



Principles of Track, Track Components, & Geometry

Presented by:
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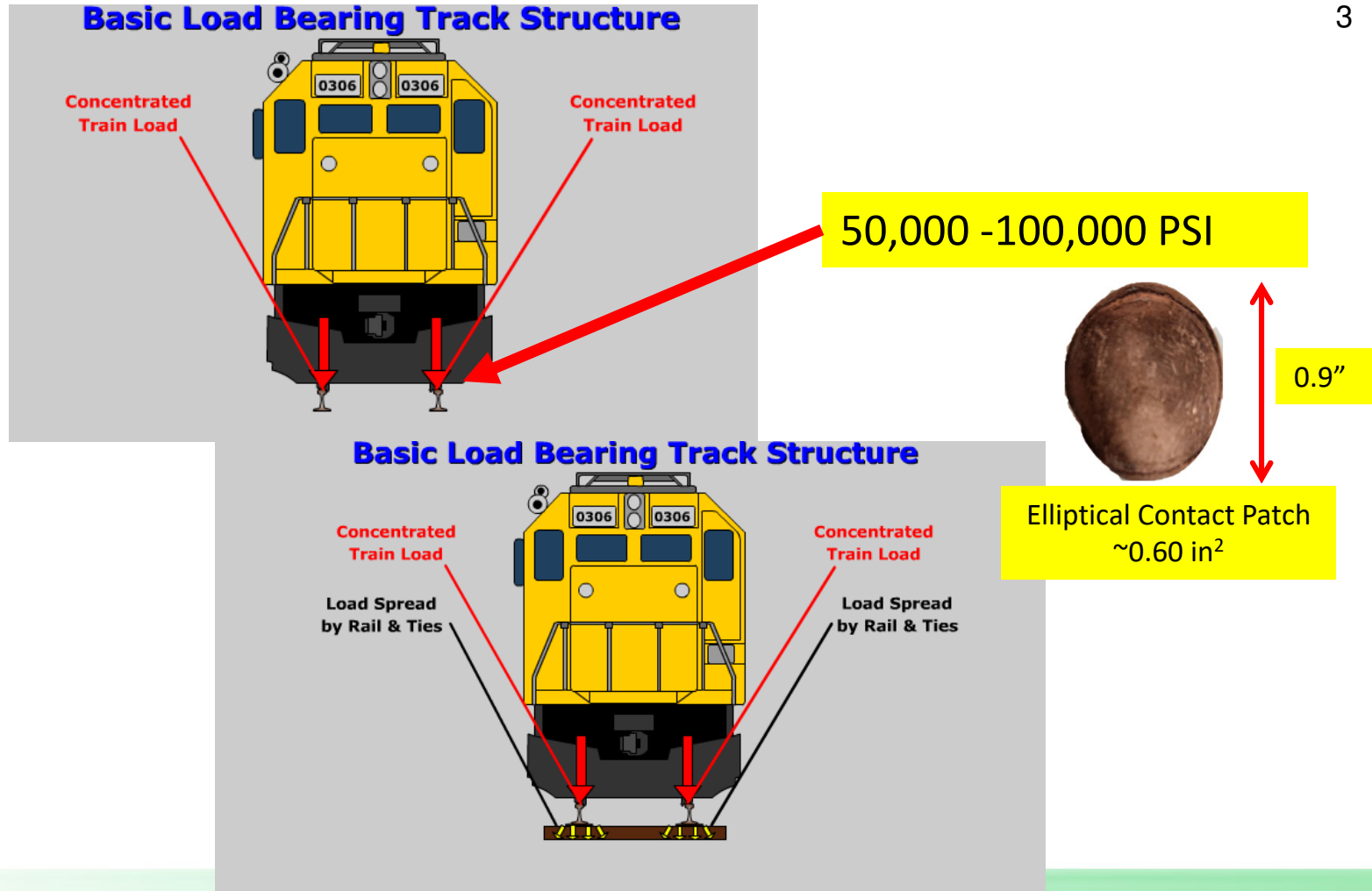


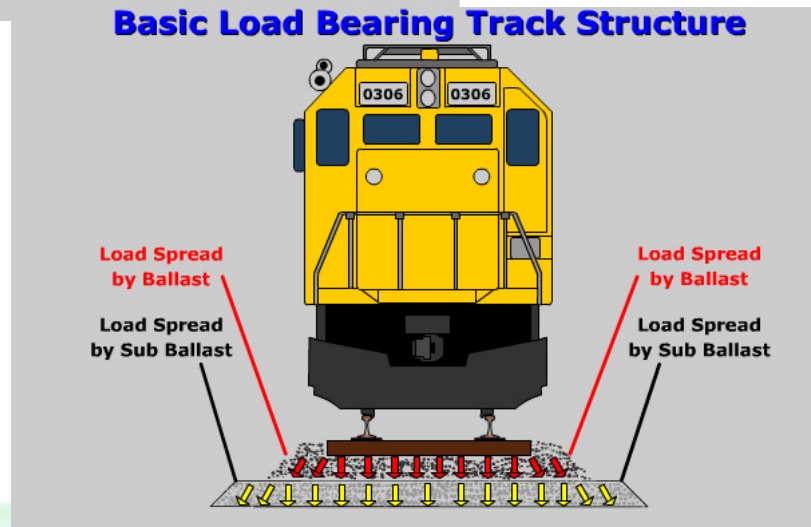
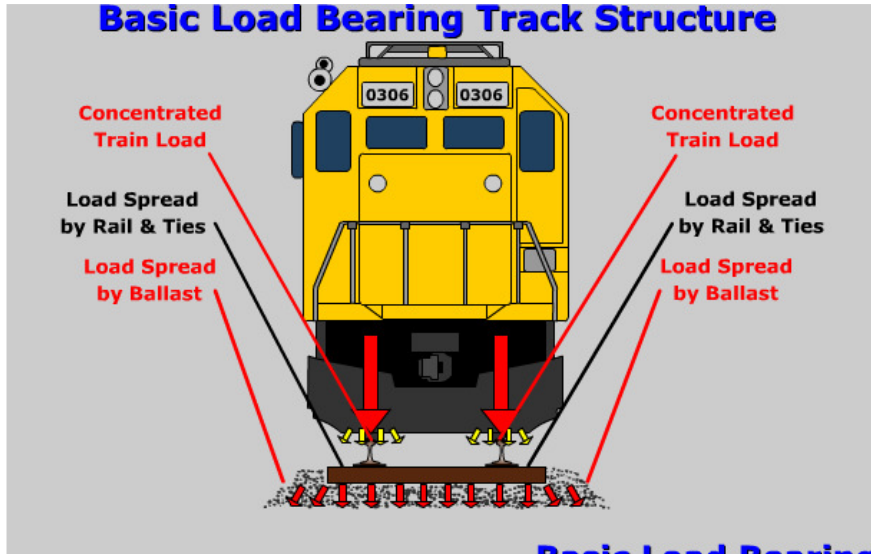
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Agenda & Topics

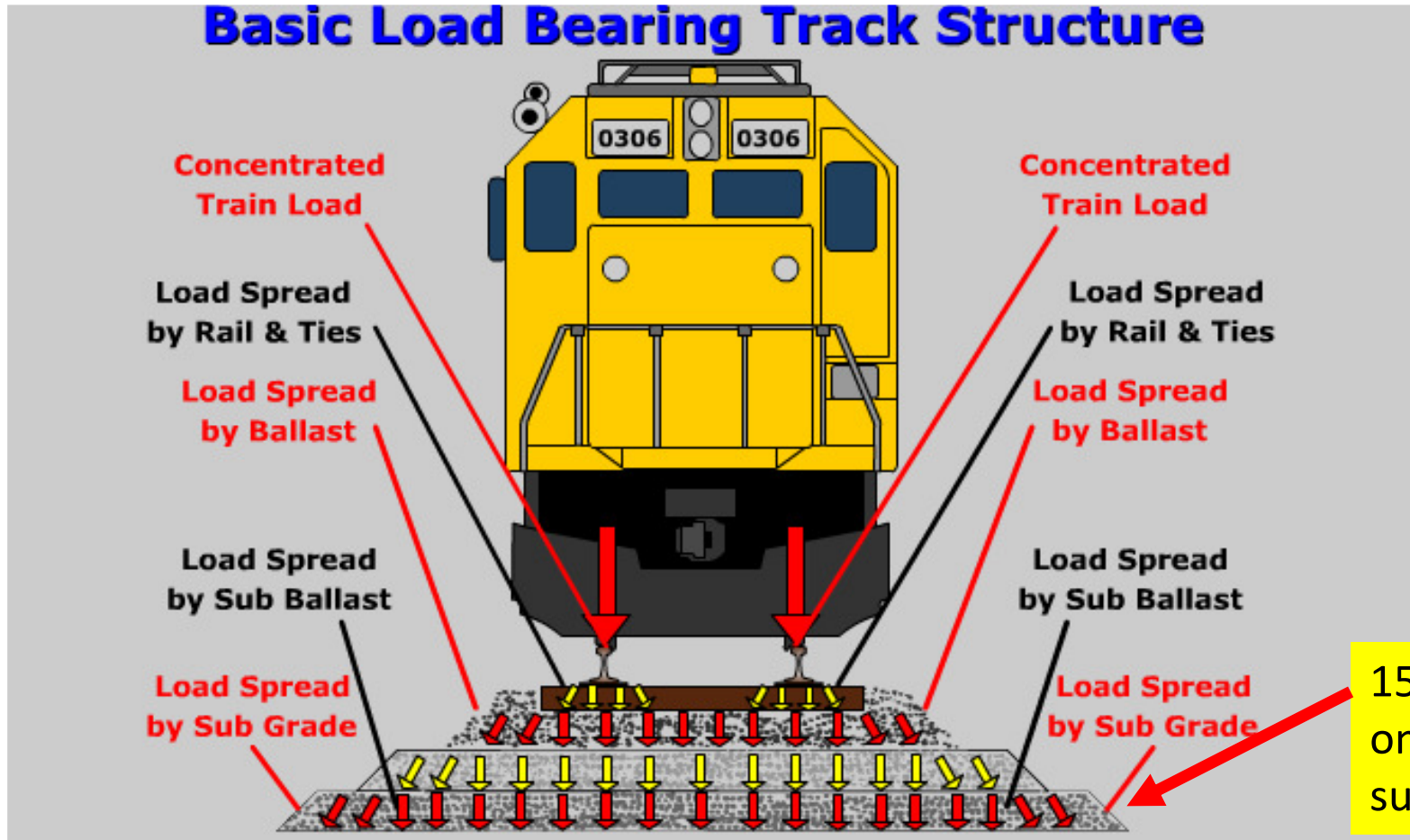
- **Track Structure as a System**
- **Curves and Curve Geometry**
- **Turnouts and components**
- **Derails**
- **OWLS and Jump Frogs**
- **Quick Summary of Track Geometry**







Basic Load Bearing Track Structure



15 - 20 PSI on the subgrade



Curves and Curve Geometry

2 characteristics of curves



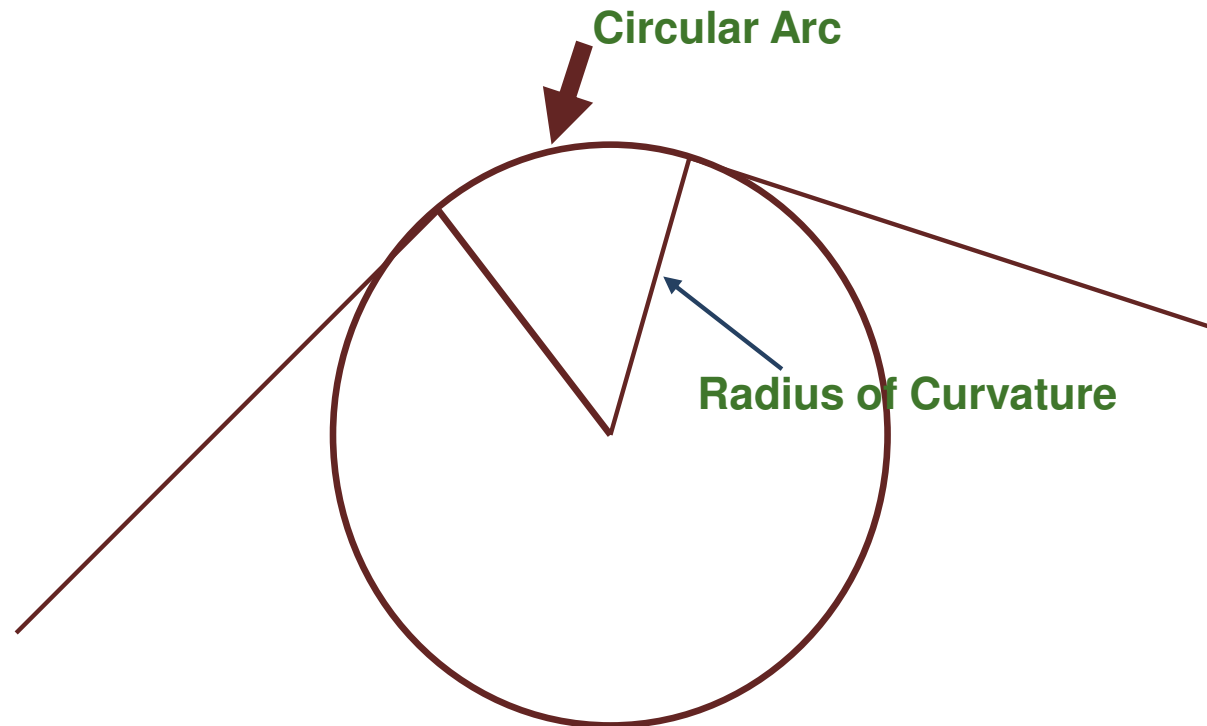
Elevation



Alignment



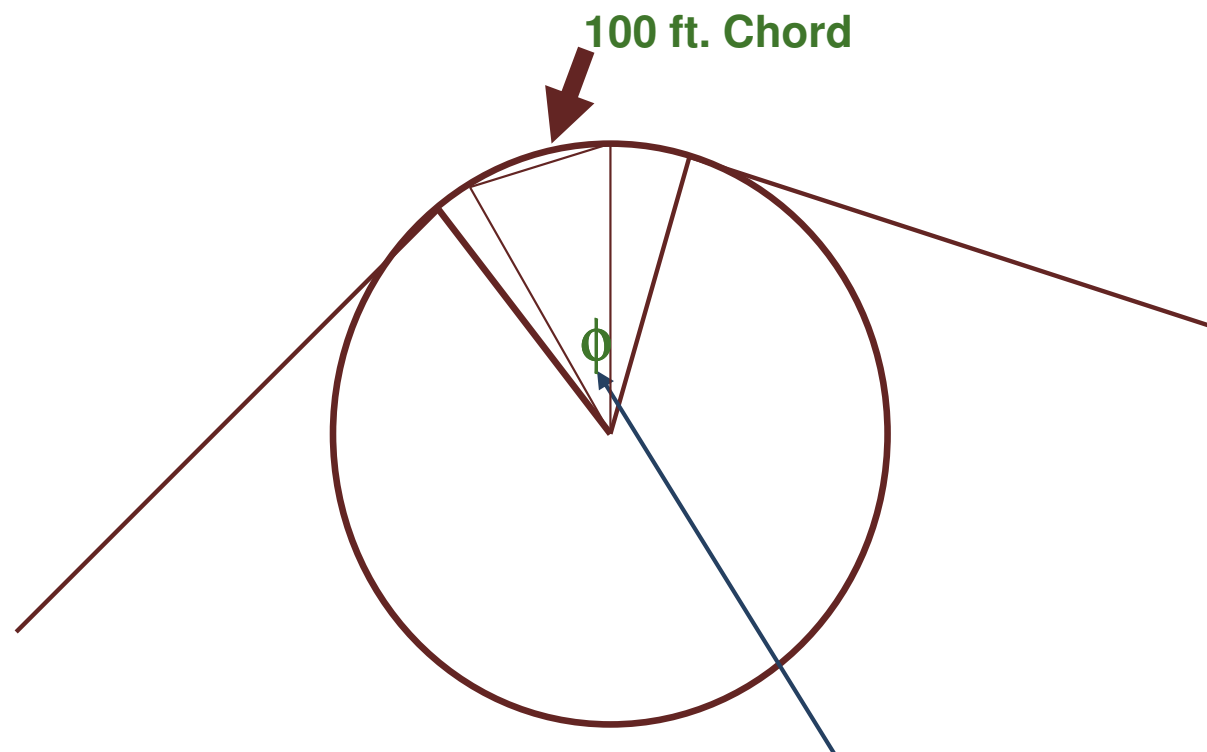
Definition of a Curve



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



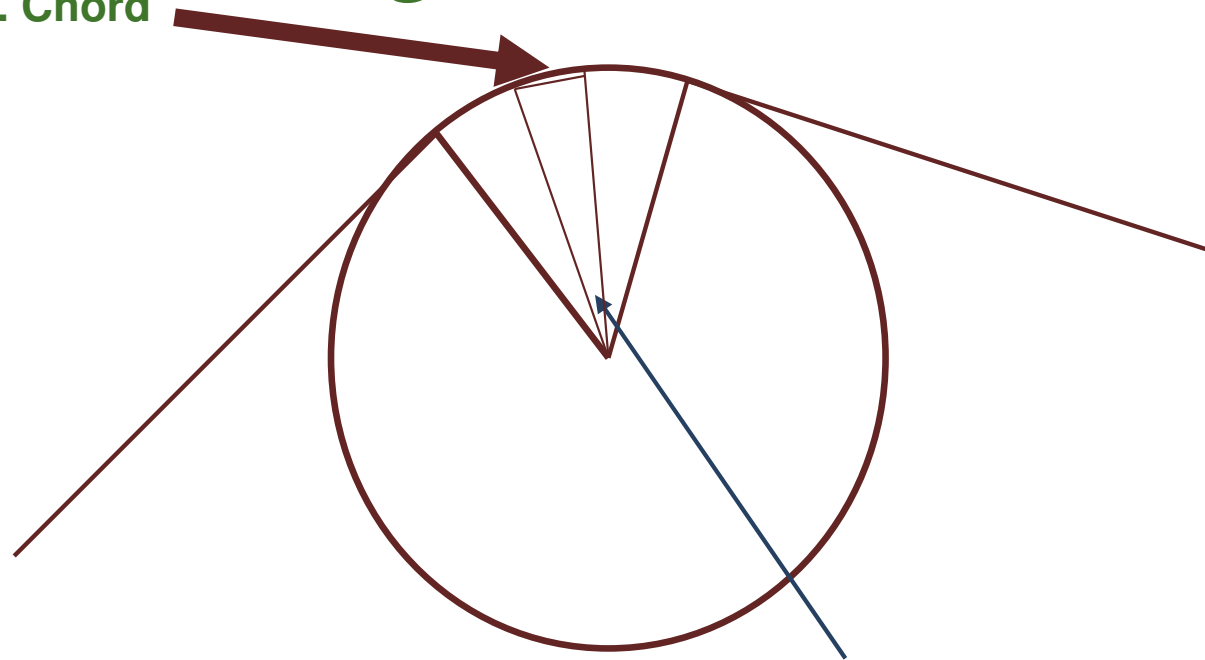
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Estimating degree of curvature using a 62 ft. chord

