



American Railway Engineering and Maintenance-of-Way Association

CHAPTER 5

TRACK¹

FOREWORD

This chapter embraces all of the Association’s recommended practices under the specific heading of “Track” except those relating to the design, details, materials and workmanship for frogs, switches, crossings and other specials trackwork, which are covered in the AREMA Portfolio of Trackwork Plans, embracing more than 100 sheets, 12-1/2” × 9” (minimum size) in a leatherette binder, which may be purchased through Association Headquarters. The use of rail expansion joints for bridges is covered in Chapter 15, Steel Structures.

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¹ The material in this and other chapters in the *AREMA Manual for Railway Engineering* is published as recommended practice to railroads and others concerned with the engineering design and construction of railroad fixed properties (except signals and communications), and allied services and facilities. For the purpose of this Manual, RECOMMENDED PRACTICE is defined as a material, device, design, plan, specification, principle or practice recommended to the railways for use as required, either exactly as presented or with such modifications as may be necessary or desirable to meet the needs of individual railways, but in either event, with a view to promoting efficiency and economy in the location, construction, operation or maintenance of railways. It is not intended to imply that other practices may not be equally acceptable.

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INTRODUCTION

The Chapters of the AREMA Manual are divided into numbered Parts, each comprised of related documents (specifications, recommended practices, plans, etc.). Individual Parts are divided into Sections by centered headings set in capital letters and identified by a Section number. These Sections are subdivided into Articles designated by numbered side headings.

Page Numbers – In the page numbering of the Manual (5-2-1, for example) the first numeral designates the Chapter number, the second denotes the Part number in the Chapter, and the third numeral designates the page number in the Part. Thus, 5-2-1 means Chapter 5, Part 2, page 1.

In the Glossary and References, the Part number is replaced by either a “G” for Glossary or “R” for References.

Document Dates – The bold type date (Document Date) at the beginning of each document (Part) applies to the document as a whole and designates the year in which revisions were last made somewhere in the document, unless an attached footnote indicates that the document was adopted, reapproved, or rewritten in that year.

Article Dates – Each Article shows the date (in parenthesis) of the last time that Article was modified.

Revision Marks – All current year revisions (changes and additions) which have been incorporated into the document are identified by a vertical line along the outside margin of the page, directly beside the modified information.

Proceedings Footnote – The Proceedings footnote on the first page of each document gives references to all Association action with respect to the document.

Annual Updates – New manuals, as well as revision sets, will be printed and issued yearly.

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American Railway Engineering and Maintenance-of-Way Association

Part 1

Tie Plates¹

— 1992 —

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¹ References, Vol. 27, 1926, pp. 633, 1366; Vol. 32, 1931, pp. 152, 821; Vol. 42, 1941, pp. 576, 836; Vol. 43, 1942, pp. 516, 767; Vol. 44, 1943, pp. 441, 448; Vol. 47, 1946, pp. 482, 636; Vol. 49, 1948, pp. 337, 639; Vol. 54, 1953, pp. 1037, 1402; Vol. 62, 1961, pp. 643, 946; Vol. 64, 1963, pp. 421, 683; Vol. 65, 1964, pp. 512, 879; Vol. 67, 1966, pp. 405, 731; Vol. 69, 1968, p. 357; Vol. 93, 1992, pp. 58, 60.

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SECTION 1.1 SPECIFICATIONS FOR STEEL TIE PLATES (1992)

1.1.1 SCOPE (1992)

- a. These specifications cover steel tie plates for use in railroad track.
- b. Either low carbon or high carbon steel tie plates may be furnished unless purchaser specifies the chemical composition to be used.
- c. ASTM A67 applies in so far as conflicts do not exist.

1.1.2 MANUFACTURE (1992)

- a. Melting Practice – The steel shall be made by any of the following processes: open-hearth, basic-oxygen, or electric-furnace.
- b. The steel shall be cast by a continuous process, in ingots, or by other methods agreed upon by the purchaser and the manufacturer.
- c. Sufficient discard shall be taken from ingots and blooms rolled from ingots to ensure freedom from injurious segregations and pipe.
- d. Tie plates shall be produced from hot rolled steel sections punched and sheared either hot or cold as appropriate to the chemical composition of the steel being used.

1.1.3 CHEMICAL COMPOSITION (1992)

1.1.3.1 Composition

- a. The chemical composition of the tie plate steel, determined as prescribed in [Article 1.1.3.2, paragraph a](#), shall be within the limits shown in [Table 5-1-1](#).
- b. Finished material representing the heat may be product tested. The product analysis shall be within the limits for product analyses specified in [Table 5-1-1](#).

Table 5-1-1. Chemical Composition

Element	Chemical Analysis Weight Percent		Product Analysis Weight Percent Allowance Beyond Limits of Specified Chemical Analysis	
	Low Carbon Tie Plates	High Carbon Tie Plates	Under Minimum Limit	Over Maximum Limit
Carbon	0.150 min to 0.349	0.350 to 0.850	0.040	0.000
Phosphorus	0.050 max	0.050 max	N/A	0.008
Sulfur	0.040 max	0.040 max	N/A	0.008

1.1.3.2 Heat or Cast Analysis

- a. Separate analysis shall be made from test samples representing one of the first three and one of the last three ingots or continuously cast blooms preferably taken during the pouring of the heat. Determinations may be made chemically or spectrographically. Any portion of the heat meeting chemical analysis requirements of [Table 5-1-1](#) may be applied. Additionally, any material meeting the product analysis limits shown in [Table 5-1-1](#) may be applied after testing such material.
- b. The first heat analysis shall be recorded as the official analysis, but the purchaser shall have access to all chemical analysis determinations.
- c. Upon request by the purchaser, samples shall be furnished to verify the analysis as determined in [Article 1.1.3.2, paragraph a](#).

1.1.4 BENDING PROPERTIES (1992)

1.1.4.1 Bend Test – Low Carbon Steel

The bend test specimen specified in [Article 1.1.5](#) shall stand being bent cold through 180 degrees around a pin the diameter of which is not greater than the thickness of the specimen without cracking on the outside of the bent portion.

1.1.4.2 Optional Bend Tests – Low Carbon Steel

If preferred by the manufacturer the following bend test may be substituted for that described in [Article 1.1.4.1](#). A piece of the rolled bar or the finished tie plate shall stand being bent cold through 90 degrees around a pin the diameter of which is not greater than the thickness of the section where bent, without cracking on the outside of the bent portion. The term “thickness” includes vertical height of ribs and shoulder where they are transverse to direction of pin.

1.1.4.3 Bend Test – High Carbon Steel

The bend test specimen specified in [Article 1.1.5](#) shall stand being bent cold through 30 degrees around a pin the diameter of which is not greater than three times the thickness of the specimen without cracking on the outside of the bent portion.

1.1.4.4 Optional Bend Test – High Carbon Steel

If preferred by the manufacturer, the following bend test may be substituted for that described in [Article 1.1.4.3](#). A piece of the rolled bar or the finished tie plate which may be bent in either direction shall stand being bent cold through 30 degrees around a pin the diameter of which is not greater than three times the thickness of the section where bent, without cracking on the outside of the bent portion. The term “thickness” includes vertical height of ribs and shoulder where they are transverse to direction of pin.

1.1.5 TEST SPECIMENS (1992)

Bend test specimens for [Article 1.1.4.1](#) or [Article 1.1.4.3](#) shall be taken longitudinally with the direction of rolling from the finished tie plates, or from the rolled bars. They shall be rectangular in section, not less than 1/2 inch in width between the planed sides, and shall have two faces as rolled. They shall be free from ribs or projections. Where the design of the tie plates is such that the specimen cannot be taken between the ribs or projections, these ribs or projections shall, in preparing the specimen, be planed off even with the main surface of the tie plate.

1.1.6 NUMBER OF TESTS (1992)

- a. One bend test shall be made from each heat of open-hearth, electric-furnace or basic-oxygen steel, or from each 25 tons where heats are not identified.
- b. If any test specimen shows defective machining or surface flaws, it may be discarded and another specimen substituted.

1.1.7 RETESTS (1992)

High carbon steel tie plates represented by bend tests failing to meet the requirements prescribed in [Article 1.1.4.3](#) or [Article 1.1.4.4](#) may be reannealed and resubmitted. If tie plates fail to meet the second test they shall be rejected.

1.1.8 FINISH AND PERMISSIBLE VARIATION IN DIMENSIONS (1992)

The tie plates shall be smoothly rolled and free from injurious warp and other imperfections in surface, and projecting fins of metal caused by shearing and punching.

The tie plate shall conform to the dimensions specified by the purchaser, subject to the permissible variations shown in [Table 5-1-2](#).

1.1.9 MARKING (1992)

The tie plate will be marked with 3/8 inch minimum height raised letters and figures when the section is rolled. The marking shall be on the top of the plate on the field side shoulder. Each finished tie plate will contain a portion of the marking. The marking will contain:

- Tie Plate Designation – AREMA Tie Plate Plan Number.
- Name or Brand of Manufacturer.

- Year of Manufacture: Last two digits of year if space limitation precludes use of four digits.
- HW: If tie plate is made of high carbon steel and hot worked. Low carbon steel plates are not marked.

1.1.10 INSPECTION (1992)

The inspector representing the purchaser shall have free entry at all times while work on the contract of the purchaser is being performed that concern the manufacture of the material ordered. The manufacturer shall afford the inspector, without charge, all reasonable facilities to satisfy him that the material is being furnished in accordance with these specifications. All tests and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

1.1.11 REJECTION (1992)

- a. Material failing to meet the requirements of these specifications will be rejected.
- b. Material that shows injurious defects subsequent to its acceptance at the manufacturer's works will be rejected, and the manufacturer shall be notified.

SECTION 1.2 DEFINITIONS (1992)

The following terms are for general use in [Part 1](#). Refer to the Glossary located at the end of the chapter for definitions.

Tie Plate	Gage Side	Shoulder
Length	Field Side	Eccentricity
Width	Rail Seat	Line Holes
Rolled Width	Rail Seat Cant	Hold Down Holes
Sheared Length		

Table 5-1-2. Tie Plate Dimension Variations

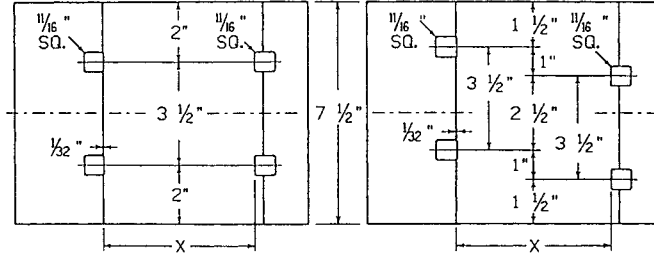
Description	Inches (thousandths)	
	Plus	Minus
A. Tie Plates with Shoulder Parallel to the Direction of Rolling		
(1) Variation from design thickness	0.030	0.030
(2) Variation from design length (rolled width)	0.125	0.125
(3) Variation from design width (sheared length)	0.188	0.188
(4) Variation from design shoulder height	0.015	0.030
(5) Variation from design rail seat width (Applies to double shoulder plates only)	0.063	0.000
B. Maximum Height of Shear Drag or Fins		
(1) At edge of plate	0.063	0.063
(2) At spike holes	0.063	0.063
C. Spike Holes (Note 1)		
(1) Variation from design size	0.030	0.030
(2) Variation from design location	0.030	0.030
(3) Skewness of holes—horizontally	0.030	0.030
(4) Sides of spike holes must allow track spikes to be driven vertically.		
D. Flatness (Concavity or convexity measured with an appropriate gage over the width, length and diagonals with the effect of shear edge deformation disregarded.)		
(1) Rail Seat	0.025	0.025
(2) Bottom of Plate (Does not apply to ribbed tie plates)	0.060	0.060
E. Rail Cant		
The rail seat shall provide for cant of 1:40, ± 5 , toward center line of track unless otherwise specified.		
F. Tie Plates		
Tie plates shall be accepted on the basis of actual weight as applied to the entire order, except that any weight supplied in excess of 3% over the weight calculated from the specified dimensions shall be the responsibility of the manufacturer.		
<p>Note 1: Spike holes are typically punched from the bottom of the plates. Measurement for size and location should be determined from the punch entering surface. Measurement of the hole location should be in relationship of the spike holes to each other. Measurement of the skewness of spike holes should be in relationship to the design location of the rail base for line holes and to the sheared edge for hold down holes. The following limits on spike hole punching normally apply: Holes are not punched closer than 1-5/8 inches center to center. Outer edge of any hole is not closer than 1/2 inch to the rolled edge for plates up to 3/8 inch in end thickness; or closer than 5/8 inch to the rolled edge for plates greater than 3/8 inch up to 1/2 inch in end thickness. Outer edge of any hole is not closer than 1 inch to the sheared edge.</p>		

SECTION 1.3 DESIGN OF TIE PLATES FOR USE WITH AREMA RAIL SECTIONS (1992)

Refer to Table 5-1-3 and Figure 5-1-1 through Figure 5-1-12 for tie plate design.

Table 5-1-3. Tie Plate Designs for use with AREMA Rail Sections

Plan Number	Figure No.	Length	
1	5-1-1	10 Inch For Use With Rail Having a 5-1/8 Inch Base	
2	5-1-2	11 Inch For Use With Rail Having a 5-1/8 to 5-3/8 Inch Base	
3	5-1-3	12 Inch For Use With Rail Having a 5-3/8 Inch Base	
6	5-1-4	12 Inch For Use With Rail Having a 5-1/2 Inch Base	
7	5-1-5	13 Inch For Use With Rail Having a 5-1/2 Inch Base	
8	5-1-6	14 Inch For Use With Rail Having a 5-1/2 Inch Base	
11	5-1-7	13 Inch For Use With Rail Having a 6 Inch Base	
12	5-1-8	14 Inch For Use With Rail Having a 6 Inch Base	
13	5-1-9	14-3/4 Inch For Use With Rail Having a 6 Inch Base	
20	5-1-10	15 Inch For Use With Rail Having a 5-1/2 Inch Base	
21	5-1-11	16 Inch For Use With Rail Having a 6 Inch Base	
22	5-1-12	18 Inch For Use With Rail Having a 6 Inch Base	
Rail		Plate	
AREMA Rail Sections	Base Widths	Plan Number	Length Inches
140RE, 136RE, 133RE, 132RE	6 inch	22	18
		21	16
		13	14-3/4
		12	14
		11	13
119RE, 115RE	5-1/2 inch	20	15
		8	14
		7	13
		6	12
100RE	5-3/8 inch	3	12
		2	11
90RA-A	5-1/8 inch	2	11
		1	10
Note 1: Tie plates are double shoulder except for plan number 1 and 2 which are single shoulder. All tie plate sections canted 1: 40. All tie plate sections have inclined ends.			



PUNCHING A - 4 SPIKE HOLES PUNCHING B - 4 SPIKE HOLES

ESTIMATED WEIGHTS IN POUNDS	
PER FOOT	18.60
PER 7 1/2"	11.63
PUNCHED	
4 HOLES	11.28
ADD FOR RIBS	
PER FOOT	0.34
PER 7 1/2"	0.21

X = NOMINAL WIDTH OF BASE OF RAILS WITH WHICH TIE PLATE IS TO BE USED.

FOR USE WITH 5/16" TRACK SPIKES.
ALL SQUARE SPIKE HOLES WILL HAVE 1/16" FILLETS IN CORNERS.
WHEN SPECIFIED -
SUPPLY SECTION WITH RIBS ON BOTTOM OF PLATE.
FURNISH WITH 3/4" SQUARE HOLES IF 5/8" TRACK SPIKES ARE TO BE USED.

Size and location of spike holes to be optional with maximum of eight.

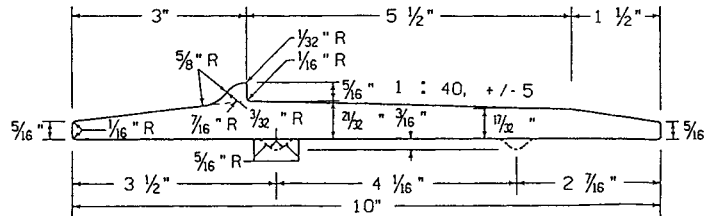
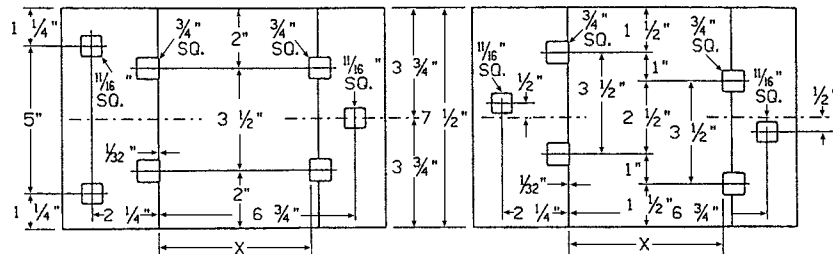


Figure 5-1-1. Plan No. 1 - AREMA 10 Inch Tie Plate for use with Rails Having 4-7/16 to 5-1/8 Inch Rail Base Width



PUNCHING A - 7 SPIKE HOLES PUNCHING B - 6 SPIKE HOLES
PUNCHING C - 4 LINE SPIKE HOLES PUNCHING D - 4 LINE SPIKE HOLES
OF PUNCHING A OF PUNCHING B

X = NOMINAL WIDTH OF BASE OF RAILS WITH WHICH TIE PLATE IS TO BE USED.

ALL SQUARE SPIKE HOLES WILL HAVE 1/16" FILLETS IN CORNERS.
WHEN SPECIFIED -
SUPPLY SECTION WITH RIBS ON BOTTOM OF PLATE.
CENTERLINE DISTANCE BETWEEN HOLD DOWN SPIKE HOLES 4 1/2" INSTEAD OF 5".

ESTIMATED WEIGHTS IN POUNDS	
PER FOOT	21.58
PER 7 1/2"	13.49
PUNCHED	
7 HOLES	12.87
6 HOLES	12.93
4 HOLES	13.05
ADD FOR RIBS	
PER FOOT	0.34
PER 7 1/2"	0.21

Size and location of spike holes to be optional with maximum of eight.

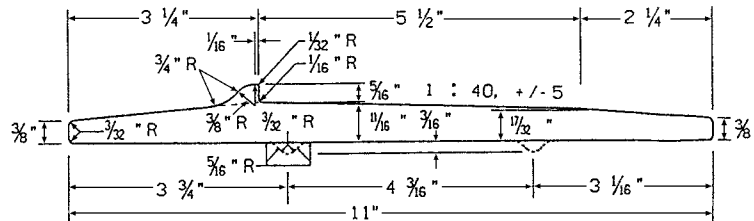
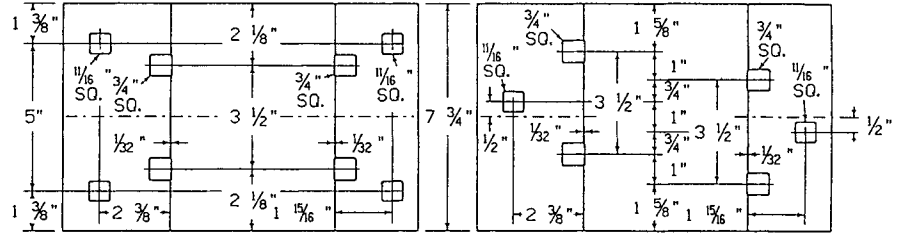


Figure 5-1-2. Plan No. 2 - AREMA 11 Inch Tie Plate for use with Rails Having 5-1/8 to 5-1/2 Inch Rail Base Width



PUNCHING A - 8 SPIKE HOLES
 PUNCHING C - 4 LINE SPIKE HOLES OF PUNCHING A
 PUNCHING B - 6 SPIKE HOLES
 PUNCHING D - 4 LINE SPIKE HOLES OF PUNCHING B

ESTIMATED WEIGHTS IN POUNDS	
PER FOOT	25.84
PER 7 3/4"	16.69
PUNCHED	
8 HOLES	15.86
6 HOLES	15.99
4 HOLES	16.12
ADD FOR RIBS	
PER FOOT	0.34
PER 7 3/4"	0.22

ALL SQUARE SPIKE HOLES WILL HAVE 1/16" FILLETS IN CORNERS. WHEN SPECIFIED -
 SUPPLY SECTION WITH RIBS ON BOTTOM OF PLATE.
 CENTERLINE DISTANCE BETWEEN HOLD DOWN SPIKE HOLES 4 1/2" INSTEAD OF 5".
 ROUND HOLES MAY BE SUBSTITUTED FOR SQUARE HOLD DOWN SPIKE HOLES.

Size and location of spike holes to be optional with maximum of eight.

