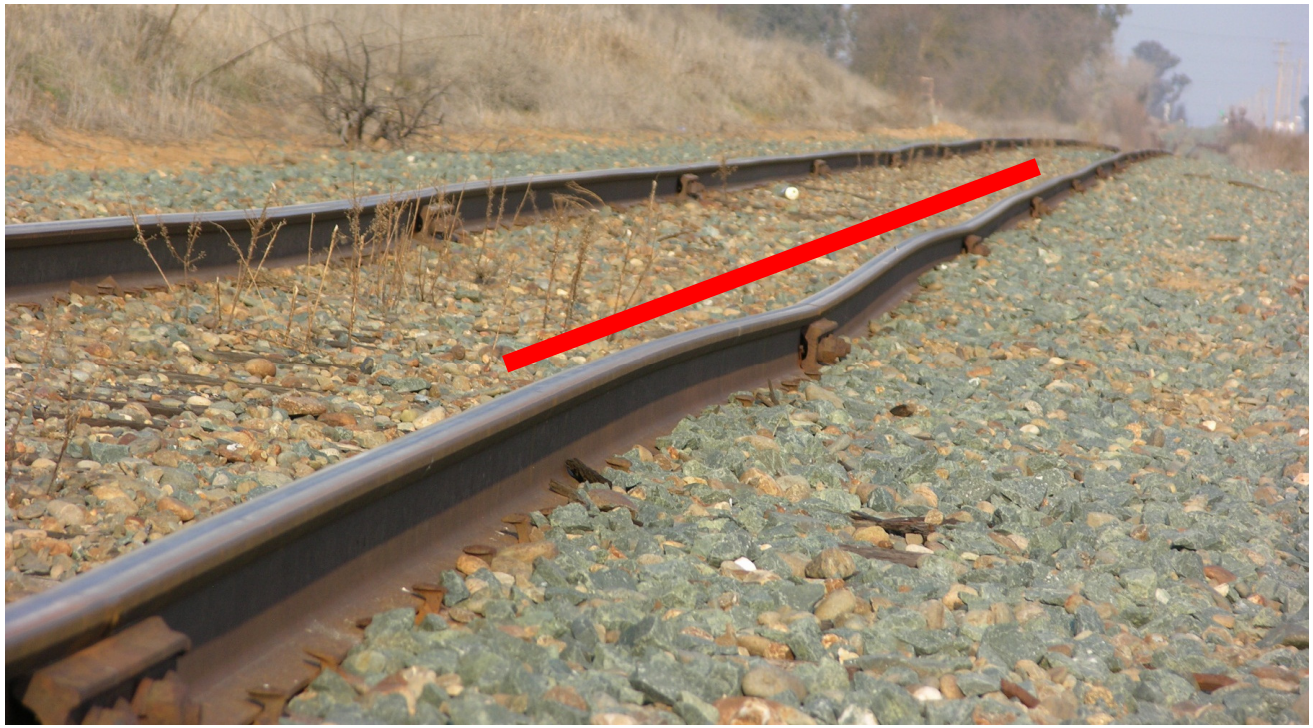
§ 213.63 Track surface.

(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

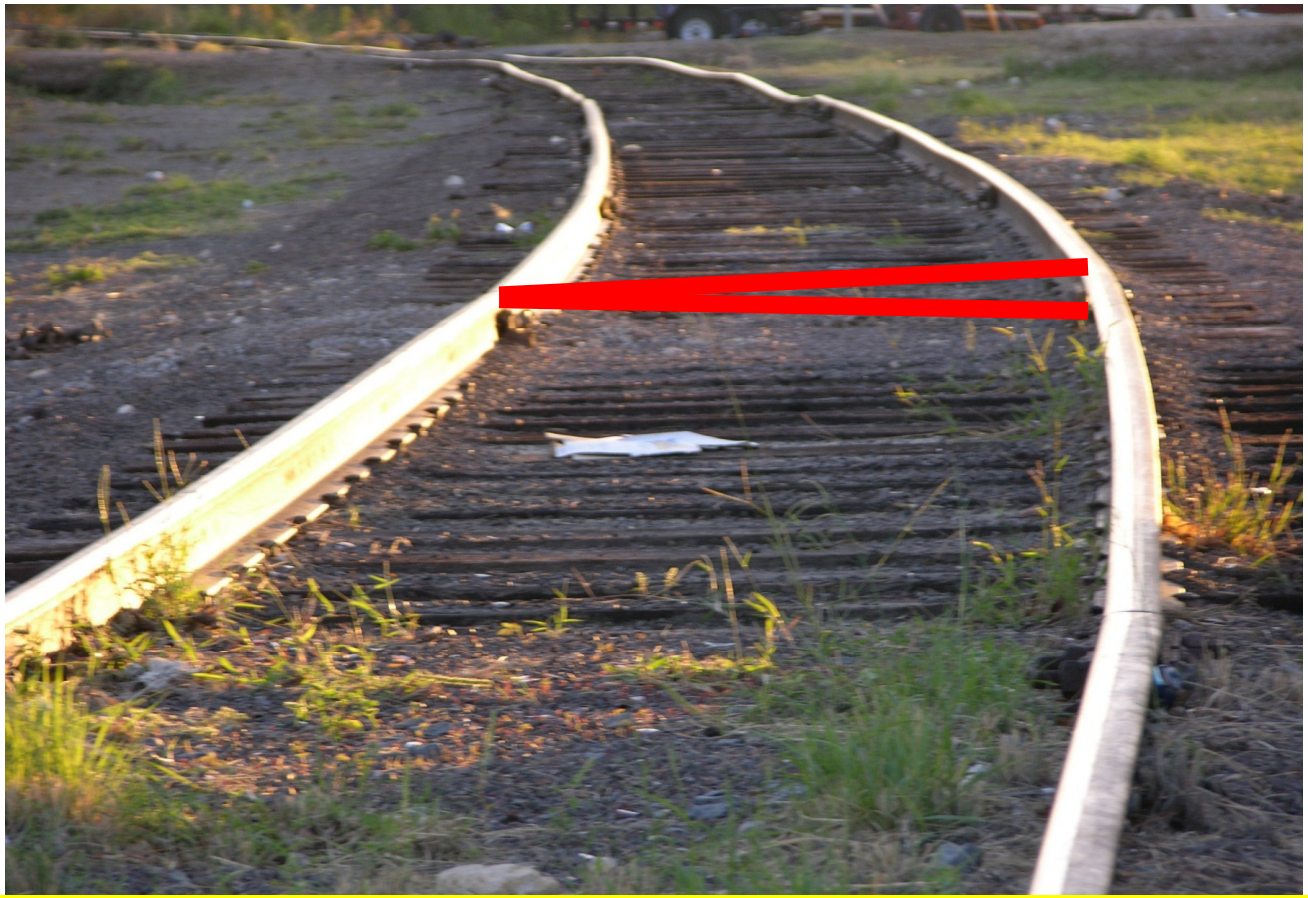
[1]Except as limited by § 213.57(a), where the elevation at any point in a curve equals or exceeds 6 inches, the difference in crosslevel within 62 feet between that point and a point with greater elevation may not be more than 11/2 inches.