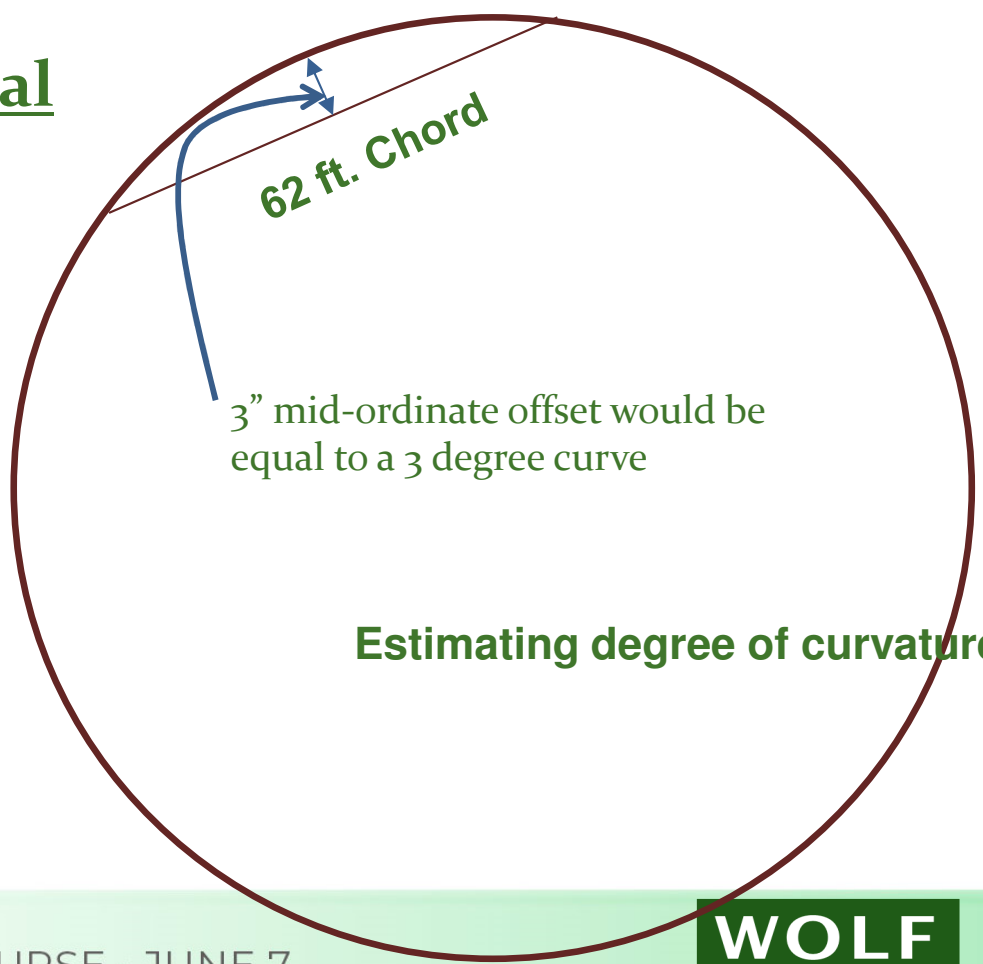
62 ft. Chord



**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

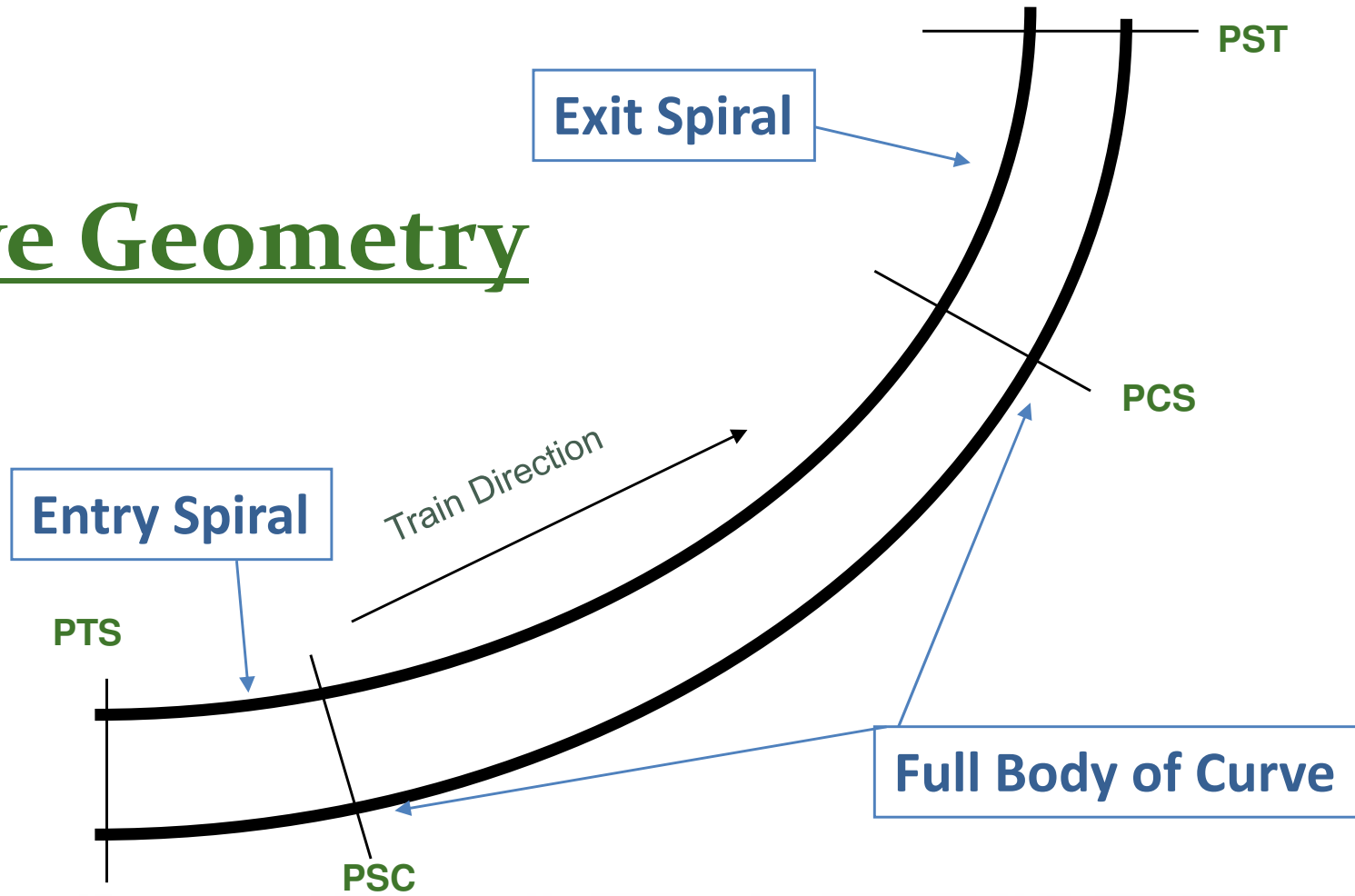


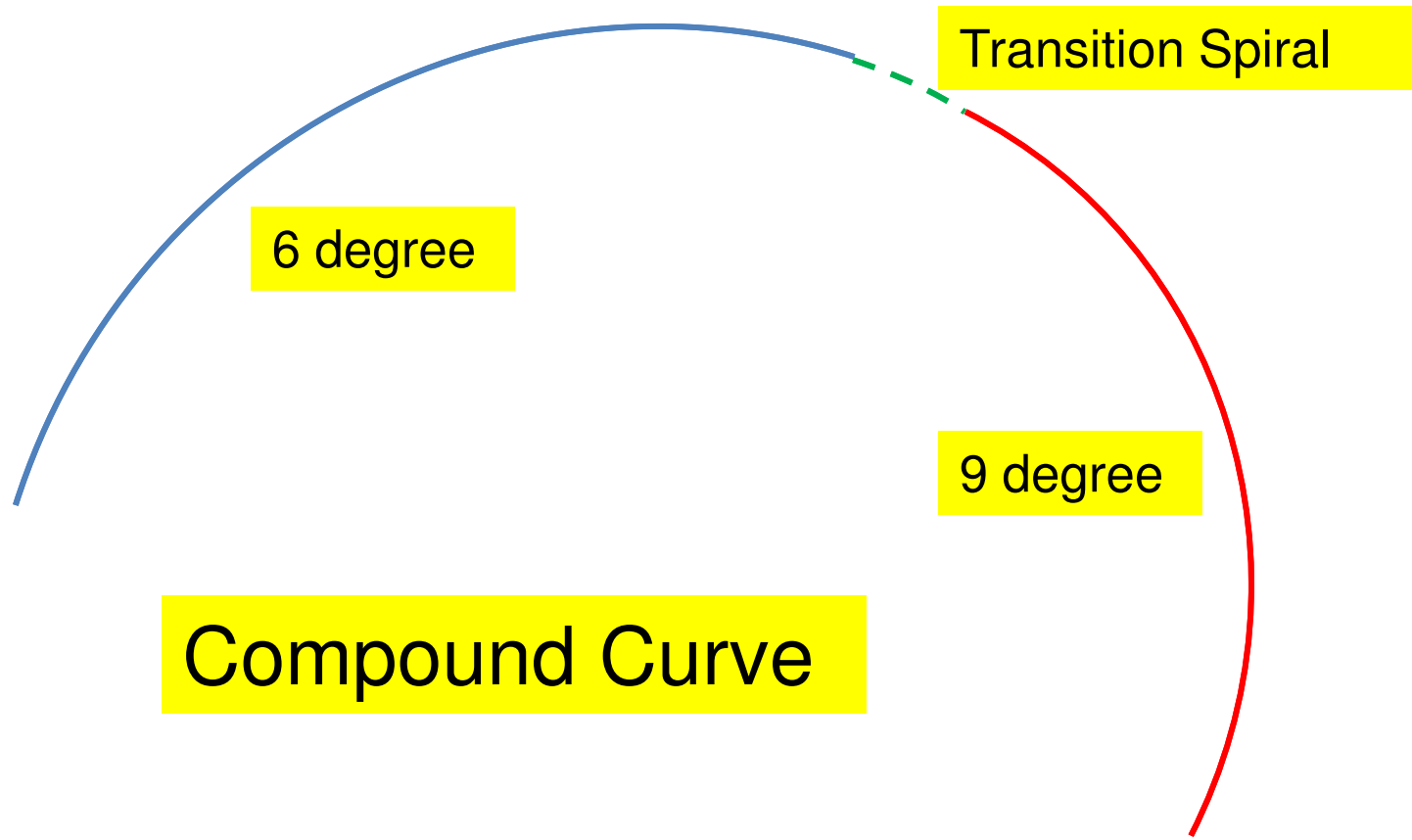
Degree of Curve & Radius

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'

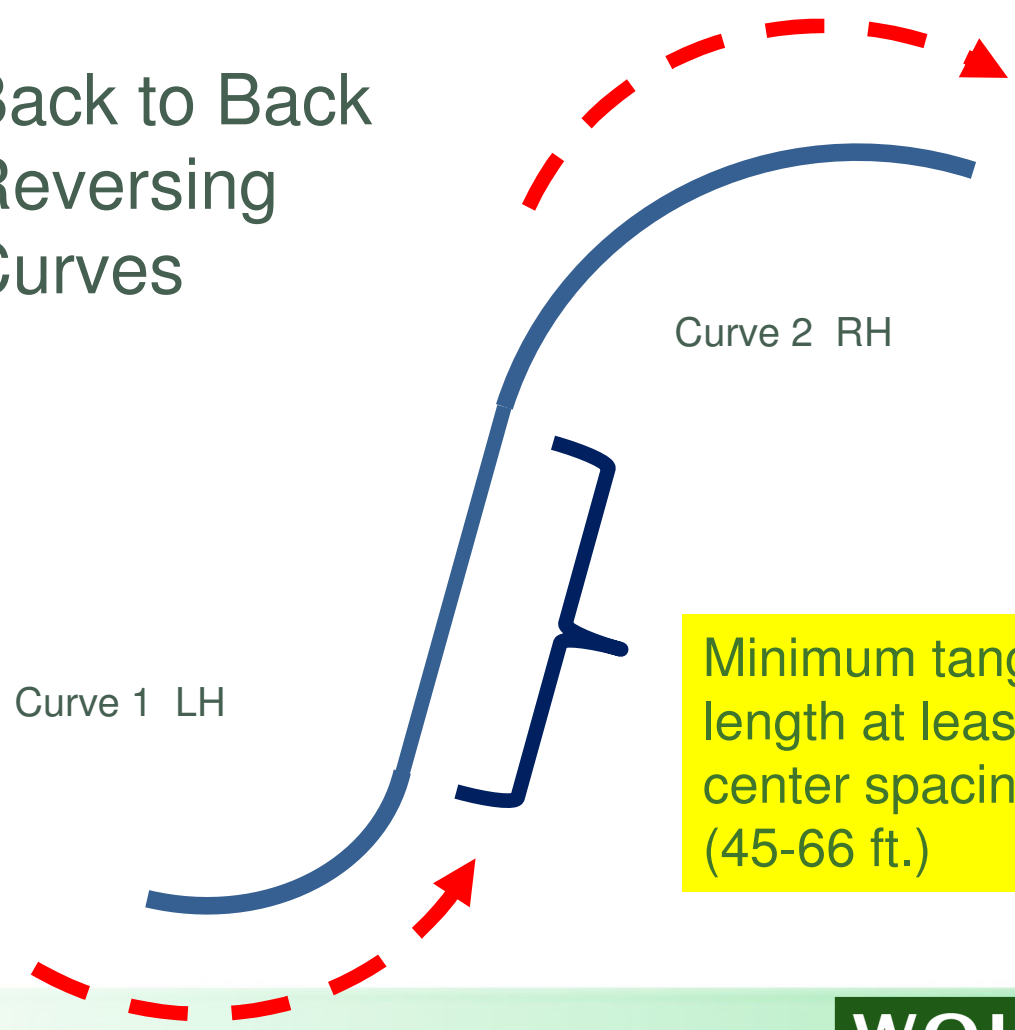


Curve Geometry





Back to Back Reversing Curves



Curve 2 RH

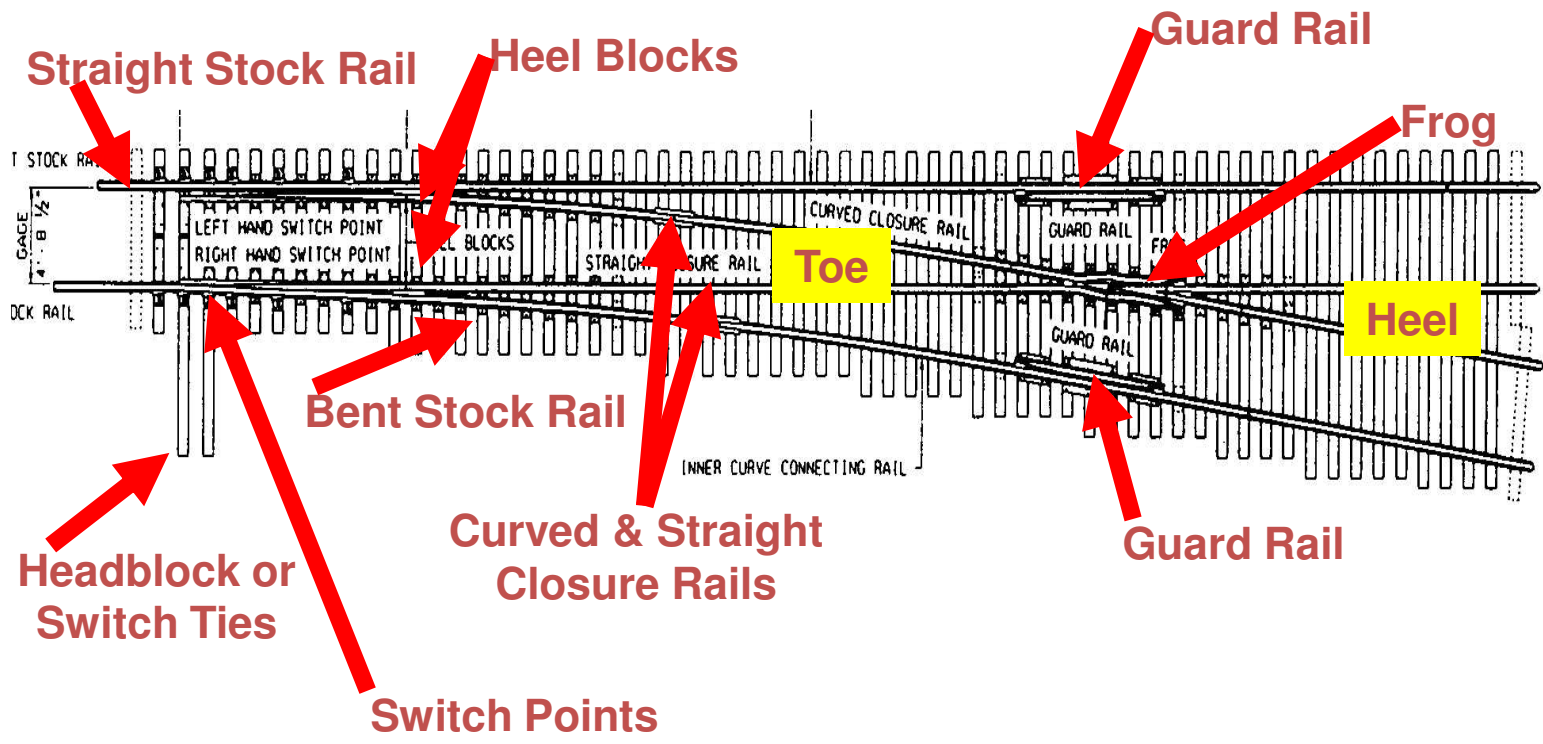
Curve 1 LH

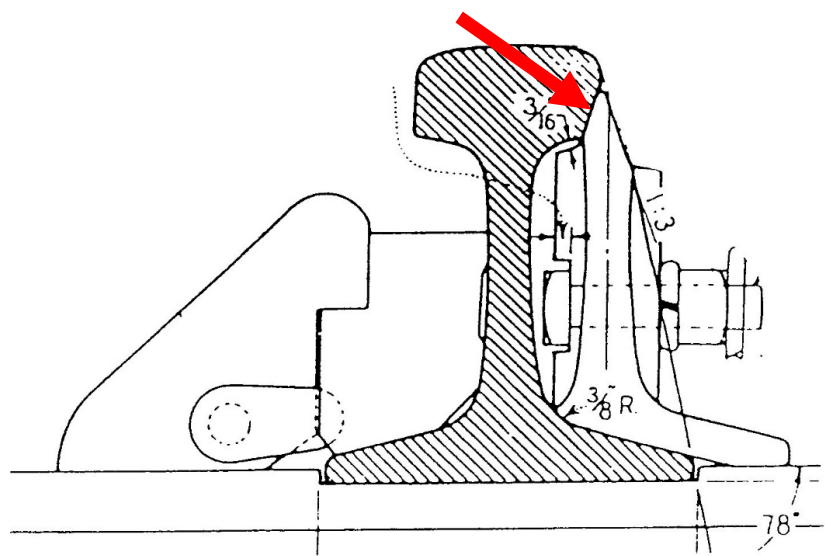
Minimum tangent length at least truck center spacing; (45-66 ft.)