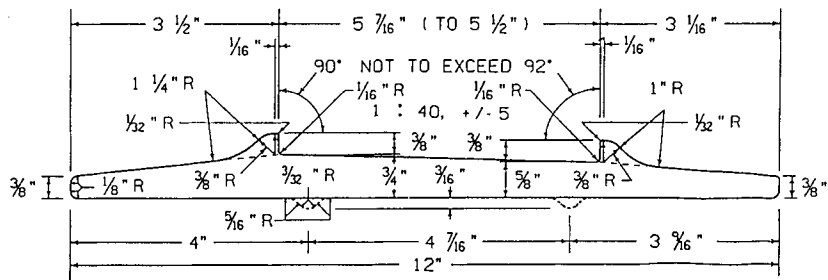
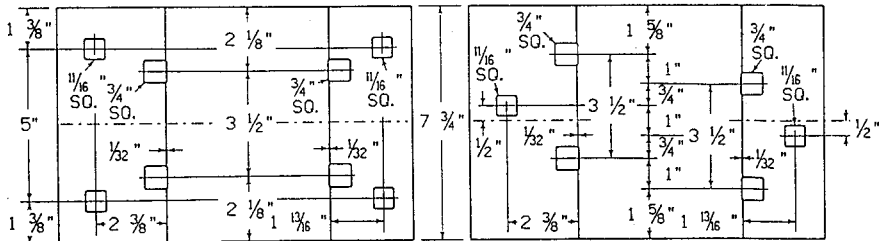


Figure 5-1-3. Plan No. 3 - AREMA 12 Inch Tie Plate for 5-3/8 Inch Rail Base Width



PUNCHING A - 8 SPIKE HOLES
 PUNCHING C - 4 LINE SPIKE HOLES OF PUNCHING A
 PUNCHING B - 6 SPIKE HOLES
 PUNCHING D - 4 LINE SPIKE HOLES OF PUNCHING B

ESTIMATED WEIGHTS IN POUNDS	
PER FOOT	25.95
PER 7 3/4"	16.76
PUNCHED	
8 HOLES	15.94
6 HOLES	16.06
4 HOLES	16.19
ADD FOR RIBS	
PER FOOT	0.34
PER 7 3/4"	0.22

ALL SQUARE SPIKE HOLES WILL HAVE 1/16" FILLETS IN CORNERS. WHEN SPECIFIED -
 SUPPLY SECTION WITH RIBS ON BOTTOM OF PLATE.
 CENTERLINE DISTANCE BETWEEN HOLD DOWN SPIKE HOLES 4 1/2" INSTEAD OF 5".
 ROUND HOLES MAY BE SUBSTITUTED FOR SQUARE HOLD DOWN SPIKE HOLES.

Size and location of spike holes to be optional with maximum of eight.

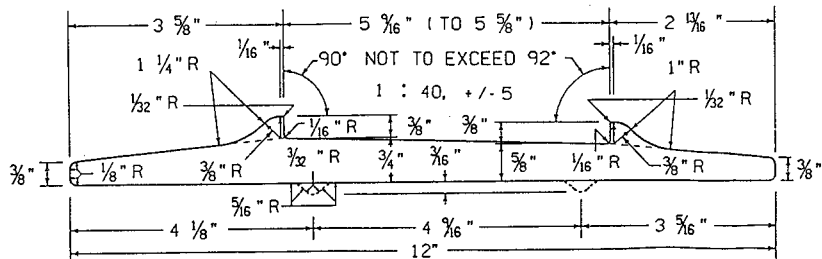
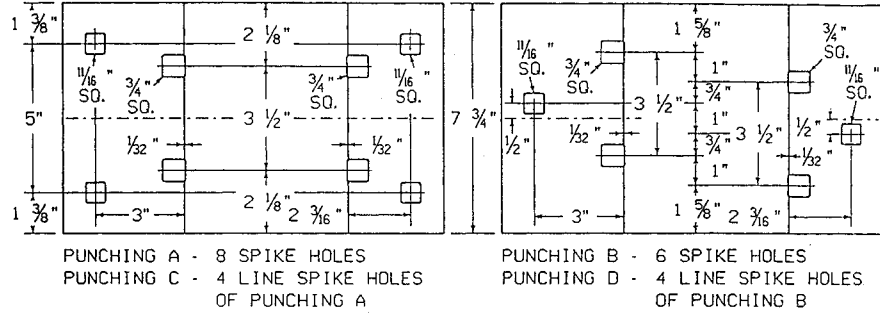


Figure 5-1-4. Plan No. 6 - AREMA 12 Inch Tie Plate for 5-1/2 Inch Rail Base Width



ESTIMATED WEIGHTS IN POUNDS	
PER FOOT	31.84
PER 7 3/4"	20.56
PUNCHED	
8 HOLES	19.60
6 HOLES	19.74
4 HOLES	19.89
ADD FOR RIBS	
PER FOOT	0.34
PER 7 3/4"	0.22

ALL SQUARE SPIKE HOLES WILL HAVE 1/16" FILLETS IN CORNERS. WHEN SPECIFIED - SUPPLY SECTION WITH RIBS ON BOTTOM OF PLATE. CENTERLINE DISTANCE BETWEEN HOLD DOWN SPIKE HOLES 4 1/2" INSTEAD OF 5". ROUND HOLES MAY BE SUBSTITUTED FOR SQUARE HOLD DOWN SPIKE HOLES.

Size and location of spike holes to be optional with maximum of eight.

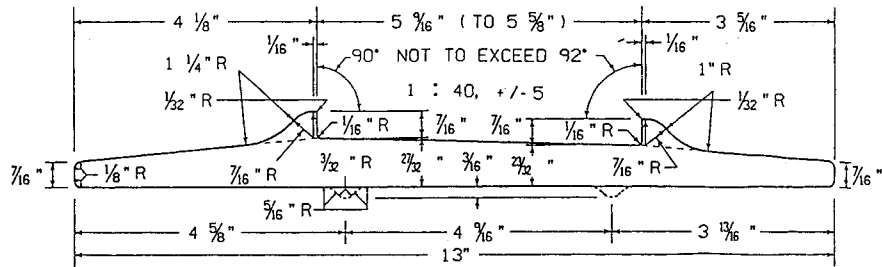
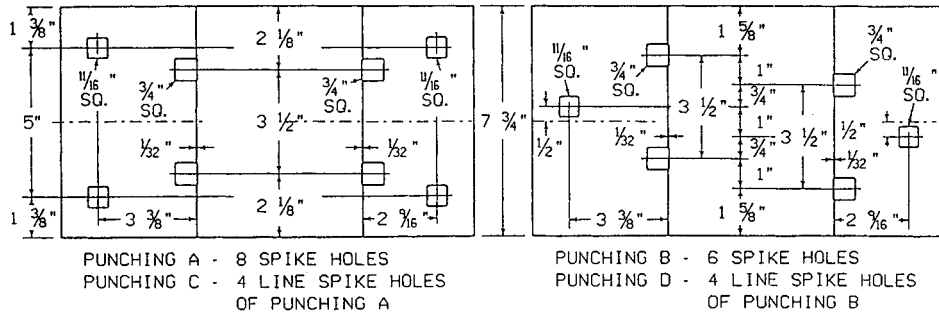


Figure 5-1-5. Plan No. 7 - AREMA 13 Inch Tie Plate for 5-1/2 Inch Rail Base Width



ESTIMATED WEIGHTS IN POUNDS	
PER FOOT	37.05
PER 7 3/4"	23.93
PUNCHED	
8 HOLES	22.90
6 HOLES	23.06
4 HOLES	23.21
ADD FOR RIBS	
PER FOOT	0.34
PER 7 3/4"	0.22

ALL SQUARE SPIKE HOLES WILL HAVE 1/16" FILLETS IN CORNERS. WHEN SPECIFIED - SUPPLY SECTION WITH RIBS ON BOTTOM OF PLATE. CENTERLINE DISTANCE BETWEEN HOLD DOWN SPIKE HOLES 4 1/2" INSTEAD OF 5". ROUND HOLES MAY BE SUBSTITUTED FOR SQUARE HOLD DOWN SPIKE HOLES.

Size and location of spike holes to be optional with maximum of eight.

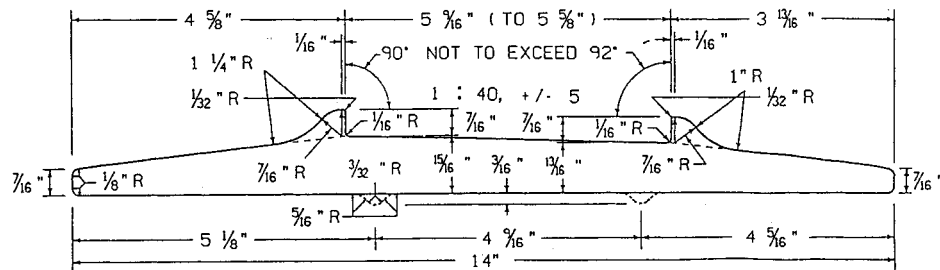
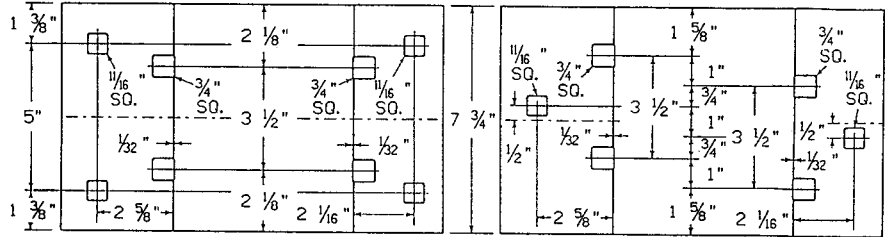


Figure 5-1-6. Plan No. 8 - AREMA 14 Inch Tie Plate for 5-1/2 Inch Rail Base Width

ESTIMATED WEIGHTS IN POUNDS	
PER FOOT	29.92
PER 7 3/4"	19.32
PUNCHED	
8 HOLES	18.41
6 HOLES	18.55
4 HOLES	18.68
ADD FOR RIBS	
PER FOOT	0.34
PER 7 3/4"	0.22

Size and location of spike holes to be optional with maximum of eight.



PUNCHING A - 8 SPIKE HOLES
 PUNCHING C - 4 LINE SPIKE HOLES
 OF PUNCHING A
 PUNCHING B - 6 SPIKE HOLES
 PUNCHING D - 4 LINE SPIKE HOLES
 OF PUNCHING B
 ALL SQUARE SPIKE HOLES WILL HAVE 1/16" FILLETS IN CORNERS.
 WHEN SPECIFIED -
 SUPPLY SECTION WITH RIBS ON BOTTOM OF PLATE.
 CENTERLINE DISTANCE BETWEEN HOLD DOWN SPIKE HOLES 4 1/2" INSTEAD OF 5".
 ROUND HOLES MAY BE SUBSTITUTED FOR SQUARE HOLD DOWN SPIKE HOLES.

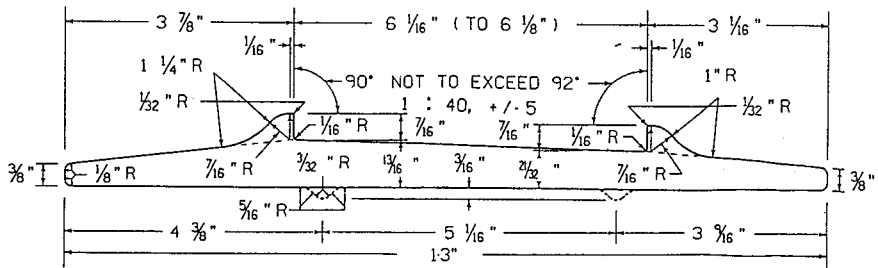
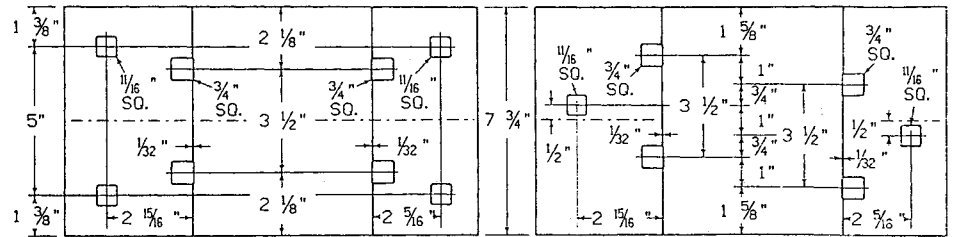


Figure 5-1-7. Plan No. 11 - AREMA 13 Inch Tie Plate for 6 Inch Rail Base Width

ESTIMATED WEIGHTS IN POUNDS	
PER FOOT	34.77
PER 7 3/4"	22.45
PUNCHED	
8 HOLES	21.47
6 HOLES	21.62
4 HOLES	21.77
ADD FOR RIBS	
PER FOOT	0.34
PER 7 3/4"	0.22

Size and location of spike holes to be optional with maximum of eight.



PUNCHING A - 8 SPIKE HOLES
 PUNCHING C - 4 LINE SPIKE HOLES
 OF PUNCHING A
 PUNCHING B - 6 SPIKE HOLES
 PUNCHING D - 4 LINE SPIKE HOLES
 OF PUNCHING B
 ALL SQUARE SPIKE HOLES WILL HAVE 1/16" FILLETS IN CORNERS.
 WHEN SPECIFIED -
 SUPPLY SECTION WITH RIBS ON BOTTOM OF PLATE.
 CENTERLINE DISTANCE BETWEEN HOLD DOWN SPIKE HOLES 4 1/2" INSTEAD OF 5".
 ROUND HOLES MAY BE SUBSTITUTED FOR SQUARE HOLD DOWN SPIKE HOLES.

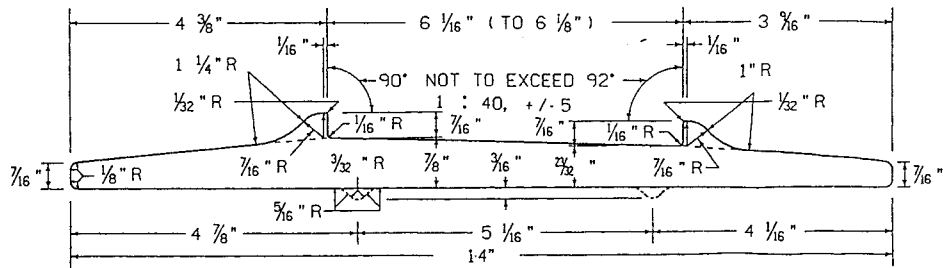
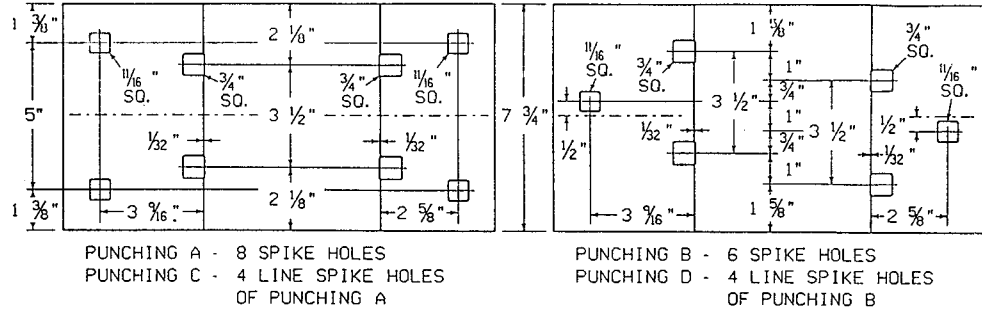


Figure 5-1-8. Plan No. 12 - AREMA 14 Inch Tie Plate for 6 Inch Rail Base Width



ESTIMATED WEIGHTS IN POUNDS	
PER FOOT	37.66
PER 7 3/4"	24.32
PUNCHED	
8 HOLES	23.32
6 HOLES	23.46
4 HOLES	23.60
ADD FOR RIBS	
PER FOOT	0.34
PER 7 3/4"	0.22

ALL SQUARE SPIKE HOLES WILL HAVE 1/16" FILLETS IN CORNERS. WHEN SPECIFIED -
 SUPPLY SECTION WITH RIBS ON BOTTOM OF PLATE.
 CENTERLINE DISTANCE BETWEEN HOLD DOWN SPIKE HOLES 4 1/2" INSTEAD OF 5".
 ROUND HOLES MAY BE SUBSTITUTED FOR SQUARE HOLD DOWN SPIKE HOLES.

Size and location of spike holes to be optional with maximum of eight.

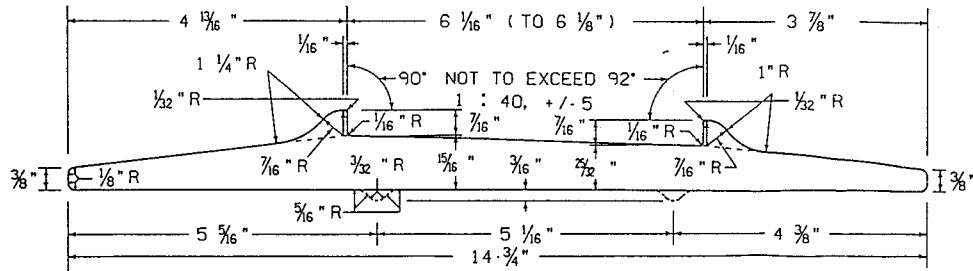
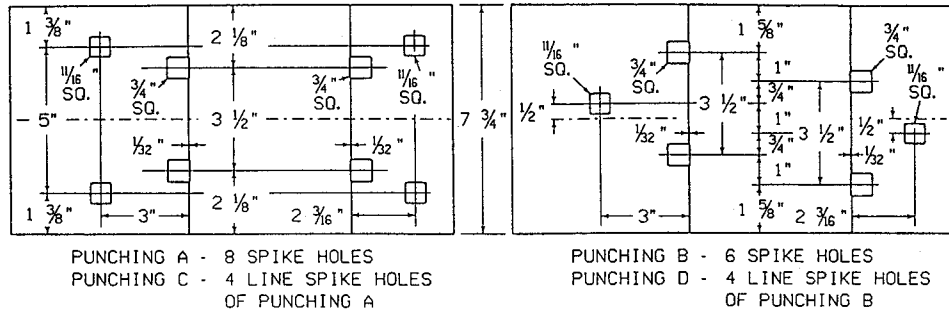


Figure 5-1-9. Plan No. 13 - AREMA 14-3/4 Inch Tie Plate for 6 Inch Rail Base Width



ESTIMATED WEIGHTS IN POUNDS	
PER FOOT	43.96
PER 7 3/4"	28.39
PUNCHED	
8 HOLES	27.22
6 HOLES	27.40
4 HOLES	27.58
ADD FOR RIBS	
PER FOOT	0.34
PER 7 3/4"	0.22

ALL SQUARE SPIKE HOLES WILL HAVE 1/16" FILLETS IN CORNERS. WHEN SPECIFIED -
 SUPPLY SECTION WITH RIBS ON BOTTOM OF PLATE.
 CENTERLINE DISTANCE BETWEEN HOLD DOWN SPIKE HOLES 4 1/2" INSTEAD OF 5".
 ROUND HOLES MAY BE SUBSTITUTED FOR SQUARE HOLD DOWN SPIKE HOLES.

Size and location of spike holes to be optional with maximum of eight.

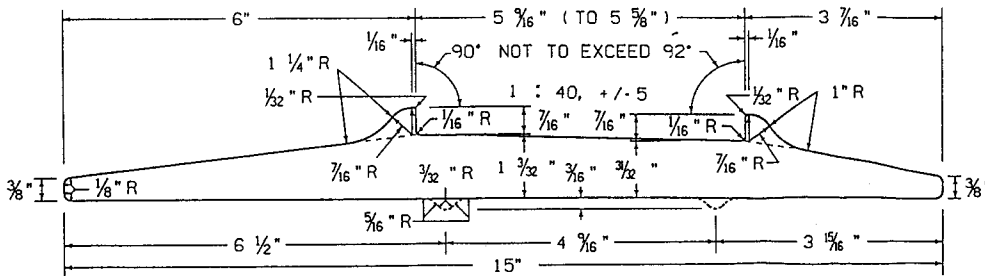


Figure 5-1-10. Plan No. 20 - AREMA 15 Inch Tie Plate for 5-1/2 Inch Rail Base Width for Curves Only

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American Railway Engineering and Maintenance-of-Way Association

Part 2

Track Spikes

— 2005 —

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SECTION 2.1 SPECIFICATIONS FOR SOFT-STEEL TRACK SPIKES¹ (2005)

2.1.1 SCOPE (2005)

This specification covers steel track cut spikes.

2.1.2 PROCESS (2005)

One or more of the following processes shall make the steel: electric-furnace, basic-oxygen.

2.1.3 CHEMICAL COMPOSITION (2005)

The carbon steel material shall conform to the following requirements as to chemical composition:

Carbon, %	.17 - .25
Manganese, %	.90 - 1.35
Silicon, %	.35 Max.
Phosphorus, %	.04 Max.
Sulfur, %	.05 Max.
Copper, %	.20 - .50
Vanadium, %	.02 Min.

2.1.4 LADLE ANALYSIS (2005)

- a. A determination for carbon and copper shall be made of each heat of steel. This analysis shall be made from a test ingot taken during the pouring of the heat. The chemical composition thus determined shall be reported to the purchaser or his representative, and shall conform to the requirements specified in [Article 2.1.3](#).
- b. When ladle analysis cannot be furnished, the manufacturer shall submit a report of the chemical analysis made on three spikes selected at random from each 10-ton lot.

2.1.5 TENSILE PROPERTIES (2005)

The purchaser may, at his option, require tension tests according to ASTM A 370 in which case the finished spikes shall conform to the following requirements as to tensile properties:

Tensile strength, min, psi	70,000
Yield strength, min, psi	46,000
Elongation in 2 in., min, percent	25

2.1.6 BENDING PROPERTIES (2005)

- a. The body of a full-size finished spike shall stand being bent cold through 120 degrees around a pin, the diameter of which is not greater than the thickness of the spike without cracking on the outside of the bent portion.

¹ References, Vol. 27, 1926, pp. 636, 1367; Vol. 35, 1934, pp. 925, 1118; Vol. 54, 1953, pp. 972, 1398; Vol. 60, 1959, pp. 786, 1170; Vol. 62, 1961, pp. 644, 946; Vol. 64, 1963, pp. 426, 683; Vol. 69, 1968, p. 357. Reapproved with revisions 1968

- b. The head of a full-size finished spike shall stand being bent backward to an angle of 55 degrees with the line of the face of the spike, without cracking on the outside of the bent portion.

2.1.7 IMPACT PROPERTIES (2005)

- a. If requested by the purchaser, the carbon steel track spikes shall meet the following Charpy V-Notch impact strength requirement at the specified temperature.

Temperature	Absorbed Energy
0 degrees F	15 Ft-Lbs. Minimum

- b. The supplemental testing shall be conducted on standard Charpy V-Notch Type "A" specimens per ASTM A 370 standard, latest revision, results to meet the above requirements.