[2]However, 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.



Vertical Profile

Crosslevel Variations/Deviation

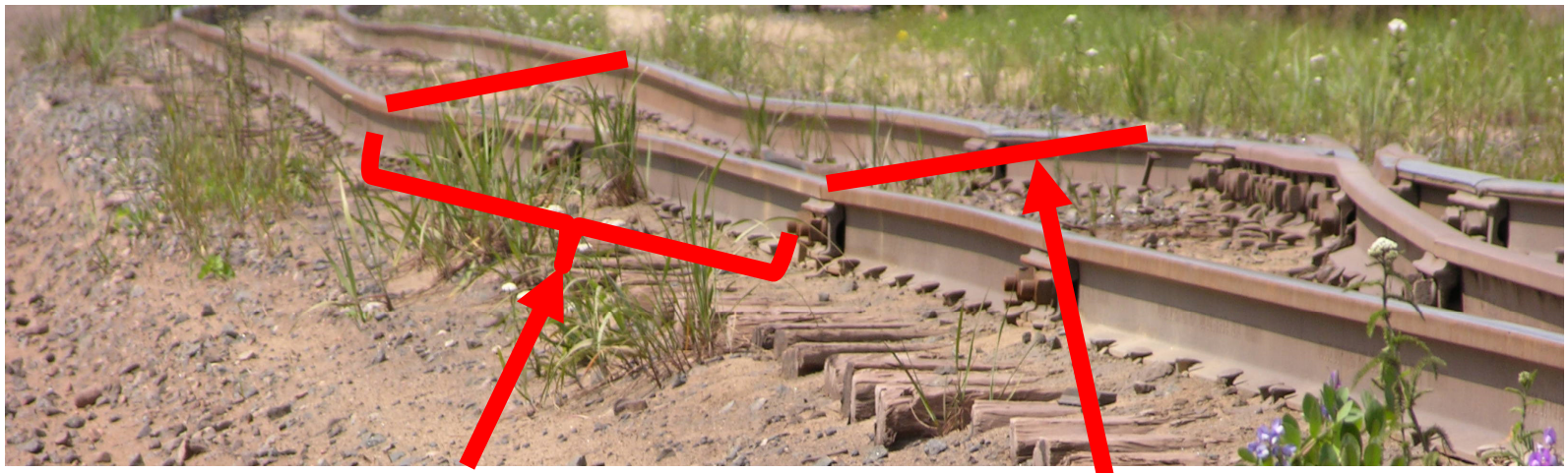


Curve Superelevation and Crosslevel

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.

§ 213.13 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.

§ 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

[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 than 11/2 inches.

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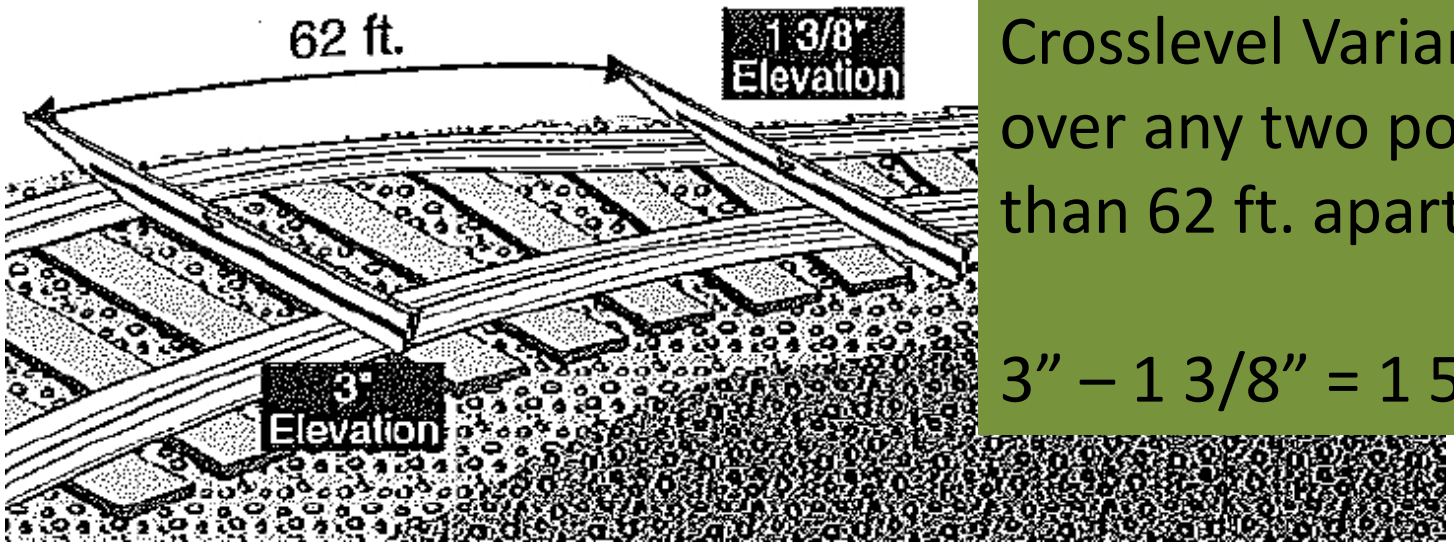
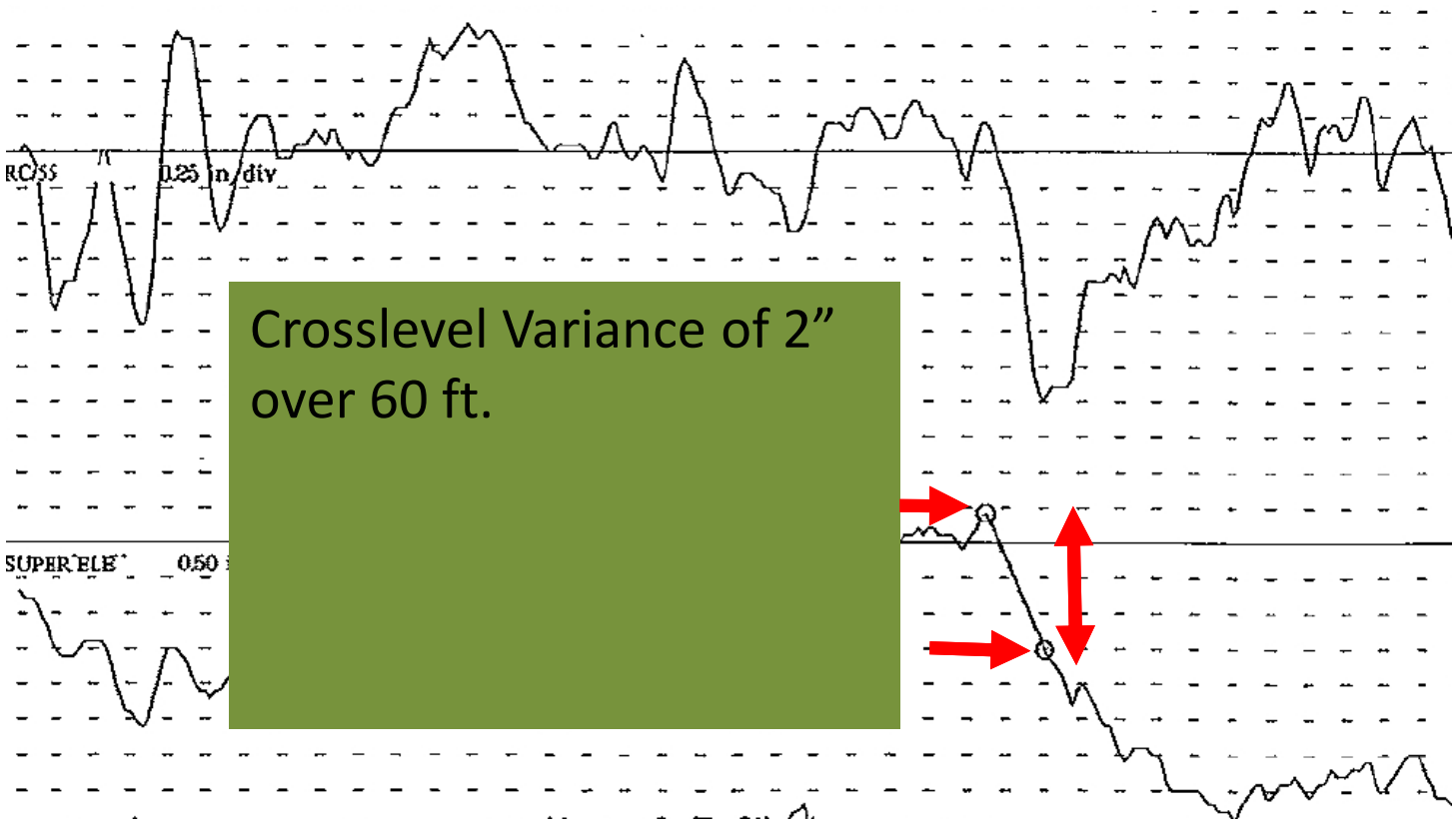
Crosslevel Variations