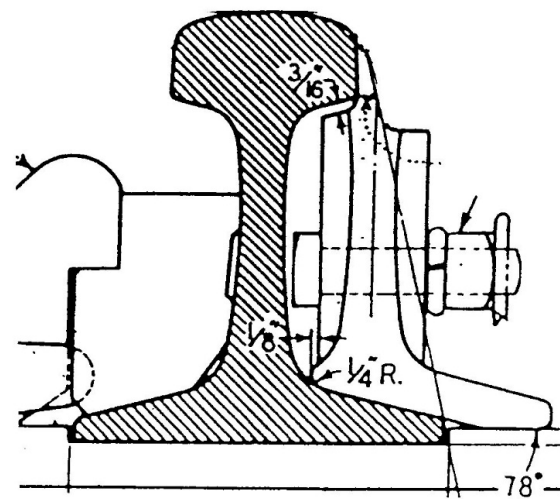
Lack of sufficient intervening tangent between back to back reverse curves







Samson Point



Standard Point



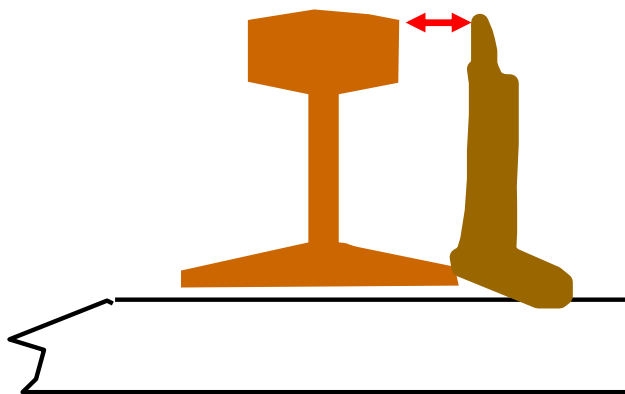
Switch Point Throws

1st. Rod = 4 3/4" +/- 1/16 ←

2nd Rod = 3 15/16" +/- 1/16

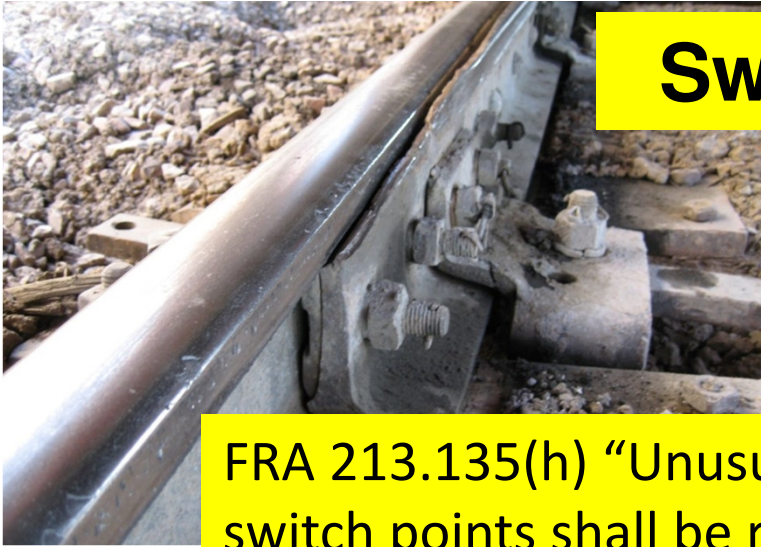
3rd Rod = 3 1/16" +/- 1/16

Note: If you can throw and latch a switch without undo force with a 1/4" obstruction behind the switch point, then adjustment of the throw is necessary to insure sufficient pressure is holding the point against the stock rail.





Switch Point Issues



FRA 213.135(h) “Unusually chipped or worn switch points shall be repaired or replaced...”





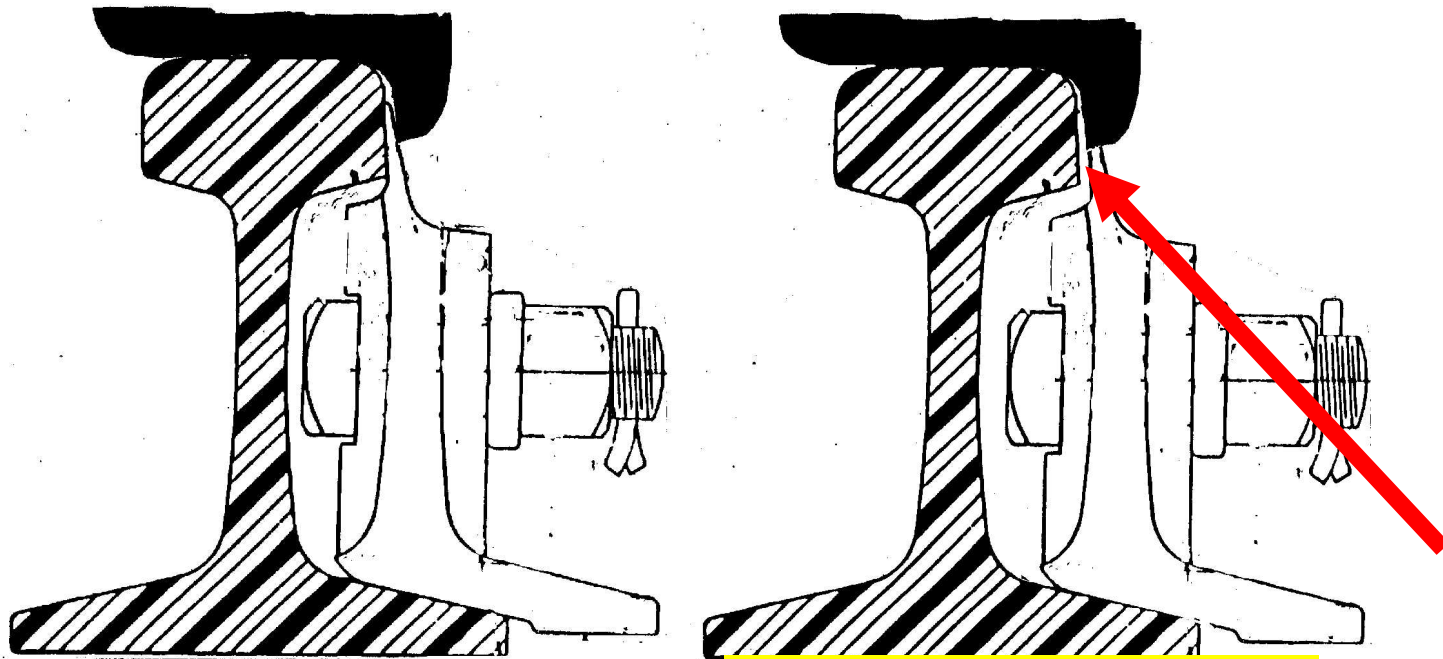
FRA Compliance: Switch point shall fit “snugly”



Gapped Switch Points



There are over 10 million wheels running around North America...many look like this!!



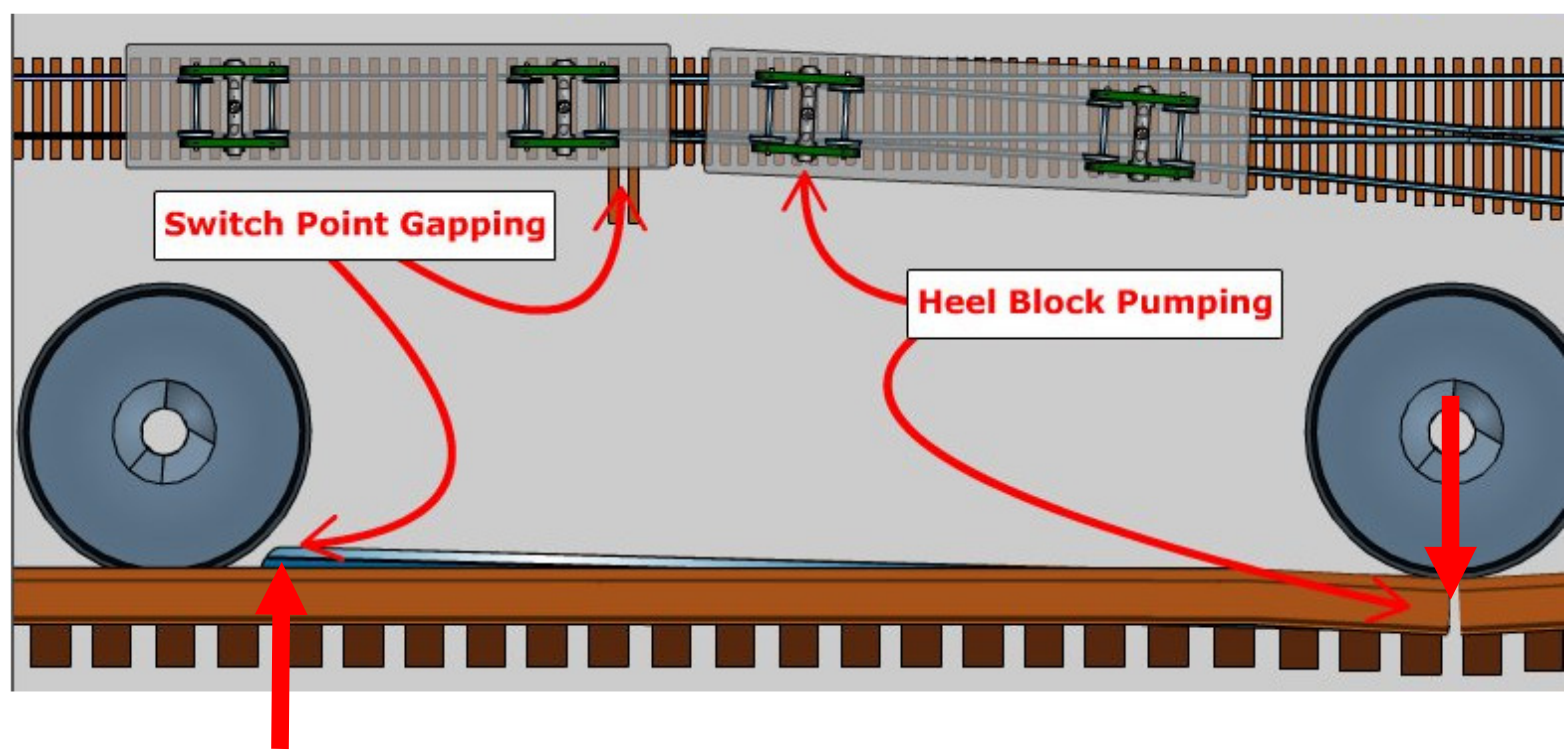
Thin flange wheel on properly fitting point; No picked point

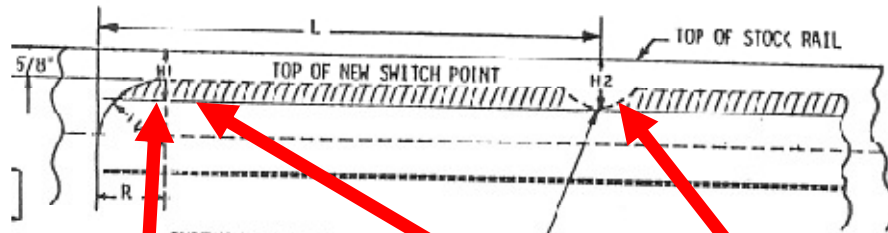
Thin flange wheel on Slightly gapped point; picked switch possible

You can't control 10+ million wheels in interchange service; You can control your switch points!



Heel Block Pumping under wheel load can lead to point raising vertically





SWITCH POINTS MUST BE REPAIRED OR REPLACED WHEN WORN OR CHIPPED TO EXCEED DIMENSION H₁ OR H₂ IN TABLE FOR EITHER SAMSON OR STANDARD POINT.

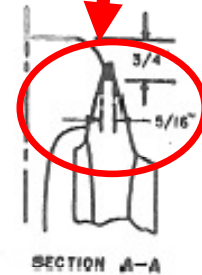
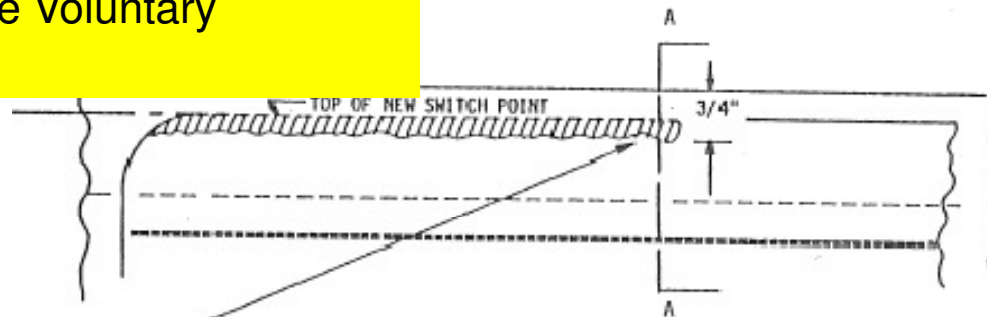
7/8" Here

3/4" Here

LENGTH OF SWITCH POINT	DISTANCE			
	R	H ₁	L	H ₂
UP TO 16'- 6"	1-1/2"	7/8"	OVER 10"	3/4"
19'6" OR OVER	1-1/2"	7/8"	OVER 16"	3/4"

5/16" flat surface

An Alternate Voluntary Standard



IMMEDIATE PROTECTION AND PROMPT CORRECTIVE ACTION IS NECESSARY WHEN CHIPPED POINT HAS UNPROTECTED FLAT VERTICAL SURFACE 5/16" WIDE AT 3/4" BELOW TOP OF STOCK RAIL FOR EITHER SAMSON OR STANDARD POINT.

SEE SECTION A-A

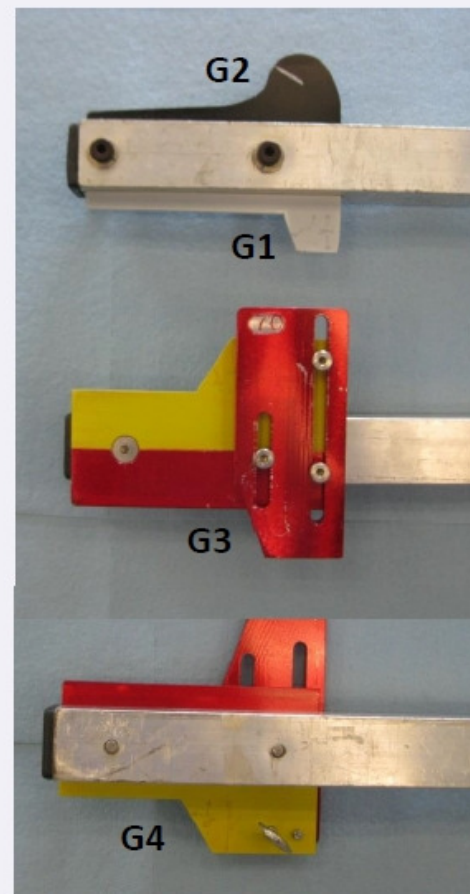


New switch point inspection gage developed by Brad Kerchoff
at Norfolk Southern Railway 2015-2016

- G1 -Chipped point
- G2 -AAR 1B wheel contact
- G3 -Severely worn wheel profile
- G4 -Gage-face wear angle



Where has the FRA been for last 7 years?



