PENNSYLVANIA LINES
WEST OF PITTSBURGH

INSTRUCTIONS
COVERING
TRACK ALIGNMENT AND GRADES

OCTOBER 1, 1909.
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These instructions are issued to secure uniform practice in track alignment and grades on the Pennsylvania Lines West of Pittsburgh, and supersede those of November 1, 1898.

In realigning or reballasting present main tracks, be governed as follows:

**Spirals:**

All main track curves over 2° 00' should be provided with spiral easement curves of a length of 60 feet for each one inch of super-elevation of outer rail; where the speed exceeds 40 miles per hour, spirals will be used on curves over 0° 45'. (See table No. 1, showing superelevation required.)

On compound curves, where the change in rate of curve exceeds 2°, the branches of the compound curve should be connected by a spiral, the length of which is 60 feet for every one inch difference in superelevation on the respective branches; except, where the speed exceeds 40 miles per hour, spirals will be used when difference in rate of curve is one degree or over.

Where it is impossible to use a spiral of the length recommended, the longest possible spiral will be used, keeping the rate of super-elevation of outer rail as nearly as practicable to 1 inch in 60 feet.
On double tracks, where the superelevation is different for the two tracks, make the spirals for both tracks the same length, using the spiral required for the greater superelevation.

**Center Line Stakes:**

Oak center line stakes 1½" x 1½" x 18" to 24" shall be set every 50 feet on circular portions of curves and not to exceed 25 feet apart on spirals.

On double tracks they shall be placed on center line between tracks and on single track in center of the track.

These stakes shall be maintained on Divisions over which fast passenger trains are operated.

**Monuments:**

Permanent monuments for the alignment shall be placed at the ends of simple curves, at the ends of spirals, at the P. C. C.'s of compound curves and at such intermediate points as are necessary for convenient re-running of curves.

On double track the monuments shall be placed on center line between tracks; on single track they shall be placed in center of track; on four tracks, in center line between the two middle tracks.

Iron pins 2 inches in diameter and about 4 feet long, or stones 6" x 6" square on top, 3 feet long, will be used for monuments. Stone should always be used in slag ballast.
Numbering Curves:
All curves should be numbered consecutively, beginning at the east (or south) end of a Division with Curve No. 1.

Number Stakes:
Standard "Number Stakes" should be set opposite the end of all main track curves opposite points where superelevation for outer rail of curve begins and ends—these stakes to show the number of the curve on the sides facing the curve and E. O., indicating track is level in cross section, on sides facing tangent. (See Figure 5.)

Superelevation:
The proper superelevation must be fixed by the Engineer of Maintenance of Way by taking into consideration the location, grade and speed. Generally, the superelevation should be made to suit high speed trains. Local conditions, such as proximity of curve to station at which all trains reduce speed or stop, water stations, railroad crossings and junctions affecting speed, are factors in determining proper superelevation.

Curves of the same degree, therefore, should not always be given the same superelevation. For example: A three degree curve at the top of a long grade should not necessarily have the same superelevation as a three degree curve at the foot of a long grade. The speed of trains is almost invariably faster over the latter than the former.

On tangent or straight track, except as noted below, points directly opposite on both rails should be kept at the same level.
On a circular curve with spirals, the outer rail should have the full superelevation at the beginning and end of circular curve.

Where a spiral is not used, the superelevation of outer rail shall be run out (all being on tangent) at the rate of 60 feet in length for each one inch of elevation to be attained.

The outer rail on curves shall be elevated in accordance with the following table based on the formula:

\[ E = \frac{g v^2}{32.2 R} \quad \text{or} \quad .0007 V^2 D. \]

\[ g = \text{the distance center to center of rails;} \]
\[ v = \text{the velocity in feet per second;} \]
\[ R = \text{the radius of the curve in feet;} \]
\[ E = \text{the superelevation of outer rail in inches;} \]
\[ V = \text{the velocity in miles per hour;} \]
\[ D = \text{the degree of curve.} \]

**TABLE No. 1.**

**TABLE OF SUPERELEVATION IN INCHES OF OUTER RAIL ON CURVES.**

<table>
<thead>
<tr>
<th>Degree of Curve</th>
<th>Speed in Miles per Hour</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>20</td>
</tr>
<tr>
<td>0° 30'</td>
<td>0</td>
</tr>
<tr>
<td>1° 00'</td>
<td>0½</td>
</tr>
<tr>
<td>1° 30'</td>
<td>0½</td>
</tr>
<tr>
<td>2° 00'</td>
<td>1</td>
</tr>
<tr>
<td>2° 30'</td>
<td>1</td>
</tr>
<tr>
<td>3° 00'</td>
<td>1</td>
</tr>
<tr>
<td>3° 30'</td>
<td>1</td>
</tr>
<tr>
<td>4° 00'</td>
<td>1½</td>
</tr>
<tr>
<td>4° 30'</td>
<td>1½</td>
</tr>
<tr>
<td>5° 00'</td>
<td>1½</td>
</tr>
<tr>
<td>5° 30'</td>
<td>1½</td>
</tr>
<tr>
<td>6° 00'</td>
<td>2</td>
</tr>
<tr>
<td>6° 30'</td>
<td>2</td>
</tr>
<tr>
<td>7° 00'</td>
<td>2</td>
</tr>
<tr>
<td>7° 30'</td>
<td>2½</td>
</tr>
<tr>
<td>8° 00'</td>
<td>2½</td>
</tr>
</tbody>
</table>

The superelevation of outer rail must not exceed 8 inches.
Superelevation Stakes:

Standard superelevation stakes should be set for all curves.