2.1.8 NUMBER OF TESTS (2005)

- a. When the option in [Article 2.1.5](#) is exercised, one tension test shall be made from each 10-ton lot or fraction thereof.
- b. One bend test of each kind specified in [Article 2.1.6a](#) and [Article 2.1.6b](#) shall be made from each lot of 5 tons or fraction thereof.
- c. The impact test shall consist of determining the average absorbed energy from the three impact-test specimens obtained from three track spikes of the same heat.

2.1.9 RETESTS (2005)

Spikes represented by bend tests failing to meet the requirements prescribed in [Article 2.1.6a](#) and [Article 2.1.6b](#) may be annealed and resubmitted. If the spikes fail to meet the requirements on the retest, they shall be rejected.

2.1.10 PERMISSIBLE VARIATIONS IN DIMENSIONS (2005)

The finished spikes shall conform to the dimensions specified by the purchaser, subject to the permissible variations specified in [Table 5-2-1](#). Dimensions contained in the drawing but not contained in the table shall have a tolerance of +/- 1/32".

Table 5-2-1. Permissible Variations From Specified Dimensions

Type	Over	Under
Cross section (shank)	1/32"	1/64"
Head	3/32"	1/32"
Length (under head to point)	1/8"	1/8"
Angle (under side of head)	1°	1°
Shank Straightness (either plane convex)	1/32"	1/32"

2.1.11 FINISH (2005)

All finished spikes shall be straight, with well-formed and centered heads, be free from injurious defects and shall be finished in a workmanlike manner. In addition, spike tips shall have a sharp point.

2.1.12 MARKING (2005)

Raised lettering or branding indicating the manufacturer and also the letters "MC", indicating medium carbon, shall be pressed on the head of each spike while it is being formed.

2.1.13 INSPECTION (2005)

The inspector representing the purchaser shall have free entry at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the material ordered. The manufacturer shall afford the inspector, without charge, all reasonable facilities to satisfy himself that the material is being furnished in accordance with these specifications. All tests and inspections shall be made at the place of manufacture, prior to shipment, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

2.1.14 REJECTION (2005)

Any materials used in the manufacture of spikes failing to meet the requirements of their specification will be rejected.

Any materials used in the manufacture of spikes that show injurious defects subsequent to their acceptance at the manufacturer's works will be rejected and the manufacturer shall be notified.

Finished spikes not meeting the requirements of this specification shall be rejected.

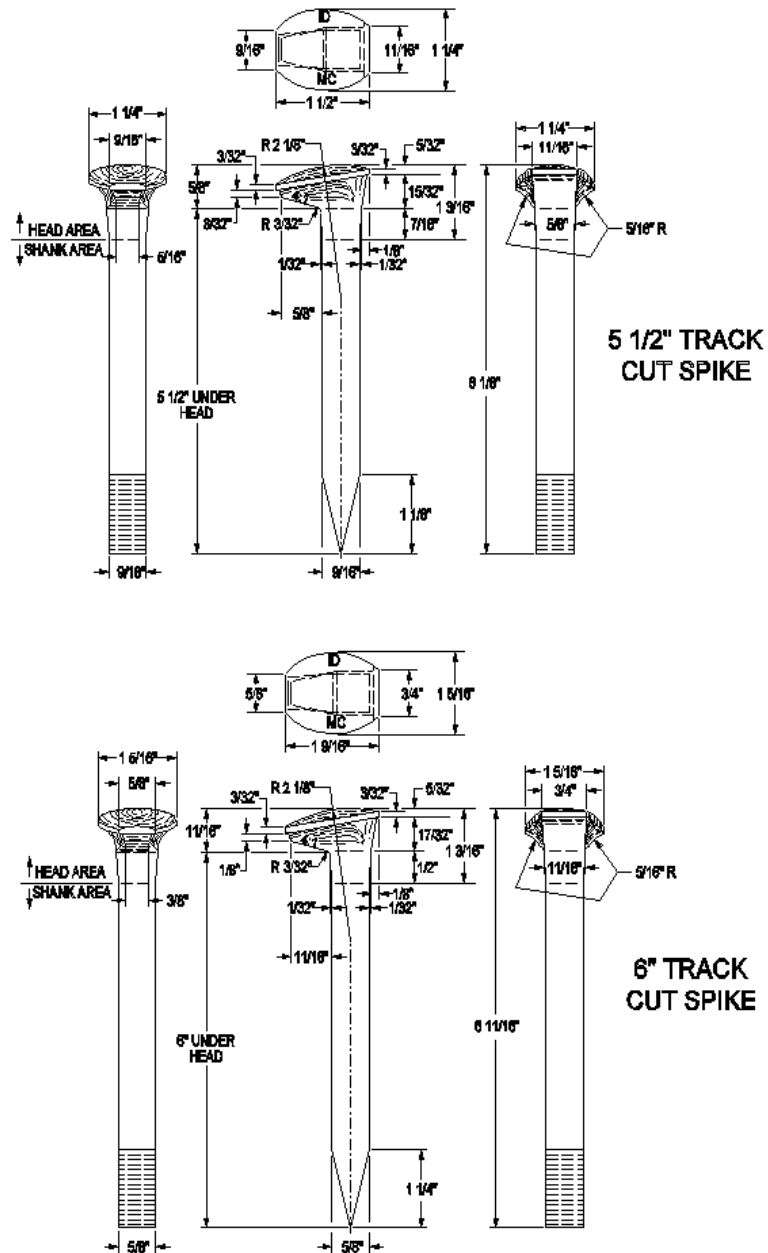
SECTION 2.2 DESIGN OF TRACK CUT SPIKE¹ (2005)

Figure 5-2-1. Track Cut Spike Design

¹ References, Vol. 22, 1921, pp. 653, 972; Vol. 35, 1934, pp. 925, 1118; Vol. 38, 1937, pp. 511, 713; Vol. 49, 1948, pp. 325, 639; Vol. 54, 1953, pp. 972, 1398; Vol. 63, 1962, pp. 487, 753. Reapproved without change 1962.

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American Railway Engineering and Maintenance-of-Way Association

Part 3

Curves

— 2014 —

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SECTION 3.1 SPIRALS¹ (1995) R(2013)

3.1.1 PURPOSE (1995) R(2013)

- a. A spiral or transition curve should be used in main-line tracks, if practicable, between tangent and curve or between the different degrees of curvature of a compound curve. A spiral is also desirable in all tracks other than main tracks, where practicable, between tangent and curves and between the different degrees of curvature of a compound curve. The form of the spiral should be such that the degree of curvature increases directly with the length. In other than main tracks with no superelevation, this permits the engine or car trucks to be directed gradually to their rotated position (required by a curve) rather than to be directed instantaneously. This will likewise tend to prevent distortion of the alignment of the main body of the curve due to the force required to produce angular acceleration. In main tracks with superelevation, this permits a uniform rate of change of elevation of the outer rail on the spiral and promotes best riding conditions by maintaining throughout the train passage from tangent to curve the desired relation between amount of superelevation and degree of curvature.
- b. The desirable length of the spiral for tracks other than main tracks with no superelevation is the maximum possible consistent with economy and the purpose of the track layout.
- c. The desirable length of the spiral for main tracks where the alignment is being entirely reconstructed or where the cost of the realignment of the existing track will not be excessive should be such that when passenger cars of average roll tendency are to be operated the rate of change of the unbalanced lateral acceleration acting on a passenger will not

¹ References, Vol. 12, 1911, part 1, pp. 417, 462; Vol. 16, 1915, pp. 731, 1145; Vol. 37, 1936, pp. 466, 1018; Vol. 41, 1940, pp. 602, 867; Vol. 42, 1941, pp. 636, 836; Vol. 48, 1947, pp. 553, 885; Vol. 54, 1953, pp. 972, 1398; Vol. 63, 1962, pp. 487, 753; Vol. 66, 1965, pp. 501, 763. Reapproved with revisions 1995.

exceed 0.03 g per sec Equation (1). Also, the desirable length in this case needed to limit the possible racking and torsional forces produced should be such that the longitudinal slope of the outer rail with respect to the inner rail will not exceed 1/744 Equation (2), which is based on an 85-foot long car.

(1) The formulas recommended to obtain the above results are:

$$L = 1.63 (E_u) V \quad \text{EQ 1}$$

where:

$$\begin{aligned} L(\text{min}) &= \text{desirable length of spiral in feet} \\ E_u &= \text{unbalanced elevation in inches} \\ V &= \text{maximum train speed in miles per hour} \end{aligned}$$

NOTE: If the spiral is to be designed for passenger equipment which has the car-body roll with respect to the track controlled by special designs, the length of spiral for this specific roll angle may be determined by the method and formula given on pages 94, 516 and 517, Vol. 65, AREMA Proceedings.

$$L = 62 E_a \quad \text{EQ 2}$$

where:

$$\begin{aligned} L(\text{min}) &= \text{desirable length of spiral in feet} \\ E_a &= \text{actual elevation in inches} \end{aligned}$$

(2) In using the above formulas for determining the length of spirals joining tangents and curves and joining curves of different radii, the maximum length of spiral produced by the two formulas should be used.

- d. It is recognized that in the case of realignment of existing tracks, EQ 1 may produce a length of spiral the construction of which would result in excessive costs. Therefore, in such cases it is felt that the length should be such that, with average roll tendency of passenger cars operated on the track, the rate of change of the unbalanced lateral acceleration acting on a passenger will not exceed 0.04 g per sec Equation (3). In this case the maximum slope EQ 2 should be retained.

(1) The formula recommended for this case in lieu of formula EQ 1 is:

$$L = 1.22 E_u V \quad \text{EQ 3}$$

where:

$$\begin{aligned} L(\text{min}) &= \text{desirable length of spiral in feet} \\ E_u &= \text{unbalanced elevation in inches} \\ V &= \text{maximum train speed in miles per hour} \end{aligned}$$

(2) In using EQ 2 and EQ 3 for determining the length of spirals joining tangents and curves and joining curves of different radii, the maximum length of spiral produced by the two formulas should be used.

3.1.2 THE SPIRAL CURVE (1965) R(2013)

The following formulas, using the notation given, are recommended for location of the spiral curve. These formulas are based upon the fundamental relation that the degree d of the spiral at any point increases in constant relation to the lengths along the spiral in stations or $d = ks$. The term k represents the rate at which the degree of curvature increases, and its value should be

selected so the spiral will attain the degree of curvature of the circular curve in a length not less than given by EQ 1, EQ 2 or EQ 3.

3.1.3 NOTATION (1965) R(2013)

- In designations for curve points, the first initial represents the alignment on the ride towards station zero, the second that away from station zero.
- Figure 5-3-1 is a diagram illustrating the application of spirals at each end of a circular curve with the stationing from the left. The notation used in the formulas will be evident from this diagram and from the following:

D = degree of circular curve

d = degree of curvature of the spiral at any point

l = Length from the T.S. or S.T., to any point on the spiral having coordinates x and y

s = length l in 100-foot stations

L = total length of spiral

S = length L in 100-foot stations

δ = central angle of the spiral from the T.S. or S.T. to any point on the spiral

Δ = central angle of the whole spiral

a = deflection angle from the tangent at the T.S. or S.T. to any point on the spiral

b = orientation angle from the tangent at any point on the spiral to the T.S. or S.T.

k = increase in degree of curvature per 100-foot station along the spiral

- All functions are in feet or degrees unless otherwise noted.

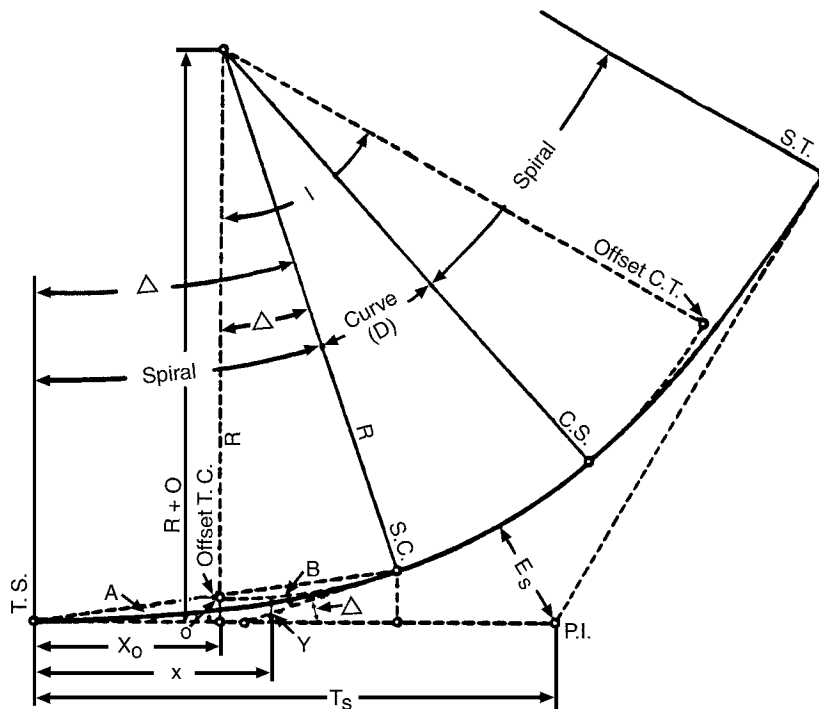


Figure 5-3-1. Spiral Applications

3.1.4 FORMULAS (2005)¹ R(2013)

$$d = ks = \frac{kl}{100}; D = kS = \frac{kL}{100} \quad \text{EQ 4}$$

$$\delta = \frac{1}{2}ks^2 = \frac{dl}{200}; \Delta = \frac{1}{2}kS^2 = \frac{DL}{200} \quad \text{EQ 5}$$

$$a = \frac{1}{3}\delta = \frac{1}{6}ks^2; A = \frac{1}{3}\Delta = \frac{1}{6}kS^2 \quad \text{EQ 6}$$

$$b = \frac{2}{3}\delta; B = \frac{2}{3}\Delta \quad \text{EQ 7}$$

$$y = 0.582\delta s - 0.00001264\delta^3 s \quad \text{EQ 8}$$

$$x = 1 - 0.003048\delta^2 s \quad \text{EQ 9}$$

$$o = 0.1454\Delta S \quad \text{EQ 10}$$

$$X_o = \frac{1}{2}L - 0.000508\Delta^2 S \quad \text{EQ 11}$$

$$T_s = (R + o)\tan\left(\frac{I}{2}\right) + X_o \quad \text{EQ 12}$$

$$E_s = (R + o)\text{exsec}\left(\frac{I}{2}\right) + o \quad \text{EQ 13}$$

3.1.5 STAKING SPIRALS BY DEFLECTIONS (1965) R(2013)

- From [EQ 10](#), [EQ 11](#) and [EQ 12](#), the T.S. and S.T. may be located from the P.I. of the curve [Figure 5-3-1](#). [EQ 13](#) is useful in adjusting the degree D of the circular curve if it is desired to limit the throw of the center of the curve, or balance the throw of existing track.
- The entire spiral may then be run from the T.S. or S.T., using [EQ 6](#) to determine the deflection angle a from the tangent to any point on the spiral.
- Deflection angles with the transit at any point on the spiral other than the T.S. may be determined from the principle that the spiral at the transit point deflects from a circular curve having the same degree as the spiral at that point at the same rate as it does from the tangent at the T.S. To continue the spiral from any intermediate transit point, the transit is backsighted on the T.S. with an angle set off equal to twice the deflection angle from the T.S. to the transit point. The transit will then read zero along the tangent to the spiral at that point. For any succeeding spiral point, the deflection angle for a circular curve having the same degree as the spiral at the transit point and a length equal to the distance

¹ The use of computer alignment software, even in chord definition mode, may generate results for curve length, stationing and tangent offsets that deviate from the values calculated using the equation in [Article 3.1.4](#). Regardless of the software package used, it is recommended that the alignment designer evaluate and confirm the acceptability of the results of any computer alignment output with the individual railroad or transit property's design policy.

from the transit to the spiral point is then calculated; to this is added the deflection angle for the same length of spiral but calculated as it would be from the T.S.

- d. To locate the spiral with the transit at the S.C. or C.S., the deflection angles to set points on the spiral are equal to the deflection angles for the corresponding points on the circular curve (extended) less the deflection angles of the spiral from the circular curve. The deflection angles of the spiral from the circular curve are the same as for the corresponding lengths of the spiral from the T.S.
- e. In staking by deflection, it is sometimes convenient to divide the spiral into a number of equal chords. The first or initial deflection a_1 may be calculated for the first chord point. The deflections for the following chord points are a_1 times the chord number squared.

3.1.6 STAKING SPIRALS BY OFFSETS (1965) R(2013)

The spiral may be staked to the midpoint by right-angle offsets from the tangent and from there to the S.C. by normal offsets from the circular curve (between the offset T.C. and the S.C.). The offset at midpoint equals $1/2 o$ and the other offsets vary as the cubes of the distances from the T.S. or the S.C.

3.1.7 APPLYING THE SPIRAL TO COMPOUND CURVES (1965) R(2013)

- a. In applying a spiral between two circular curves of a compound curve, the length of spiral is determined from the speed of operation and the difference in elevation of the two circular curves (EQ 1, EQ 2, or EQ 3). The spiral offset o may be found from the formula given using a value of D equal to the difference in the degrees of curvature of the two circular curves. The spiral extends for one-half its length each side of the offset point of compound curvature. The spiral deflects from the inside of the flatter curve and from the outside of the sharper curve at the same rate as it would from the tangent. The spiral may be staked by deflection angles from either end. If the transit is located at the spiral point on the flatter curve, reading zero when sighting along the tangent to the circular curve, the deflection angles to set points on the spiral are equal to the deflection angles for corresponding points on the circular curve (extended) *plus* the deflection angles of the spiral. If the transit is set at the spiral point on the sharper curve, the deflection angles are equal to the deflection angles for that circular curve (extended) *minus* the deflection angles for the spiral.
- b. As an alternative, the spiral can be staked out by offsets from the two circular curves. The offset at the middle point of the spiral equals $1/2 o$, and the other offsets vary as the cubes of the distances from the ends of the spiral.

SECTION 3.2 STRING LINING OF CURVES BY THE CHORD METHOD¹ (2010)

3.2.1 SCOPE (2010)

- a. String lining of curves may be used to supplement the engineer's survey or the alignment system of track maintenance equipment. The method outlined below is applicable to both circular and spiral curves where the angle between the tangents does not change. This is an iterative method that will enable a trained user to develop the throws at each station and smooth the horizontal alignment throughout the curve. Briefly, the method consists of dividing the curve to be lined into 31-foot stations, recording the mid-ordinates of the chords spanning each two stations, and designating a reasonable amount of throw to each station.

¹ References, Vol. 36, 1935, pp. 561, 977; Vol. 41, 1940, pp. 557, 867; Vol. 54, 1953, pp. 973, 1398; Vol. 63, 1962, pp. 487, 753. For more detailed information see Vol. 34, 1933, pp. 493–508. Reapproved with revisions 1962.

- b. The purpose of string lining is to obtain a curve that is smooth and offers good ride quality. This result can be obtained by developing an alignment in which the mid-ordinates at each station of the circular curve are as nearly uniform as possible. A considerable difference in the mid-ordinates of the circular part of the curve should be avoided.
- c. String lining is based on the following:
- (1) The mid-ordinates of a circular curve are indicative of its degree of curvature. Therefore, the mid-ordinates of a circular curve of uniform radius are equal for a chord of uniform length. The mid-ordinates of a spiral curve will vary incrementally along the length of the spiral.
 - (2) For all practical purposes for curves with more than 193-foot radius (less than 30 degrees of curvature) the mid-ordinate of a given length chord varies directly with the degree of curve. The sum of the mid-ordinates of the realigned curve must equal the sum of the mid-ordinates of the original curve. As stated, any consistent length chord can be used. Generally, a 62-ft chord is used in welded track, and in jointed track the chord length is equal to the rail length used in that particular jointed track section.
 - (3) The throw at any station on a curve will change the ordinate at that point equal to the throw.
 - (4) The throw will increase or decrease the mid-ordinate at adjacent stations by an amount equal to one-half the throw; always increasing when the throw decreases and decreasing when the throw increases.

3.2.2 TOOLS REQUIRED (2010)

At a minimum, the following tools are required: a strong string line or chord with a 62-ft usable length, a 50-ft steel tape, marking crayon, a suitable rule graduated to inches and tenths, and a pad of forms (see [Table 5-3-1](#)). These tools should be augmented with a set of two (2) blocks, 1-inch thick, to be used as offsets to facilitate the mid-ordinate measurements in track.

3.2.3 PROCESS (2010)

3.2.3.1 FORM

- a. The sample form is shown in [Table 5-3-1](#).
- b. Column Descriptions:
 - (1) Col. 1 is for station numbers.
 - (2) Col. 2, headed *Measured*, is to record measured mid-ordinates in inches and tenths, shown as a whole number. For example, if an ordinate is measured as 3.8 inches, then enter 38 on the form.
 - (3) Col. 3, headed *Revised*, shows the revised or trial mid-ordinates.
 - (4) Col. 4, headed *Difference*, shows the algebraic difference/error between the ordinates in Col. 2 and Col. 3.
 - (5) Col. 5, headed *Sum of Differences*, shows the net sum of the differences up to and including this station.
 - (6) Col. 6 is for the resultant half-throw.
 - (7) Col. 7 is for the full throw, which is double the figure shown in Col. 6. A negative throw indicates that the track at that station is to be thrown inwards, while positive throw indicates that the track is to be thrown outwards.
 - (8) Col. 8 is obtained by subtracting algebraically the full throw from one-half the gage (28.25").

- (9) Col. 9, headed *Remarks*, is for notes that are necessary for proper alignment, such as obstructions, track centers in multi-track areas, etc., and revised superelevation to be used on the curve, which is contingent on the speed of trains running over this curve.