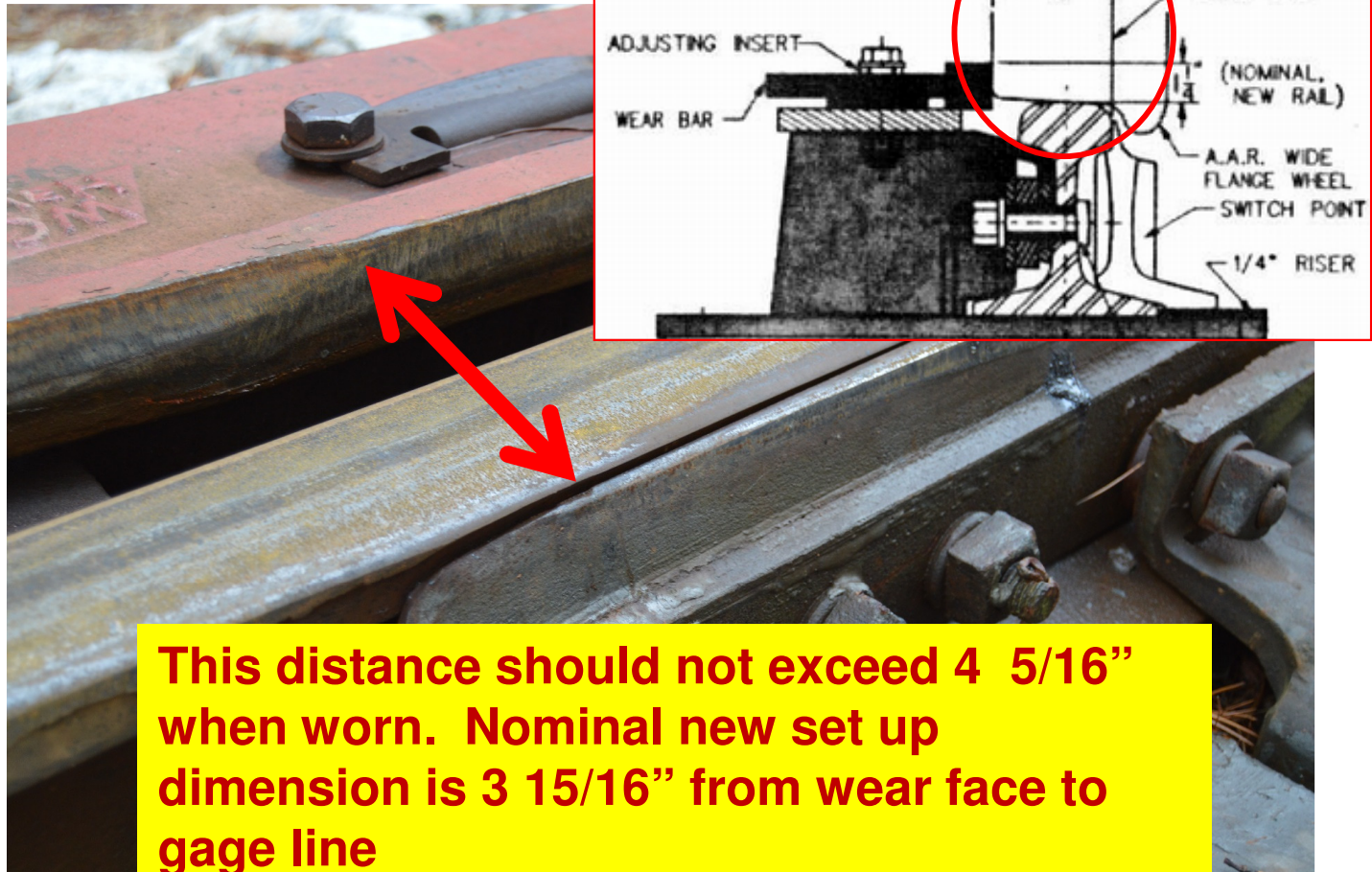
Switch Point Protectors – Good or Bad?



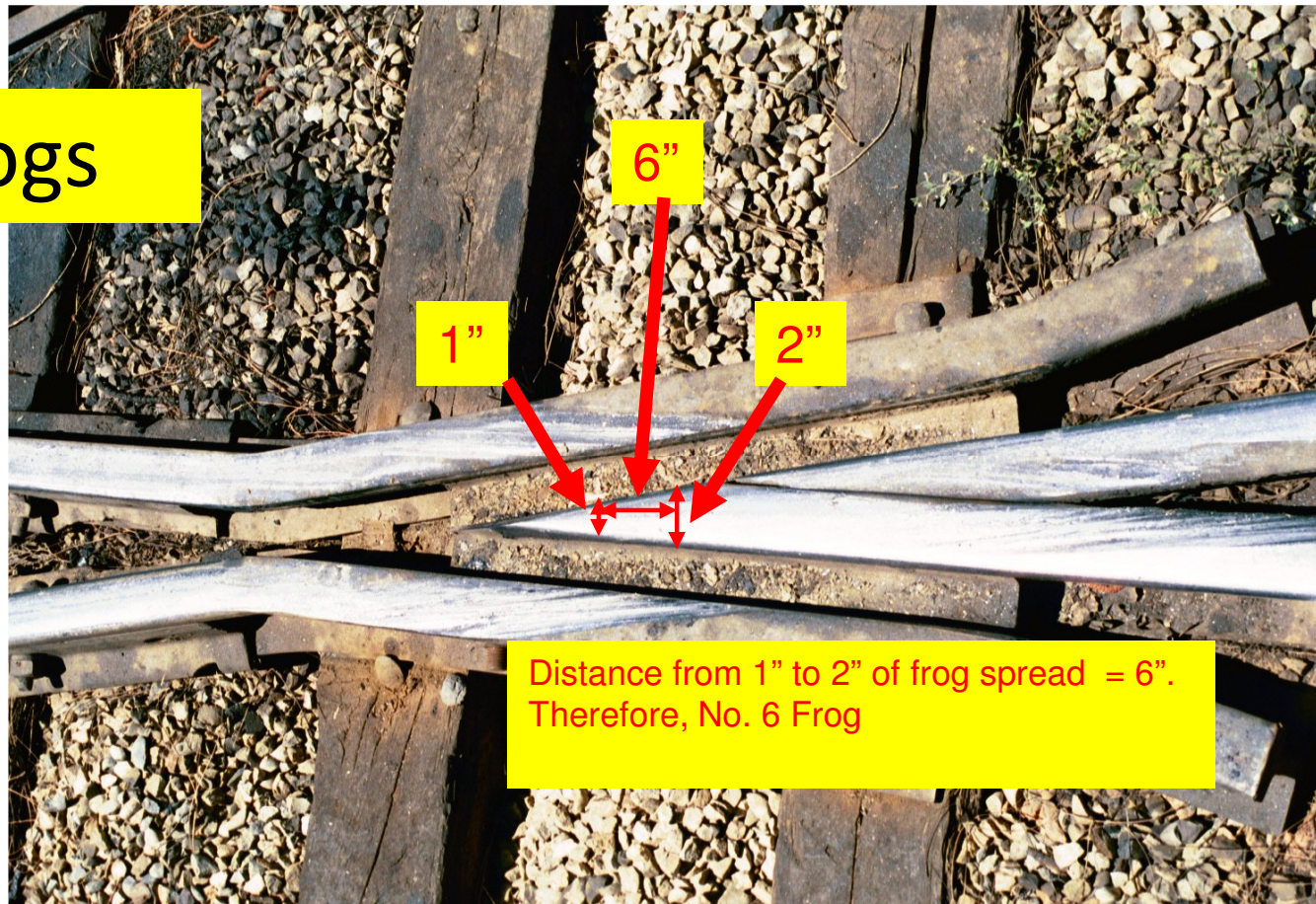
Wheel shavings indicating misaligned wheels

Heavy wear on switch point protector





Switch Frogs



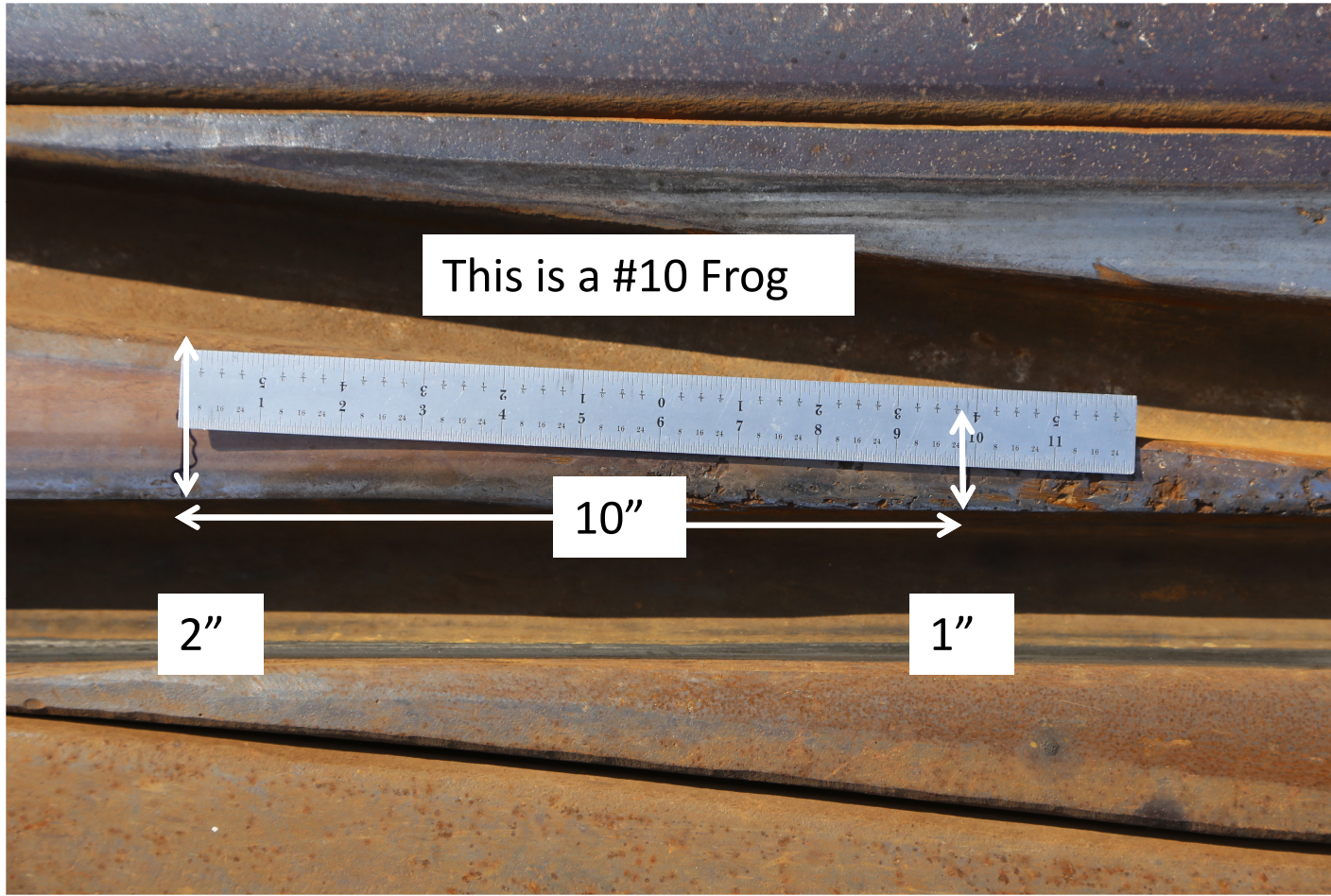
How to determine frog number



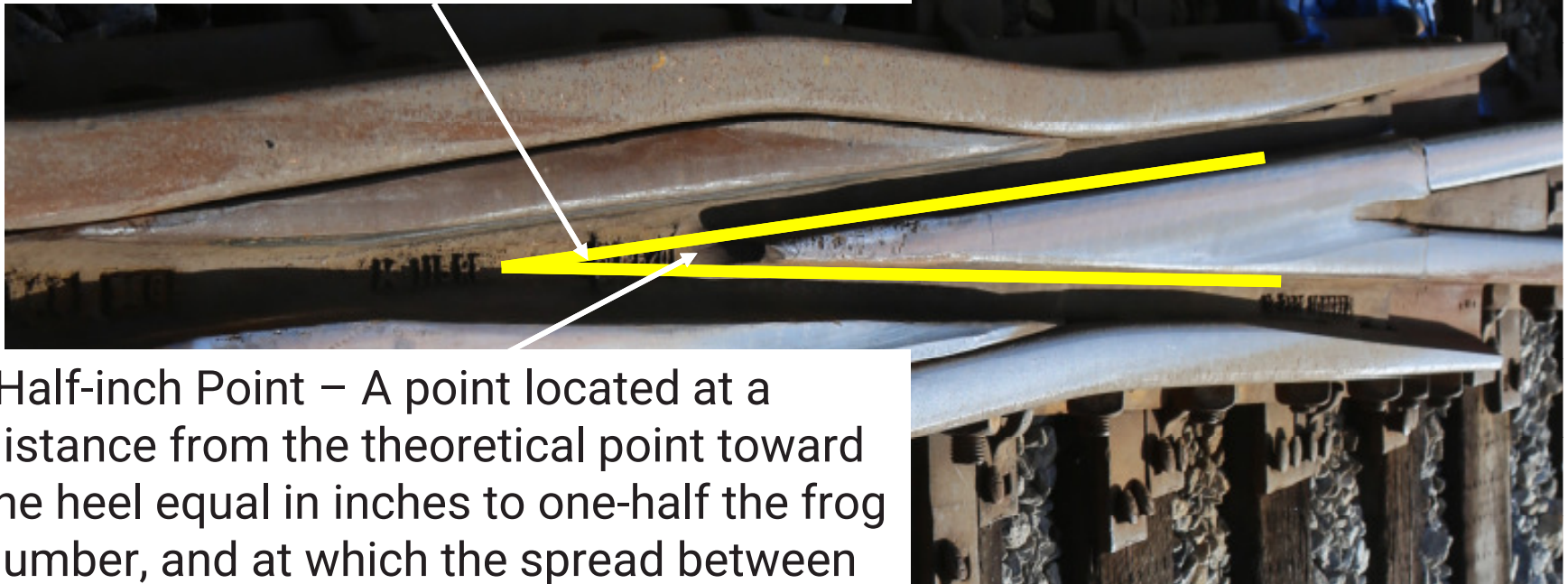
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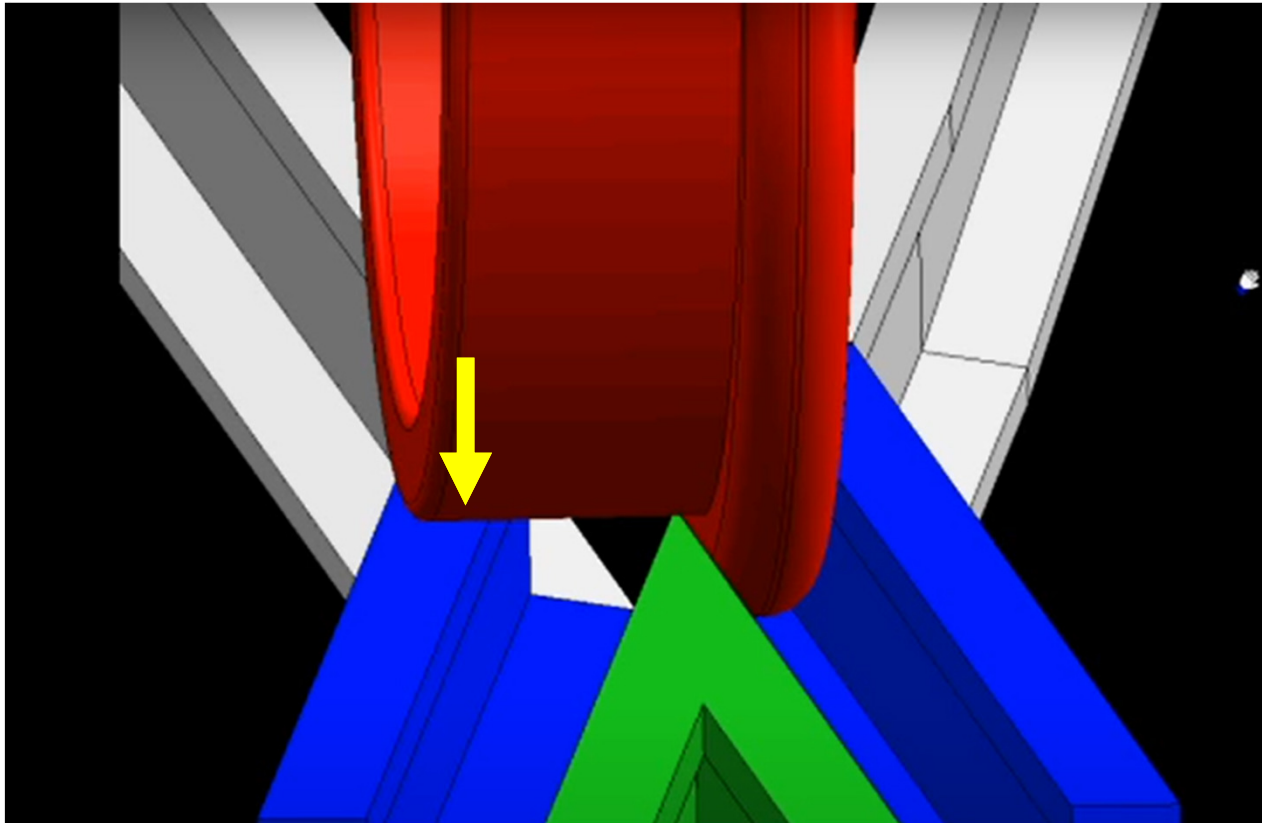
WRI 2023

