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A. Spirals & Superelevation

1. Definitions

   **Chord**
   A string-line measurement between two points on the track (typically 62’) for determining alignment or surface.
   Using a 62’ chord on curves will determine the approximate degree of curvature. With the chord stretched between two gauge points on a rail, measure the distance from the rail to the string-line at the mid-ordinate (31’ foot mark). Each inch of offset equals one degree of curvature.

   **Designated Elevation**
   The superelevation established for a curve based on train speed and other railroad characteristics.
   **Note:** When surfacing, the outer rail on a curve is raised to provide the designated superelevation.

   **Grade rail**
   The inner or “low” rail on a curve that remains at grade level. Or either rail on tangent track.
   **NOTE:** For alignment & crosslevel purposes on tangent track, either rail can be used as the grade rail, as long as the same rail is used throughout.

   **Gauge Point**
   A point on the gauge side of, and 5/8” below the running surface of a rail, for the purpose of measuring gauge or alignment.

   **Spiral**
   The gradual and uniform introduction of curvature from tangent into full curve, or from one degree of curve to another in compound curves.

   **Tangent**
   Straight track.

   **Transition**
   The points where the alignment of the track changes from tangent, to spiral, to full curvature are referred to as the transition points.

   **Superelevation**
   The vertical distance of the outer rail of a curve above the inner rail.

   **Unbalanced** (or Underbalance)
   Superelevation in a curve that is less than what would provide an equal distribution of force to each rail from a train travelling around a curve at maximum authorized speed.

2. Spirals

   (a) Entering the spiral (or easement) between a tangent and a curve, the elevation must increase at a uniform rate from the point of zero superelevation to the point of full superelevation.

   (b) Where possible, reverse curves should be separated by tangent of at least 78 feet in length, unless authorized by Regional Chief Engineer or Director of Engineering.
(c) Minimum spiral lengths for new construction and for re-alignment of existing tracks are to be designed in accordance with the following.

<table>
<thead>
<tr>
<th>Speed (MPH)</th>
<th>Minimum length for each ½” of Superelevation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Up to 50</td>
<td>31 feet</td>
</tr>
<tr>
<td>55 to 80</td>
<td>39 feet</td>
</tr>
</tbody>
</table>

3. **Superelevation**

(d) Designated Superelevation will be based on Appendix “A” and modified only by the Regional Chief Engineer, taking into account the desired speed, degree of curvature and physical characteristics of the segment of railroad. **This designated elevation is to be used by all field forces when performing any work on curves.**

(e) Curves will be superelevated using a 2” unbalanced scale, based on the assigned freight train speed for each curve. **Superelevation table for 2” Unbalance attached as Appendix “A”**

(f) Except as provided in Tables 2 A&B for “deviation from zero crosslevel”, the outside rail of a curve shall not be lower than the inside rail (reverse elevation).

(g) The minimum superelevation on a curve must be maintained for the train with the highest authorized timetable speed. For instance, if passenger trains are operated in addition to freight, superelevation must meet the requirements of FRA “Maximum Allowable Operating Speeds” based on the speed of the passenger train.

(h) Increments of 1/4” will be used in establishing the superelevation to be maintained on a curve.

(i) When practical, the transition points of the curve should be marked with paint across the tie, or by paint marker on the tie plate or base of rail. Transition points are marked while facing the direction of increasing mileage as follows:

- TS – Tangent to Spiral
- SC – Spiral to Curve
- CS – Curve to Spiral
- ST – Spiral to Tangent

(j) Designated Superelevation must not be less than 3/4”, or exceed the following unless approved by the Regional Chief Engineer or Director of Engineering:

- 5” in Canada; or on US Lines where speed is less than 30 MPH.
- 6” on US Lines in track classes 3 through 5.

Note: The above limits are for “designated” superelevation. The maximum actual superelevation allowed to exist in track shall not exceed those of FRA or Transport Canada regulations. In addition, Maximum Allowable Curving Speeds shall not exceed those of FRA or Transport Canada regulations.
(k) The elevation maintained for each curve should be the elevation that minimizes wear of both rails as much as possible.

(l) Excessive crushing out of the low rail usually indicates too much superelevation, whereas unusual gauge face wear on the high rail indicates not enough superelevation. If excessive wear or rail crushing is occurring on a particular curve, bring it to the attention of the Chief Engineer for review and possible adjustment of the designated superelevation.

(m) Where there are adjacent tracks on a curve, the minimum distance between track centers shall be increased to account for curvature and superelevation at a rate of 2” per degree of curvature. Superelevation of the outer track must not exceed the superelevation of an adjacent inner track unless track centers are increased and additional 2-1/2” for each 1” difference in superelevation.