3.2.3.2 SITE PREPARATION

- a. All work is done on the outside rail of the curve. First stand on tangent several rail lengths back from the curve and locate the beginning of the curve as closely as possible by eye. Mark this point on the rail as Station 0.
- b. Mark a point on the rail, 31-ft back along the tangent as Station -1 (minus 1). If the chord lengths are other than 62 feet, the distance from Station 0 to Station -1 should be half the chord length selected.
- c. Begin at Station 0 (using the steel tape), mark 31-ft points around the entire curve and number these points consecutively as Stations 1, 2, 3, etc. For chord lengths other than 62 feet, use a distance between points of half the chord length. Continue the stationing at least two stations beyond the point of tangency, which is also located by eye. These station numbers are entered in Col. 1 of the sample form shown in [Table 5-3-1](#).
- d. Begin at Station 0 (using the 62-ft chord and rule), measure the mid-ordinates in tenths of inches from the gage point on the outside rail to the string line joining Stations -1 and 1. This is entered in Col. 2 of the form. Proceed in this manner around the curve, measuring the mid-ordinate at each station and entering them on the form. If offset blocks must be used, the measurement must be compensated for the offset.

3.2.3.3 CALCULATING THE THROWS

- a. By inspection of the measured ordinates in Col. 2, the beginning and ending of the spiral curves can be located as nearly correct as possible. In the example in [Table 5-3-1](#) the end of the east spiral is taken at Station 7, while the end of the west spiral is taken at Station 24.
- b. By inspection of the measured ordinates in Col. 2 between the SC point and the CS point, select a revised ordinate and enter in Col.3.
- c. In Col. 4 enter the differences between the measured ordinate, Col. 2, and the revised ordinate, Col. 3, in tenths of an inch. If the ordinate in Col. 3 at any station is larger than that in Col. 2, the sign of the difference in Col. 4 is minus. Conversely, if the revised ordinate is less than the measured ordinate the sign of the difference is plus.
- d. In Col. 5 enter the algebraic sums of the differences (shown in Col. 4) up to and including stations being entered. See the following example:

Station -1: Since this is ahead of the curve and in tangent track, then enter zero (0) in all columns. except Col. 8.

Station 0: There is no difference between Col. 4 and the zero (0) in Sta. -1, Col. 5. Therefore, enter 0 in Col.5.

Station 1: The algebraic difference between Col.2 and Col. 3 is -2. This is then added to the sum shown in Sta. 1, Col. 5, which is 0. Therefore, enter -2 in Sta.1, Col. 5.

Station 2: The algebraic difference between Col.2 and Col.3 is +1. This is then added to the sum shown in Sta. 1, Col. 5, which is -2. Therefore, enter -1 in Sta.2, Col. 5.

- e. In Col. 6 the half-throw is entered. The result shown here is the algebraic sum of Col. 5 up to and including the preceding station. See the following example:

Station -1: Since this is ahead of the curve and in tangent track, than enter zero (0) in all columns are zero (0), except Col. 8.

Station 0: The sum of values in Col. 5 at all preceding stations (ie. Sta.-1) is zero (0). Therefore, enter 0 in Col.6.

Station 1: The sum of values in Col. 5 at all preceding stations (ie. Sta. -1 + Sta. 0) is 0. Therefore, enter 0 in Col.6.

Station 2: The sum of values in Col. 5 at all preceding stations (ie. Sta. -1 + Sta. 0 +Sta. 1) is -2. Therefore, enter -2 in Col.6.

- f. In Col. 7 the full throw is entered. The full throw is obtained by multiplying the half-throw in Col. 6 by 2.
- g. In the example, the computations based on selected revised spiral ordinates in sub-column A [Table 5-3-1](#), carried through to Col. 6, indicate a half-throw of 31 or a full-throw of 5.2 inches at Station 7, which is too great. The minus sign of the half-throw indicates that ordinates slightly smaller should be selected. Slightly smaller spiral ordinates are therefore entered in sub-column B and the curve ordinate of 45 is carried out through Station 11. This gives too great a throw in the positive direction.
- h. Therefore, interpolate a spiral between those used in sub-columns A and B, and enter these new spiral ordinates in sub-column C. The curve ordinate of 46 is carried out a few stations below the S.C. (spiral curve) at Station 7. Computing a third time through to column 6, the half-throw at Station 7 is -26 and at Station 11 is -10, which gives a practical throw. For trial, the circular curve ordinate of 46 in Col. 3 is carried through to Station 23 (one station back on the circular curve from the C.S. (curve spiral) and extension made to Col. 6, where the half-throw is +31.
- i. Sum up in Col. 2 the measured ordinates from Stations 24 to 32, inclusive, in the original spiral, which total 190. The sum of the measured ordinates from Stations 0 to 23, inclusive is 922, bringing the total sum of measured ordinates to 1112. The sum of the revised ordinates from Stations 0 to 23, inclusive is 921. To assure that Col. 5 will end at 0, the sum of the revised spiral ordinates from stations 24 to 32, inclusive, must equal 191. Such revised spiral ordinates are entered in sub-column "C."
- j. Carrying the calculations through to Col. 6, the sum of differences check out to 0, but the final half-throw is + 17, indicating that the trial spiral ends in a parallel tangent. To end on the original tangent, both Cols. 5 and 6 must balance and therefore, an adjustment of the revised ordinates is necessary and is made according to the following rule.
- k. When the final half-throw is positive, subtract from the revised ordinates having high station numbers and add an equal amount to the ordinates having low station numbers, choosing stations in pairs such that the sum of the differences of station numbers, taken in pairs, equals the numerical amount of the final half-throw. When the final half-throw is negative, reverse the procedure, subtracting from the ordinates having low station numbers and adding to those having high station numbers.
- l. Since in [Table 5-3-1](#) the final half-throw is +17, an ordinate (or ordinates) of a low station number will have to be increased and that of a high station number decreased. As it is desirable to keep the spiral uniform, change Station 24 from 47 to 46 and Station 22 from 46 to 47. This change will decrease the final half-throw by 2 or $1 \times (\text{Sta } 24 - \text{Sta } 22)$. Now change Station 29 from ordinate 14 to ordinate 13. Then following the rule, subtract $(17 - 2 = 15)$ from Station 29, leaving 14 and increase the ordinate at Station 14 from 46 to 47. Enter these revised ordinates in sub-column "D," carrying out these computations again to Col. 6, the final half-throw becomes 0 and the ordinates are now balanced.
- m. Computations are simplified by treating the entries in Cols. 2, 3, 4, 5 and 6 as whole numbers, and placing decimal points in Col. 7, as shown in [Table 5-3-1](#).
- n. In working out string lining problems considerable assistance can be gained by plotting the measured mid-ordinates against the station numbers. [Figure 5-3-2](#) shows the results for the curve given in [Table 5-3-1](#). By plotting the mid-ordinates in this manner, the ends of the spiral, as well as points of compounding, can be determined readily and an estimate of the average ordinate to use on the circular curve section can be closely determined.

- o. When tabulations are completed and the curve staked, a copy of the form should be given the track supervisor to enable the application of the proper superelevation at the various stations as the track is lined.

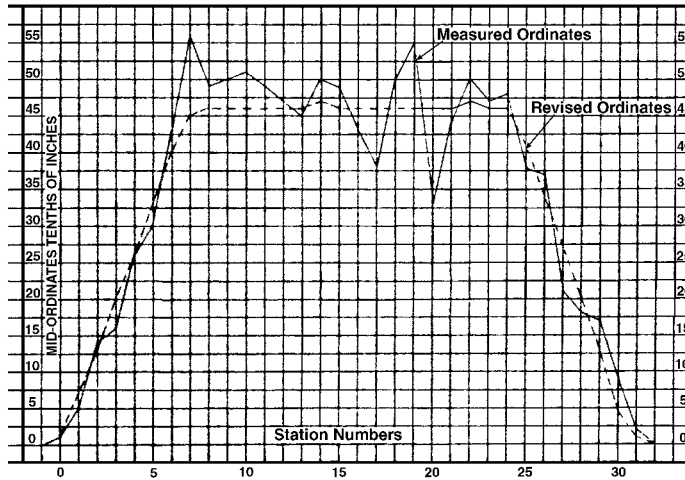


Figure 5-3-2. Platting Mid-ordinates

Table 5-3-1. Sample Form – Stationing from East to West

Station Numbers	Ordinates				Difference				Sum of Differences Up to and Including the Station	Half Throw Sum Col. 5 up to and Including Preceding Station				Full Throw	Gage to Tack	Remarks				
	Measured	Revised			Col.2 – Col.3															
		1	2	3	4	A	B	C		D	A	B	C				D	A	B	C
T.S.	-1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	28.25	
	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	28.25	
	1	5	7	6	7	-2	-1	-2	-2	-1	-2	0	0	0	0	0	0	0	28.25	
	2	14	13	13	13	+1	+1	+1	-1	0	-1	-2	-1	-2	-2	-1	-2	-4	28.65	
	3	16	20	19	20	-4	-3	-4	-5	-3	-5	-3	-1	-3	-3	-1	-3	-6	28.85	
	4	26	27	26	26	-1	0	0	-6	-3	-5	-8	-4	-8	-8	-4	-8	-1.6	29.85	
	5	30	34	32	33	-4	-2	-3	-10	-5	-8	-14	-7	-13	-14	-7	-13	-2.6	30.35	
S.C.	6	43	40	39	40	+3	+4	+3	-7	-1	-5	-24	-12	-21	-24	-12	-21	-4.2	32.45	
	7	56	46	44	45	+10	+12	+11	+3	+11	+6	-31	-13	-26	-31	-13	-26	-5.2	33.45	
	8	49	47	45	46	+2	+4	+3	+5	+15	+9		-2	-20		-2	-20	-4.0	32.25	
	9	35	47	45	46	-12	-10	-11	-7	+5	-2		+13	-11		+13	-11	-2.2	30.45	
	10	51	47	45	46	+4	+6	+5	-3	+11	+3		+18	-13		+18	-13	-2.6	30.85	
	11	49	47	45	46	+2	+4	+3	-1	+15	+6		+29	-10		+29	-10	-2.0	30.25	
	12	43			46			-3			+3		+44	-4		+44	-4	-8	29.05	
	13	45			46			-1			+2			-1			-1	-2	28.45	
	14	50			46	47		+4	+3		+6	+5		+1	+1	+2	+1	+2	28.05	
	15	49			46			+3			+9	+8		+7	+6	+1.2	+6	+1.2	27.05	
	16	43			46			-3			+6	+5		+16	+14	+2.8	+14	+2.8	25.45	
	17	38			46			-8			-2	-3		+22	+19	+3.8	+19	+3.8	24.45	
	18	50			46			+4			+2	+1		+20	+16	+3.2	+16	+3.2	25.05	
	19	55			46			+9			+11	+10		+22	+17	+3.4	+17	+3.4	24.85	
	20	33			46			-13			-2	-3		+33	+27	+5.4	+27	+5.4	22.85	
	21	44			46			-2			-4	-5		+31	+24	+4.8	+24	+4.8	23.45	
	22	50			46	47		+4	+3		0	-2		+27	+19	+3.8	+19	+3.8	24.45	
	23	47			46			+1			+1	-1		+27	+17	+3.4	+17	+3.4	24.85	
C.S.	24	48			47	46		+1	+2		+2	+1		+28	+16	+3.2	+16	+3.2	25.05	
	25	38			41			-3			-1	-2		+30	+17	+3.4	+17	+3.4	24.85	
	26	37			34			+3			+2	+1		+29	+15	+3.0	+15	+3.0	25.25	
	27	21			27			-6			-4	-5		+31	+16	+3.2	+16	+3.2	25.05	
	28	18			20			-2			-6	-7		+27	+11	+2.2	+11	+2.2	26.05	
	29	17			14	13		+3	+4		-3	-3		+21	+4	+8	+4	+8	27.45	
	30	9			7			+2			-1	-1		+18	+1	+2	+1	+2	28.05	
S.T.	31	2			1			+1			0	0		+17	0	0	0	0	28.25	
	32	0			0			0			0	0		+17	0	0	0	0	28.25	
	Sum	1112				1112														

SECTION 3.3 ELEVATIONS AND SPEEDS FOR CURVES¹ (2011)

3.3.1 ELEVATION OF CURVES (2011)

- a. The approximate formula:

$$e = \frac{Bv^2}{32.16R}$$

EQ 14

where:

- e = Equilibrium elevation in feet
- B = Bearing distance of track level on rails in feet
- v = Velocity in feet per second
- R = Radius of curve in feet

will give, for small angles where the sine and the tangent are approximately equal, essentially correct theoretical equilibrium elevation for the outer rail of curves.

- b. From the foregoing may be derived the simplified formula,

$$E = 0.0007 V^2 D$$

where:

- E = Equilibrium elevation in inches of the outer rail (center to center of rails, or 4' -11-1/2")
- D = Degree of curve
- V = Speed in miles per hour

- c. Equilibrium speed on a curve is the speed at which the resultant of the weight and the centrifugal force is perpendicular to the plane of the track. Therefore, the components of the centrifugal force and the weight in the plane of the track are balanced. If it were possible to operate all classes of traffic at the same speed on a curve, the ideal condition for smooth riding and minimum rail wear would be obtained by elevating for equilibrium. However, curved track must handle several classes of traffic operating at various speeds, which results in slow trains causing more than normal wear on the inside rail and high-speed trains more on the outside rail.
- d. The car body assumes a different position when the speed of the car is greater than the equilibrium speed. In this case, the elevation will not be completely effective in balancing out the centrifugal force created by the circular motion of the car. With this unbalanced force acting at the center of gravity of the car body, the body will be displaced outwardly and will tilt on the springs and swing hangers toward the outside of the curve. Under normal conditions, when the car is above the equilibrium speed, the car body will not incline from the vertical at an angle as great as the track angle. The difference between the track angle and the car angle is called the roll angle. The less the roll angle, the better comfort obtained in going around curves.
- e. Safety and comfort limit the speed with which a passenger train may negotiate a curve. Any speed which gives comfortable riding on a curve is well within the limits of safety. Experience has shown that the conventional baggage cars, passenger coaches, diners, and Pullman cars will ride comfortably around a curve at a speed which will require an elevation about 3 inches higher for equilibrium. Equipment designed with large center bearings, roll stabilizers, and

¹ References, Vol. 3, 1902, pp. 56, 78; Vol. 5, 1904, pp. 528, 562; Vol. 6, 1905, pp. 754, 759; Vol. 12, 1911, part 1, pp. 402, 465; Vol. 15, 1914, pp. 594, 1063; Vol. 16, 1915, pp. 732, 1145; Vol. 30, 1929, pp. 895, 899, 1426; Vol. 36, 1935, pp. 557, 968; Vol. 37, 1936, pp. 466, 468, 1015; Vol. 41, 1940, pp. 554, 556, 867; Vol. 48, 1947, pp. 553, 885; Vol. 54, 1953, pp. 1082, 1404; Vol. 57, 1956, pp. 764, 1072; Vol. 63, 1962, pp. 487, 753. Reapproved with revisions 1962.

outboard swing hangers can negotiate curves comfortably at greater than 3 inches unbalanced elevation because there is less car body roll. It is suggested that where complete passenger trains are equipped with cars utilizing the foregoing refinements that a lean test be made on the equipment to determine the amount of body roll. Lean tests may be made on tangent track by running one side of the car onto oak shims, using winches to move the car on and off the shims. Cars should be elevated to three heights: usually 2 inches, 4 inches, and 6 inches. If the roll angle is less than 1 degree 30', experiments indicate that cars can negotiate curves comfortably at 4-1/2 inches unbalanced elevation.

- f. The inner rail should preferably be maintained at grade.
- g. [Table 5-3-2](#) gives the equilibrium elevation of various degrees of curvature for speed in miles per hour in multiples of five (which is the general practice used on speed limit signs).

Table 5-3-2. Equilibrium Elevation for Various Speeds on Curves

D = Degree of Curve	V = Speed in Miles per Hour																		
	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100
0° 30'	1/4	1/4	1/4	1/4	1/2	1/2	3/4	3/4	1	1-1/4	1-1/2	1-1/2	1-3/4	2	2-1/4	2-3/4	3	3-1/4	3-1/2
1° 00'	1/4	1/4	1/2	1/2	3/4	1	1-1/4	1-1/2	1-3/4	2-1/4	2-3/4	3	3-1/2	4	4-1/2				
1° 30'	1/4	1/4	1/2	3/4	1	1-1/2	1-3/4	2-1/4	2-3/4	3-1/4	4	4-1/2							
2° 00'	1/4	1/2	3/4	1	1-1/2	1-3/4	2-1/4	3	3-1/2	4-1/4									
2° 30'	1/4	1/2	3/4	1-1/4	1-3/4	2-1/4	3	3-3/4	4-1/2										
3° 00'	1/4	1/2	1	1-1/2	2	2-3/4	3-1/2	4-1/2											
3° 30'	1/4	3/4	1	1-3/4	2-1/4	3-1/4	4	5											
4° 00'	1/2	3/4	1-1/4	1-3/4	2-3/4	3-1/2	4-1/2												
4° 30'	1/2	3/4	1-1/2	2	3	4													
5° 00'	1/2	1	1-1/2	2-1/4	3-1/4	4-1/2													
5° 30'	1/2	1	1-3/4	2-1/2	3-1/2	4-3/4													
6° 00'	1/2	1	1-3/4	2-3/4	4														
6° 30'	1/2	1-1/4	2	3	4-1/4														
7° 00'	1/2	1-1/4	2	3-1/4	4-1/2														
7° 30'	3/4	1-1/4	2-1/4	3-1/2	4-3/4														
8° 00'	3/4	1-1/2	2-1/4	3-1/2															
9° 00'	3/4	1-1/2	2-3/4	4															
10° 00'	3/4	1-3/4	3	4-1/2															
11° 00'	1	1-3/4	3-1/4	5															
12° 00'	1	2	3-1/2																

$$E = 0.0007V^2D$$

Based on rounding up to nearest 1/4"

The formula within this table can be used to calculate additional values.

3.3.2 UNBALANCED SUPERELEVATION (2011)

- a. For a specified speed the amount of superelevation required for a balanced (equilibrium) condition is determined by the formula stated in [Article 3.3.1](#). Excessive elevation for the speeds operated will result in excessive wear on the low rail or may even cause low rail rollover. Too little elevation for the speed operated will cause excessive wear on the high rail or may cause the wheel to climb the high side and derail. Not all trains operate at the same speed through a curve. Railways will specify the amount of unbalance utilized up to a regulated maximum amount. The maximum unbalance at which railways are permitted to operate is set by the appropriate governmental regulatory body.
- b. Following are a number of considerations that should be reviewed when determining what the final unbalance should be on a curve.
 - (1) The average train speed in each direction compared to the posted zone speed.

The average train speed over a curve may be affected by such factors as:

 - Multi-track versus single track and operating practices
 - Direction of loaded versus empty train traffic
 - Train operation criteria (weight to power ratio)
 - Location of signals, sidings, stations, grade crossings, railway crossing diamonds, permanent speed restrictions
 - Physical constraints such as bridges, tunnels and grades
 - (2) Frequency and weight ratio between freight and passenger traffic and the difference in zone speed between freight and passenger trains. For example, on predominately passenger lines, speed will be the determining factor for superelevation as opposed to tonnage on a freight line.
 - (3) Train make-up and equipment types. For example, freight vs. passenger, or standard freight cars vs. double stacked containers or bi-level passenger cars.
 - (4) Physical constraints limiting proper lengths of spiral curves.
 - (5) Areas with chronic alignment and/or surface-related problems.
 - (6) Railway economic maintenance policies. Railways based on their traffic pattern may prefer to maximize superelevation and minimize superelevation unbalance to reduce the effects of centrifugal force upon vehicles, track structures and roadbed.
 - (7) Railway track maintenance tolerances. Track maintenance tolerances as defined by governmental and operating railway regulations are generally greater than the initial construction tolerances and thus take precedence for the purpose of determining clearances at structures such as tunnels or bridges where superelevation affects track clearances.
- c. On some railways and for certain heavy tonnage main tracks, a computer program that simulates train operation over a specified section of track can be used to determine necessary curve superelevation, lengths of easement curves, speed zones and permanent speed restrictions. Where there is no computer program available, the desired superelevation can be determined by first calculating the equilibrium elevation using the formula shown in [Article 3.3.1.b](#) of this section, and then establishing an actual superelevation based on selection of an appropriate unbalance.
- d. The relationship between Unbalance and Velocity is demonstrated by:

$$V_{\max} = \sqrt{((E_a + U) / .0007D)}$$

where: V_{\max} = Velocity of train (maximum allowed speed in MPH)

E_a = Actual Elevation (inches)

U = Unbalance (inches)

D = Degree of Curvature (decimal degrees)

- e. The Unbalance Superelevation tables provided below are for illustration only. The tables show values based on 5" maximum superelevation which is a typical maximum for freight train operations. The user must take into consideration the requirements of governmental and operating railway regulations when determining an appropriate unbalanced superelevation. There is no fixed rule to determine the superelevation of every curve from theory alone. It is the responsibility of the operating railway to take into account all the variables involved to make choices based on their operating environment.