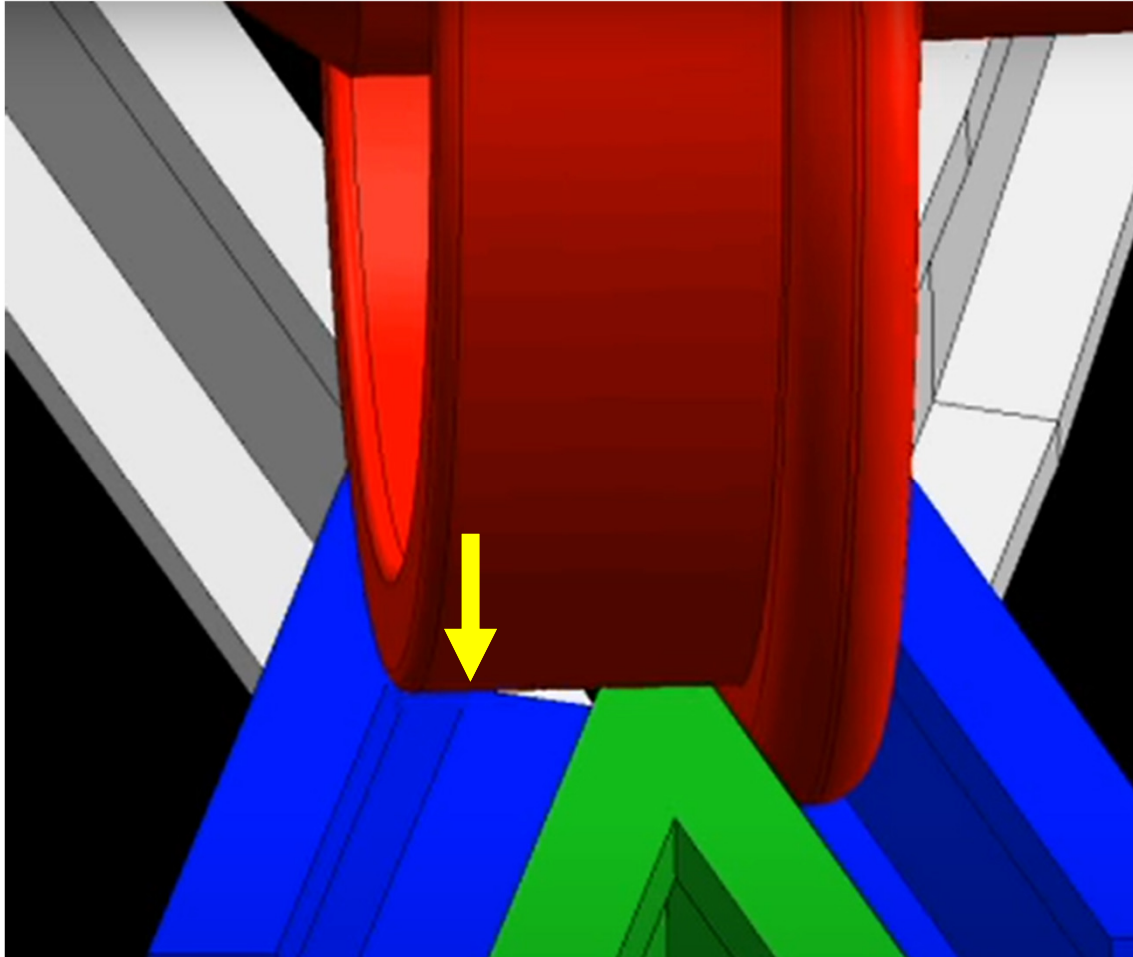


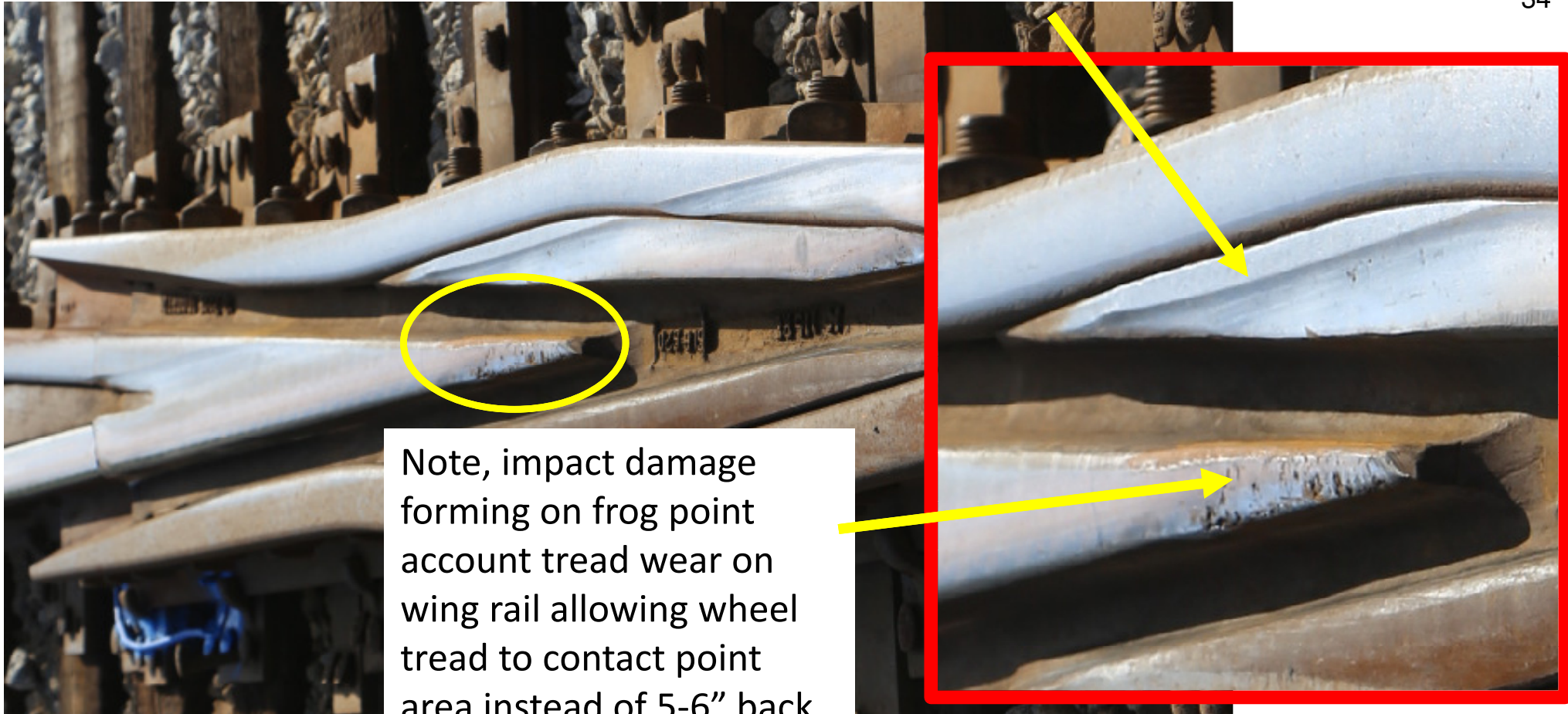
- Theoretical/point – The point of intersection of the gauge lines of a frog.



- Half-inch Point – A point located at a distance from the theoretical point toward the heel equal in inches to one-half the frog number, and at which the spread between the gauge lines is one-half inch. It is the origin from which measurements are usually made.



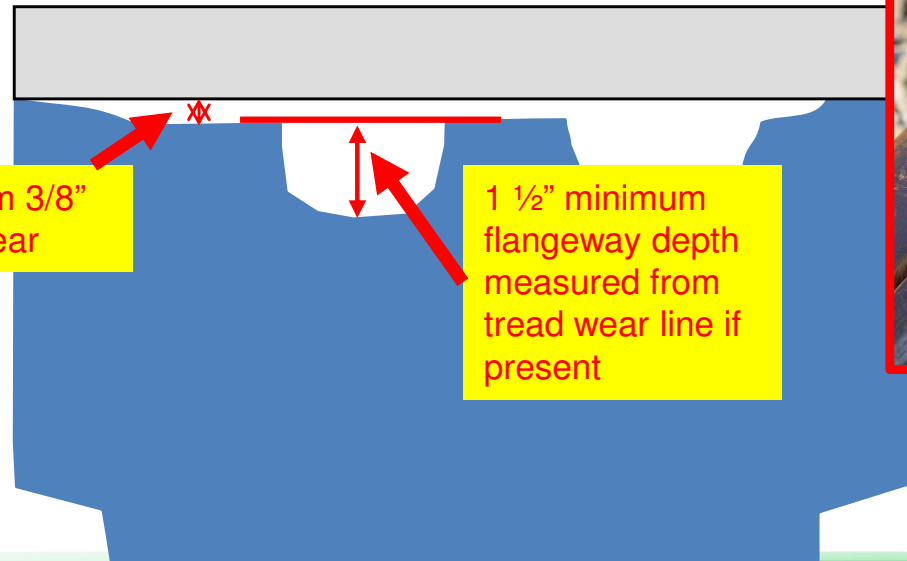




Note, impact damage forming on frog point account tread wear on wing rail allowing wheel tread to contact point area instead of 5-6" back on point



Tread wear on wing rail surface FRA 213.137(c)

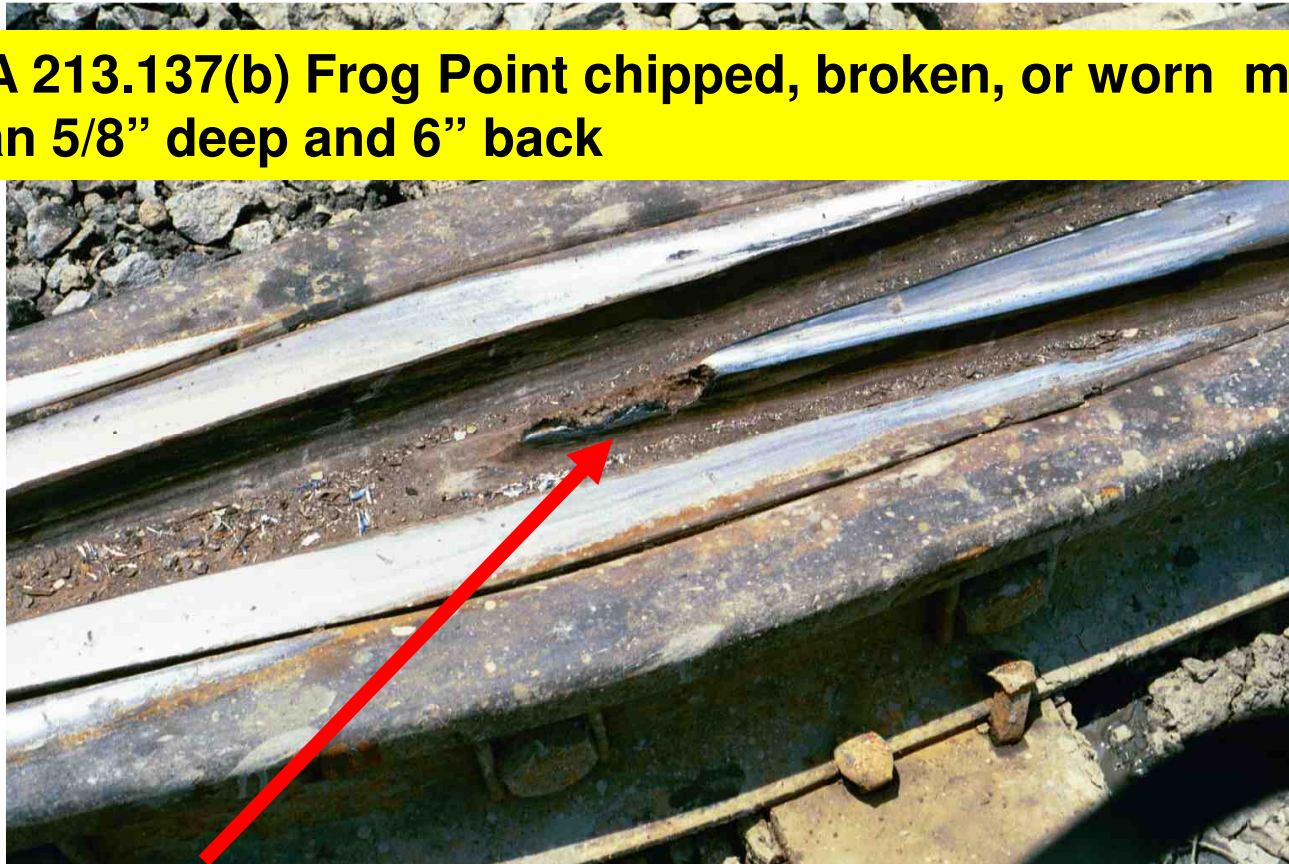


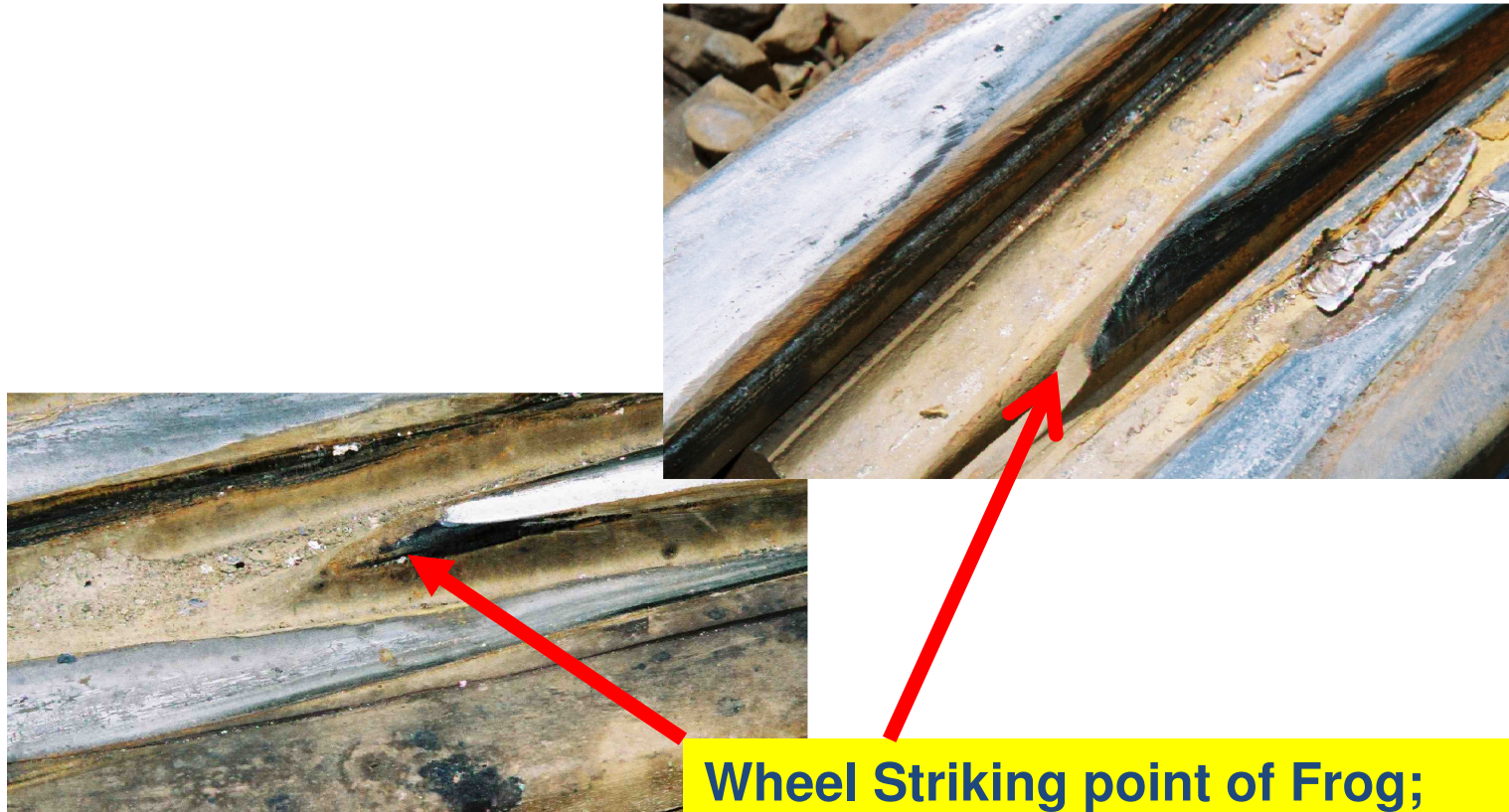
Maximum 3/8"
Tread wear

1 1/2" minimum
flangeway depth
measured from
tread wear line if
present



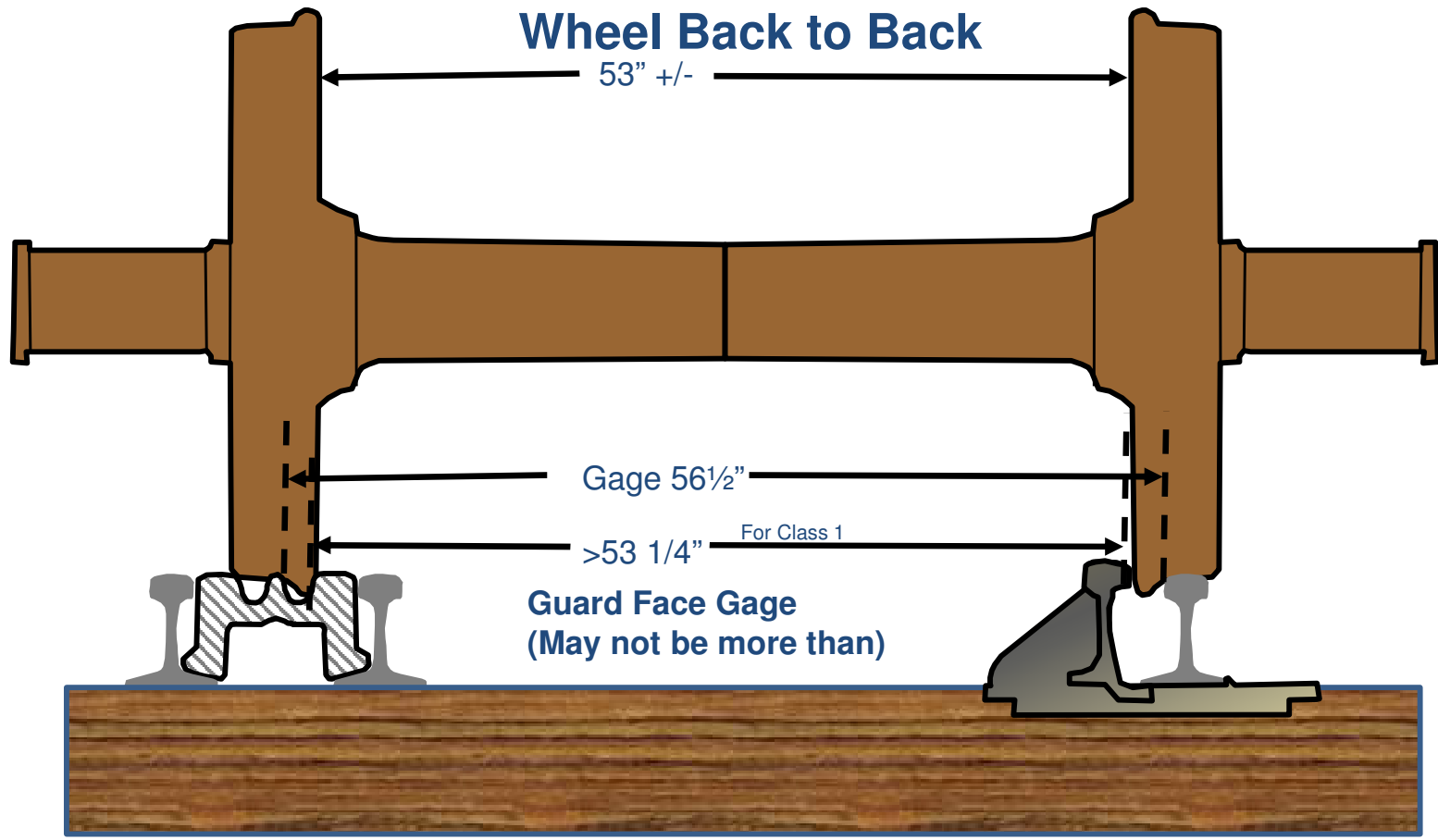
FRA 213.137(b) Frog Point chipped, broken, or worn more than 5/8" deep and 6" back