On simple circular curves superelevation stakes shall be placed opposite the ends of curves.

Where spirals are used, stakes shall be placed opposite the ends of circular curves.

Show on face of stakes towards tangents or spirals the correct superelevation of circular curve, and on sides facing circular curve the degree of curve.

On compound curves elevation stakes shall be placed opposite points marking changes in superelevation.

See sketches, pages 11 and 12.

Location of Number and Superelevation Stakes:

All Number and Superelevation Stakes for one or more tracks having same superelevation should be placed on the outside of curve eight (8) feet from rail.

Where two tracks occur of different superelevation, stakes should be set both inside and outside of curve eight (8) feet from nearest rails.

Where there are four main tracks of varying superelevation, place stakes both inside and outside of curves. Those on outside should have superelevations of the two tracks nearest them shown one above the other, the top figure showing superelevation of track nearest stake.

Inside stakes should be similarly marked.
Grades:

No grades shall be introduced exceeding in rate the maximum established for the engine stage in which said grade occurs.

Compensation on Curves:

When a curve is located on a grade and the combined effect of the curve and grade resistances constitutes the controlling factor of the train load, the grade on curve should be compensated as follows:

At stations or points where trains are liable to stop, the grades on curves should be reduced at the rate of 0.05 per cent. for each degree of curve.

At all other points the grades on curves should be reduced at the rate of 0.04 per cent. for each degree of curve.

The compensation may generally be attained by adjusting the raise in track when reballasting.

Vertical Curves:

Where changes of grade occur in the profile the gradient lines should be connected by vertical curves, observing the following rules:

A vertical curve will consist of as many equal chords as there are whole tenths of a foot in the algebraic difference of the two gradient lines less one.

The length of the chords will generally be 100 feet, but if for some special reason it becomes necessary to use a shorter vertical curve, the chord lengths may be reduced.

The change from one gradient line to another will be made by a variation in rate of grade for each chord equal to the algebraic
difference between the rates of the two gradient lines divided by the number of whole tenths in the algebraic difference. This change of rate will be approximately 0.1 foot per chord.

Examples:

1. To change from a level grade to + 0.68' per 100'.
   Number of chords in vertical curve = 6—1 = 5.
   Length of vertical curve = 100 x 5 = 500'.
   Rate of change from chord to chord = \( \frac{0.68}{6} = 0.113 \)
   - Rate on first chord = + 0.113
   - Rate on second = + 0.226
   - Rate on third = + 0.339
   - Rate on fourth = + 0.452
   - Rate on fifth = + 0.565

2. To change from a grade of +0.6' per 100' to -0.5 per 100'.
   Number of chords in vertical curve = 11—1 = 10.
   Length of vertical curve = 100 x 10 = 1,000'.
   Rate of change from chord to chord = \( \frac{1.1}{11} = 0.1 \)
   - Rate on first chord = + 0.5
   - Rate on sixth chord = 0.0
   - Rate on second = + 0.4
   - Rate on seventh = -0.1
   - Rate on third = + 0.3
   - Rate on eighth = -0.2
   - Rate on fourth = + 0.2
   - Rate on ninth = -0.3
   - Rate on fifth = + 0.1
   - Rate on tenth = -0.4

If, for example, at some special place the vertical curve must be 700 feet long instead of 1,000 feet, then use 70' chords, keeping rate of grade on chords same as above.

Grade Stakes:

Grade stakes should be set for the top of rail at least every 100 feet on curve and tangents to insure uniform surface. The inner or low rail on curve will be kept to established grade shown on profile.
On curves with two or more tracks, the inner or low rails should be maintained at the same elevation.

Grade stakes shall be set for all vertical curves.

G. L. PECK,
General Manager.

October 1, 1908.
PENNSYLVANIA LINES WEST OF PITTSBURGH
EXAMPLES SHOWING LOCATION AND
INFORMATION TO BE GIVEN ON NUMBER AND
ELEVATION STAKES ON CURVES.
Curves spiralled, tracks same super-elevation.

Curves spiralled, tracks with different super-elevations, spirals same length for both tracks.

Compound Curve.

Compound Curve. To have elevation posts "A" only if super-elevation is same for both tracks. To have A & B posts with different super-elevations. B posts to have elevations only.

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EXAMPLES SHOWING LOCATION AND INFORMATION TO BE GIVEN ON NUMBER AND ELEVATION STAKES ON CURVES.