Table 5-3-3. 1" Unbalanced Superelevation for Various Speeds on Curves

D = Degree of Curve	V = Speed in Miles per Hour																		
	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100
0° 30'	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	3/4	1	1-1/4	1-3/4	2	2-1/4	2-1/2
1° 00'	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	3/4	1-1/4	1-3/4	2	2-1/2	3	3-1/2	4-1/4	4-3/4		
1° 30'	1/2	1/2	1/2	1/2	1/2	1/2	3/4	1-1/4	1-3/4	2-1/4	3	3-1/2	4-1/4	5					
2° 00'	1/2	1/2	1/2	1/2	1/2	3/4	1-1/4	2	2-1/2	3-1/4	4-1/4	5							
2° 30'	1/2	1/2	1/2	1/2	3/4	1-1/4	2	2-3/4	3-1/2	4-1/2									
3° 00'	1/2	1/2	1/2	1/2	1	1-3/4	2-1/2	3-1/2	4-1/4										
3° 30'	1/2	1/2	1/2	3/4	1-1/4	2-1/4	3	4											
4° 00'	1/2	1/2	1/2	3/4	1-3/4	2-1/2	3-1/2	4-3/4											
4° 30'	1/2	1/2	1/2	1	2	3	4-1/4												
5° 00'	1/2	1/2	1/2	1-1/4	2-1/4	3-1/2	4-3/4												
5° 30'	1/2	1/2	3/4	1-1/2	2-1/2	3-3/4													
6° 00'	1/2	1/2	3/4	1-3/4	3	4-1/4													
6° 30'	1/2	1/2	1	2	3-1/4	4-3/4													
7° 00'	1/2	1/2	1	2-1/4	3-1/2														
7° 30'	1/2	1/2	1-1/4	2-1/2	3-3/4														
8° 00'	1/2	1/2	1-1/4	2-1/2	4-1/4														
9° 00'	1/2	1/2	1-3/4	3	4-3/4														
10° 00'	1/2	3/4	2	3-1/2															
11° 00'	1/2	3/4	2-1/4	4															
12° 00'	1/2	1	2-1/2	4-1/4															

$$E_a = 0.0007V^2D - 1''$$

Based on 5" maximum superelevation

Based on 1/2" minimum superelevation

Based on rounding up to nearest 1/4"

Table 5-3-4. 2" Unbalanced Superelevation for Various Speeds on Curves

D = Degree of Curve	V = Speed in Miles per Hour																		
	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100
0° 30'	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	3/4	1	1-1/4	1-1/2
1° 00'	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	3/4	1	1-1/2	2	2-1/2	3-1/4	3-3/4	4-1/2	5
1° 30'	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	3/4	1-1/4	2	2-1/2	3-1/4	4	4-3/4				
2° 00'	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1	1-1/2	2-1/4	3-1/4	4	5						
2° 30'	1/2	1/2	1/2	1/2	1/2	1/2	1	1-3/4	2-1/2	3-1/2	4-1/2								
3° 00'	1/2	1/2	1/2	1/2	1/2	3/4	1-1/2	2-1/2	3-1/4	4-1/2									
3° 30'	1/2	1/2	1/2	1/2	1/2	1-1/4	2	3	4-1/4										
4° 00'	1/2	1/2	1/2	1/2	3/4	1-1/2	2-1/2	3-3/4	5										
4° 30'	1/2	1/2	1/2	1/2	1	2	3-1/4	4-1/2											
5° 00'	1/2	1/2	1/2	1/2	1-1/4	2-1/2	3-3/4												
5° 30'	1/2	1/2	1/2	1/2	1-1/2	2-3/4	4-1/4												
6° 00'	1/2	1/2	1/2	3/4	2	3-1/4	4-3/4												
6° 30'	1/2	1/2	1/2	1	2-1/4	3-3/4													
7° 00'	1/2	1/2	1/2	1-1/4	2-1/2	4-1/4													
7° 30'	1/2	1/2	1/2	1-1/2	2-3/4	4-1/2													
8° 00'	1/2	1/2	1/2	1-1/2	3-1/4	5													
9° 00'	1/2	1/2	3/4	2	3-3/4														
10° 00'	1/2	1/2	1	2-1/2	4-1/2														
11° 00'	1/2	1/2	1-1/4	3	5														
12° 00'	1/2	1/2	1-1/2	3-1/4															

$$E_a = 0.0007V^2D - 2"$$

Based on 5" maximum superelevation
 Based on 1/2" minimum superelevation
 Based on rounding up to nearest 1/4"

Table 5-3-5. 3" Unbalanced Superelevation for Various Speeds on Curves

D = Degree of Curve	V = Speed in Miles per Hour																			
	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	
0° 30'	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2
1° 00'	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1-1/2	1/2	1/2	1/2	1/2	1/2
1° 30'	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1	1-1/2	2-1/4	3	3-3/4	4-3/4	2-3/4	3-1/2	4	
2° 00'	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1-1/4	2-1/4	3	4	5						
2° 30'	1/2	1/2	1/2	1/2	1/2	1/2	1/2	3/4	1-1/2	2-1/2	3-1/2	4-1/2								
3° 00'	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1-1/2	2-1/4	3-1/2	4-3/4									
3° 30'	1/2	1/2	1/2	1/2	1/2	1/2	1	2	3-1/4	4-1/2										
4° 00'	1/2	1/2	1/2	1/2	1/2	1/2	1-1/2	2-3/4	4											
4° 30'	1/2	1/2	1/2	1/2	1/2	1	2-1/4	3-1/2	5											
5° 00'	1/2	1/2	1/2	1/2	1/2	1-1/2	2-3/4	4-1/4												
5° 30'	1/2	1/2	1/2	1/2	1/2	1-3/4	3-1/4	5												
6° 00'	1/2	1/2	1/2	1/2	1	2-1/4	3-3/4													
6° 30'	1/2	1/2	1/2	1/2	1-1/4	2-3/4	4-1/2													
7° 00'	1/2	1/2	1/2	1/2	1-1/2	3-1/4	5													
7° 30'	1/2	1/2	1/2	1/2	1-3/4	3-1/2														
8° 00'	1/2	1/2	1/2	1/2	2-1/4	4														
9° 00'	1/2	1/2	1/2	1	2-3/4	4-3/4														
10° 00'	1/2	1/2	1/2	1-1/2	3-1/2															
11° 00'	1/2	1/2	1/2	2	4															
12° 00'	1/2	1/2	1/2	2-1/4	4-3/4															

$$E_a = 0.0007V^2D - 3''$$

3" unbalanced is typical maximum allowable

Based on 5" maximum superelevation

Based on 1/2" minimum superelevation

Based on rounding up to nearest 1/4"

Table 5-3-6. 4" Unbalanced Superelevation for Various Speeds on Curves

D = Degree of Curve	V = Speed in Miles per Hour																			
	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	
0° 30'	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2
1° 00'	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1-1/4	1-3/4	2-1/2	3
1° 30'	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1-1/4	2	2-3/4	3-3/4	4-3/4			
2° 00'	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1-1/4	2	3	4	5						
2° 30'	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1-1/4	2-1/2	3-3/4	5	4-3/4							
3° 00'	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1-1/4	2-1/2	3-3/4	5								
3° 30'	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1	2-1/4	3-1/2	5									
4° 00'	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1-3/4	3	4-1/2										
4° 30'	1/2	1/2	1/2	1/2	1/2	1/2	1-1/4	2-1/2	4											
5° 00'	1/2	1/2	1/2	1/2	1/2	1/2	1-3/4	3-1/4	4-3/4											
5° 30'	1/2	1/2	1/2	1/2	1/2	1/2	2-1/4	4												
6° 00'	1/2	1/2	1/2	1/2	1/2	1-1/4	2-3/4	4-3/4												
6° 30'	1/2	1/2	1/2	1/2	1/2	1-3/4	3-1/2													
7° 00'	1/2	1/2	1/2	1/2	1/2	2-1/4	4													
7° 30'	1/2	1/2	1/2	1/2	3/4	2-1/2	4-1/2													
8° 00'	1/2	1/2	1/2	1/2	1-1/4	3	5													
9° 00'	1/2	1/2	1/2	1/2	1-3/4	3-3/4														
10° 00'	1/2	1/2	1/2	1/2	2-1/2	4-3/4														
11° 00'	1/2	1/2	1/2	1	3															
12° 00'	1/2	1/2	1/2	1-1/4	3-3/4															

$$E_a = 0.0007V^2D - 4"$$

3" unbalanced is typical maximum allowable

Based on 5" maximum superelevation

Based on 1/2" minimum superelevation

Based on rounding up to nearest 1/4"

SECTION 3.4 SPEEDS OF TRAINS THROUGH LEVEL TURNOUTS (2014)

- a. Tables 5-3-7 and 5-3-9 Turnouts with Straight Switch Points (AREMA) for 3" and 2" unbalance respectively and Tables 5-3-8 and 5-3-10 Turnouts with Curved Switch Points (AREMA) for 3" and 2" unbalance respectively show maximum speeds through level turnouts giving riding conditions equivalent to those obtained in traversing a curve elevated 3" or 2" less than that required for equilibrium.
- b. Speeds through turnouts with either straight or curved switch points are calculated from the equation $E=0.0007V^2D-U$ (see Section 3.3, Elevations and Speeds for Curves (2011)), where D equals the degree of curvature of the closure curve or the switch curve, whichever is sharper. For turnouts with straight switch points, D for the switch point curve is the degree of curvature of a curve having a central angle equal to the switch angle and a chord length equal to the length of the switch points. (See Plan No. 910 and No. 920 in the AREMA *Portfolio of Trackwork Plans* and the Chapter 5 Glossary for an explanation of terms).

Sample Calculations used to clarify paragraph b for U = 3" unbalance

E = equilibrium elevation in inches

V = velocity of train in MPH

D = degree of curvature in decimal degrees

U = unbalance in inches

No. 24 lateral turnout, switch radius is 5105.62 vs. center line radius of 5103.26, so the center line radius governs. The degree of curve for center line radius is 1 degree, 7 minutes, 22 seconds or 1.1228 degrees.

$$V = \text{SQRT} (3 / 0.0007 * 1.1228) = 61.78 \text{ mph}$$

Therefore, use 60 mph in table

No. 24 equilateral turnout, the centerline radius will be double that of a No. 24 lateral and the degree of curve will be half the degree or 0.5614 degree.

$$V = \text{SQRT} (3 / 0.0007 * 0.5614) = 87.37$$

Therefore, use 85 mph in table

Sample calculation for straight point turnouts: For example, for the #10 turnout with 16'6" points (1° 48' 32" or 1.8080 degree switch angle), the effective curvature is determined from $D_c = [1.8089 / (16.5/100)] = 10.9630\text{deg}$. Equilibrium speed associated with this D_c is $\text{SQRT}(3/0.0007*10.9630) = 19.77 \text{ MPH}$, shown as 20 MPH in the table.

Similarly, the #8 curved 13'0" switch point is not governed by the 550.75' closure curve radius as implied by Paragraph b, but effectively by its 1° 41' 31" switch point entry angle (effective D_c of 13.0150 degree. or 440' radius), which would reduce the Table 5-3-8 maximum speed to 18 MPH.

- c. For passenger trains completely equipped with cars in which the lean tests show a roll angle of less than 1 degree 30 minutes, trains may operate comfortably through turnouts at 12% higher speeds than those indicated in the foregoing.
- d. As noted in paragraph a, the speeds shown in the following tables only consider the situation of a train traversing a curve elevated at 3 inches and 2 inches less than what is required for equilibrium. Speeds described in paragraph a do not take into consideration such things as the existence of discontinuities in the running and guiding edges, incidences of partially unbalanced lateral acceleration and lateral forces while negotiating a turnout. The designer may reduce

desired speeds through level turnouts shown in the tables after considering the aforementioned factors and additional factors such as comfort, maintainability, and other site specific factors.

- e. For turnout alignments with an entry angle, such as AREMA-style alignments the designer should check the entry angle of the switch if it governs allowable speed. Wheel climb criterion, such as Nadal's limit or distance based criteria should be used to determine the allowable speed of the switch portion of the turnout. The lowest allowable speed of the three(switch entry angle, switch radius, and closure curve radius) should govern the turnout.

Table 5-3-7. Turnouts with Straight Switch Points (AREMA) for 3" Unbalance

Turnout Number	Length of Switch Points	Maximum Speed in Miles Per Hour	
		Lateral Turnouts	Equilateral Turnouts
7	16'-6"	17	23
8	16'-6"	19	27
9	16'-6"	20	28
10	16'-6"	20	28

Table 5-3-8. Turnouts with Curved Switch Points (AREMA) for 3" Unbalance

Turnout Number	Length of Switch Points	Maximum Speed in Miles Per Hour	
		Lateral Turnouts	Equilateral Turnouts
6	13'-0"	15	21
7	13'-0"	18	25
8	13'-0"	20	28
9	19'-6"	22	30
10	19'-6"	25	35
11	19'-6"	28	39
12	19'-6"	29	40
14	26'-0"	34	49
15	26'-0"	38	53
16	26'-0"	40	57
20	39'-0"	50	70
24	39'-0"	60	85

Table 5-3-9. Turnouts with Straight Switch Points (AREMA) for 2" Unbalance

Turnout Number	Length of Switch Points	Maximum Speed in Miles Per Hour	
		Lateral Turnouts	Equilateral Turnouts
7	16'-6"	13	19
8	16'-6"	16	22
9	16'-6"	16	23
10	16'-6"	16	23

Table 5-3-10. Turnouts with Curved Switch Points (AREMA) for 2" Unbalance

Turnout Number	Length of Switch Points	Maximum Speed in Miles Per Hour	
		Lateral Turnouts	Equilateral Turnouts
6	13'-0"	12	17
7	13'-0"	14	20
8	13'-0"	17	23
9	19'-6"	18	25
10	19'-6"	20	28
11	19'-6"	22	32
12	19'-6"	25	35
14	26'-0"	28	40
15	26'-0"	31	33
16	26'-0"	33	47
20	39'-0"	41	58
24	39'-0"	50	71

SECTION 3.5 MINIMUM TANGENT LENGTHS REQUIRED BETWEEN REVERSE CURVES FOR YARD OPERATIONS¹ (1984) R(2014)

3.5.1 NO SPIRAL AND NO SUPERELEVATION (1984) R(2014)

- a. There appears to be no need for tangent between reverse curves of 6 degrees or less.

References, Vol. 80, 1979, p. 197; Vol. 85, 1984, p. 23. Reapproved without change 1962.

- b. For reverse curves over 6 degrees but under 13 degrees, tangents should be provided between the curves at least as long as those indicated in [Table 5-3-11](#).

Table 5-3-11. Reverse Curves and Tangent Length

Degree of Reverse Curves	Recommended Tangent Length
Under 6°	0 feet
6° – 7°	10 feet
7° – 8°	20 feet
8° – 9°	25 feet
9° – 10°	30 feet
10° – 11°	40 feet
11° – 12°	50 feet
12° – 13°	60 feet

- c. Some critical conditions might be observed in any yard. For example a simple No. 8 turnout to a track paralleling the one from which it diverges on 13-foot centers will provide approximately 41 ft of tangent between the toe of frog and point of reverse curve, which is probably not sufficient for critical consists between nearly 12 degree curves. A No. 8 turnout to parallel track on 14-foot center increases the tangent to about 49 feet which should cause no problems.
- d. For curves above 13 degrees, the maximum coupler angle is exceeded regardless of the length of tangent between curves. Curves above 13 degrees should, therefore, be avoided.
- e. Extreme long car-short car combinations should not be operated- over reverse curves of 10 degrees or larger.

3.5.2 WITH SPIRALS AND SUPERELEVATION (1984) R(2014)

- a. The minimum tangent length between reverse curves with spirals and superelevation should not be less than the length of the longest car that is to traverse the curves.
- b. Consideration should also be given to the chord length being used by the automatic lining equipment when establishing the minimum tangent length.

SECTION 3.6 VERTICAL CURVES (2002)

- a. Vertical curves as calculated in item (f) below should be used to connect all changes in gradients.
- b. The length of vertical curve is determined by changes in gradient, vertical acceleration and the speed of the train.
- c. The purpose of the vertical curve is to ease the change of the gradients in order to reduce coupler and diaphragm binding and eliminate the danger of breaking trains in two as a direct result of train action. In addition, the proper vertical curve will provide for passenger comfort on passenger trains. Vertical curves should be designed as long as physically and economically possible.
- d. A vertical curve which is concave upwards shall be denoted as a sag. A vertical curve which is concave downwards shall be denoted as a summit.

- e. The vertical curve may be either circular or parabolic in shape.
- f. The **minimum** length of the vertical curve for both sags and summits is determined by the following formula (except that in no case should the length of the vertical curve be less than 100 feet long):

$$L = \frac{D \times V^2 \times K}{A}$$

Where: A = vertical acceleration in feet/sec/sec (ft/sec²)
 D = Absolute value of the difference in rates of grades expressed as a decimal
 K = 2.15 conversion factor to give L in feet
 L = Length of vertical curve in feet
 V = Speed of the train in miles per hour

- g. The recommended vertical acceleration (A) should be selected based on the type of operations and is the same for both sags and summits.

Freight Operations:

A = 0.10 feet/sec/sec

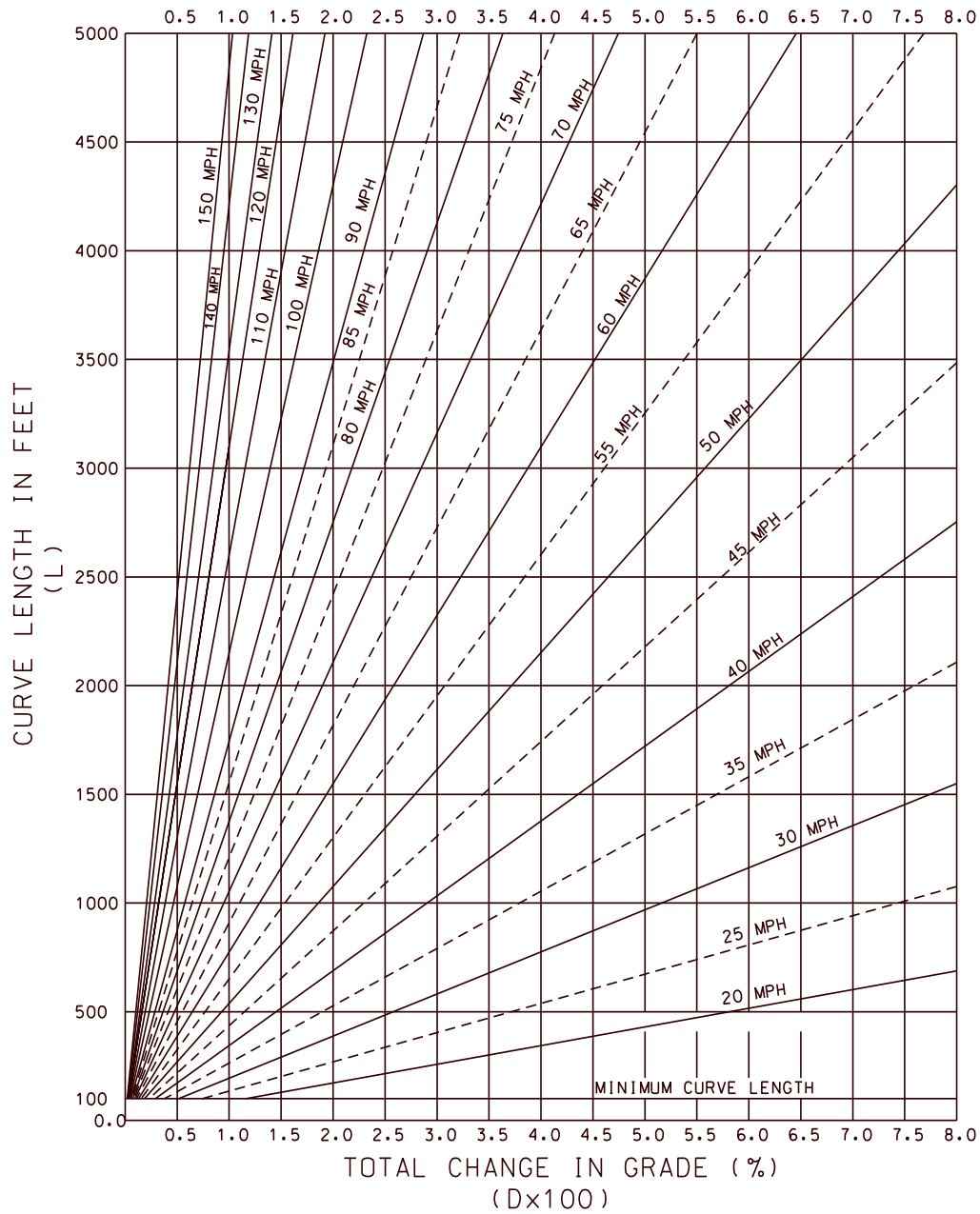
Passenger and Transit Operations:

A = 0.60 feet/sec/sec

- h. The minimum distance between vertical curves shall not be less than 100 ft.
- i. The train speed which should be used in the above formula for establishing the length of vertical curve should be the maximum speed found on that particular subdivision or route. Special attention should be paid to locations where local conditions have dictated a speed restriction now in place, but where such a restriction might be removed at a later date.
- j. It is not recommended to place turnouts within the limits of a vertical curve.
- k. Curves constructed to this formula should not present any problems for the current generation of equipment. Slow speed curves, such as hump crests, should, however, be designed with consideration for vertical clearance rather than using this formula.

NOTE: Values for various speeds and change in gradients have been graphed for reference.