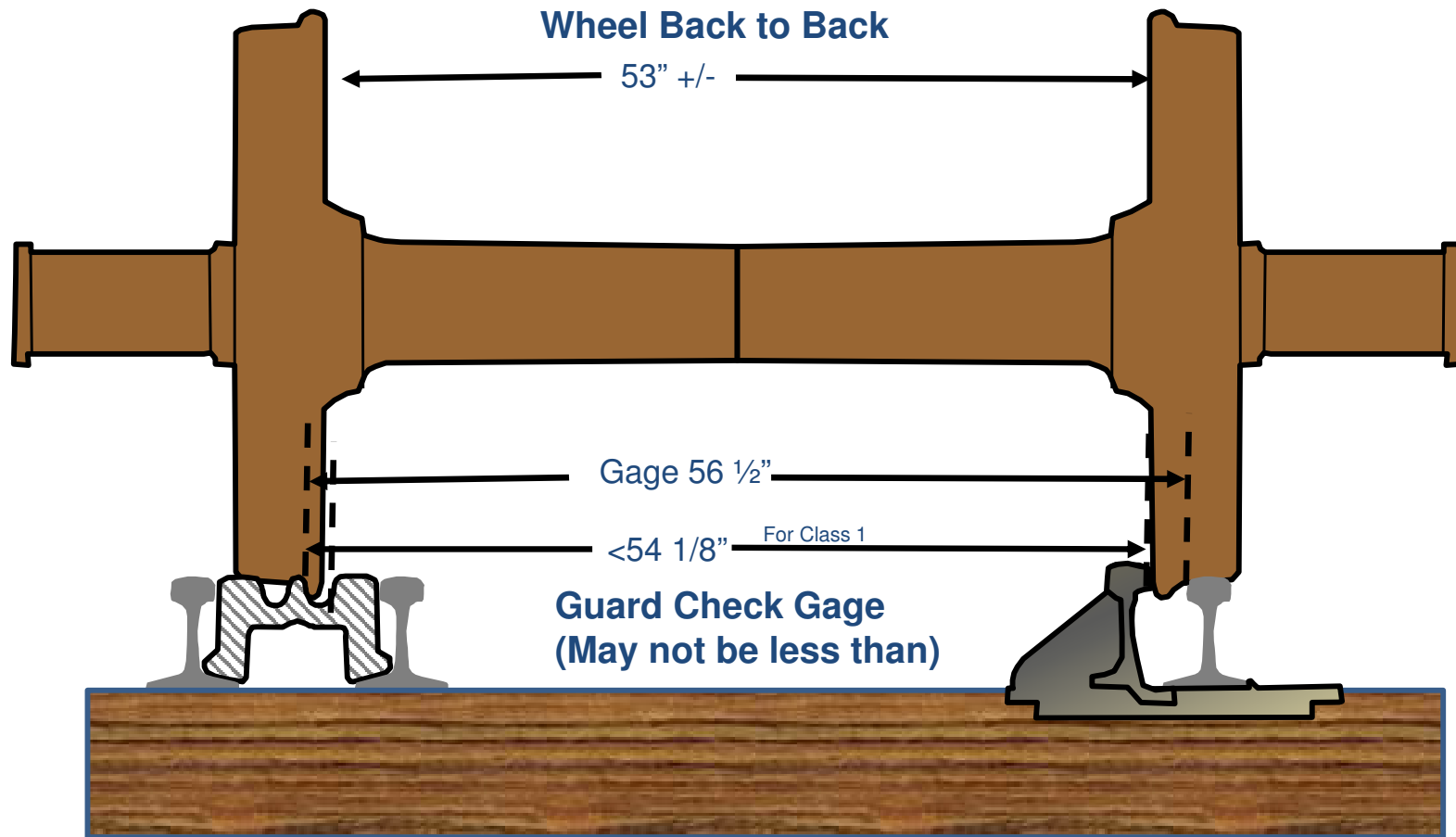


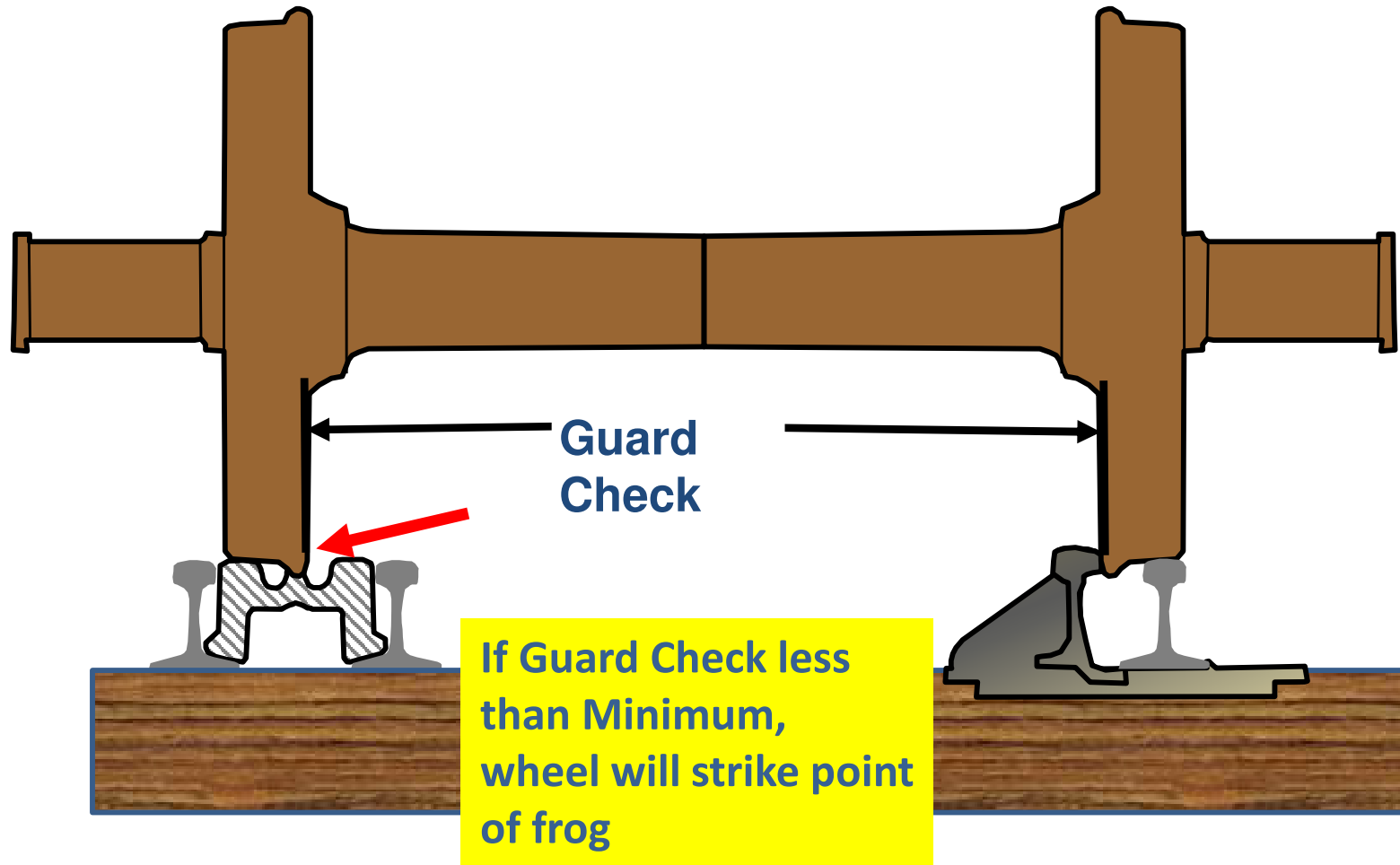


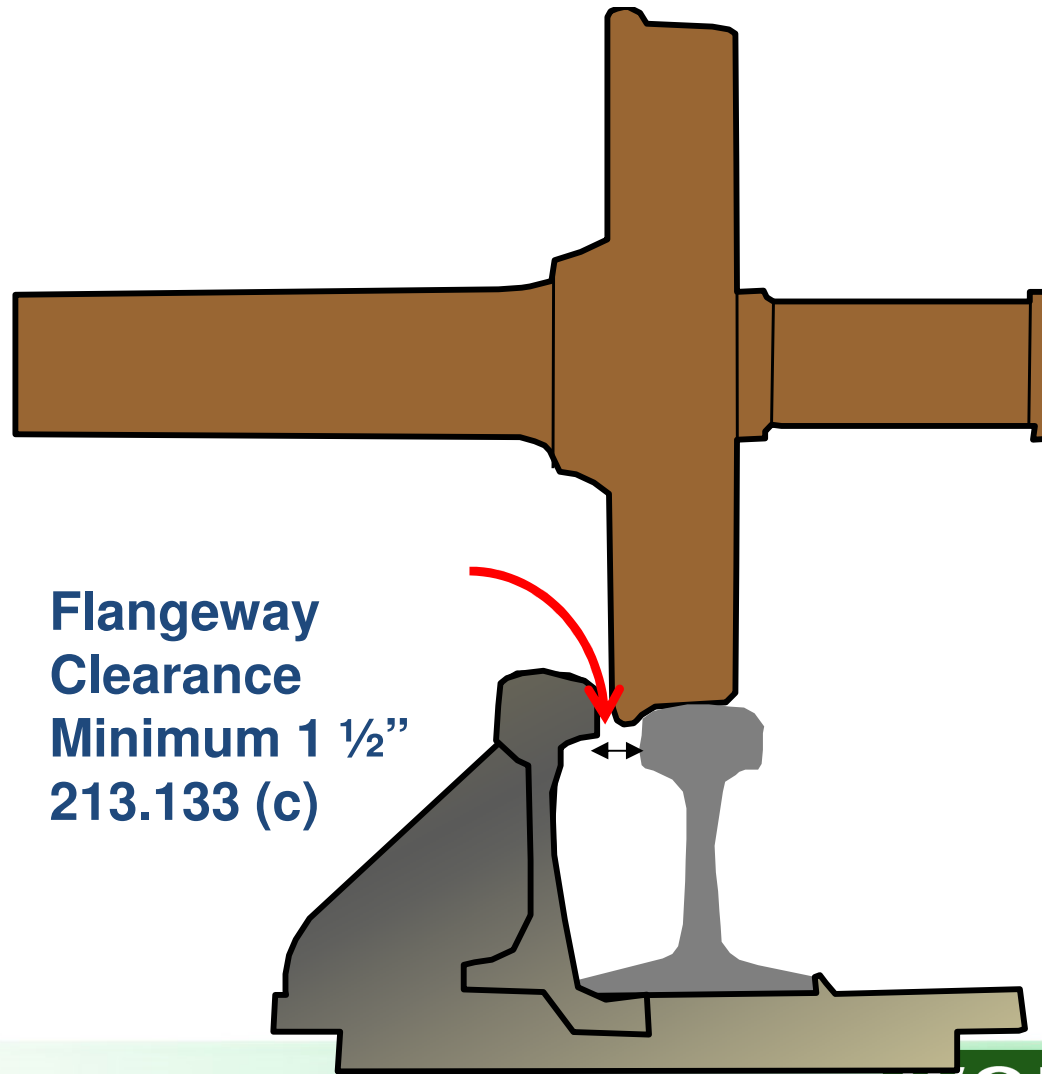
**Wheel Striking point of Frog;
Guard check less than minimum**

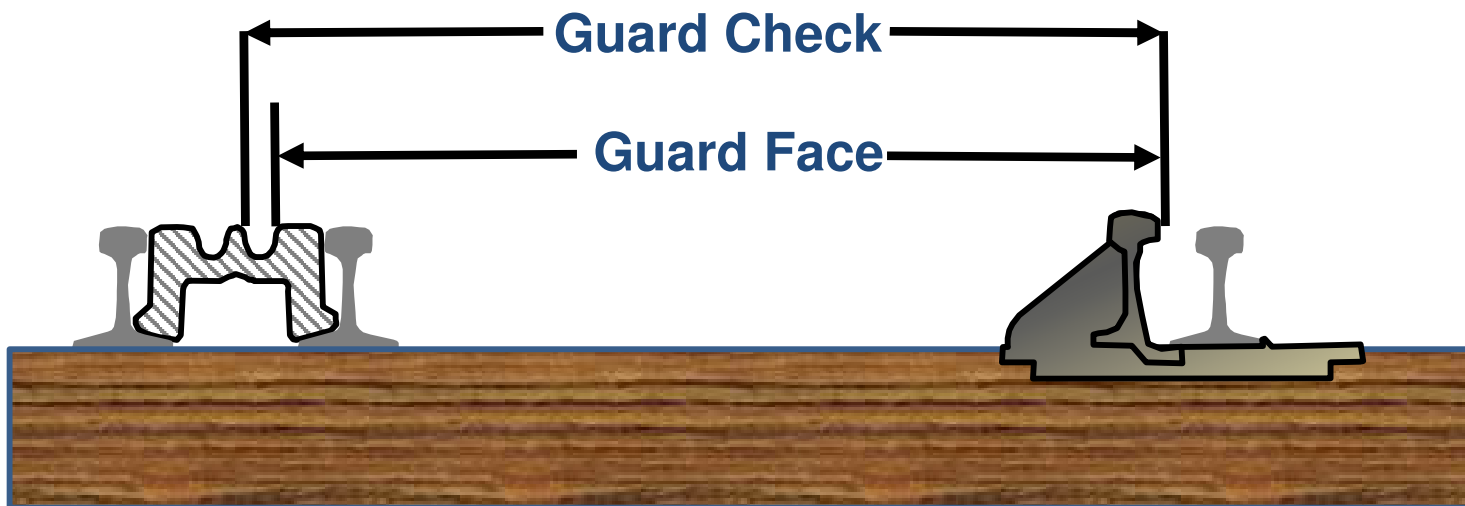










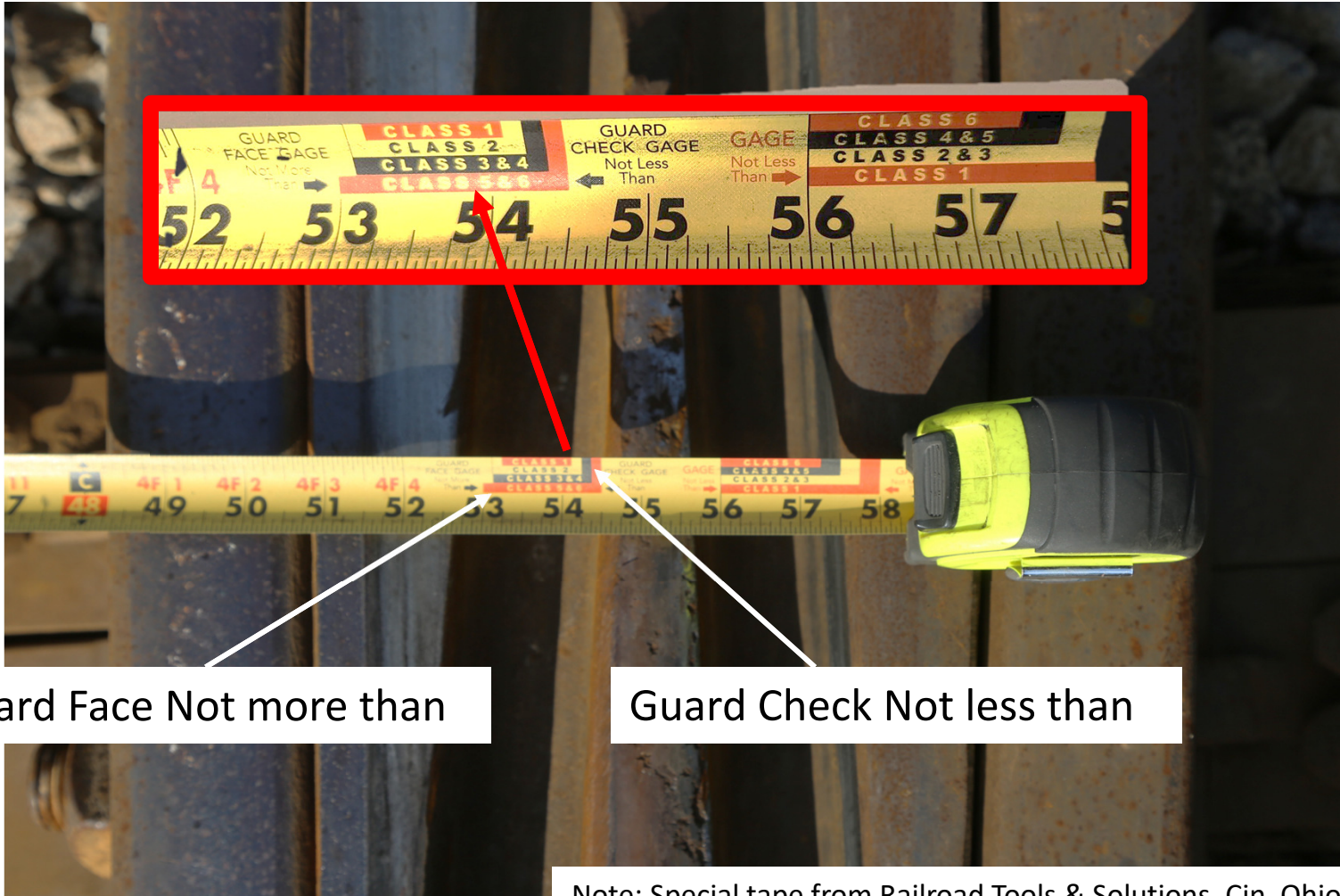


213.143 Guard Check and Face Gage

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"





Guard Face Not more than

Guard Check Not less than

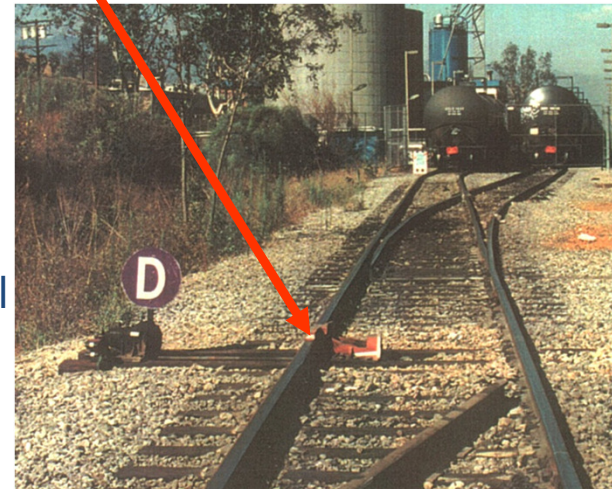
Note: Special tape from Railroad Tools & Solutions, Cin. Ohio

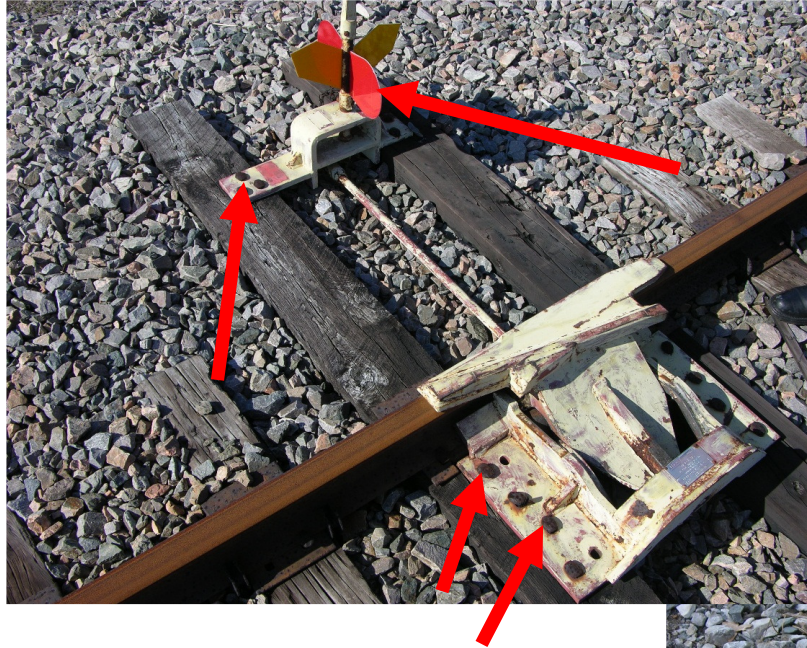


§ 213.205 Derails.

