TRACK GEOMETRY INSPECTION REPORT EXPLANATION

GENERAL

During *Automated Track Inspection Program* (ATIP) surveys, the Track Geometry Measurement System (TGMS) collects data on ATIP cars, and a console program generates a ***Track Geometry Inspection Report*** (TGIR). This report makes the analysis of the track easier to read and comprehend than attempting to read exceptions from a video strip chart alone. TGIR is generated electronically for printing in near real-time onboard ATIP cars or can be reprocessed later upon request to the Federal Railroad Administration (FRA). Report copies are transmitted electronically as a Portable Document Format (PDF) using satellite or Internet communications. Copies are distributed as follows:

1. One copy is given to the railroad
2. Two copies are given to the principal FRA Inspector
3. One copy is sent to the FRA Washington headquarters

TGIR consists of six separate sections. Exceptions are not reported for profile and alignment when ATIP car speed is less than five (5) and fifteen (15) miles per hour, respectively. The sample interval for track surveyed is one (1) foot. An exception is reported when track geometry values exceed the prescribed limit and are sustained over a minimum length of two (2) feet. Further explanation of ATIP report information is accessible on the website at: http://www.fra.dot.gov.

SECTION I - TITLE INFORMATION

The *Title Information Section* contains the report title, ATIP car designation, survey number, railroad, milepost limits, survey geography, contractor information, and certificate of accreditation.

SECTION II – REGULATORY INFORMATION

The *Regulatory Information Section* lists minimum track geometry safety limits in accordance with the *Federal Track Safety Standards* (FTSS). Railroad authorized train speed determines the Class of Track, which categorizes the minimum or maximum track geometry requirements. The following texts, in tabular form, are excerpted from Title 49 *U.S. Code of Federal Regulations* Part 213 Subpart C and G.

Subpart C §213.53 Gage

(a) Gage is measured between the heads of the rails at right-angles to the rails in a plane five-eights of an inch below the top of the rail head.
(b) Gage shall be within the limits prescribed in Table 1:

Class of Track	Must be at least (inches)	But not more than (inches)
Excepted	n/a[1]	4 feet 10 ¼ (58 ¼)
Class 1	4 feet 8 (56)	4 feet 10 (58)
Class 2 and 3	4 feet 8 (56)	4 feet 9 ¾ (57 ¾)
Class 4 and 5	4 feet 8 (56)	4 feet 9 ½ (57 ½)

Table 1

[1] Not Applicable

TRACK GEOMETRY INSPECTION REPORT EXPLANATION

Subpart C §213.55 Alignment
Alignment may not deviate from uniformity more than the amount prescribed in Table 2:

Class of Track	Tangent Track	Curved Track	
	The deviation (inches) of the mid-offset from a 62-foot line[2] may not be more than—	The deviation (inches) of the mid-ordinate from a 31-foot chord[3] may not be more than—	The deviation (inches) of the mid-ordinate from a 62-foot chord may not be more than—
Class 1	5	n/a	5
Class 2	3	n/a	3
Class 3	1 ¾	1 ¼	1 ¾
Class 4	1 ½	1	1 ½
Class 5	¾	½	⅝

Table 2

Subpart C §213.57 Curves: Elevation and Speed Limitations
(a) The maximum crosslevel on the outside rail of a curve may not be more than 8 inches on track Classes 1 and 2 and 7 inches on Classes 3 through 5. Except as provided in §213.63, the outside rail of a curve may not be lower than the inside rail.
(b)(1) The maximum allowable operating speed for each curve is determined by the following formula—

$$V_{max} = \sqrt{(E_a + 3) \div (.0007 \times D)} \quad (1)$$

(c)(1) For rolling stock meeting the requirements specified in paragraph(d) of this section, the maximum operating speed for each curve may be determined by the following formula—

$$V_{max} = \sqrt{(E_a + 4) \div (.0007 \times D)} \quad (2)$$

Where:
- V_{max} = Maximum allowable operating speed (miles per hour).
- E_a = Actual Elevation of the outside rail (inches).
- D = Degree of curvature (degrees). Degree of curvature is determined by averaging the degree of curvature over the same track segment as the elevation.

Subpart C §213.59 Elevation of Curved Track: Runoff
(a) If a curve is elevated, the full elevation shall be provided throughout the curve, unless physical conditions do not permit. If elevation runoff in a curve, the actual minimum elevation shall be used in computing the maximum allowable operating speed for that curve under §213.57(b).

(b) Elevation runoff shall be at a uniform rate, within the limits of track surface deviation prescribed in §213.63 and it shall extend at least the full length of the spirals. If physical conditions do not permit a spiral long enough to accommodate the minimum length of runoff, part of the runoff may be on tangent track.