RECOMMENDED MINIMUM LENGTH VERTICAL CURVES
FOR
FREIGHT LINES

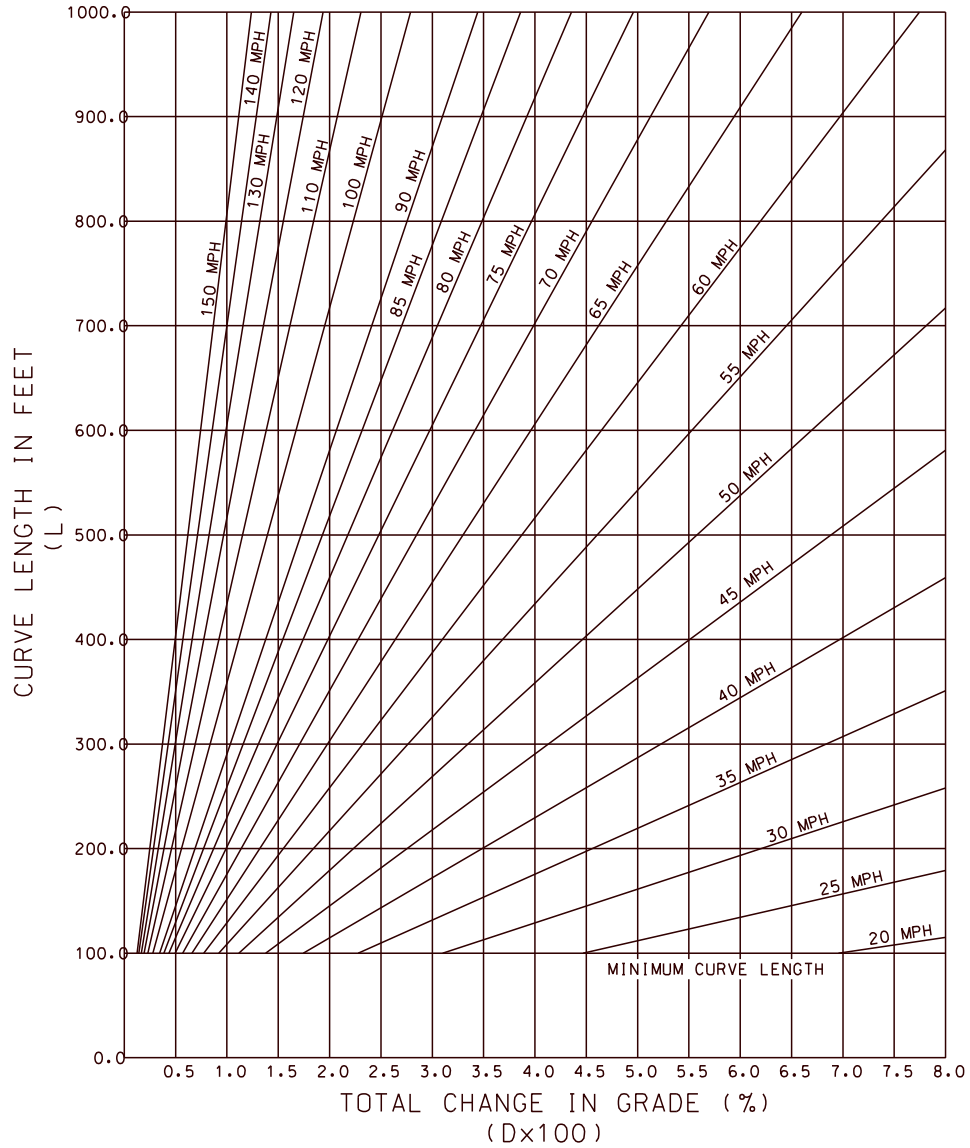


FORMULA: $L = (D \times V^2 \times K) / A$

WHERE: V = Speed of the train in miles per hour.
 L = Length of vertical curve in feet.
 D = Absolute value of the difference in rates of grades expressed as a decimal.
 A = 0.1 feet/sec/sec.
 K = 2.15 = conversion factor to give L in feet.

Figure 5-3-3. Recommended Minimum Length Vertical Curves for Freight Lines

RECOMMENDED MINIMUM LENGTH VERTICAL CURVES
FOR
TRANSIT AND PASSENGER LINES

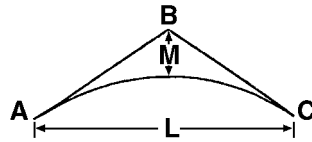


FORMULA: $L = (D \times V^2 \times K) / A$

WHERE: V = Speed of the train in miles per hour.
 L = Length of vertical curve in feet.
 D = Absolute value of the difference in rates of grades expressed as a decimal.
 A = 0.6 feet/sec/sec.
 K = 2.15 = conversion factor to give L in feet.

Figure 5-3-4. Recommended Minimum Length Vertical Curves for Transit and Passenger Lines

1. One such form of vertical curve is developed as follows:



L = Length of vertical curve in 100-ft stations

M = Correction in elevation at B

When vertical curve is concave downwards –

$$M = \frac{(\text{Elev B} \times 2) - (\text{Elev A} + \text{Elev C})}{4}$$

When vertical curve is concave upwards –

$$M = \frac{(\text{Elev A} + \text{Elev C}) - (\text{Elev B} \times 2)}{4}$$

- m. The correction for any other point on a vertical curve is proportional to the square of its distance from A or C to B.
 n. Corrections are – when the vertical curve is concave downwards and + when the vertical curve is concave upwards

Example Calculation for Freight Operations

Crest curve with 0.50% ascending grade meeting a 0.50% descending grade. Maximum design speed is 50 MPH.

A = 0.10 feet/sec/sec vertical acceleration (Freight)

D = Absolute value of $(+.005) - (-.005) = 0.01$

K = 2.15 conversion factor to give L in feet

V = 50 MPH design speed

$$L = \frac{D \times V^2 \times K}{A} = \text{Length of vertical curve in feet}$$

$$L = \frac{(0.01) \times (50\text{MPH})^2 \times 2.15}{0.10 \text{ feet/sec/sec}} = 537.50 \text{ feet} \quad \text{say } 540 \text{ feet}$$

Example Calculation for Passenger and Transit Operations

Sag curve with 0.50% descending grade meeting a 0.50% ascending grade. Maximum design speed is 75 MPH.

A = 0.60 feet/sec/sec vertical acceleration (Passenger and Transit)

D = Absolute value of $(-0.005) - (+0.005) = 0.01$

K = 2.15 conversion factor to give L in feet

V = 75 MPH design speed

$$L = \frac{D \times V^2 \times K}{A} = \text{Length of vertical curve in feet}$$

$$L = \frac{(0.01) \times (75\text{MPH})^2 \times 2.15}{0.60 \text{ feet/sec/sec}} = 201.56 \text{ feet} \quad \text{say } 205 \text{ feet}$$

SECTION 3.7 COMPENSATED GRADIENTS (2013)

3.7.1 AREMA RECOMMENDED PRACTICE FOR COMPENSATED GRADIENTS (2013)

- a. Compensation of gradients due to horizontal curvature is recommended on all gradients, but is essential on ruling gradients.
- b. The purpose of the compensated gradient is to equate the total resistance of a train on a horizontal curve on a gradient to that of the total resistance of a train on tangent track on a gradient.
- c. The amount of gradient compensation is determined by the compensation factor and the degree of curve.
- d. The recommended compensation factor to be used is 0.04 percent per degree of curve. Curvature adds to the resistance 0.8 lb for each ton of train weight for each degree of curve. This corresponds to the resistance created by standard three piece trucks on non-lubricated curves. A 1 percent grade adds resistance of 20 lb per ton resulting in a 1 degree curve being equivalent to a 0.04 percent grade in resistance.

e. The recommended compensated gradient due to curvature shall be calculated as follows:

$$G_c = G - 0.04D$$

Where: G= gradient before compensation, expressed in percent
 D= degree of curve expressed in decimals of degrees
 G_c = compensated gradient expressed in percent

f. Grades on curved track will be reduced by an amount equivalent to 0.04 x degree of curve.

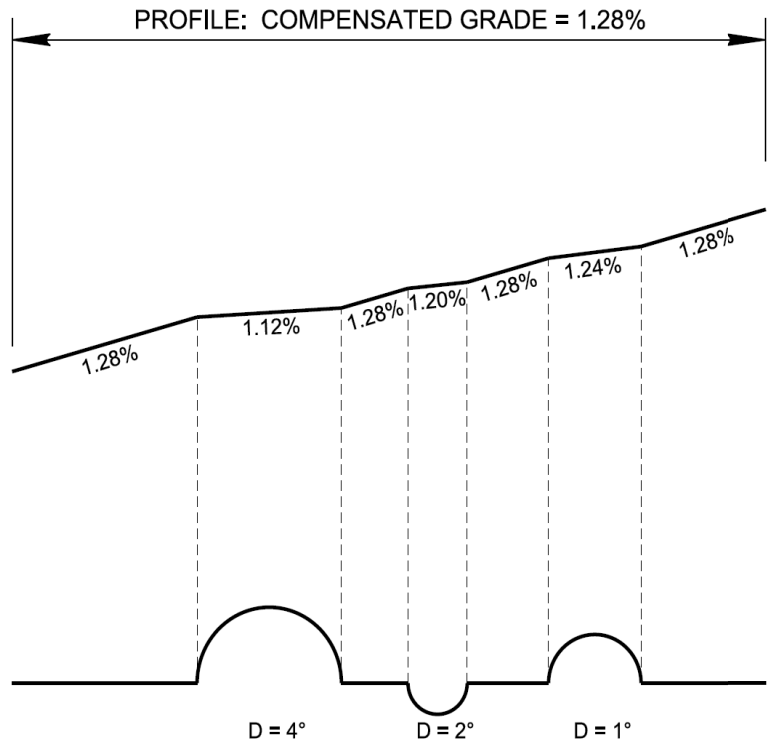
Example:

A train travelling around a 4, 2 and 1 degree curve on a 1.28 percent grade (uncompensated) experiences a combined resistance equal to:

1.48% grade for a 4 degree curve (1.28% + 0.04 x 4 = 1.28 + 0.16 = 1.44%)

1.36% grade for a 2 degree curve (1.28% + 0.04 x 2 = 1.28 + 0.08 = 1.36%)

1.32% grade for a 1 degree curve (1.28% + 0.04 x 1 = 1.28 + 0.04 = 1.32%)



HORIZONTAL ALIGNMENT DATA

GRADE COMPENSATION = 0.04% PER DEGREE OF CURVE

To maintain an effective grade of 1.28 percent, the actual grade must be reduced through the:

4 degree curve by 0.16 percent to a 1.12 percent gradient (1.28 – 0.16),

2 degree curve by 0.08 percent to a 1.20 percent gradient (1.28 – 0.08),

1 degree curve by 0.04 percent to a 1.24 percent gradient (1.28 – 0.04).

SECTION 3.8 PERMANENT MONUMENTS¹ (2012)

Where permanent alignment monuments are used, they should be placed at points of tangent, points of spiral, points of change of curvature, summits, and at such other points along curves or tangents as will enable the alignment to be reproduced with surveying equipment.

¹ References, Vol. 5, 1904, pp. 528, 536; Vol. 54, 1953, pp. 1083, 1404; Vol. 63, 1962, pp. 487, 753. Reapproved with revisions 1962.

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American Railway Engineering and Maintenance-of-Way Association

Part 4

Track Construction

— 2014 —

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SECTION 4.1 SPECIFICATIONS FOR TRACK CONSTRUCTION¹ (2014)

4.1.1 SCOPE (1984)

- a. The work covered by these specifications will include the laying and ballasting of the tracks mentioned, on previously prepared subgrade, ready for the operation of trains.
- b. Where continuous welded rail is laid the requirements of these specifications are modified by [Article 4.1.2](#).
- c. Track construction may be performed in two distinct manners:
 - employment of contractor.
 - employment of railroad track forces. If the latter manner is used, replace subsequent references to contractor with railroad track forces.
- d. The railway company’s authorized representative shall arrive at a clear understanding with the contractor as to the force to be employed and the speed with which the work shall proceed. Prior to starting the work, the contractor shall notify the railroad company’s representative at least five working days in advance so that adequate arrangements can be made for the prosecution of the work.
- e. Track materials:

¹ References, Vol. 24, 1923, pp. 457, 1166; Vol. 41, 1940, pp. 554, 867; Vol. 53, 1952, pp. 768, 1123; Vol. 54, 1953, pp. 972, 1398; Vol. 63, 1962, pp. 488, 753; Vol. 67, 1966, pp. 406, 731; Vol. 68, 1967, p. 399; Vol. 82, 1981, p. 204; Vol. 85, 1984, p. 23. Reapproved with additions 1984.

- The railway company will furnish track materials on cars or on the ground in the material yard and/or;
 - The contractor will supply and transport track materials to the job site and all material shall be subject to the approval of the railway company.
- f. The contractor shall provide all tools and equipment needed in connection with this work.
- g. The railway company will provide the necessary inspector or inspectors, and the instructions of such inspectors regarding the quality and type of work to be done shall be complied with at all times by the contractor.
- h. The contractor shall supply the necessary supervision and labor to prosecute the work properly and in such numbers as may be required by the railroad's chief engineer or his authorized representative, and at the request of the chief engineer or his representative will remove any supervisor or man not satisfactory to the railway company.
- i. No track shall be laid and no track materials shall be placed on the roadbed until the subgrade shall have been constructed and finished to true planes according to the stakes set by the representative of the railway.
- j. The railway company's representative shall set all center and grade stakes, which stakes shall be followed by the contractor in lining and surfacing track.
- k. Ties shall be placed on _____ inch centers in main tracks and on _____ inch centers in sidings, yard, and industry tracks. They shall be laid at right angles to the rail with the ends lined uniformly as may be specified.
- l. Timber ties:
- (1) Railway company will determine size of tie to be used and type of timber acceptable.
 - (2) Ties shall be placed in the track with the wide surface nearest the heart down and square to the line of the rail.
 - (3) When necessary the ties must be adzed to get a full and even bearing for the tie plate. Excessive adzing must be avoided. All newly adzed surfaces shall be coated with an approved preservative.
 - (4) Tie plates will be used under running rails on all tracks.
 - (5) Tie plates should be free of dirt and foreign material when installed.
 - (6) Care must be exercised to see that canted tie plates are applied so as to cant the rail inward.
 - (7) Tie plates must be placed square with the rail and centered on the tie. Particular care must be given to see that the tie plate shoulders are never under the base of the rail and that the tie plates are well seated on the ties and the rail properly seated on the tie plate.
 - (8) Ties shall be spiked with two rail-holding spikes on each rail and with additional rail-holding and plate-holding spikes as specified by the railway. Other railway approved fastening devices may be used.
 - (9) All cut spikes shall be started and driven vertically and square with the rail and so driven as to allow 1/8 inch to 3/16 inch space between the underside of the head of the spike and the top of the base of the rail. In no case shall the spikes be overdriven, or straightened while being driven.
 - (10) Spikes on gage side of running rail are to be placed across from each other and spikes on the field side of the running rail are to be placed across from each other. The pattern to be held consistent.
 - (11) Switch ties will be placed in turnouts and crossovers as shown on AREMA Trackwork Plans unless otherwise specified by Railway.

- m. Concrete ties:
- (1) Concrete ties of a design approved by the railway shall be used. All ties shall be properly cured before applying rails.
 - (2) Care shall be taken in the transportation, handling, placing, and tamping of ties to avoid chipping and cracking of the concrete. Any ties which have been so damaged, in the judgment of the railway company's inspector, as to be unserviceable shall be removed and replaced.
 - (3) The bottom of the rail, the tie pad and tie plate (if used), and the bearing surface of the tie shall be cleaned before rail is laid.
 - (4) All rail fastening systems for concrete ties shall be installed per manufacturer's specifications. Any exposed metal components shall be protected against corrosion.
 - (5) Use of concrete ties under joints should be avoided.
- n. Where relay rail is used, care shall be exercised in matching adjacent rails to prevent lipped or uneven joints, and any mismatched rail ends shall be welded or ground.
- o. When laying jointed rail, approved expansion shims shall be used to provide the proper opening between rails, and a rail thermometer shall be used to determine the thickness of shims in accordance with the recommendations in [Part 5, Track Maintenance – Section 5.3, Temperature Expansion for Laying Rails \(1967\)](#).
- p. Necessary gaging shall be done at the time rail is laid and, unless otherwise provided, the gage shall be 4'-8-1/2" between points 5/8 inch below the top of rail on the two inside edges of the rails.
- q. No holes are to be burned in rail under any circumstances. When drilling is necessary all chips and burrs shall be removed before applying joints.
- r. All joints shall be fully bolted and fitted with approved spring washers.
- s. All bolts shall be tightened to prescribed torque before track is turned over to operation. Bolts shall be tightened in the proper sequence to properly seat joints, beginning at the center of the joint and working both ways to the ends of the joint.
- (1) Prescribed corrosion resistant lubricant shall be applied to bolts by supplier or prior to installation.
 - (2) Track bolts will be retightened within an appropriate period after track has been put into service, as determined by the railway.
- t. Insulated joints shall be installed, as required, in accordance with the railway's instructions.
- u. Joints in opposite rails on tangents shall be staggered not less than 12 feet apart, joints on curves in opposite rails shall not be staggered less than 8 feet and not more than 12 feet apart except as closer joints may be required at insulated joints or turnouts. In laying rail on curves, care shall be taken to put in short rails at proper intervals in the low rail and in the low rail side on tangents adjacent to the curve to maintain the proper stagger throughout the curve.
- v. Rail joints will not be placed in road crossings or within the limits of switch points or guard rails.
- (1) A lubricant shall be applied on the rail within the area of the joint bar at time of installation.
 - (2) Rail joints shall be applied so that bars are not cocked between base and head of rail. Bars are to be properly seated in rail.

- w. In yard tracks or sidings so designated by the railway, track may be prefabricated in panels and laid with the joints opposite.
- x. Rail anchors shall be applied in accordance with [Part 5, Track Maintenance – Section 5.4, Rail Anchor Patterns Number of Rail Anchors to Resist Rail Creepage \(1987\)](#), unless otherwise specified by the railway. Rail anchors pattern shall be spaced approximately uniformly along the rail length. To avoid tie skewing, the anchors must be applied against the same tie on opposite rails. Rail anchors when applied must have full bearing against a sound tie.
- y. On curves, the outer rail shall be given superelevation in accordance with [Part 3, Curves – Section 3.3, Elevations and Speeds for Curves \(2011\)](#), unless otherwise specified by the railway.
- z. Switches:
 - (1) All switches, frogs and guard rails shall be placed in accordance with the proper plan of the AREMA Trackwork Plans, unless otherwise specified by the railway.
 - (2) Switches shall be left in proper adjustment, special care being given to the bending of the stock rail.
- aa. Drainage of the roadbed is necessary before good track can be secured or maintained. It is of the first importance that drainage be given careful detailed consideration at all points.
 - (1) Cross drains shall be installed wherever necessary to obtain proper drainage.
 - (2) To prevent water from coming over the top of cuts, interception ditches must be constructed to carry the water along the top of the cut and drain into a water course at the ends of the cut.
 - (3) Side ditches along the track shall be constructed to a grade that will permit water to flow freely and not form pools and seep into the roadbed. Ditches must be examined frequently and cleared of obstacles interfering with the free flow of water.
- ab. Ballast as required shall be supplied in accordance with [Article 4.1.1e](#).
- ac. Ballast shall be unloaded by the contractor as the means provided by the railway company permit. The unloaded material shall be leveled down. Care shall be taken not to destroy or disturb the grade stakes.
- ad. The preliminary surfacing gang shall follow the unloading as closely as the regularity of the ballast supply will permit. When using jacks, they shall be placed close enough together to prevent undue bending of the rail or strain on the joints. Both rails shall be raised at one time and as nearly uniformly as possible. The track shall be so lifted that after a period of not less than 3 days after the last lift it will be necessary to give it a final lift of not less than 1 inch nor more than 2 inches to bring it to the grade of the stakes. All ties that are pulled loose shall be replaced to proper position and shall have a bearing against the rail and be properly secured to the rail. Ballast shall be well packed or tamped from a point 12 inches inside each rail for 8-foot ties, 15 inches inside each rail for 8'-6" ties, and 18 inches inside each rail for 9-foot ties, on both sides of the ties to the end of ties. Tamping shall not be permitted at the center of the tie between the above-stated limits, but this center shall be filled lightly. Both ends of the ties shall be tamped simultaneously, and tamping inside and outside of the rail shall be done at the same time. Thorough tamping of ballast under the rail seat shall be required.
- ae. When the track has been raised to within 1 or 2 inches of the final grade and properly compacted by traffic, a finishing lift shall be made by jacking up the track to the height provided by the grade stakes, making necessary allowance for settlement. In making the finishing lift, a spot board and level board or tamping jack with built-in raising wire and level, or other suitable mechanical means shall be used to bring the track to a true and finished surface.

- af. The track shall be placed in good alignment before the finishing lift is made, but a lining gang or other mechanical means of lining shall follow immediately behind the finishing lift and shall line the track to accurate alignment. Stakes shall be set for the alignment before the finishing lift is made and the final alignment shall conform to the stakes.
- ag. The contractor shall trim the ballast to conform to the standard ballast section, and the railway company for this purpose shall supply its standard ballast cross section plans. The portion of the subgrade outside the ballast line shall be left with a full, even surface and the shoulder of the subgrade properly dressed to the standard roadbed section. The contractor shall dispose of any surplus ballast after trimming the ballast section as directed by the representative of the railway company.
- ah. Traffic shall not be permitted upon the newly constructed track section until the track has been accepted by the railroad or upon receipt of a written order from an appropriate representative of the railroad.
- ai. The contractor shall install and secure promptly all stock guards, crossing plank and similar facilities adjacent to or forming a part of the track.
- aj. The contractor shall remove from the railway company's property all rubbish and waste from the work or dispose of it as directed by the representative of the railway company. After completing the work the contractor shall remove from the railway company's property, and from all public and privately owned property, at his own expense, all temporary structures and waste resulting from his operations.
- ak. The contractor is to understand that any work not specifically mentioned in the specifications, but which is necessary, either directly or indirectly, for the proper carrying out of the intent thereof, shall be required and applied, and he shall perform all such work just as if it were particularly defined or described. Unless specifically mentioned above, all work shall conform to the standards of the railway company.

4.1.2 APPENDIX I – WHERE TRACK IS CONSTRUCTED WITH CONTINUOUS WELDED RAIL (CWR) (2014)

- a. No track shall be laid, and no track materials shall be placed on the roadbed, until the subgrade has been finished and the sub-ballast placed and compacted, and the design track alignment and controls have been established.
- b. The railway company shall provide the contractor a copy of their Procedures for the Installation, Adjustment, Maintenance and Inspection of CWR. The contractor will comply with all requirements of this document, including required record keeping, annual training requirements of employees in CWR procedures and the railway company specific procedures and requirements.
- c. It is the railway company's responsibility to establish the desired rail laying temperature. Contractor shall ensure that the CWR is laid at or above this desired temperature, or contractor will make the required adjustment in accordance with the railway company's written procedures. All necessary information related to laying CWR shall be recorded as required by the railway company's procedures.
- d. When laying CWR in new track construction, the rail ends should be laid without expansion gap, and [Paragraph 4.1.1o](#) will not apply.
- e. [Paragraph 4.1.1u](#) will not apply when using CWR.
- f. A string of CWR should not end on the deck of an open-deck bridge nor may it be less than a minimum distance specified by the railroad from the face of the backwall on the at-grade side.