Any two Crosslevel measurements less than 62’ apart



Crosslevel Variance over any two points less than 62 ft. apart.

3” – 1 3/8” = 1 5/8”


Crosslevel Variance of 2”
over 60 ft.

§ 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

[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 than 11/2 inches.

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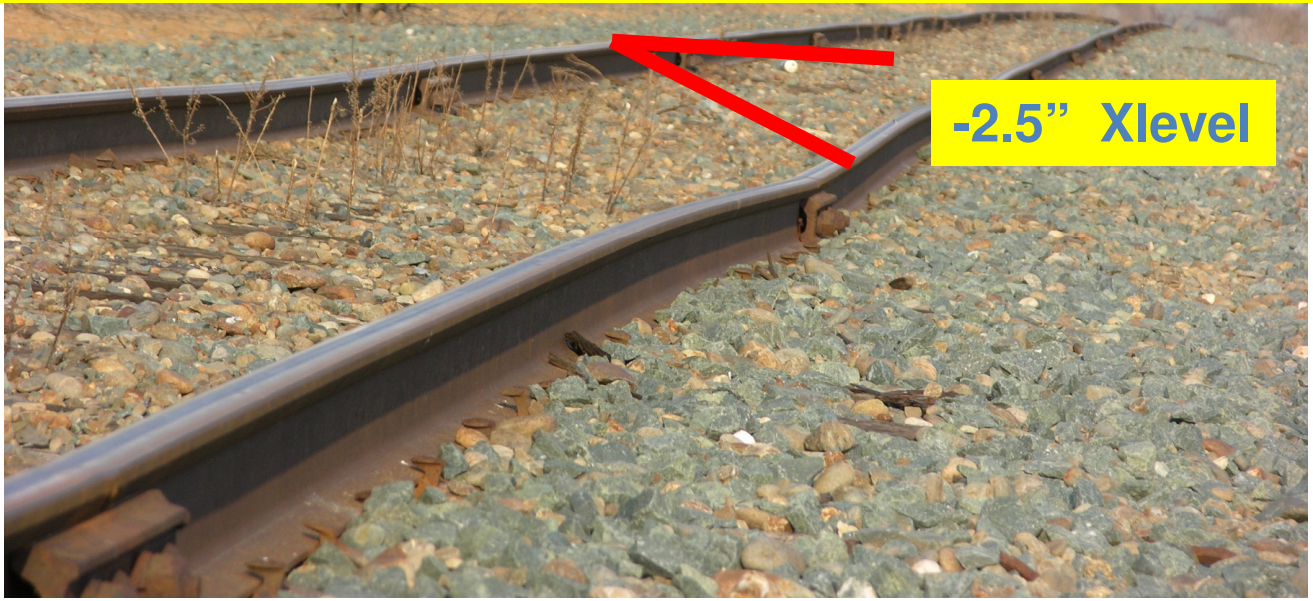
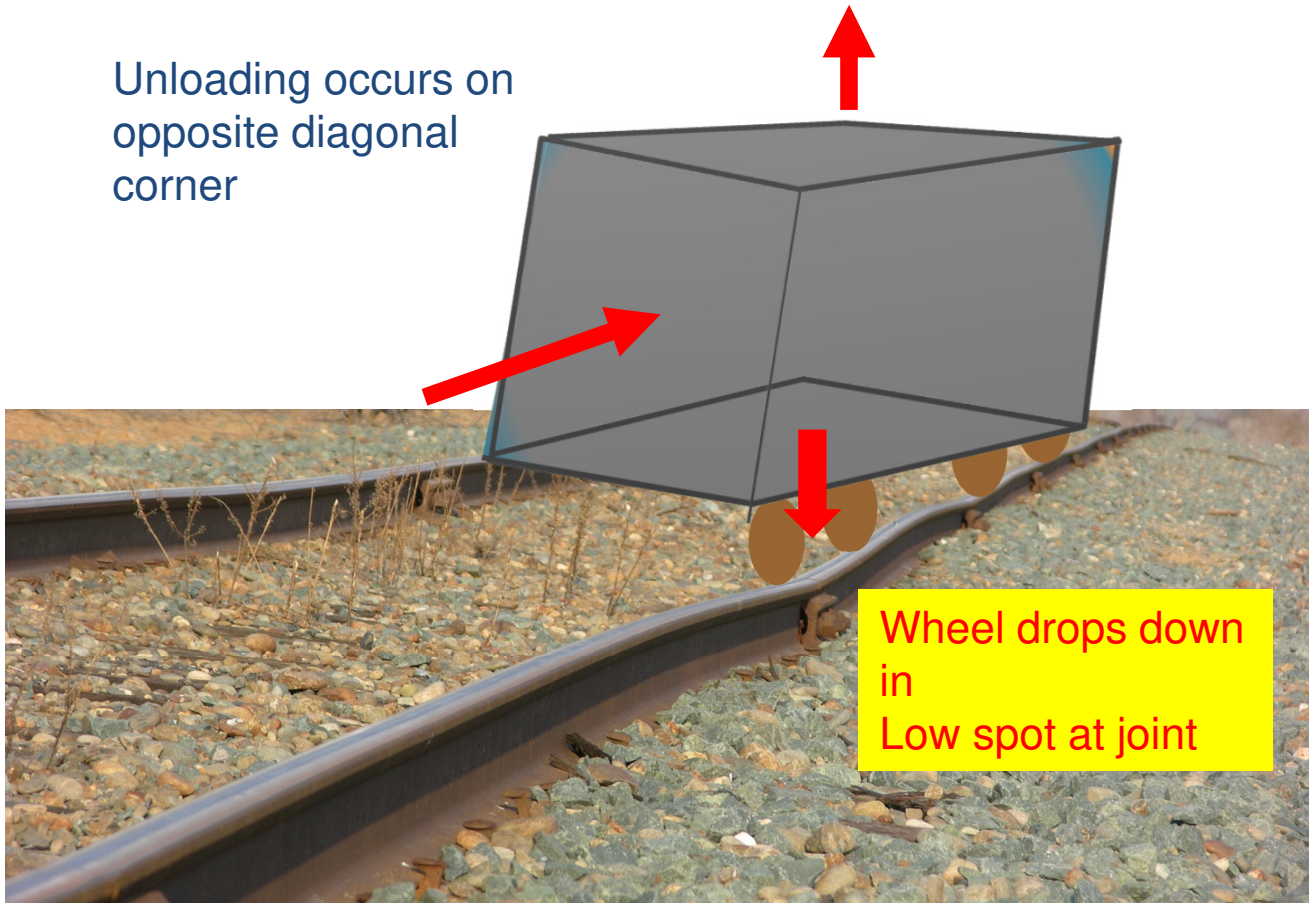
Crosslevel Deviations