B. **Gauge, Alignment & Surface**

Deviations approaching maximum allowable limits for gauge, alignment and surface are listed in Section C - Tables 1A and 1B.

Maximum allowable deviations for gauge, alignment and surface are listed in Section C - Tables 2A and 2B.

1. **Gauge:**
   (a) Gauge shall be measured at right angles to the track between points on the opposite gauge side of rails at a point 5/8” below the top of rail.
   (b) Standard gauge is 56-1/2” (4’ 8-1/2”)
   (c) Gauge shall not be allowed to become less than 56” (4’8”)

   Note: On Canadian railways, where gauge is less than 56”, refer to Transport Canada “Track Safety Rules for restrictions and tolerances.

2. **Alignment**
   (a) The measurement for alignment shall be the maximum mid-offset (on tangents) or mid-ordinate (on curves) measurement of a 62’ or 31’ chord measured at the gauge point.
   (b) On curved track, the outside (high) rail shall be used as the line rail. On tangent track, either rail may be used as the line rail providing the same rail is used throughout.
   (c) The maximum mid-offset/mid-ordinate is established by centering visible misalignments on the chord.

3. **Surface**
   (a) The measurement for surface shall be the maximum (positive or negative) mid-ordinate of a 62’ chord measured along the top surface of the rail.
   (b) The maximum mid-ordinate is established by centering visible peaks or sags on the chord.

4. **Crosslevel**
   (a) The measurement for crosslevel shall be the difference in elevation between the grade rail and the other rail, measured with a level board.
   (b) Before taking cross level measurements, always check the accuracy of the level board.
C. Track Geometry Defects

1. Urgent Defects
   (a) Urgent defects are those that have exceeded the tolerances of Transport Canada “Track Safety Rules” (Table 2A) or, FRA “Track Safety Standards” (Table 2B)
   (b) Immediate remedial action must be taken for geometry defects that exceed the maximum tolerances in Tables 2A and 2B, by;
      i. Repairing the defect
      ii. Applying an appropriate slow order or;
      iii. Removing the track from service

2. Priority Defects
   (a) Priority defects (Tables 1A & 1B) are the Genesee & Wyoming maintenance tolerances that are approaching maximum allowable tolerances of Transport Canada “Track Safety Rules” or FRA “Track Safety Standards”.

   NOTE: After all “Urgent” defects have been repaired, a maintenance plan should be initiated to repair priority defects.

3. Track Geometry Vehicles
   (a) Genesee & Wyoming Engineering will review geometry testing requirements annually and a schedule of testing will be issued to the railroads affected.
   (b) On Canadian Railways, minimum track inspection frequencies are based on the operation of a geometry test vehicle.

   See Genesee & Wyoming “Track Inspection” Standards – Table C-2 (c) and Item D-5 (b)
   (c) Genesee & Wyoming may utilize any of three types of testing vehicles depending on the characteristics of the railroad to be tested.
      a. Class I cars (CP Rail, CN TEST, UP, NS etc.)
      b. Holland “TrackSTAR”
      c. Small Hi-rail trucks equipped with a geometry testing system.
# Table 1A – Priority Defects (Canadian Railways)