4.1.3 APPENDIX II – MINIMUM SPECIFICATIONS FOR JOINTED INDUSTRIAL TRACK CONSTRUCTION (2014)

- a. Industrial track will be considered as track servicing industry, with speed limit of 10 mph.
- b. Tie Requirements – use treated mixed 6 inch wood ties, or equal, no less than 8'-0" long, and spaced at maximum of 24 inch centers.
- c. Rail – new or AREMA Class 2 relay rail or better (see Table 4-3-17 [Rail Grading Classification by Wear](#)). No rail less than 112RE, with properly drilled holes, should be used
- d. Tie Plates – new or relay tie plates must be used on all ties. All plates must have same cant and be properly sized to match the base of rail being used.
- e. Spikes – 5/8"×6" new or used track spikes should be used. Two rail holding spikes will be installed per tie plate. One additional spike should be considered for use on curves of 5 degrees or more.
- f. 1/2" superelevation shall be used in curves, unless specified differently by railway/owner.
- g. Maximum curvature of 10 degrees should be used. If sharper curvature is required, approval of servicing railroad may be necessary.
- h. Maximum recommended grade is 2% and 0.4% at locations on track where cars are spotted. If steeper grade is required, approval of servicing railroad may be necessary.
- i. Turnouts – use #8 or greater. If smaller turnout is required, approval of servicing railroad may be necessary.
 - (1) Box anchor every other switch tie.
 - (2) Switch point guard on turnout side switch point with heavy traffic is recommended.
 - (3) Refer to AREMA *Portfolio of Trackwork Plans* for construction details.
 - (4) One additional spike per tie plate should be used on curve closure rails in turnout.
- j. Rail Anchors – use 16 anchors per 39 feet of track; four nonconsecutive ties box-anchored per rail. Anchors shall be new or reconditioned and designed for the base of rail being installed.
- k. Rail Joints – for the rail section being installed, use matching joint bars fully bolted with lock washers. Maintain minimum 12 foot joint stagger where possible. Expansion shim of hardwood or fiber should be used to control expansion per [Table 5-5-4](#).
- l. Ballast – use AREMA #5 gradation with Los Angeles Abrasion Test of not greater than 35%, per ASTM C-535. Ballast depth should be a minimum of 6 inches from bottom of tie. Ballast section must remain level with top of tie between adjacent tracks to provide level walking area.
- m. Gaging shall be done at the time rail is laid and, unless otherwise provided, gage shall be 4'-8-1/2" plus or minus 1/8" between points 5/8 inch below the top of rail on the gage face of the rails.
- n. Crossings – Crossings should be constructed in accordance with customer and railroad requirements and specifications. Depending on vehicular traffic and volume, an economical crossing surface can be selected along with the required type of warning devices (signs/signals/gates). Rail joints should not be located within the crossing limits.
- o. Appliances such as derails, wheel stops, bumping posts, and signage will be installed as required.

SECTION 4.2 PROPER USAGE OF THE VARIOUS TYPES OF FROGS (2012)

Refer to Section 300 of the AREMA *Portfolio of Trackwork Plans* for standard plans for frog usage recommendations.

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Part 5

Track Maintenance

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SECTION 5.1 SPECIFICATIONS FOR LAYING RAIL¹ (1995)

5.1.1 SCOPE (1995)

- a. The location shall be as designated by chief maintenance officer of the railroad.
- b. The several classes of rail shall be laid as shown in [Table 5-5-1](#).

Table 5-5-1. Rail Classes

Class of Rail	Standard Length Feet	Color or Design	Use
No. 1 – low carbon	39	Uncolored	Any track
No. 1 – high carbon	39	Blue end	No restriction
No. 1 – “A” Rails	–	Yellow end	Any track
No. 1 – Short lengths	–	Green end	Any track
No. 2	39 or under	White end	Any track
X-Rail	39 or under	Brown end	Where designated by chief maintenance officer

5.1.2 UNLOADING (1995)

- a. Rail shall be unloaded from the car with an approved derrick or crane and placed with the head up without dropping, with sufficient support under the base.
- b. Rails shall be unloaded opposite the locations in which they are to be placed in the track, with suitable gaps being allowed for short lengths. Rails shall be so placed that the joints in each line of rail shall be not more than 30 inches from the centers of the opposite rails and preferably not more than 18 inches. Locations of joints can be best determined with a steel tape.
- c. Proper lengths of rail for road crossings, station platforms, bridges and other special locations shall be unloaded in a safe and convenient location, where they will not constitute an obstruction.
- d. To minimize the cutting of new full-length rails, short rails shall also be distributed in proper places to provide for proper spacing at insulated joints and for connections to switches.
- e. Joints, turnouts and fastenings shall be unloaded and distributed concurrently with the rail, except that small material shall be left in the containers until the time of laying the rail.

5.1.3 PREPARATION OF TRACK (1988)

- a. Track shall be in good surface prior to the laying of new rail, and where curve realignment work will require heavy throws, such work shall be done before the new rail is laid.
- b. No portion of the track structure, the absence of which will impair its integrity, may be removed prior to the relaying of the rail. Full flag protection or slow-order protection, as may be necessary, shall be provided in cases where rail is being laid under traffic.

¹ References, Vol. 42, 1941, pp. 663, 836; Vol. 52, 1951, pp. 518, 818; Vol. 53, 1952, pp. 769, 1123; Vol. 54, 1953, pp. 972, 1398; Vol. 59, 1958, pp. 1007, 1278; Vol. 61, 1960, pp. 954, 1235; Vol. 62, 1961, pp. 643, 946; Vol. 63, 1962, pp. 488, 753; Vol. 96, p. 30. Reapproved with revisions 1995.

5.1.4 LAYING (1988)

- a. As the rail is laid, all joints shall be given a brush coat of a metal preservative in accordance with [Section 5.8, Wayside Lubrication of Rail on Curves \(1992\)](#).
- b. Tie plates shall have a full and uniform bearing on ties and the bearings on each tie shall be in the same plane. Adzing shall be done where necessary to fulfill these requirements. All spike holes shall be plugged with treated tie plugs after the old spikes and tie plates have been removed. Creosote oil, heated when necessary, shall be applied to the ties after adzing.
- c. Where new rail is to be laid, the track shall be fully tie plated. Where possible, plates shall be applied after preparation of tie plate beds and before the placing of the new rail.
- d. Where practical, rail shall be laid against the current of traffic on multiple-track lines and against the predominant tonnage movement on single track.
- e. Standard metal, fiber or wood shims shall be placed between the ends of adjacent rails to ensure proper space allowance for expansion, as indicated in [Table 5-5-2](#).

Table 5-5-2. Shim Determination

33-Foot Rail 160 Joints per Mile		39-Foot Rail 135 Joints per Mile		78-Foot Rail 68 Joints per Mile	
Rail Temperature Deg F	Expansion Inches	Rail Temperature Deg F	Expansion Inches	Rail Temperature Deg F	Expansion Inches
Below -10	5/16	Below 6	5/16	Below 35	5/16
-10 to 14	1/4	6 to 25	1/4	35 to 47	1/4
15 to 34	2/16	26 to 45	3/16	48 to 60	3/16
35 to 59	1/8	46 to 65	1/8	61 to 73	1/8
60 to 85	1/16	66 to 85	1/16	74 to 85	1/16
Over 85	None	Over 85	None	Over 85	None

- f. Where shims are used they shall be removed to within 12 rails of the laying.
- g. In tunnels where the temperature is above 70 degrees F, rails shall be laid close without bumping; where the temperature is below 70 degrees F, an opening of 1/16 inch shall be allowed (for 39-foot rail) for each 20 degrees F reduction in temperature.
- h. A rail thermometer shall be used to ascertain the temperature of the rail and in making the reading it shall be placed on the rail base on the side away from the sun.
- i. Rails shall be placed one at a time except that in cases of busy traffic where trains cannot be diverted to other tracks, stretches of rail not over 20 in number may be bolted together at one side of the track and then lined into place, using care to maintain the expansion allowance uniformly. Rails shall be laid without bumping or striking and with the ends square.

- j. Rails shall be laid or installed so that joints will not be placed in road crossings within the limits of switch points or guard rails, or within 6 feet of the ends of open-floor bridges. Where rails longer than standard are needed for such locations, they shall be at least 60 feet long.
- k. Rail joints shall be applied before the track is spiked, the joint bars to be lined up with rail in vertical position and the bolts tightened by starting in the middle of the joint and working towards the ends. Spring washers or other similar approved appliances shall be used.
- l. All spikes shall be started and driven vertically and square with the rail and so driven as to allow 1/8 inch to 3/16 inch space between the under side of the head of the spike and the top of the base of the rail. In no case shall the spikes be overdriven or straightened while being driven. No spikes shall be driven against the ends of joint bars.
- m. The full quota of rail anchors shall be applied prior to the passage of a train over the new rail.
- n. In laying the second line of rail, gaging shall be done at least at every third tie.
- o. When necessary to make a temporary connection for the passage of a train, the union shall be made with a rail of the section being renewed. The closure rail shall not be less than 14 feet long, and shall be connected to the new rail by a compromise joint if the rails are of different sections. The connection rail shall have a full number of bolts and spikes. At the completion of a day's work a short section of new rail not less than 18 feet long shall be used in making the closure and shall be connected to the old rail with a compromise joint.

5.1.5 COMPLETION OF WORK (1988)

- a. All rail laid down on any given date shall be fully spiked, bolted and anchored at the end of the day's work. Bolt holes made in the field shall be drilled and not burned with a torch.
- b. After rail has been laid, the tops of adjacent rail ends may be ground to a level surface, or low connecting rail built up by welding to proper height.
- c. Rail ends shall be cross slotted and beveled at mill or as soon after laying as required.
- d. Markings indicating the classification of released rail shall be placed on it promptly, and such rail and its fixtures loaded promptly.
- e. It is desirable that other renewals of track material shall follow rail laying as promptly as possible.
- f. All ties on which the newly laid rail does not have a full bearing shall be tamped and the spikes redriven; proper slow orders shall be maintained until this is done. If weather conditions do not permit this work to be carried out, any loose ties may be temporarily shimmed.
- g. Where necessary, bolts shall be given a second tightening. After the ballasting and resurfacing of the track have been completed the bolts shall be tested and, if required, brought to a predetermined tension.

SECTION 5.2 LAYING AND MAINTENANCE OF CONTINUOUS WELDED RAIL¹ (1988)

5.2.1 PRESENT PRACTICE (1988)

- a. Present practice is to lay Continuous Welded Rail (CWR) in lengths of approximately 1,320 or 1,440 feet, except for special lengths required for certain locations such as road crossings, turnouts or railroad crossings. The normal string length can be any length deemed practical by the user, considering his welding facility, length of rail train, physical characteristics of the railroad, equipment available or any other reason.
- b. CWR should not be laid across long open deck bridges without special consideration. Additional information may be found in [Chapter 15, Steel Structures](#). The end of a string should terminate a sufficient distance from the end of a bridge to allow proper anchorage. Rail anchors should not be used on an open deck bridge without special precaution. If structural stresses are significant on bridge, CWR can be laid stress-free by using sliding rail joints. If rail cannot be laid stress-free, a structure analysis should be made to avoid damage.
- c. Prior to the laying of CWR, the maximum and minimum rail temperatures experienced in the area should be determined and recorded, as laying procedures are dependent on the total range of temperature to be experienced by the rail. For more detailed information, see [Paragraph 5.2.4p](#) on subsequent pages.

5.2.2 PREPARATION OF TRACK PRIOR TO UNLOADING CONTINUOUS WELDED RAIL (CWR) (1988)

- a. Replace defective ties so that a good tie condition is assured with sufficiently sound ties to maintain adequate gage, surface, and line. If heavy tie renewals are required, consideration should be given to allowing sufficient time to allow restabilization of track structures.
- b. Surface and line should be corrected.
- c. If required, add sufficient ballast to provide the recommended ballast section for CWR. (See [Chapter 1, Roadway and Ballast, Part 2, Ballast](#).)
- d. Prior to unloading CWR, present practice is to trench through road crossings and street crossings where practical and fill the trench with old ties to allow continued use of the crossings. Also, wing fences and cattle guards should be removed. The running rail of motor car set-offs should be removed and an open trench made through the set-off area in which CWR can be placed.
- e. CWR, when unloaded on open deck bridges, should be secured to prevent lateral movement. When CWR is unloaded across open deck bridges, it is generally necessary to provide some type of support for the rail on each side of the bridge. These supports are usually timber or pieces of lightweight rail securely fastened in the spaces between the bridge ties and under the guard rails so that the CWR will be on a level approximately even with the top of the bridge ties. The spacing of these supports should not exceed 20 to 30 feet center to center, depending on the rail section stiffness. When rail is unloaded across ballasted-deck bridges, it is generally the practice to unload it in the same manner as on regular track, except caution should be taken to retain the rail on the bridge and allow for proper clearance for traffic.
- f. Before CWR is unloaded over open deck bridges, all hook bolts, spacers, and other fastenings should be checked, and all replacements, additions, and tightening that are required should be done.

¹ References, Vol. 80, 1978, p. 174; Vol. 88, 1987, p. 57; Vol. 89, 1988, p. 80. Revised 1988.

5.2.3 HANDLING AND TRANSPORTING CONTINUOUS WELDED RAIL (CWR) (1988)

5.2.3.1 Before Loading CWR

- a. Carefully inspect the rail train running gear, draft gear, and air brake system to insure no irregularities exist.
- b. Properly position all coupler blocking to insure that slack action will not develop in transit. Secure lift-pin handles to prevent uncoupling.
- c. Tie-down car equipment should be arranged so that it will not be damaged when loading CWR strings.
- d. All defective rollers or racks should be replaced or repaired and the entire train lubricated as required.
- e. Transition or run-down rollers should be properly elevated and secured to provide a smooth and safe operation.
- f. Train must be blue-flagged or switch-spiked against the loading track or other safety precautions taken to prevent coupling.

5.2.3.2 Loading CWR

- a. Each string should be equipped with adequate nosing or a rail shoe for ease in guiding strings in an upright position. If point men are necessary to guide the strings on the train, positive communication should be maintained between the point man and pusher operator.
- b. Each string should overhang the terminal rail racks on the end cars a sufficient distance to insure the strings will not pull through the terminal rack when the train is negotiating the greatest curvature on its route. Recommended overhang length is 15 to 20 feet. When necessary, lateral restraint should be provided for these strings to prevent their extending beyond the sides of the car when negotiating curves.
- c. Each string should be tied down securely, and conveniently near the center of the train. A paint mark should be made on the head of each rail at tie-down point to determine if rail clamp slippage is occurring in transit.
- d. A loaded buffer car of sufficient height should be placed at each end of the rail train before movement of rail to its destination is commenced.
- e. Lift-pin handles of the buffer cars should be secured to prevent uncoupling.

5.2.3.3 Transporting CWR

- a. Each rail train should be accompanied by a person qualified to insure its proper handling and to inspect the load and train at every opportunity for defective equipment or fastenings. If providing a rider is not practical, then the tie-down of each rail train should be frequently inspected at every opportunity by qualified persons to assure that the rail remains adequately tied down throughout transit.
- b. The loaded rail train must be handled as a unit at all times and should be positioned next to the engine when handled with other traffic. The empty rail train should be handled as a unit at the rear of the train.

- c. Sudden stops, starts, and rough coupling should be avoided. Cars should not be dropped onto a rail train or rail train dropped onto other cars. The loaded or empty rail train should not remain coupled to the locomotive when it is switching other cars.
- d. The loaded rail train speed should be reduced below maximum speeds as necessary in the territory over which it passes. There is usually no speed restriction on an empty rail train.

5.2.3.4 Unloading CWR

- a. The locomotives should push the rail train during unloading operations so the enginemen may readily see the entire operation.
- b. The train and engine crews should be instructed that rough handling with sudden stops or jerks will not be permitted. Sufficient braking should be maintained on the rail train to control any slack run-in.
- c. Portable radios should be provided in order that constant communication may be maintained between the engine crew and the supervisors in charge of unloading. Radio units and spares should be checked beforehand to insure they are operating properly.
- d. CWR should be unloaded in an upright position.
- e. Once the strings have been drawn through the unloading threaders and the rail is partially on the ground, a back-up movement should not be permitted. If, in cases of emergency, it is necessary to make a back-up movement, then each string should be equipped with a shoe and each guided by a point man.
- f. CWR strings should be unloaded on each shoulder of the track so that the strings are unloaded as near to the ends of the ties as possible. Care should be taken to offset the ends of the strings after the rail is unloaded, and periodic checks should be made to see that the ends remain offset until the rail is installed. This is necessary to prevent rails from fouling the track in the event the rail moves. A block of wood may be used between rail ends to maintain the offset.
- g. All tie-down fastenings should be loaded and secured before the empty rail train is returned to the welding plant.

5.2.4 LAYING PROCEDURE FOR CONTINUOUS WELDED RAIL (CWR) ON EXISTING TRACK (1988)

- a. Distribute tie plates in center of track or at the end of the ties as the rail handling procedure dictates.
- b. Material should be distributed ahead of laying operation, but such may be done within the laying organization.
- c. Remove anchors, throw to one side of track or load and dump in piles.
- d. Remove joint bolts unless bolted track is to be removed in strings. (Use of machine(s) recommended.)
 - (1) Remove frozen bolts by burning or cutting.
 - (2) Remove old joint material from laying area.
- e. Remove spikes (use of machine(s) recommended), load scrap and dump in piles on one side of track.
- f. Set old rail out. A crane should be used for this operation.
- g. Throw out old plates on opposite side of track from scrap.

- h. Plug spike holes.
- i. Remove sufficient ballast from cribs for adzing and anchor application. (Use of machine(s) recommended.)
- j. Drive spike stubs.
- k. Adz ties sufficiently for good plate bearing. (Use of machine(s) recommended for uniform surface.) The adzed surface should be treated with a preservative.
- l. Place plates on ties in proper location with cant in proper direction.
- m. Set tie plates to gage. Double-shoulder tie plates should be used for all CWR laid. Every fourth tie should be drilled and a gage plug inserted to hold plate to gage. (Use of machine(s) recommended.) The rail should be laid at 56-1/2 inches gage unless specifically changed by railroad.
- n. The welded rail should be placed onto the plates by use of machine with a threader or tongs. When laying CWR, the rail ends should be laid without expansion gap.

NOTE: Where it is necessary to move strings longitudinally, they should be pulled into position to maintain rail in a state of tension. Bumping CWR into position is not recommended.

- o. All joints should be either field welded or glued and insulated joints glued.
- p. CWR should be laid when the rail temperature is within the temperature range specified by the following equation (see also [Figure 5-5-1](#) and [Figure 5-5-2](#)):

$$\text{Minimum D.R.T.} = \frac{2H_t + L_t}{3} + 10$$

$$\text{Maximum D.R.T.} = \left[\frac{2H_t + L_t}{3} + 25 \right] \pm 5$$

D.R.T. = Desired Rail Temperature

H_t = Highest Rail Temperature

L_t = Lowest Rail Temperature

Example: In an area where CWR is to be laid, the maximum summer rail temperature is 125 degrees F and the lowest rail temperature in the winter is -35 degrees F:

$$\text{Minimum D.R.T.} = \frac{2 \times 125 - 35}{3} + 10 = 82^\circ$$

$$\text{Maximum D.R.T.} = \left[\frac{2 \times 125 - 35}{3} + 25 \right] \pm 5 = 97^\circ \pm 5^\circ$$

In this case the rail may be installed at temperatures between 82 degrees and 102 degrees F.

- q. Rail should be heated or cooled as necessary to the desired laying temperature, or adjusted mechanically at a later time. When it is necessary to heat or cool the rail to the preferred laying temperature, the procedures to be followed are:
 - (1) A reliable contact-type pyrometer should be used in order to determine the rail temperature immediately.