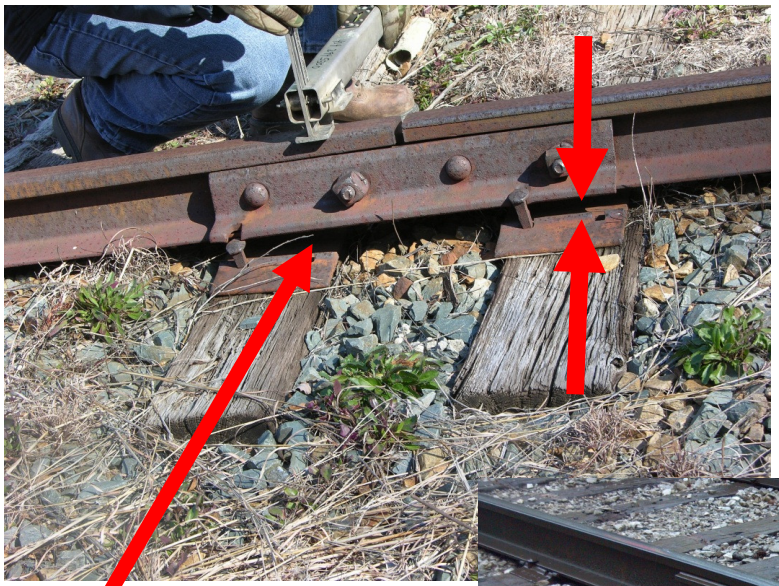
Deviation from Zero Crosslevel at any point on tangent, or reverse crosslevel in curves may not be more than

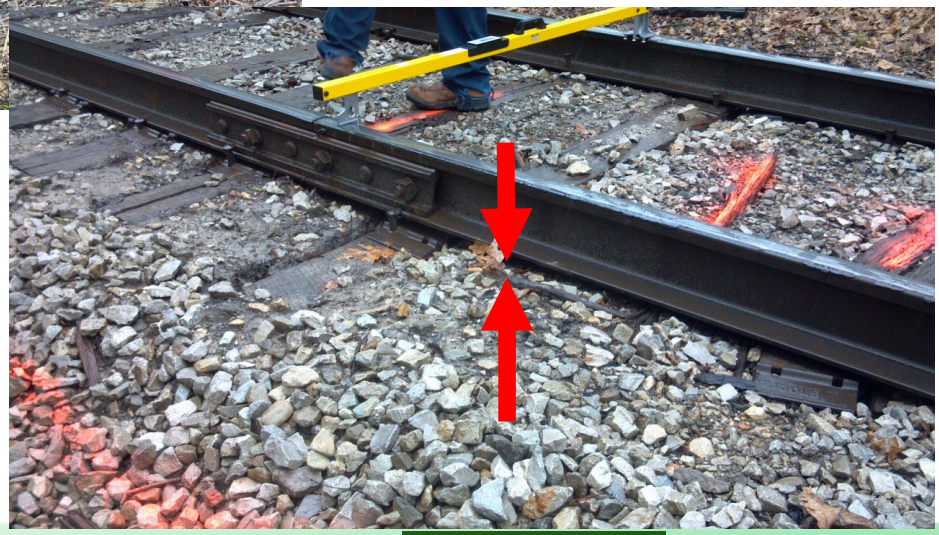
Class	1	2	3	4	5
Deviation	3”	2”	1 ¾”	1 1/4”	1 ”