<table>
<thead>
<tr>
<th>Speed (mph)</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Passenger</strong></td>
<td>15</td>
<td>30</td>
<td>60</td>
<td>80</td>
<td>95*</td>
<td>101</td>
</tr>
<tr>
<td><strong>Freight</strong></td>
<td>10</td>
<td>25</td>
<td>40</td>
<td>60</td>
<td>80</td>
<td>101</td>
</tr>
<tr>
<td><strong>WIDE GAUGE</strong></td>
<td>1464 mm</td>
<td>1454 mm</td>
<td>1454 mm</td>
<td>1454 mm</td>
<td>1454 mm</td>
<td>1454 mm</td>
</tr>
<tr>
<td></td>
<td>57-5/8&quot;</td>
<td>57-1/4&quot;</td>
<td>57-1/4&quot;</td>
<td>57-1/4&quot;</td>
<td>57-1/4&quot;</td>
<td>57-1/4&quot;</td>
</tr>
<tr>
<td><strong>ALIGNMENT</strong></td>
<td><strong>Tangents &amp; Curves 62'</strong></td>
<td>95 mm</td>
<td>57 mm</td>
<td>35 mm</td>
<td>29 mm</td>
<td>13 mm</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3-3/4&quot;</td>
<td>2-1/4&quot;</td>
<td>1-3/8&quot;</td>
<td>1-1//8&quot;</td>
<td>1/2&quot;</td>
</tr>
<tr>
<td><strong>RUN OFF</strong></td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td><strong>SURFACE</strong></td>
<td>The deviation from uniform profile on either rail at the mid-ordinate elevation of an 18.9 m (62') chord may not be more than</td>
<td>50 mm</td>
<td>38 mm</td>
<td>32 mm</td>
<td>25 mm</td>
<td>19 mm</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2&quot;</td>
<td>1-1/2&quot;</td>
<td>1-1/4&quot;</td>
<td>1&quot;</td>
<td>3/4&quot;</td>
</tr>
<tr>
<td><strong>CROSS LEVEL from DESIGN on SPIRALS</strong></td>
<td>Deviation from designated elevation on spirals may not be more than</td>
<td>25 mm</td>
<td>25 mm</td>
<td>25 mm</td>
<td>19 mm</td>
<td>17 mm</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1&quot;</td>
<td>1&quot;</td>
<td>1&quot;</td>
<td>3/4&quot;</td>
<td>11/16&quot;</td>
</tr>
<tr>
<td><strong>WARP in SPIRALS</strong></td>
<td>Variation in cross level on spirals in any 31 feet may not be more than</td>
<td>48 mm</td>
<td>41 mm</td>
<td>29 mm</td>
<td>24 mm</td>
<td>16 mm</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1-7/8&quot;</td>
<td>1-5/8&quot;</td>
<td>1-1/8&quot;</td>
<td>15/16&quot;</td>
<td>5/8&quot;</td>
</tr>
<tr>
<td><strong>CROSS LEVEL from DESIGN on TANGENTS &amp; CURVES</strong></td>
<td>Deviation from zero cross level at any point on tangent or from designated elevation on curves between spirals may not be more than</td>
<td>25 mm</td>
<td>25 mm</td>
<td>25 mm</td>
<td>25 mm</td>
<td>17 mm</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1&quot;</td>
<td>1&quot;</td>
<td>1&quot;</td>
<td>1&quot;</td>
<td>11/16&quot;</td>
</tr>
<tr>
<td><strong>WARP in TANGENTS &amp; CURVES</strong></td>
<td>The difference in cross level between any two points less than 18.9 m (62') apart on tangents and curves between spirals may not be more than</td>
<td>57 mm</td>
<td>38 mm</td>
<td>35 mm</td>
<td>29 mm</td>
<td>19 mm</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2-1/4&quot;</td>
<td>1-1/2&quot;</td>
<td>1-3/8&quot;</td>
<td>1-1/8&quot;</td>
<td>3/4&quot;</td>
</tr>
<tr>
<td><strong>DELTA GAUGE MEASUREMENT</strong></td>
<td>Geometry Car – The difference between the unloaded gauge and loaded gauge measurements may not be more than:</td>
<td>5/8&quot;</td>
<td>5/8&quot;</td>
<td>5/8&quot;</td>
<td>5/8&quot;</td>
<td>5/8&quot;</td>
</tr>
</tbody>
</table>

*For LRC Trains, 100 mph  
Including Express Trains

**MAXIMUM SUPERELEVATION**

If Existing Superelevation exceeds 5 inches, arrangements must be made to restore to the correct designated elevation.
Table 1B – Priority Defects (US Railroads)

<table>
<thead>
<tr>
<th>TRACK CLASS</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Passenger</td>
<td>15</td>
<td>30</td>
<td>60</td>
<td>80</td>
<td>90</td>
</tr>
<tr>
<td>Freight</td>
<td>10</td>
<td>25</td>
<td>40</td>
<td>60</td>
<td>80</td>
</tr>
</tbody>
</table>

**WIDE GAUGE**
The distance between the gauge points of the rails 5/8” below the top of the rail may not be more than:

- Speed (mph) | 1 | 2 | 3 | 4 | 5
- Passenger   | 57-5/8" | 57-1/4" | 57-1/4" | 57-1/4" | 57-1/4"
- Freight     | 57-5/8" | 57-1/4" | 57-1/4" | 57-1/4" | 57-1/4"

**ALIGNMENT**

- **Tangent 62'**
The deviation of the mid-offset from a 62’ line may not be more than:

- Speed (mph) | 1 | 2 | 3 | 4 | 5
- Passenger   | 3-3/4" | 2-1/4" | 1-3/8" | 1-1/8" | 1/2"
- Freight     | 3-3/4" | 2-1/4" | 1-3/8" | 1-1/8" | 1/2"

- **Curve 62'**
The deviation of the mid-ordinate from a 62’ chord may not be more than:

- Speed (mph) | 1 | 2 | 3 | 4 | 5
- Passenger   | 3-3/4" | 2-1/4" | 1-3/8" | 1-1/8" | 1/2"
- Freight     | 3-3/4" | 2-1/4" | 1-3/8" | 1-1/8" | 1/2"

- **Curve 31'**
The deviation of the mid-ordinate from a 31’ chord may not be more than:

- Speed (mph) | 1 | 2 | 3 | 4 | 5
- Passenger   | N/A | N/A | 7/8" | 3/4" | 3/8"
- Freight     | N/A | N/A | 7/8" | 3/4" | 3/8"

**RUNOFF**
The runoff in any 31 feet of rail at the end of a raise may not be more than:

- Speed (mph) | 1 | 2 | 3 | 4 | 5
- Passenger   | N/A | N/A | N/A | N/A | N/A
- Freight     | N/A | N/A | N/A | N/A | N/A

**SURFACE**
The deviation from uniform profile on either rail at the mid-ordinate of a 62’ chord may not be more than:

- Speed (mph) | 1 | 2 | 3 | 4 | 5
- Passenger   | 2" | 1-1/2" | 1-1/4" | 1" | 3/4"
- Freight     | 2" | 1-1/2" | 1-1/4" | 1" | 3/4"

**CROSS LEVEL from DESIGN on TANGENTS & CURVES**
Deviation from zero cross level at any point on tangent or from designated elevation on curves between spirals may not be more than:

- Speed (mph) | 1 | 2 | 3 | 4 | 5
- Passenger   | 1" | 1" | 1" | 1" | 11/16"
- Freight     | 1" | 1" | 1" | 1" | 11/16"

**WARP 62**
The difference in cross level between any two points less than 62’ apart may not be more than:

- Speed (mph) | 1 | 2 | 3 | 4 | 5
- Passenger   | 2-3/4" | 2-1/4" | 2" | 1-3/4" | 1-1/2"
- Freight     | 2-3/4" | 2-1/4" | 2" | 1-3/4" | 1-1/2"

**WARP 31**
Difference in cross level between any two points 31’ apart in spirals may not be more than:

- Speed (mph) | 1 | 2 | 3 | 4 | 5
- Passenger   | 1-7/8" | 1-5/8" | 1-1/8" | 15/16" | 5/8"
- Freight     | 1-7/8" | 1-5/8" | 1-1/8" | 15/16" | 5/8"

**DELTA GAUGE MEASUREMENT**
Geometry Car – The difference between the unloaded gauge and loaded gauge measurements may not be more than:

- Speed (mph) | 1 | 2 | 3 | 4 | 5
- Passenger   | 5/8" | 5/8" | 5/8" | 5/8" | 5/8"
- Freight     | 5/8" | 5/8" | 5/8" | 5/8" | 5/8"

**MAXIMUM SUPERELEVATION**

If Existing Superelevation exceeds 6 inches, arrangements must be made to restore to the correct designated elevation.
### Table 2A – Urgent Defects (Canadian Railways)

<table>
<thead>
<tr>
<th>Speed (mph)</th>
<th>TRACK CLASS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td><strong>Passenger</strong></td>
<td>15</td>
</tr>
<tr>
<td><strong>Freight</strong></td>
<td>10</td>
</tr>
</tbody>
</table>

**WIDE GAUGE**

The distance between the gauge points of the rails 16 mm (5/8") below the top of the rail may not be more than:

- 1473mm (58")
- 1467mm (57-3/4")
- 1467mm (57-3/4")
- 1461mm (57-1/2")
- 1461mm (57-1/2")

**ALIGNMENT TANGENT 62°**

The maximum out-of-line measurement calculated from mid-offset measurements of an 18.9 m (62°) chord may not be more than:

- 127 mm (5")
- 76 mm (3")
- 44 mm (1-3/4")
- 38 mm (1-1/2")
- 16 mm (3/4")

**ALIGNMENT CURVE 62°**

The maximum out-of-line measurement calculated from mid-ordinate measurements of an 18.9 m (62°) chord may not be more than:

- N/A
- N/A
- N/A
- N/A
- 15 mm (5/8")

**RUNOFF at END of a RAISE**

The runoff in any 9.45 m (31”) at the end of a raise may not be more than:

- 88 mm (3-1/2")
- 76 mm (3")
- 51 mm (2")
- 38 mm (1-1/2")
- 25 mm (1")

**SURFACE**

The deviation from uniform profile on either rail at the mid-ordinate of an 18.9 m (62°) chord may not be more than:

- 76 mm (3")
- 70 mm (2-3/4")
- 57 mm (2-1/4")
- 51 mm (2")
- 32 mm (1-1/4")

**CROSS LEVEL from DESIGN on SPIRALS**

Deviation from designated elevation on spirals may not be more than:

- 44 mm (1-3/4")
- 38 mm (1-1/2")
- 32 mm (1-1/4")
- 25 mm (1")
- 19 mm (3/4")

**WARP 31**

Variation in cross level on spirals in any 31 feet may not be more than:

- 51 mm (2")
- 44 mm (1-3/4")
- 32 mm (1-1/4")
- 25 mm (1")
- 19 mm (3/4")

**CROSS LEVEL from DESIGN on TANGENTS & CURVES**

Deviation from zero cross level at any point on tangent or from designated elevation on curves between spirals may not be more than:

- 76 mm (3")
- 51 mm (2")
- 44 mm (1-3/4")
- 32 mm (1-1/4")
- 25 mm (1")

**WARP 62**

The difference in cross level between any two points less than 18.9 m (62°) apart on tangents and curves between spirals may not be more than:

- 76 mm (3")
- 51 mm (2")
- 44 mm (1-3/4")
- 32 mm (1-1/4")
- 25 mm (1")

*For LRC Trains, 100 mph  
+ Including Express Trains

**MAXIMUM SUPERELEVATION**

Existing Superelevation shall not be allowed to exceed 6 inches.
Table 2B – Urgent Defects (US Railroads)

<table>
<thead>
<tr>
<th>Speed (mph)</th>
<th>TRACK CLASS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Passenger</td>
<td>15</td>
</tr>
<tr>
<td>Freight</td>
<td>10</td>
</tr>
</tbody>
</table>

**WIDE GAUGE**
The distance between the gauge points of the rails 5/8” below the top of the rail may not be more than

- 58”
- 57-3/4”
- 57-3/4”
- 57-1/2”
- 57-1/2”

**ALIGNMENT TANGENT 62’**
The deviation of the mid-offset from a 62 foot line may not be more than:

- 5”
- 3”
- 1-3/4”
- 1-1/2”
- 3/4”

**ALIGNMENT CURVE 62’**
The deviation of the mid-ordinate from a 62 foot chord may not be more than:

- 5”
- 3”
- 1-3/4”
- 1-1/2”
- 5/8”

**ALIGNMENT CURVE 31’**
The maximum out-of-line measurement calculated from mid-ordinate measurements of an 9.45 m (31’) chord may not be more than

- N/A
- N/A
- 1-1/4”
- 1”
- 1/2”

**RUNOFF at END of a RAISE**
The runoff in any 31’ at the end of a raise may not be more than

- 3-1/2”
- 3”
- 2”
- 1-1/2”
- 1”

**SURFACE**
The deviation from uniform profile on either rail at the mid-ordinate of 62’ chord may not be more than

- 3”
- 2-3/4”
- 2-1/4”
- 2”
- 1-1/4”

**CROSS LEVEL**
Deviation from zero cross level at any point on tangent or reverse croslevel elevation on curves may not be more than

- 3”
- 2”
- 1-3/4”
- 1-1/4”
- 1”

**WARP 62**
The difference in cross level between any two points less than 62’ apart may not be more than*1,2

- 3”
- 2-1/4”
- 2”
- 1-3/4”
- 1-1/2”

**WARP 31**
Where determined by engineering decision prior to promulgation of this rule, due to physical restrictions on spiral length and operating practices and experience, the variation in croslevel 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 croslevel within 62 feet between that point and a point with greater elevation may not be more than 1-1/2 inches. (Footnote 1 is applicable September 21, 1999.)

2- However, to control harmonics on Class 2 through 5 jointed track with staggered joints, the croslevel 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.)

**MAXIMUM SUPERELEVATION**

Existing Superelevation shall not be allowed to exceed 8 inches on Classes 1 & 2 track, and; 7 inches on Classes 3 through 5 track.
### Track Geometry

**Appendix A - Superelevation Table (2" Unbalanced)**

<table>
<thead>
<tr>
<th>Curvature</th>
<th>Deg.</th>
<th>Min.</th>
<th>20 mph</th>
<th>25 mph</th>
<th>30 mph</th>
<th>35 mph</th>
<th>40 mph</th>
<th>45 mph</th>
<th>50 mph</th>
<th>55 mph</th>
<th>60 mph</th>
<th>65 mph</th>
<th>70 mph</th>
<th>75 mph</th>
<th>80 mph</th>
<th>85 mph</th>
</tr>
</thead>
</table>

**Design Superelevation for Freight Trains**

- 10 -