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.)





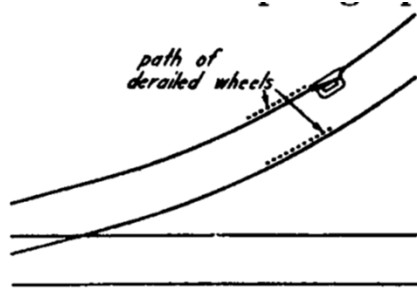
Fixed HB style



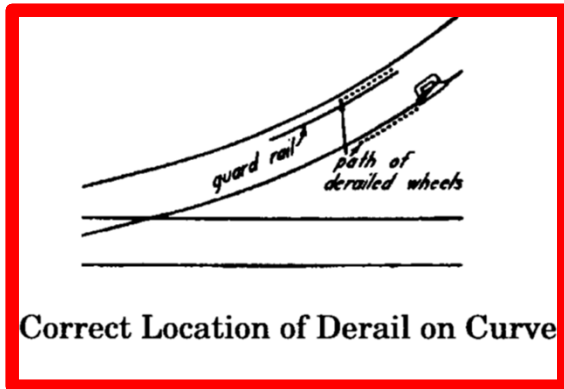
Make sure derails are visible to crews

Bi-directional Nolan style



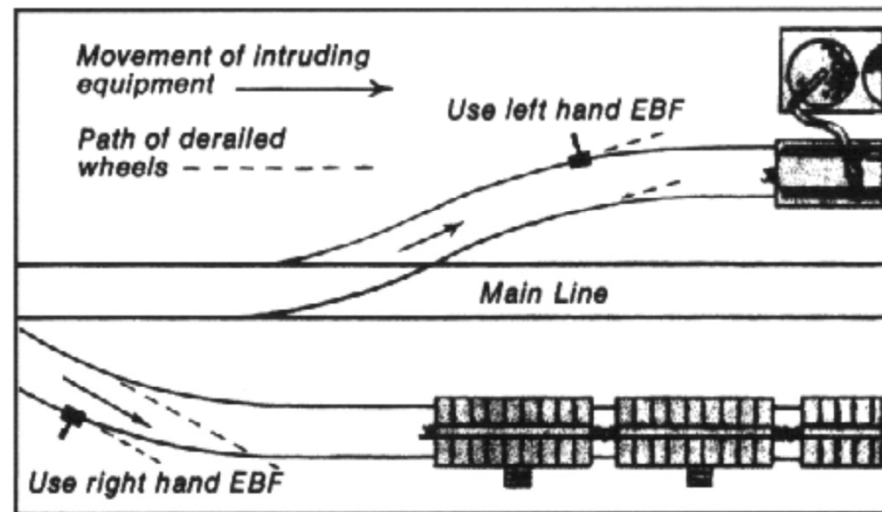


Incorrect Location of Derail on Curve



Correct Location of Derail on Curve

Proper location of derails



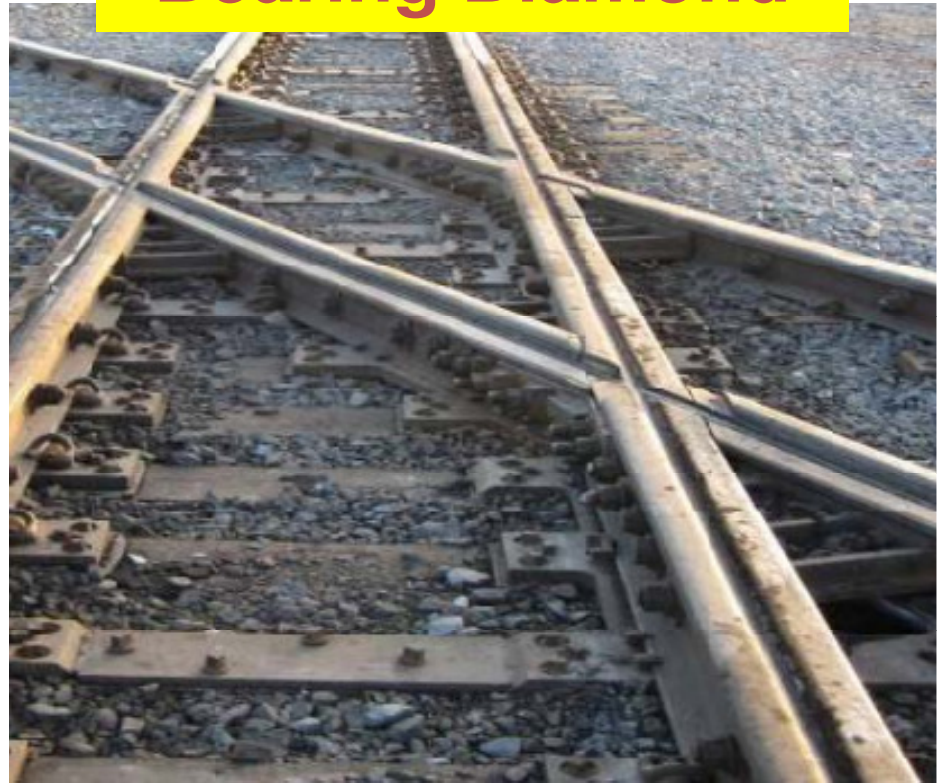
Courtesy of Western Cullen Hayes

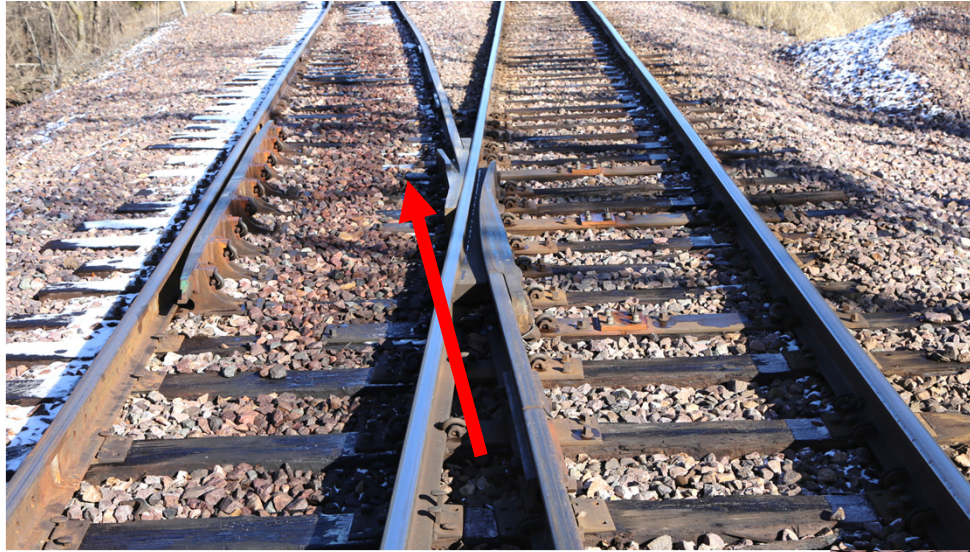


OWLS – One Way Low Speed Diamond



Full Flange Bearing Diamond





Jump Frogs



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Question – Could this lead to internal rail flaw growth?



Individual Geometry Topics

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



For North American Freight Operations⁵²

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



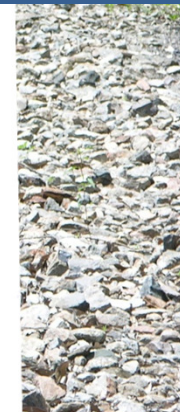


§ 213.53 Gage.

- (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

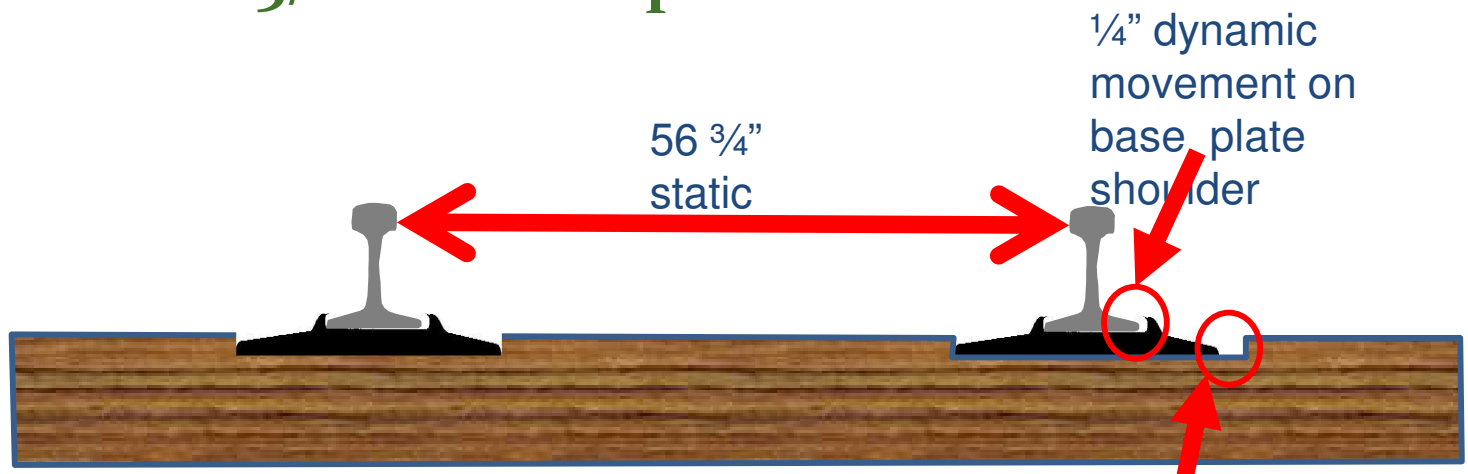


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Gage – Distance between the rail heads measured 5/8” below top of rail



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

57 1/2" total gage for FRA Compliance

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

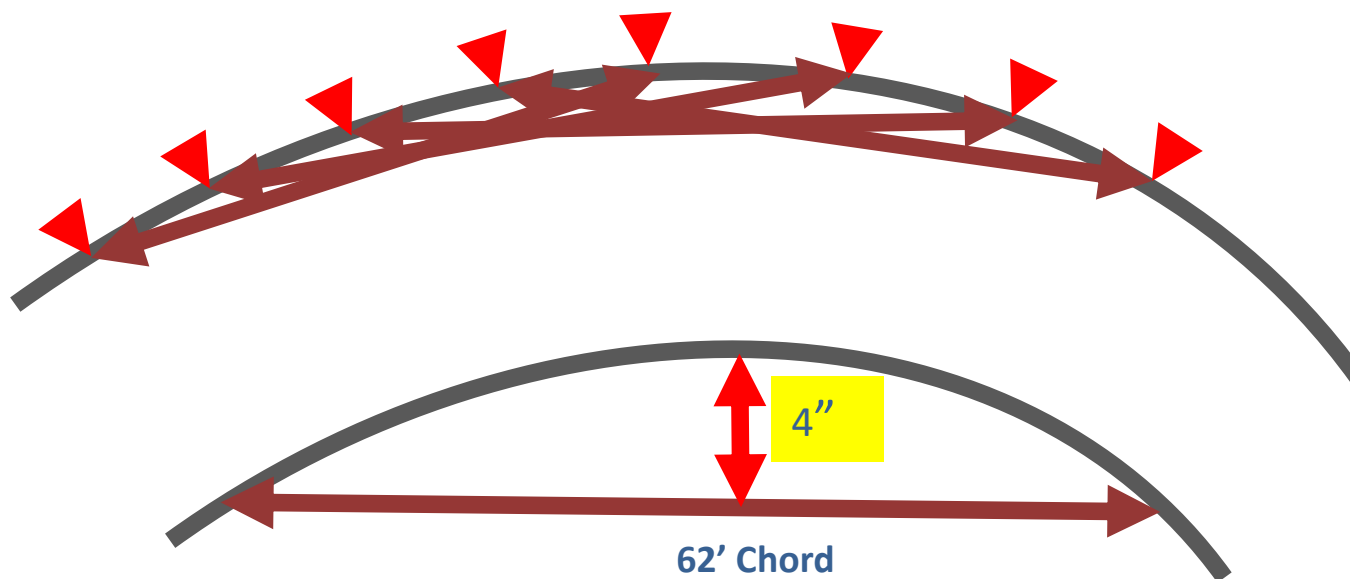
§ 213.13 Measuring track not under load.
 When unloaded track is measured to determine compliance with requirements of this part, the amount of rail movement, if any, that occurs while the track is loaded must be added to the measurements of the unloaded track.



Alignment Deviations



Measuring Alignment with 62' Chord - Stringlining



Midordinate Measurement

4" = 4 Degree Curve



§ 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:

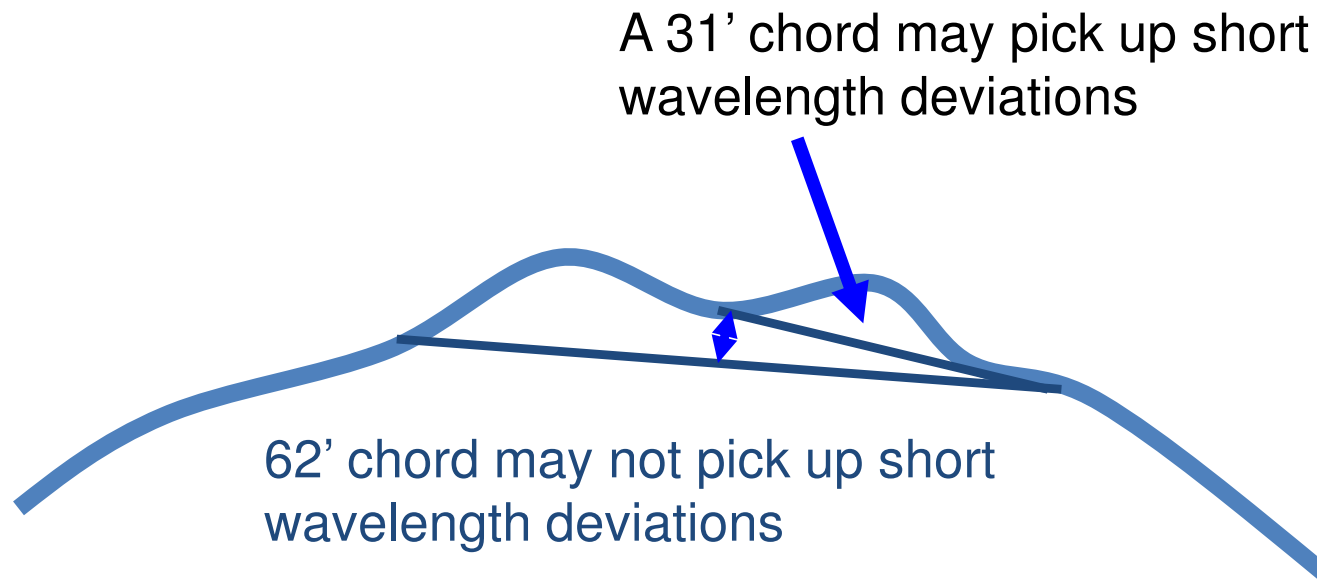
Class of Track	Tangent Track	Curved Track	
	The deviation of the mid-offset from a 62-foot line [1] may not be more than --	The deviation of the mid-ordinate from a 31-foot chord [2] may not be more than --	The deviation of the mid-ordinate from a 62-foot chord [2] may not be more than --
1	5"	N/A ³	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





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



§ 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.

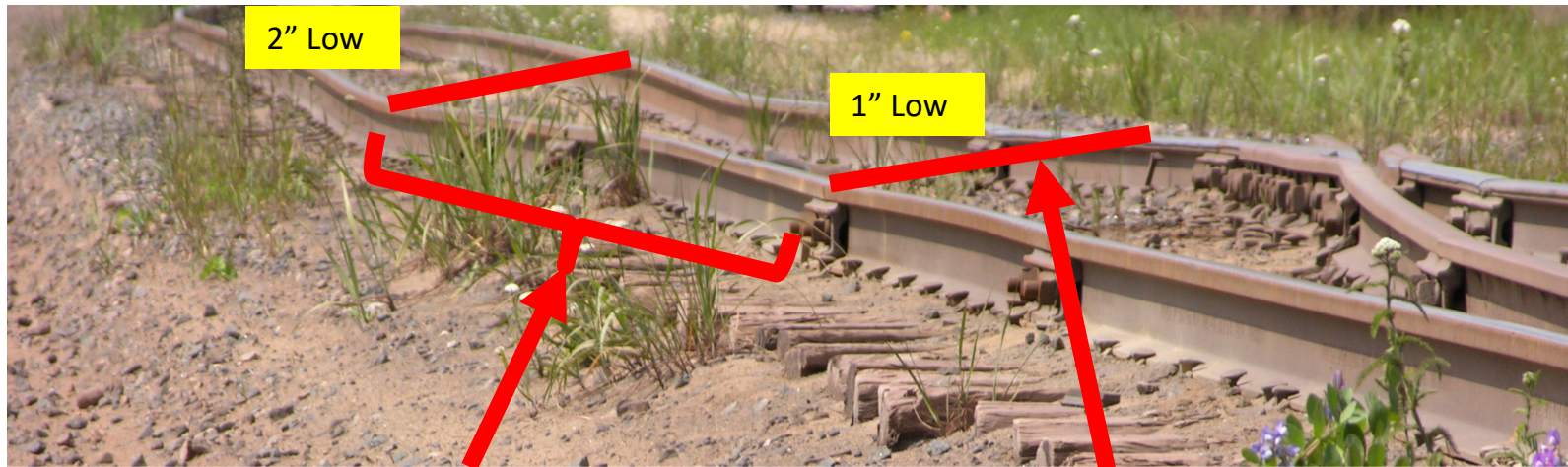


2 Key Words Used in the FRA Regulations

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' of 1". Variations are relative differences between any two measurements.