[2] The ends of the line shall be at points on the gage side of the line rail, five-eighths (⅝) of an inch below the top of the railhead. Either rail may be used as the line rail; however, the same rail shall be used for the full length of that tangential segment of track.
[3] The ends of the chord shall be at points on the gage side of the outer rail, five-eighths of an inch below the top of the railhead.

TRACK GEOMETRY INSPECTION REPORT EXPLANATION

Subpart C §213.63 Track Surface
Each owner of track to which this part applies shall maintain the surface of its track within the limits prescribed in Table 3:

	Class of Track				
Description	**1 (inches)**	**2 (inches)**	**3 (inches)**	**4 (inches)**	**5 (inches)**
The runoff in any 31-feet of rail at the end of a raise may not be more than—	3 ½	3	2	1 ½	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 ¾	2 ¼	2	1 ¼
The deviation from zero crosslevel at any point on tangent or reverse crosslevel elevation on curves may not be more than—	3	2	1 ¾	1 ¼	1
The difference in crosslevel between any two points less than 62-feet apart may not be more than— See Footnote: * [4] [5]	3	2 ¼	2	1 ¾	1 ½
*Where determined by engineering decision prior to the promulgation of this rule, 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 ¾	1 ¼	1	¾

Table 3

Subpart G §213.323 Track Gage
(a) Gage is measured between the heads of the rails at right-angles to rails in a plane five-eight of an inch below the top of the rail head.
(b) Gage shall be within the limits prescribed in Table 4:

Class of Track	**The gage must be at least—**	**But not more than—**	**The change of gage within 31-feet must not be greater than—**
6	4 feet 8 inches	4 feet 9 ¼ inches	½ inch
7	4 feet 8 inches	4 feet 9 ¼ inches	½ inch
8	4 feet 8 inches	4 feet 9 ¼ inches	½ inch
9	4 feet 8 ¼ inches	4 feet 9 ¼ inches	½ inch

Table 4

[4] 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 1 ½ inches.
[5] However, to control harmonics on Class 2 through 5 jointed track with staggered joints, the crosslevel differences shall not exceed 1 ¼ 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.

TRACK GEOMETRY INSPECTION REPORT EXPLANATION

Subpart G §213.327 Alignment

(a) Uniformity at any point along the track is established by averaging the measured mid-chord offset values for nine consecutive points centered around that point, which are spaced according to Table 5:

Chord Length	Spacing
31-feet	7 feet 9 inches
62-feet	15 feet 6 inches
124-feet	31-feet

Table 5

(b) For a single deviation, alignment may not deviate from uniformity more than the amount prescribed in Table 6:

Class of Track	The deviation (inches) from uniformity of the mid-chord offset for a 31-foot chord may not be more than—	The deviation (inches) from uniformity of the mid-chord offset for a 62-foot chord may not be more than—	The deviation (inches)from uniformity of the mid-chord offset for a 124-foot chord may not be more than—
6	½	¾	1 ½
7	½	½	1 ¼
8	½	½	¾
9	½	½	¾

Table 6

(c) For three or more non-overlapping deviations from uniformity in track alignment occurring within a distance equal to five times the specified chord length, each of which exceeds the limits in Table 7, each owner of the track to which this subpart applies shall maintain the alignment of the track within the limits prescribed for each deviation**.**

(d)

Class of Track	The deviation (inches) from uniformity of the mid-chord offset for a 31-foot chord may not be more than—	The deviation (inches) from uniformity of the mid-chord offset for a 62-foot chord may not be more than—	The deviation (inches) from uniformity of the mid-chord offset for a 124-foot chord may not be more than—
6	⅜	½	1
7	⅜	⅜	⅞
8	⅜	⅜	½
9	⅜	⅜	½

Table 7

Subpart G §213.329 Curves, elevation and speed limitations

(a) The maximum crosslevel on the outside rail of a curve may not be more than 7 inches. The outside rail of a curve may not be more than ½ inch lower than the inside rail.

(b)(1) The maximum allowable operating speed for each curve is determined by the following formula—

$$V_{max} = \sqrt{(E_a + 3) \div (.0007 \times D)} \qquad (3)$$

(c) For rolling stock meeting the requirements specified in paragraph (d) of this section, the maximum operating speed for each curve may be determined by the following formula—

$$V_{max} = \sqrt{(E_a + 4) \div (.0007 \times D)} \quad (4)$$

Where:

V_{max} = Maximum allowable operating speed (miles per hour).
E_a = Actual Elevation of the outside rail (inches).
D = Degree of curvature (degrees). Degree of curvature is determined by averaging the degree of curvature over the same track segment as the elevation.
E_u = Unbalanced elevation (inches)

Subpart G §213.331 Track Surface

(a) For a single deviation in track surface, each owner of track to which this subpart applies shall maintain the surface of its track within the limits prescribed in Table 8:

	Class of Track			
Track Surface	**6 (inches)**	**7 (inches)**	**8 (inches)**	**9 (inches)**
The deviation from uniform[6] profile on either rail at the mid-ordinate of a 31-foot chord may not be more than—	1	1	¾	½
The deviation from uniform profile on either rail at the mid-ordinate of a 62-foot chord may not be more than—	1	1	1	¾
The deviation from uniform profile on either rail at the mid-ordinate of a 124-foot chord may not be more than—	1 ¾	1 ½	1 ¼	1 ¼
The difference in crosslevel between any two points less than 62-feet apart may not be more than[7]—	1 ½	1 ½	1 ½	1 ½

Table 8

(b) For three or more non-overlapping deviations in track surface occurring within a distance equal to five times the specified chord length, each of which exceeds the limits in Table 9, each owner of the track to which this subpart applies shall maintain the surface of the track within the limits prescribed for each deviation.

	Class of Track			
Track Surface	**6 (inches)**	**7 (inches)**	**8 (inches)**	**9 (inches)**
The deviation from uniform profile on either rail at the mid-ordinate of a 31-foot chord may not be more than—	¾	¾	½	⅜
The deviation from uniform profile on either rail at the mid-ordinate of a 62-foot chord may not be more than—	¾	¾	¾	½
The deviation from uniform profile on either rail at the mid-ordinate of a 124-foot chord may not be more than—	1 ¼	1	⅞	⅞

Table 9

[6] Uniformity of profile is established by placing the midpoint of the specified chord at the point of maximum measurement.

[7] However, to control harmonics on jointed track with staggered joints, the crosslevel differences shall not exceed 1 ¼ 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.

TRACK GEOMETRY INSPECTION REPORT EXPLANATION

SECTION III - EXCEPTION LIST REPORT

This section of the TGIR lists the location and magnitude of each detected exception, which exceeds the FTSS. The header of this section consists of report title identification text, milepost and geographic information, processing ID number, and survey acquisition date.

The column headings indicate specific exception information. From left to right, the headings identify the railroad milepost (*MP*) and distance (*FT*) from the milepost where the exception group ended. The *Parameter* column identifies (top to bottom) a variety of parameters, e.g., Class of Track, and track changes, posted speed, WSD, bridges, grade crossing and other geographical features (turnouts, grade crossings, curves, *etc.*) as well as exceptions being reported according to up or down milepost train direction. Exceptions indicated with an '*' are advisory and serve to emphasize a potential safety condition. Bold parameter text indicates serious noncompliance or an advisory. Most parameters are self-explanatory. Parameters showing *L Cant NEG*, for example, are processed by the Rail Profile System, which considers the design cant of the tie plate, usually a 1:40 ratio. Rail cant (degrees) is either positive or negative. Positive cant means the rail is canting inward to the gage side. Negative rail cant means the rail is canting outward to the field side.

To abate environmental issues, ATIP cars no longer spray paint on the crossties for exception location. A very accurate onboard GPS system 'tags' all parameters with a *Latitude* and *Longitude* coordinate. On-track exceptions may be located for reinspections by using a combination of the TGIR download of GPS data into handheld into a GPS device, the video strip chart (oscillograph) paper printout, or the software program *GeoEdit*.

Exception distance is referenced in the direction of travel by either *increasing or decreasing* mileposts. ATIP cars count the number of feet from the last entered milepost. Reading from the TGIR, if the mileposts are *increasing* (*e.g.,* 9, 10, 11), the footage from a milepost is added and directly read, *i.e.,* an exception located at milepost 10+1584 would be interpreted as 1,584 from milepost 10 (decimally milepost 10.30) in the direction of travel.

If the mileposts are *decreasing* (*e.g.,* 11, 10, 9), the footage from a milepost is subtracted from the milepost and directly read, *i.e.,* an exception located at milepost 10+1320 feet (specifically between milepost 10 and milepost 9), would be interpreted as 1,320-feet from milepost 10 or located at milepost 9+3960 feet (decimally milepost 9.75) in the opposite direction of travel. Depending upon ATIP car speed, there is a delay (translating to a distance of up to 400-feet) reaction time regarding exception *TGMS* calculations and locations as viewed from the observation end of ATIP cars.

Geometry exceptions that are associated with a length (*i.e.,* gage, warp, and harmonic rock) are measured from an exception reference point in the direction of travel. For example, a warp length of 56-feet is located at milepost 9+3960; after computer calculation, the other end to the warp is located at 9+3904 (56-feet from the exception reference point, but in the opposite direction of travel).