Unloading occurs on opposite diagonal corner



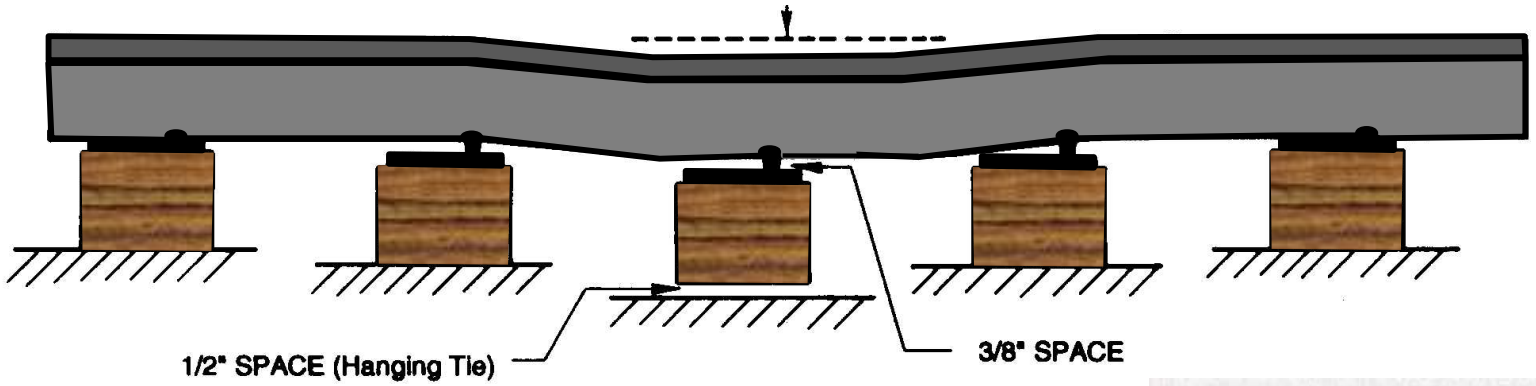
Wheel Unloading/Lift due to Crosslevel Variation Between rear and front trucks





Hanging Ties

MEASURED CROSSLEVEL 1”



MEASURED CROSS LEVEL	1"
SPACE UNDER TIE PLATE	3/8"
SPACE UNDER TIE	1/2"
ACTUAL CROSSLEVEL UNDER LOAD	1 7/8"

§ 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.

MEASURING CROSSLEVEL NOT UNDER LOAD

§ 213.63 Track surface.

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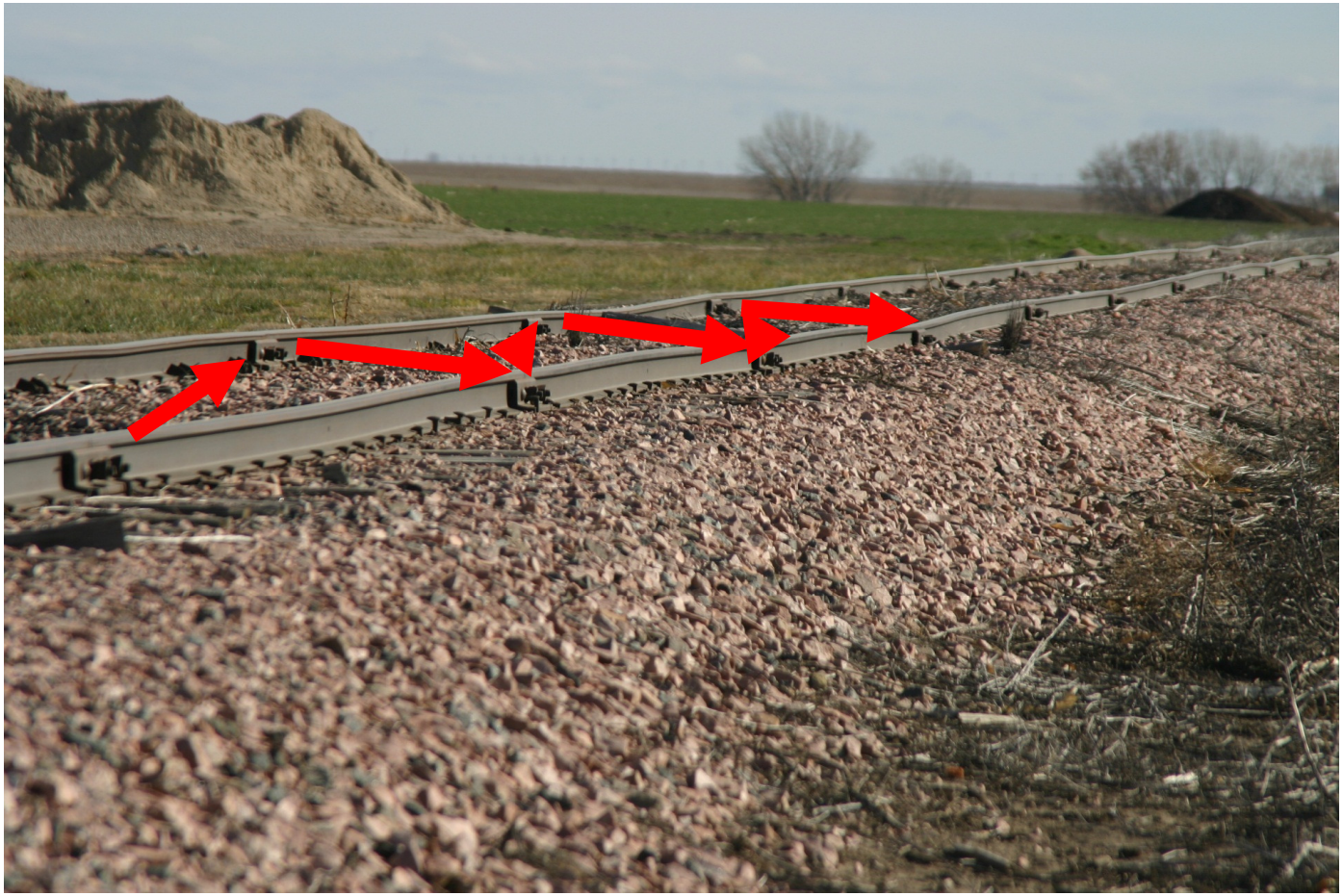
	1	2	3	4	5
The runoff in any 31 feet of rail at the end of a raise may not be more than	3 1/2	3	2	1 1/2	1
The deviation from uniform profile on either rail at the mid-ordinate of a 62-foot chord may not be more than	3	2 3/4	2 1/4	2	1 1/4
The deviation from zero crosslevel at any point on tangent or reverse 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

[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 than 11/2 inches.