This is a deviation from zero Crosslevel of 1"; or a deviation from where the Crosslevel should be. Deviations are singular measurements.



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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



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(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:

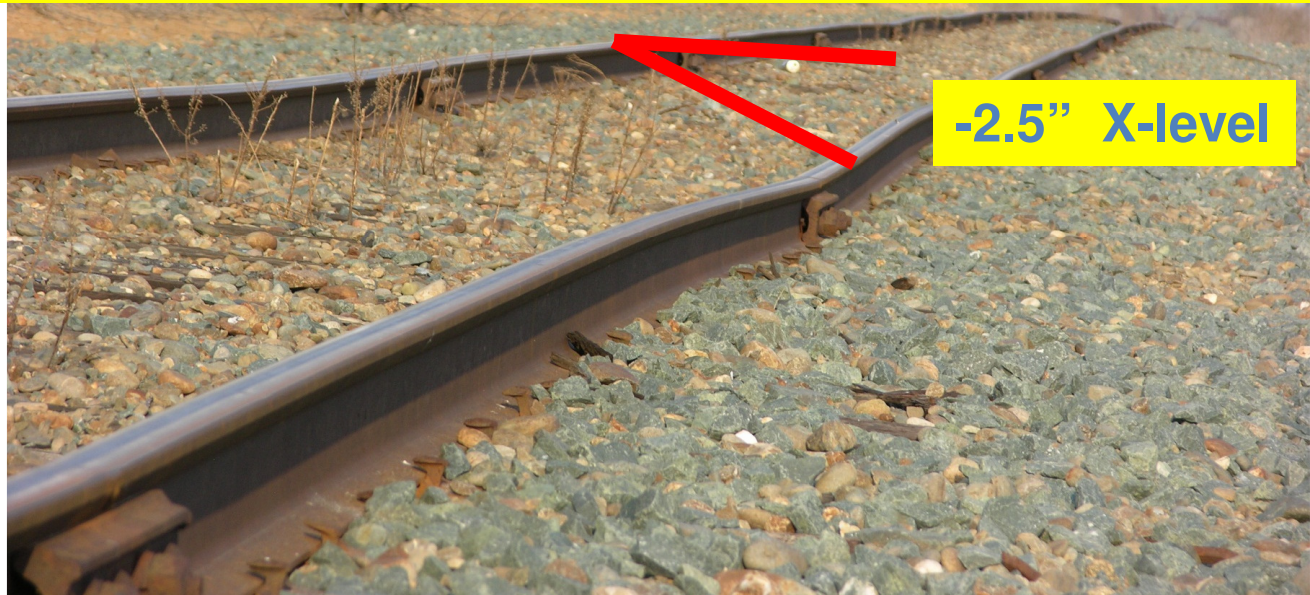
Track surface (inches)	Class of track				
	1	2	3	4	5
The runoff in any 31 feet of rail at the end of a raise may not be more than	3 1/2	3	2	1 1/2	1
The deviation from uniform profile on either rail at the mid-ordinate of a 62-foot chord may not be more than	3	2 3/4	2 1/4	2	1 1/4
The deviation from zero 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.

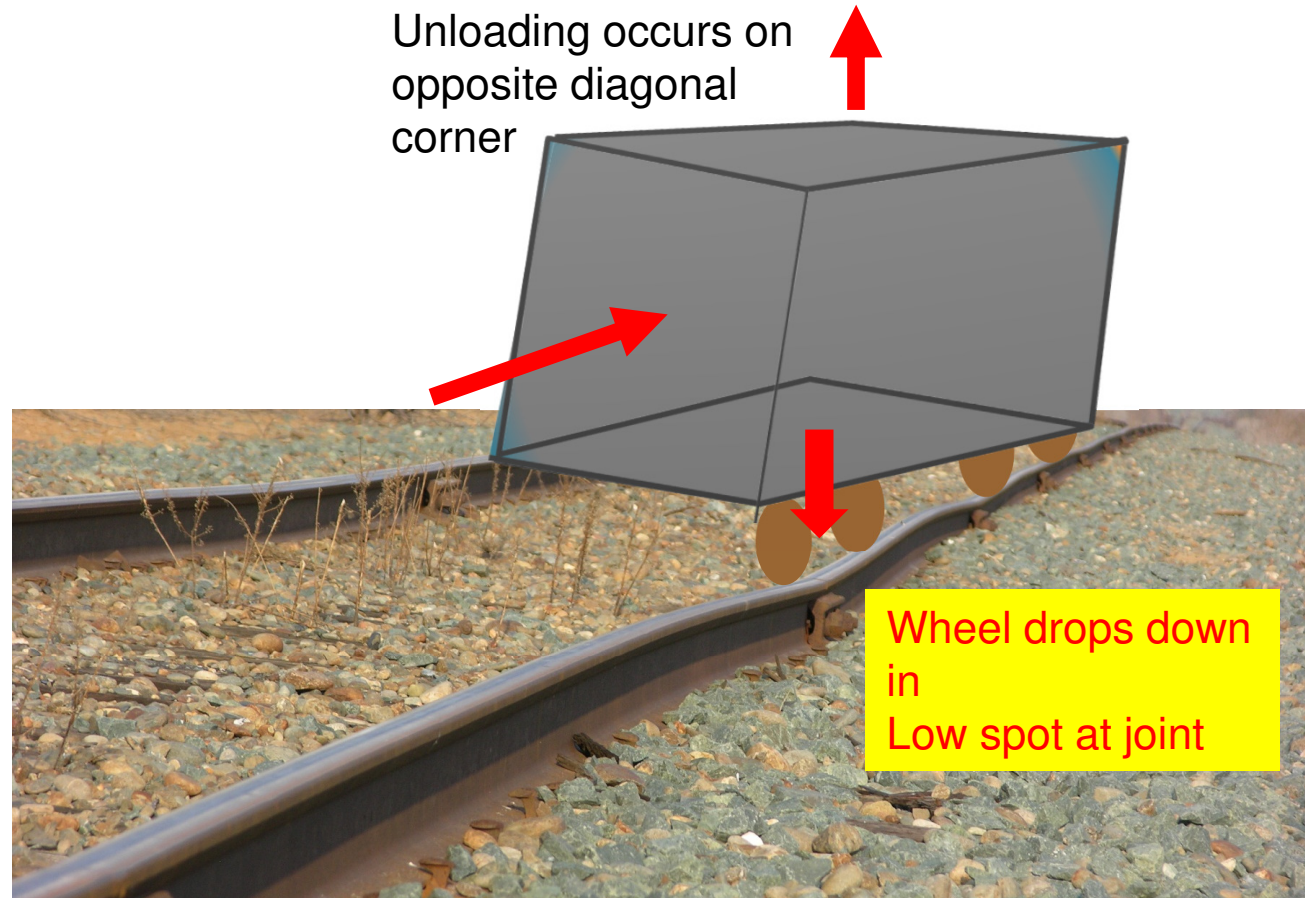


Crosslevel Deviations



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**



§ 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:

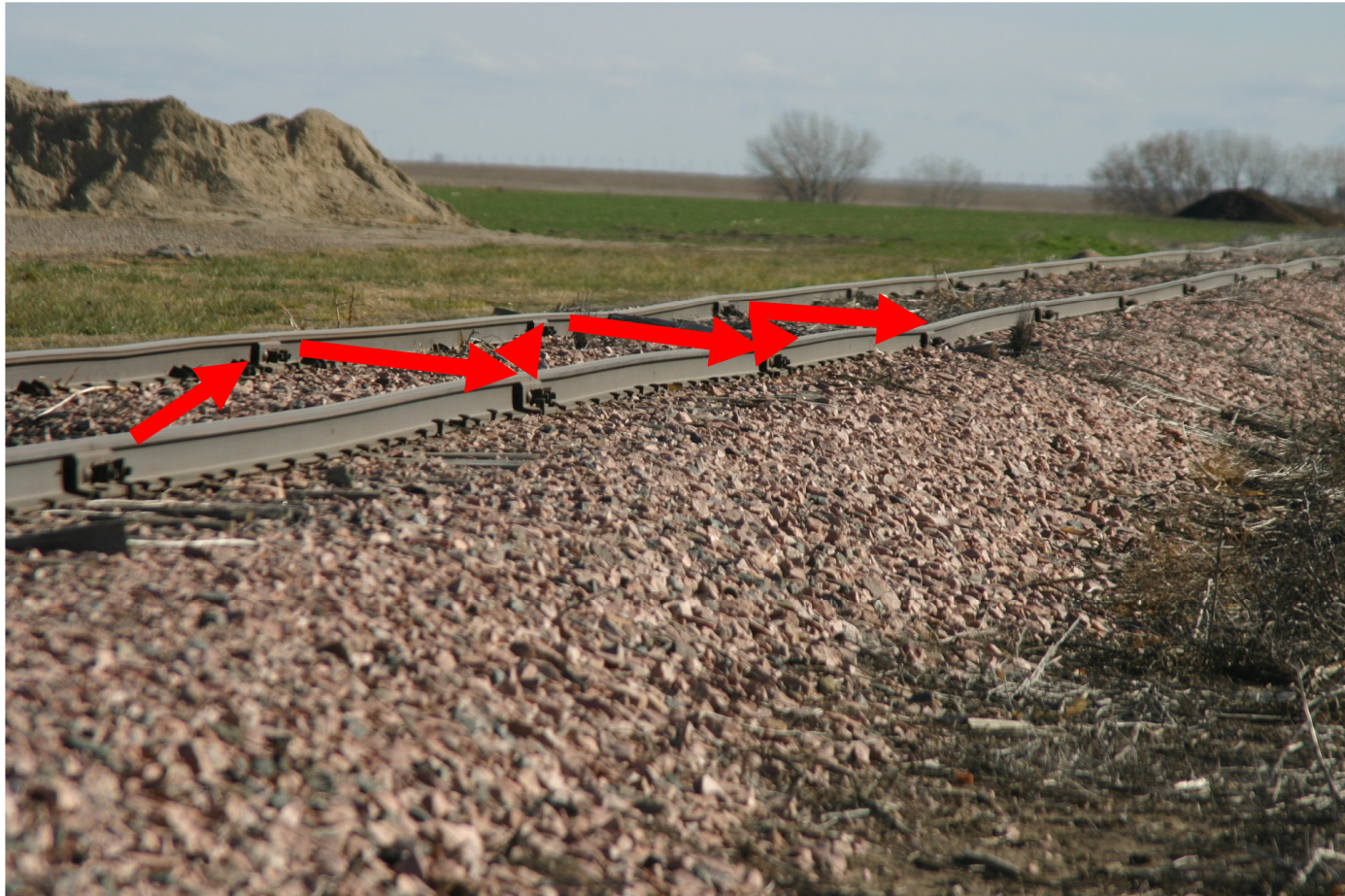
Track surface (inches)	Class of track				
	1	2	3	4	5
The runoff in any 31 feet of rail at the end of a raise may not be more than	3 1/2	3	2	1 1/2	1
The deviation from uniform profile on either rail at the mid-ordinate of a 62-foot chord may not be more than	3	2 3/4	2 1/4	2	1 1/4
The deviation from zero 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
(Joints
staggered
greater
than 10'
apart)**



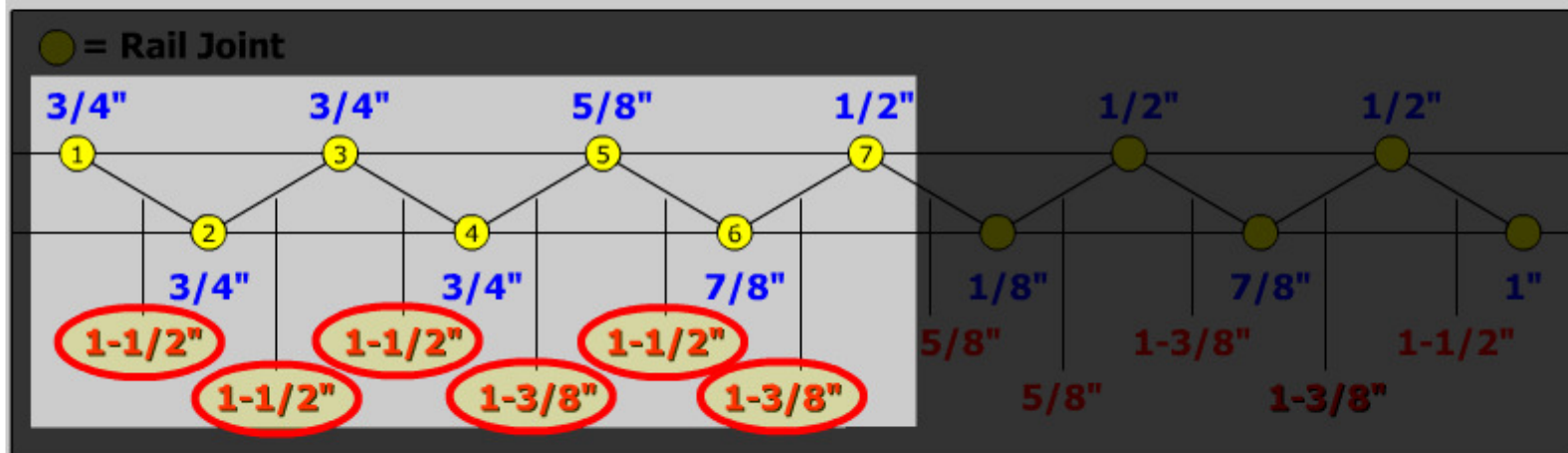
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FRA - Harmonic Rock-Off II

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:

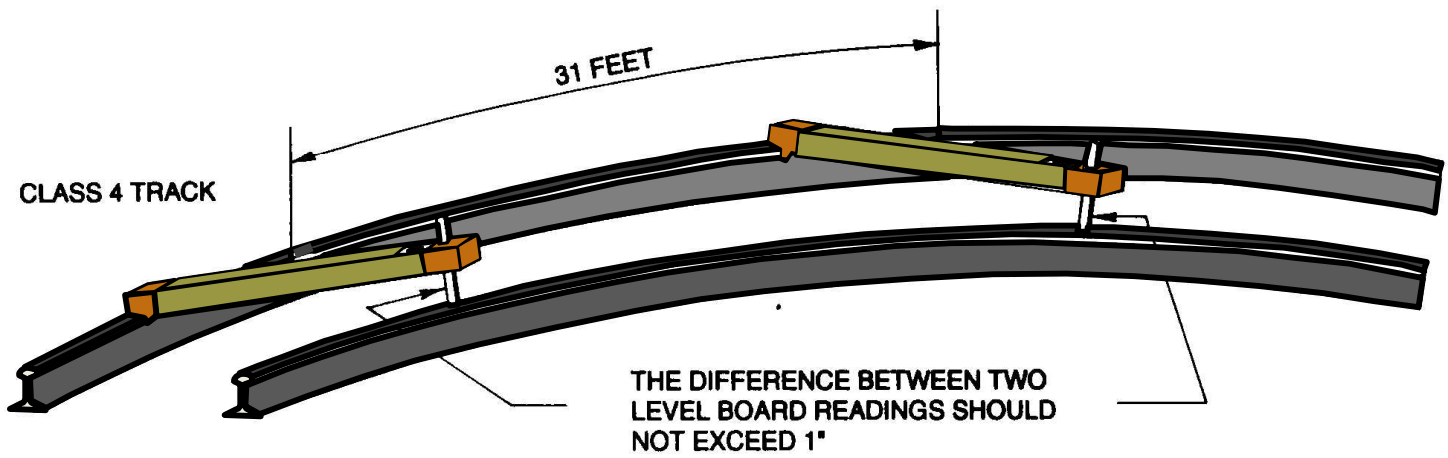
Track surface (inches)	Class of track				
	1	2	3	4	5
The runoff in any 31 feet of rail at the end of a raise may not be more than	3 1/2	3	2	1 1/2	1
The deviation from uniform profile on either rail at the mid-ordinate of a 62-foot chord may not be more than	3	2 3/4	2 1/4	2	1 1/4
The deviation from zero 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"

§ 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.



Vertical Profile Deviations



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Vertical profile deviation caused by poor subgrade



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



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

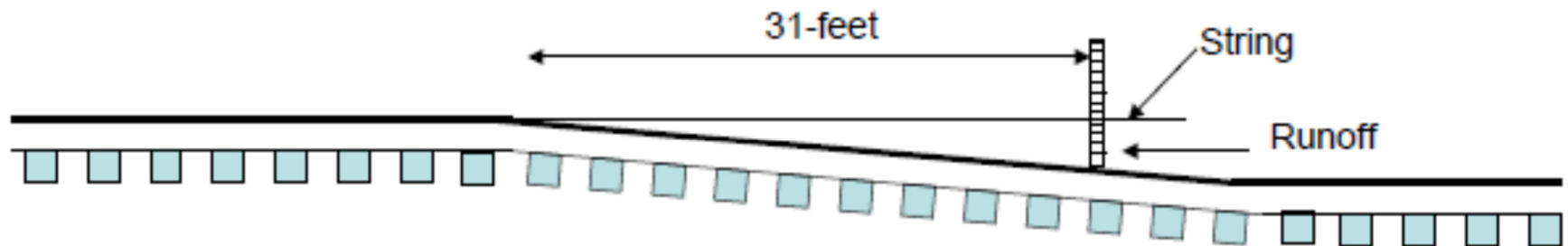
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Rate of Runoff over 31 feet



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



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