The *Value* column contains the maximum exception value measured by the geometry system. The *Length* column lists the length that the exception extends. The *TSC* (T = tangent, B = Beginning spiral, E = Ending Spiral, C = curve body) column heading provides further information for each detected exception. The TSC column specifies the type of track on which the exception occurred. *LC* (limiting class) and *PC* (posted class) columns indicate the limiting Class of Track and the posted Class of Track, respectively. The *Track* column identifies the track number the ATIP car surveyed. For the purpose of ATIP surveys, the TGIR designates tracks 1-4 as standard notations for double or multiple controlled track configurations. A single main track is designated as five (5), where single track exists. A controlled siding is designated six (6), and track seven (7) notations represent all 'other than main', non-controlled tracks, and '*Excepted'* track.

TRACK GEOMETRY INSPECTION REPORT EXPLANATION

SECTION IV - CURVE ANALYSIS REPORT

The header of this section consists of report title identification text, milepost and geographic information, processing ID number, and survey acquisition date. Below the survey geography is a sign convention for Elevation and Curvature. A curvature and elevation column will show a minus sign (-) preceding the degree/minutes indicating curvature to the left and (R)ight rail high or elevated, respectively. Conversely, a plus + sign (not shown) indicates curvature to the right and (L)eft rail high.

The column heading *Curve Analysis Report* provides the curve location, average curvature and elevation values, limiting speed information using three (3) inches of unbalance, including a section that lists values from four (4) through nine (9) inches of cant deficiency. Although four (4) inches of cant deficiency is usually applied to legacy passenger equipment, other types of rolling stock equipment with comparable suspension systems, centers of gravity, and cross-sectional areas may perform equally well. ATIP considers the different types of rail equipment operating over the surveyed track, but the default is 3-inches of unbalance. The following formula maybe helpful in solving unbalance:

$$U_b = E_a - ((V^2 \times D) \div 1430) \quad (5)$$

Where:

U_b = Unbalance

E_a = Average Elevation

V^2 = Velocity (mile per hour) squared

D = Average Degree of Curvature

Left to right, the start of the curve (tangent-spiral) and end of the curve (spiral-tangent) are listed by the *Starting* and *Ending* columns and include the respective milepost number and the distance in feet. *Length* is the overall length of the curve from the point of spiral to the point of tangent. *Average* values of *Curve* (degrees/minutes, e.g., 3/7 means 3 degrees and 7 minutes of curvature) and *Elev* (elevation) give the average of all points measured in the body of the curve (point-of-curve to point-of-spiral). The *Limiting Point* heading specifies the milepost and feet from the milepost. The *Speed* column is divided into *Post* (posted speed) and *LMT* (Limiting Speed) values in miles per hour. Posted speed is provided to FRA by the track owner and entered into the *TGMS* onboard ATIP cars. The *LMT* column indicates the maximum allowable speed (V_{max}) information for each curve in accordance with §213.57(b) using the 3-inch unbalance formula.

The column headings *Curve* (curvature) and *Elev* (elevation) provide the actual curvature and elevation used to compute the limiting speed. Limiting speed values of 10 miles per hour or more below the posted speed are considered serious noncompliance and may invoke a civil penalty. The column *Total* FT/GRP (feet/group) offers the total number of feet where the computed speed is lower than the posted speed and also lists the number of continuous groups of points that are lower than the posted speed in the curve. For a compound curve, each output line containing curve body information is listed on a separate line without spacing between lines.

SECTION V - EXCEPTION SUMMARY REPORT

The header of this section consists of a summary of the track geometry exceptions, which were detected during the survey, report title identification text, milepost and geographic information, processing ID number, and survey acquisition date.

TRACK GEOMETRY INSPECTION REPORT EXPLANATION

Left to right, the column headings provide for specific summary information. The *Milepost* heading indicates the starting milepost number for each entry line. The *FT* (feet) column provides the distance in feet between each milepost marker. Each column lists the exception description. Listed under each exception are the headings *TOT EXC, EXC FT* and *2CL Drop* (total exception, exception feet, and two class drop). The *TOT EXC* column lists the total number of exceptions, which were detected during each mile for that exception. The *EXC FT* column lists the total length in feet of the exceptions detected, inclusive of group exceptions. The *2CL Drop* column indicates serious safety noncompliance where track conditions exist that require two or lower track reclassifications in order to meet all the requirements of *Subpart C* and applicable sections of *Subpart G*.

The *Lim and Cls* (limiting and posted class) heading provides the lowest computed track class for the combined exceptions. If there is more than one Class of Track in a given mile, a separate entry for each class change will occur. The last column *Trk* (Track) provides the track number notation. The last entry shows the total miles surveyed, exceptions per 100 miles, a comparison to the national average of major Class 1 railroads, as well as all railroads surveyed by ATIP, and total miles and percentage of concrete crossties.