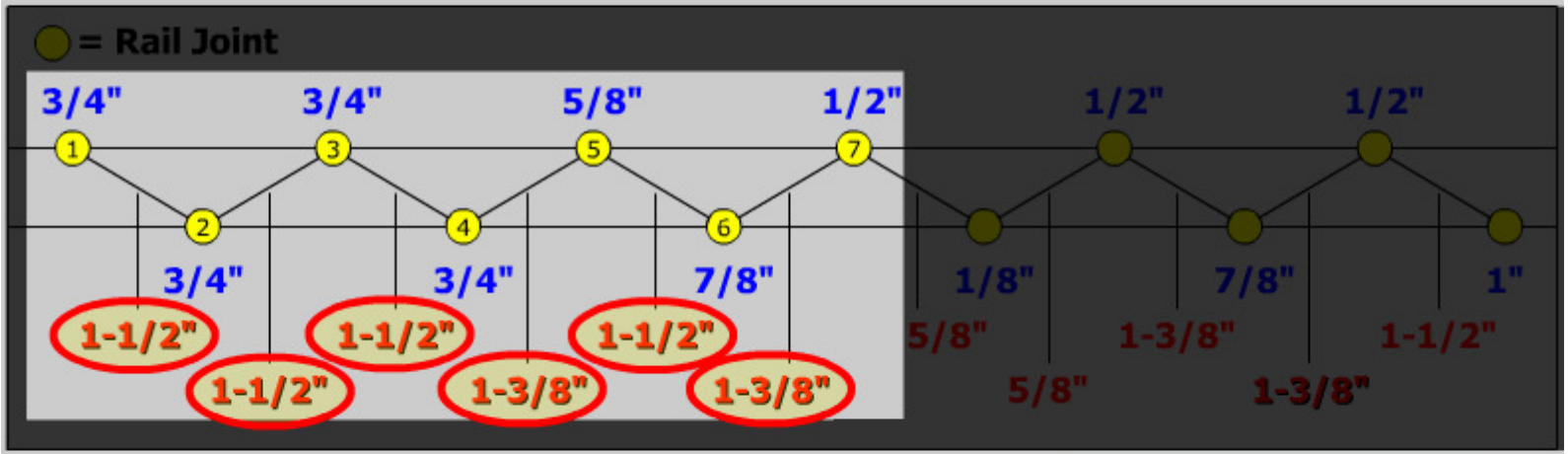
[2]However, to control harmonics on Class 2 through 5 jointed track with staggered joints, the crosslevel differences shall not exceed 11/4 inches in all of six consecutive pairs of joints, as created by seven low joints. Track with joints staggered less than 10 feet apart shall not be considered as 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.

Staggered Jointed Rail (Joints staggered greater than 10’ apart)



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.

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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

[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 than 11/2 inches.

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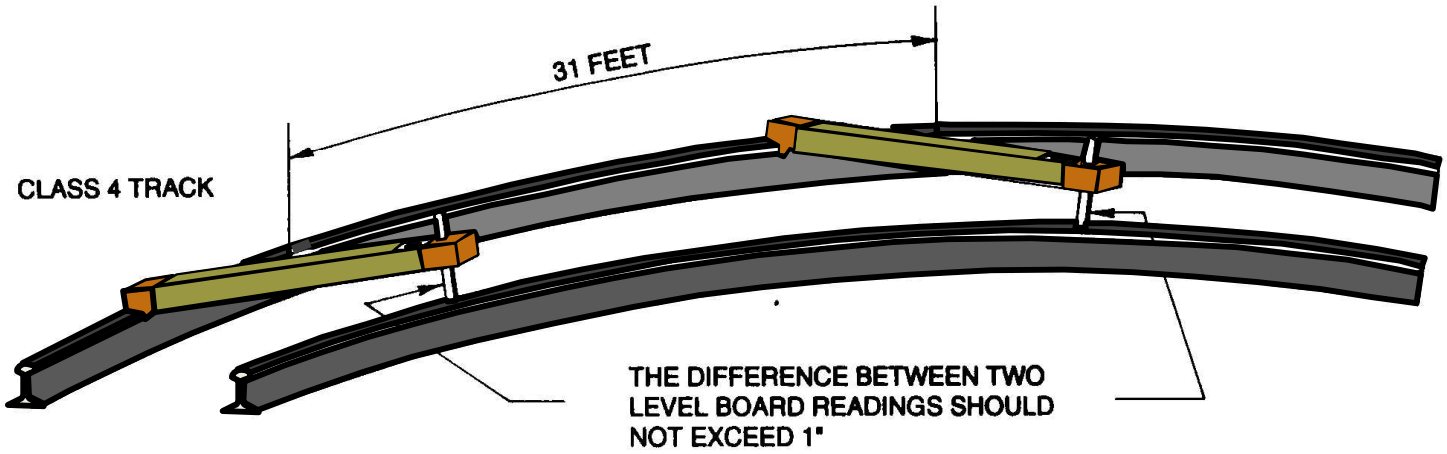
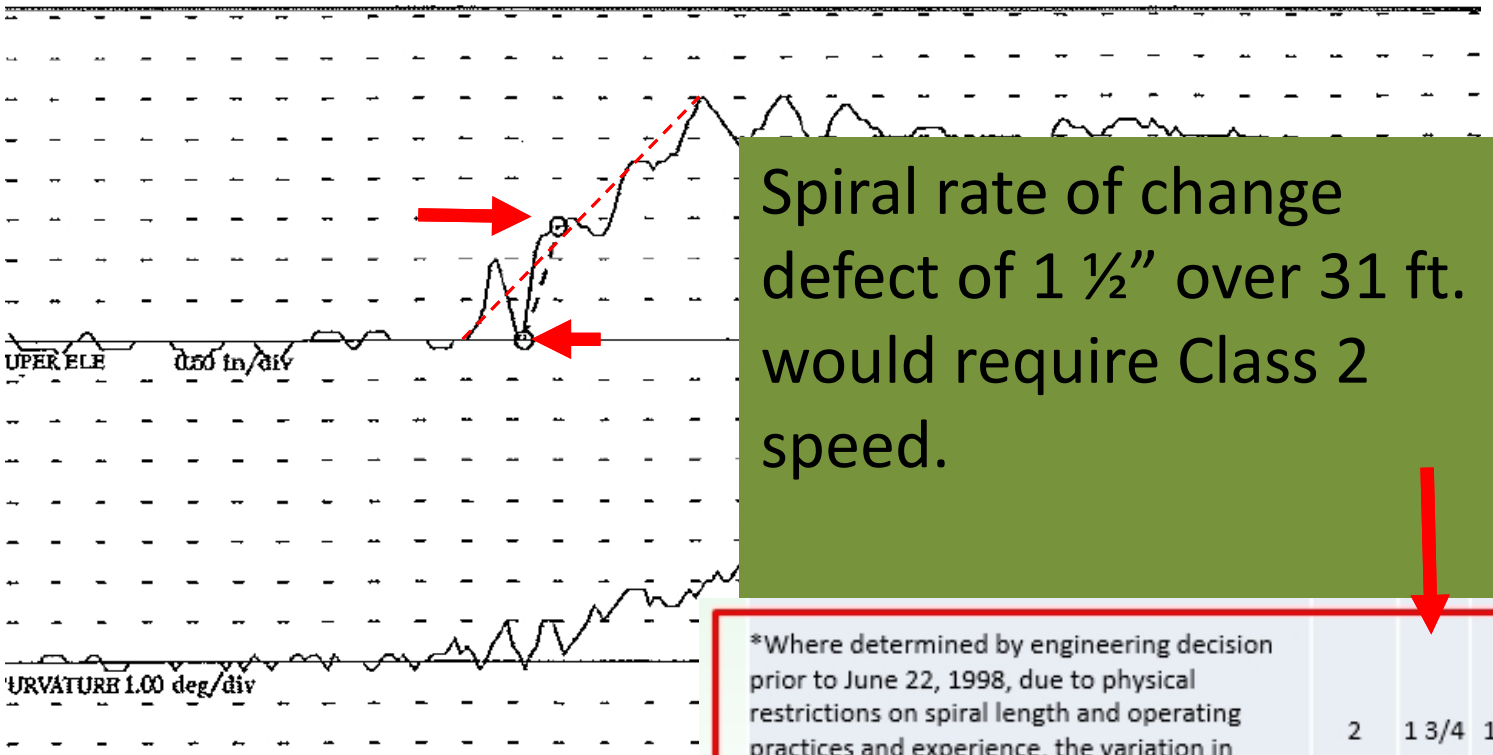
VARIATION IN CROSSLEVEL ON SPIRALS



	CLASS OF TRACK				
	1	2	3	4	5
VARIATION IN CROSSLEVEL ON SPIRALS IN ANY 31' MAY NOT BE ANY MORE THAN	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	½”	3/8”	3/8”
3	1”	¾”	3/8”
4	1 ½”	1”	1/4”
5	2”	1 1/8”	1/8”
6	2 ½”	1 7/8”	3/4”



Spiral rate of change defect of 1 ½" over 31 ft. would require Class 2 speed.

*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

§ 213.63 Track surface.

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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

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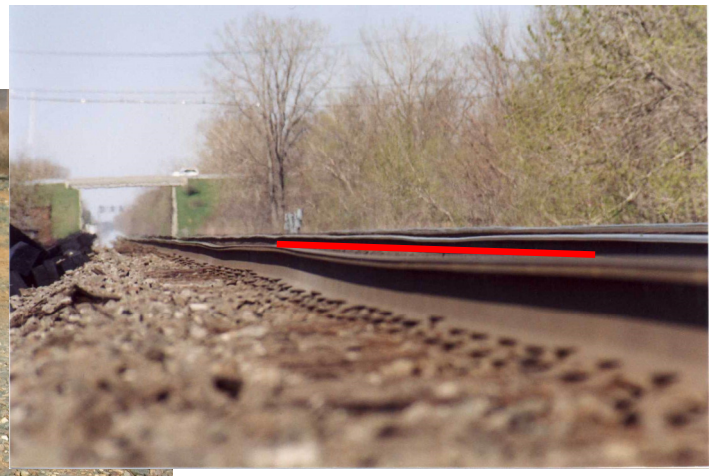
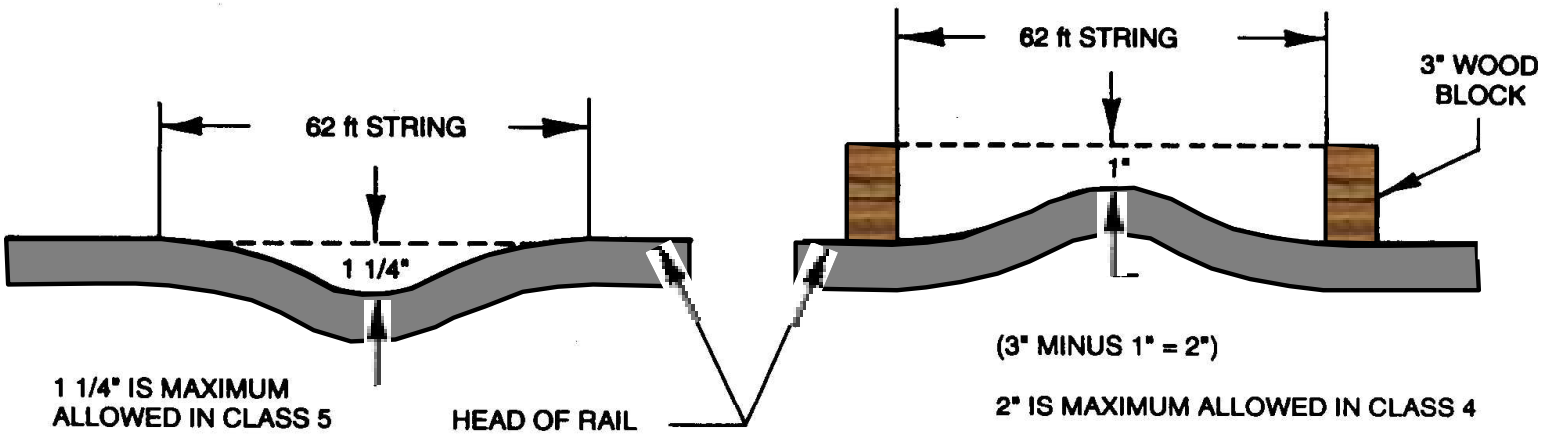
Vertical Profile Deviations



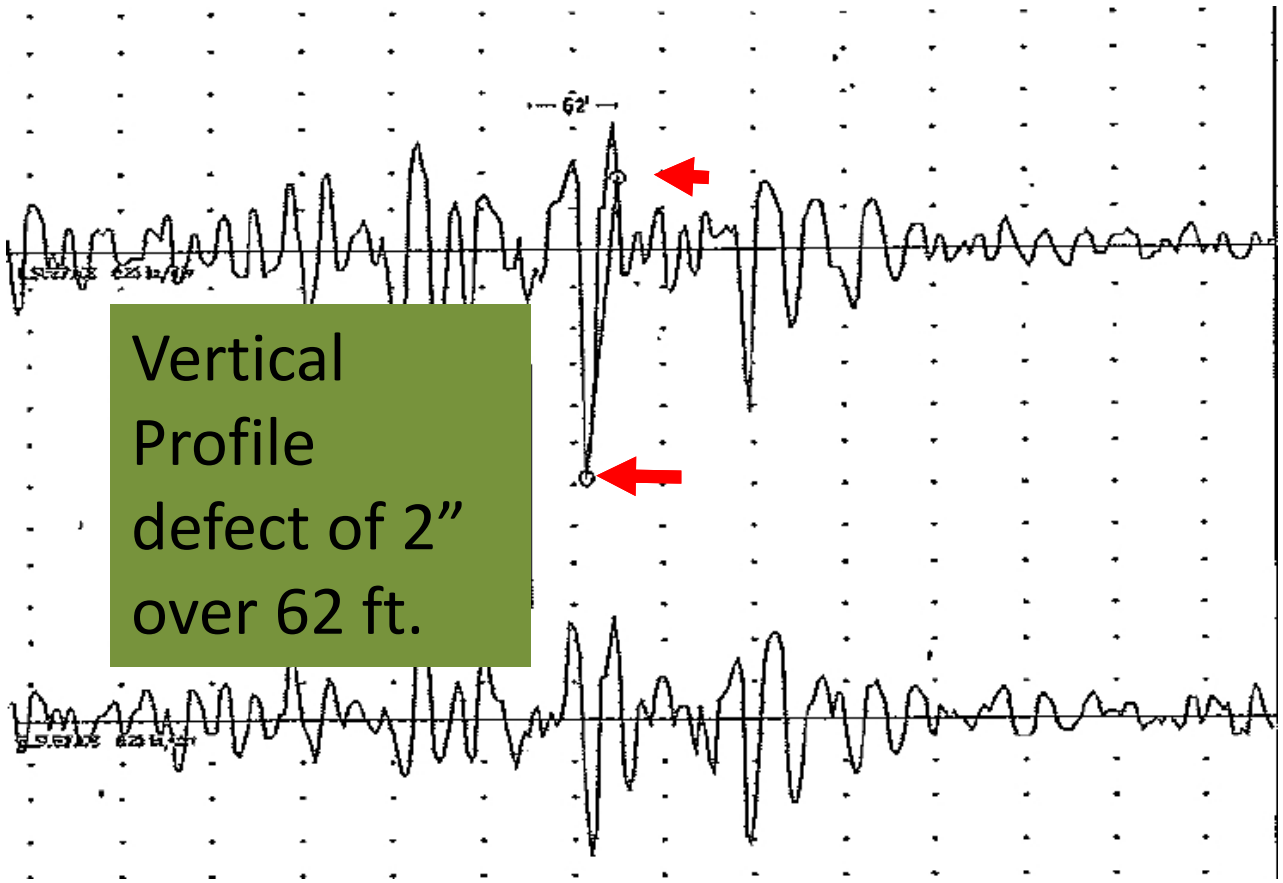
Vertical profile deviation caused by poor subgrade

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"


62'
Vertical Profile defect of 2” over 62 ft.

§ 213.63 Track surface.

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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

[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 than 11/2 inches.

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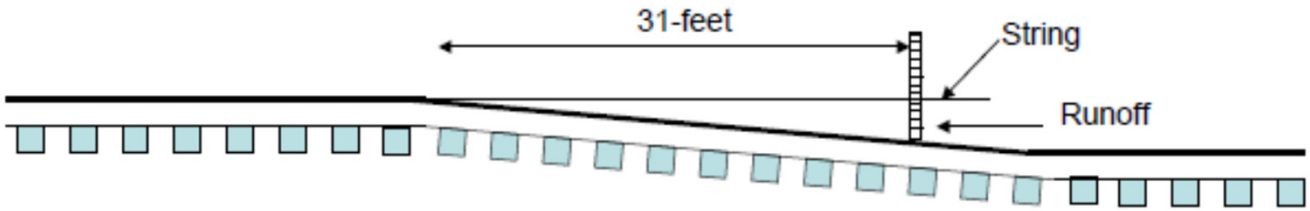
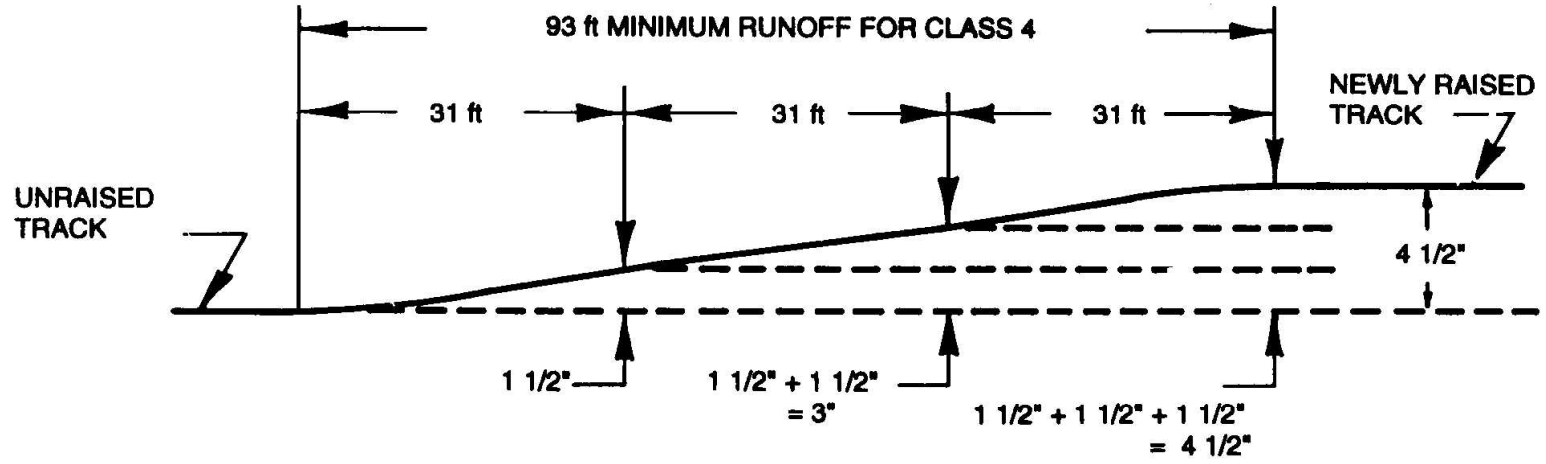
Frost Heaves causing a raise in the track due to track degradation



Rate of Runoff over 31 feet

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



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


The End