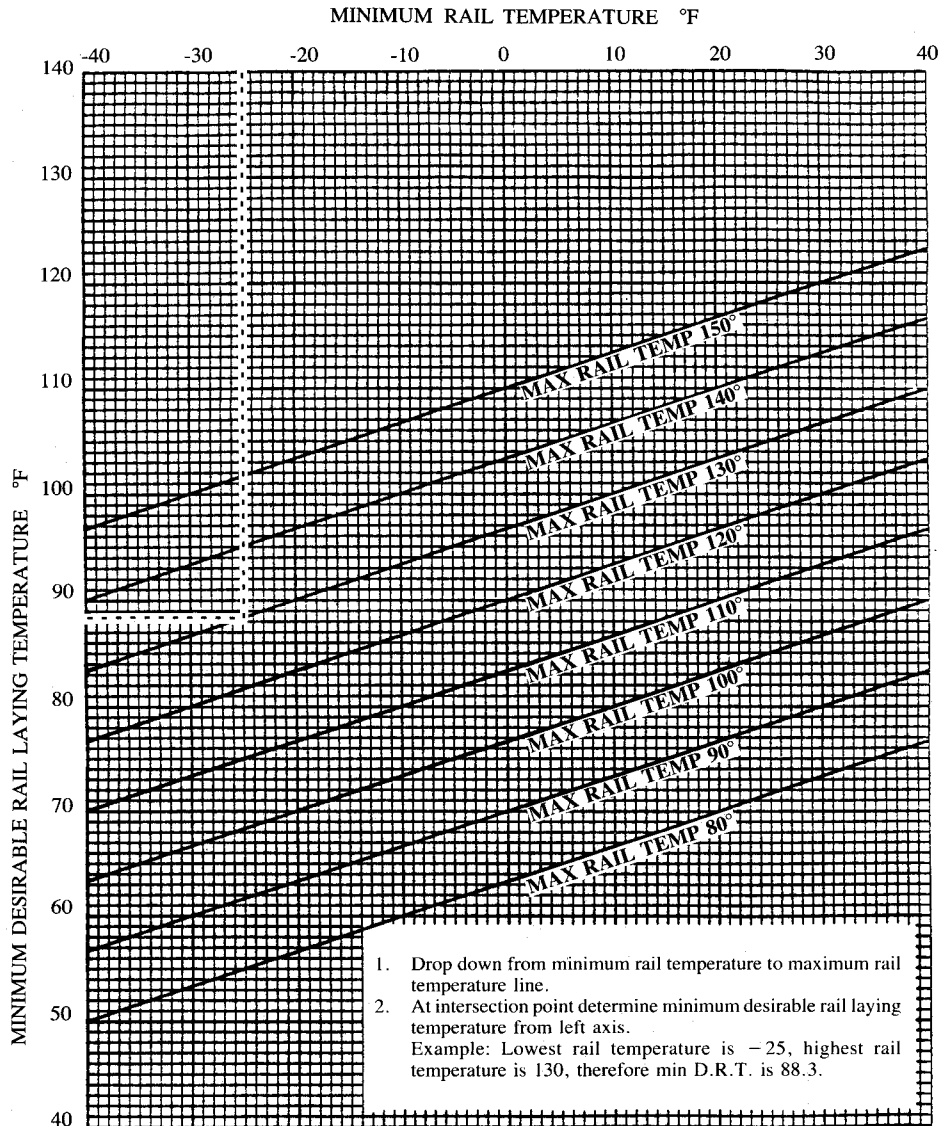


Figure 5-5-1. Minimum Rail Laying Temperature

- (2) Reference points should be marked on the rail, and tie plates and rail expanded in accordance with [Table 5-5-3](#), to insure that the rail string is being uniformly elongated.
 - (3) To insure that the rail is elongating in accordance with the heat input, the tie plates should be tapped or rail vibrated to assist the movement of the rail.
 - (4) The laying and/or adjusted temperature and string number may be painted on the rail at the end of each string or similar effective tagging procedures carried out. A list of these temperatures should be forwarded to the proper office for engineering reference.
- r. Ties should be pre-bored with machine(s).
- s. Drive spikes should be installed in accordance with the practice of the railroad. (Use of machine(s) recommended.)

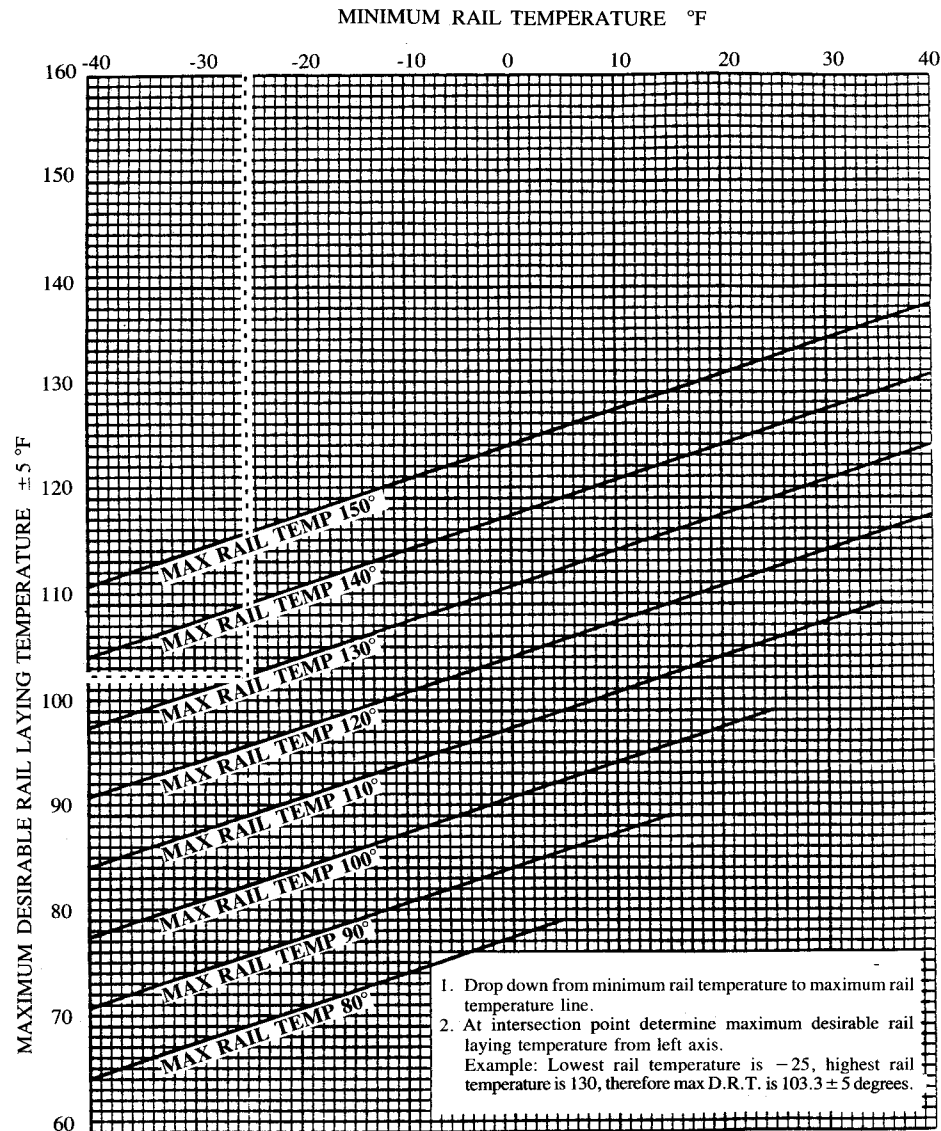


Figure 5-5-2. Maximum Rail Laying Temperature

- t. Rail anchors should be applied immediately behind the laying of CWR and all rail laid each day should be fully anchored before the day's work is completed. The rail should be anchored in accordance with [Section 5.4, Rail Anchor Patterns Number of Rail Anchors to Resist Rail Creepage \(1987\)](#). (Use of machine(s) recommended.)
- u. Joints should be made with a fully bolted standard joint except where field welding is to follow promptly. If at all possible, joints should not occur in road crossings or on an open deck bridge.
- v. At permanent bolted joints when necessary to field cut and drill rail, the cut should be sawed square, the holes properly drilled, chamfered or peened and deburred. Rail ends of all field cut rail should be beveled and end hardened, if practical. Flame cuts should be avoided. (Flame cutting is permitted for field welding, see [Chapter 4, Rail, Section 4.4, Recommended Repair of Defective or Broken Rail in CWR](#).)
- w. If field welding of strings is to be done, all CWR should be laid or adjusted to the preferred laying temperature beforehand.

Table 5-5-3. Continuous Welded Rail Expansion Segment (Inches)

Temperature Differential Degrees F	Number of 39-Foot Rail Lengths			
	9	18	27	36
5	9/64	9/32	27/64	9/16
10	9/32	9/16	27/32	1-1/8
15	27/64	27/32	1-17/64	1-11/16
20	9/16	1-1/8	1-11/16	2-1/4
25	45/64	1-13/32	2-7/64	2-13/16
30	27/32	1-11/16	2-17/32	3-3/8
35	63/64	1-31/32	2-61/64	3-15/16
40	1-1/8	2-1/4	3-3/8	4-1/2
45	1-17/64	2-17/32	3-51/64	5-1/16
50	1-13/32	2-13/16	4-7/32	5-5/8
55	1-35/64	3-3/32	4-41/64	6-3/16
60	1-11/16	3-3/8	5-1/16	6-3/4
65	1-53/64	3-21/32	5-31/64	7-5/16
70	1-31/32	3-15/16	5-21/32	7-7/8

- x. Scrap and relay material should be picked up prior to final surface and alignment.
- y. Finish surface and line track. Refer to [Paragraph 5.2.2c](#). (Use of machine(s) recommended.)
- z. Dress track. (Use of machine(s) recommended.)

5.2.5 CONSTRUCTION OF A NEW LINE OF RAILROAD WITH CONTINUOUS WELDED RAIL (CWR) (1988)

- a. Before CWR installation is begun, roadbed and sub-ballast and material distribution should be complete. Ties should then be placed, properly spaced and lined. Plates should be placed on ties, and plates on each fourth tie should be pre-gaged. Concrete ties should have rail-holding accessories distributed for rapid application.
- b. Rollers should be available to be placed in line with each rail, for the length of one string. Rollers should be supported not over 40 feet apart for rail under 115 lb and 50 feet apart for rail 115 lb and over. Top of roller should be a minimum of 3 inches above rail seat.
- c. A wide-axle machine (WAM) with boom for lifting rail to make connections and removing rollers, should be available to straddle ties, moving away from the rail train while pulling two rails.
- d. Rail train is moved to the end of existing track. A ramp car should be placed at the end of the rail train to provide a transition from the rail train to the track structure.

- e. Two ramps should be placed, one for each rail, connecting the end of car to the top of running rail. This will avoid dropping of rail end when it is finally pulled out of car.
- f. The WAM, straddling ties, should cable-pull two rails from car until ends of rail can be connected to the frame of the WAM at approximate gage.
- g. WAM then moves away from the rail train, pulling both rails. The rails will lower onto the rollers, which will permit both rails to be pulled from train by WAM in one continuous move.
- h. Three temporary gage rods, spaced 100 feet apart, starting 100 feet behind the WAM, should be clamped to the ball of the two rails being unloaded. These rods will prevent rails being pulled by WAM from bouncing, spreading or overturning.
- i. Radio communication between starting point, WAM, and rail train engine is essential. Starting point advises WAM when to stop, back up and allow joint connections to be made between running rails and rail unloaded.
- j. After these connections are made, remove rollers and seat rail on plates working away from rail train. Rollers should be moved ahead on the new construction to prepare for unloading of next two rails.
- k. Rail-holding devices on concrete ties and spikes in wood ties should then be applied in sufficient quantity to preserve gage while the rail train is moved ahead.
- l. When rail train reaches the end of rails, process can be repeated.
- m. If open deck bridges are encountered, rail should be disconnected from WAM, and the WAM moved around to the other end of the bridge. The rail should be pulled across bridge by cable, then reconnected to WAM for continued laying.
- n. Completion of track, including full spiking, application of rail anchors or other devices, ballasting, surfacing, lining and dressing, should follow the rail train closely.

5.2.6 INSPECTION OF CONTINUOUS WELDED RAIL (CWR) IN TRACK (1988)

- a. Attention should be given to adequacy of ballast section, particularly at sinks, culverts, on ballasted-deck bridges, at ends of all bridges, road crossings, through turnouts, where vehicles are driven along right-of-way, and where foot paths cross tracks.
- b. In the spring and in the fall, a special inspection of joints in welded rail should be made for bent and missing bolts. At this time, anchor position should be checked and anchors repositioned against the ties if necessary.
- c. Look for evidence of rail moving through anchors. It may be necessary to make temperature adjustments, revise anchor pattern, or add additional anchors.
- d. Look for evidence of track moving downhill or with the current of traffic by noting if anchored ties are moving toward non-anchored ties. It may be necessary to relieve undesirable stresses by cutting out rail at head end of movement and adding rail at other end. In this case, additional anchors should be added.
- e. If there are short flat spots in curve alignment or minor line kinks in tangent track, determine if ties are floating in the ballast section by digging out a tie end. Welded rail must be kept tightly tamped.
- f. Determine if base of rail is seated uniformly on tie plates. If rail is tilted on one side of base, it may be necessary to relieve pressure to prevent buckling or pull-apart.

5.2.7 MAINTENANCE OF CONTINUOUS WELDED RAIL (CWR) IN TRACK (1988)

5.2.7.1 General

- a. Recommend AREMA ballast section should be maintained at all times. When ballast is disturbed, consideration should be given to the use of ballast compacting equipment to minimize the effect of the disturbance.
- b. Good tie condition should be maintained at all times with sufficiently sound ties to maintain adequate gage, surface and line.
- c. Rail anchorage should be maintained in accordance with [Section 5.4, Rail Anchor Patterns Number of Rail Anchors to Resist Rail Creepage \(1987\)](#).
- d. Tie renewals and surfacing should be carried out when the temperature is the same or lower than the laying or adjusting temperature.

5.2.7.2 Tie Renewals

- a. Do not remove more ballast from ends of ties to be replaced or from cribs than is absolutely necessary.
- b. Surface and alignment of track should not be disturbed more than is absolutely necessary.
- c. There should be sufficient adjacent ties properly spiked for every tie from which spikes and anchors have been removed. Where heavy tie renewals are required, renewals should be done in two or more passes, and sufficient time should be allowed between passes to insure that the new ties are firmly embedded in the ballast.
- d. Installation of spikes and rail anchors should be made immediately after new tie insertion.
- e. Upon completion of tie renewals, recommended ballast section should be immediately re-established.

5.2.7.3 Surfacing

- a. Track should not be surfaced until sufficient ballast is distributed to provide recommended ballast section after surfacing.
- b. Track should not be raised more than necessary to maintain good surface.
- c. When surfacing track out-of-face, both rails should be raised simultaneously, maintaining cross level.

5.2.7.4 Lining

- a. Track should not be lifted above established profile when lining.
- b. Ballast must be replaced at the ends of ties immediately after lining.

5.2.7.5 Repair of Buckled Track

- a. When immediate temporary repairs are necessary, track should be lined to best possible curve, and the required clearance provided.
- b. For permanent repairs, tracks should be restored to correct line and specification for CWR.

5.2.7.6 Repair of Broken Rails, Pull Aparts and Other Defects

- a. If the rail pull-apart is 3 inches or less, rail anchors should be removed on each side of the pull-apart a sufficient distance to recover the rail movement. A distance of 195 feet in each direction may be used as a general guideline.
- b. Heat shall be applied to the rail on both sides of the pull-apart working in the direction toward the gap to obtain closure. Heat may be applied to only one side of the pull-apart when it is close to special trackwork (turnout, rail crossing) or to a highway crossing.
- c. Heat may be applied by various methods (thawing can, oil soaked rope, propane heater car), or mechanical means (hydraulic tension devices) may be substituted for heat. Rail may be vibrated to facilitate movement for rail closure.
- d. Rail anchors should be reapplied immediately after obtaining rail closure.
- e. Open flames must not be applied to rail on open deck bridges. Use mechanical means, if available, or saw cut in a short section of rail not less than 18 feet in length.
- f. Install bolted joints (according to Article 5.2.7.7 Maintenance of Joints) or make field welds (according to Chapter 4, Rail, Section 3.13 Specification for the Quality Assurance of Thermite Welding of Rail), as determined by conditions.
- g. Surface any low ties at the pull-aparts.
- h. Install or reapply any missing or loose rail anchors for the rail on the opposite side of the track.
- i. Foreman or supervisor must complete and submit the railroad's prescribed form for unadjusted rail locations, and forms for subsequent permanent repairs.
- j. When a straight break occurs and there is no other defect in the rail, joint bars may be applied until permanent repairs can be made. Care should be taken to assure proper bearing of the joint bars. (See Chapter 15, Steel Structures, Part 8, Miscellaneous, Article 8.3.3.5 if break is on or within 200 feet of an open deck bridge.)
- k. For field repair of weld failures, refer to Chapter 4, Rail, Part 2, Specifications, Section 4.4 Recommended Repair of Defective or Broken Rail in CWR.
- l. Timely late summer or early autumn inspection of the track (for conditions of rail running through the anchors, anchors moving away from the ties, loose anchors, or insufficient anchor pattern) followed by corrective repairs as indicated may be helpful in preventing pull-aparts.
- m. In territory with 4-hole joint bars or with lighter rail sections (100 pound or lighter), selective speed restrictions at ambient temperatures of -5 degrees Fahrenheit (= -20 degrees Celsius) or below may be considered to help prevent pull-aparts.

5.2.7.7 Maintenance of Joints

- a. All joints should be fully bolted and bolts kept tight at all times. Bent bolts should be replaced.
- b. Particular care should be exercised at all joints to assure good surface to protect rail ends from deterioration.

5.2.8 TRANSPOSING CONTINUOUS WELDED RAIL (CWR) (1988)

NOTE: Rail should be at the preferred laying temperature or it must be adjusted at a later time.

- a. Saw cut both rails at entering end of curve at a location where rail contours match.

Track

- b. Remove inside line spikes and rail anchors from both rails around curve. (Spike pullers recommended.)
- c. Nip outside spikes where required.
- d. Set low rail into center of track. (One off-track crane recommended.)
- e. Saw-cut high rail at leaving end of curve at location where rail contours match.
- f. Set high rail into tie plates on low side. (Use of off-track crane recommended in [paragraph d.](#))
- g. Field-weld new low side rail at entering end of curve.
- h. Insert tie plugs on new low rail. If tie conditions require it, the ties should be adzed and creosoted at this point.
- i. Respike new low rail. (Recommend use of spike driver.)
- j. Saw-cut low rail at leaving end of curve.
- k. Set low rail into tie plates on high side. (Use off-track crane recommended in [paragraph d.](#))
- l. Field-weld new low rail at leaving end of curve.
- m. Field-weld new high side rail at entering end of curve.
- n. Insert tie plugs on new high rail. If tie conditions require it, the ties should be adzed and creosoted at this point.
- o. Respike new high rail. (Recommend spike driver.)
- p. Apply rail anchors to conform to the standard specified for laying CWR (See [Paragraph 5.2.4](#)). (Recommend two rail anchor machines.)
- q. Field-weld new high side rail at leaving end of curve.

5.2.9 INDEX OF CONTINUOUS WELDED RAIL MANUAL MATERIAL (1987)

Page	Title
1-2-8	Ballast Section
4-2-3	Specifications for Steel Rails
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4-3-55	Inspection and Classification of Secondhand Rail for Welding
4-3-59	Thermite Welding – Rail Joints
4-3-46	Recommended Field Repairs to Pressure Butt Weld Failures
5-4-1	Specification for Track Construction
5-5-18	Rail Anchor Patterns – Number of Rail Anchors to Resist Rail Creepage
14-7-3	Rail Reclamation Plants
4-2-3	Weight of Rail

SECTION 5.3 TEMPERATURE EXPANSION FOR LAYING RAILS¹ (1967)

5.3.1 GENERAL (1988)

- a. When laying rails, a rail thermometer shall be used to ascertain the temperature of the rail, and in making the reading it shall be placed on the rail base on the side away from the sun. This reading shall be taken periodically during the day as the temperature of the rail can change decidedly from the early morning hours to the later afternoon hours, in winter as well as in summer-time laying.
- b. To allow for expansion, openings between the ends of rail should be as shown in [Table 5-5-4](#).

Table 5-5-4. Rail End Openings for Allowance of Expansion

33-Foot Rail 160 Joints per Mile		39-Foot Rail 135 Joints per Mile		78-Foot Rail 68 Joints per Mile	
Rail Temperature Degrees F	Expansion Inches	Rail Temperature Degrees F	Expansion Inches	Rail Temperature Degrees F	Expansion Inches
Below -10	5/16	Below 6	5/16	Below 35	5/16
-10 to 14	1/4	6 to 25	1/4	35 to 47	1/4
15 to 34	3/16	26 to 45	3/16	48 to 60	3/16
35 to 59	1/8	46 to 65	1/8	61 to 73	1/8
60 to 85	1/16	66 to 85	1/16	74 to 85	1/16
Over 85	None	Over 85	None	Over 85	None

¹ References, Vol. 32, 1931, pp. 155, 824; Vol. 49, 1948, pp. 325, 639; Vol. 54, 1953, pp. 973, 1398; Vol. 63, 1962, pp. 488, 753; Vol. 68, 1967, p. 358. Reapproved with revisions 1967.

SECTION 5.4 RAIL ANCHOR PATTERNS NUMBER OF RAIL ANCHORS TO RESIST RAIL CREEPAGE¹ (1987)

5.4.1 GENERAL (1988)

- a. In order to provide effective restraint to rail creepage, a sufficient number of rail anchors should be applied to the gage side against the same tie on opposite rails, and lie in contact with the side of the tie. The number of anchors required and their spacing will vary with the kind of ballast used, the depth of ballast in the cribs, the size and condition of the ties, track profile and curvature, the density and direction of rail traffic as well as other factors and local conditions.
- b. Insufficient anchors can result in ballast displacement, tie bunching and skewing, track buckling and pull-aparts.

5.4.2 JOINTED TRACK AND WHERE TEMPERATURE EXPANSION IS PROVIDED (1988)

5.4.2.1 Main Track

- a. For traffic density approximately the same in each direction, a minimum of 16 anchors should be installed for each 39-foot length of track (8 per rail) on light density lines to resist the longitudinal forces exerted through the rail to the cross ties. On heavier density lines and at special problem locations, upwards of 32 anchors or more may be required for each 39-foot length of track. Ties should be box anchored (i.e. anchors applied against both sides of the tie on opposite rails), and boxed ties should be spaced approximately equidistant along the rail length, as shown in [Figure 5-5-3](#), Diagram 1 and 2.
- b. When the longitudinal force exerted through the rail to the cross ties is predominantly in one direction because:
 - The traffic is single direction only;
 - Most loads or a predominance of heavy cars are hauled in only one direction;
 - The grades are excessive or train braking causes the rail to run in one direction or traffic has bunched the rail causing tight joints;

a minimum of 20 rail anchors should be installed for each 39-foot length of track (10 per rail) on light density line. Most of the anchors should be placed so as to resist the single direction longitudinal forces. At least four back-up anchors should be installed to provide for an occasional reversal of forces and to prevent excessive opening in the event of a broken rail. The back-up anchors should be placed so as to box the same ties on opposite rails near the quarter points of the track panel. On heavy density lines or at special problem locations, additional anchors may be required to resist the unbalanced longitudinal forces and to provide for the reversal of forces. In each instance, the same ties on opposite rails should be boxed and spaced equally along the rail length. See [Figure 5-5-4](#).

5.4.2.2 Passing Sidings and Yard Main Running Tracks

These tracks require the same number of anchors as the main track.

5.4.2.3 Yard and Industrial Tracks

Where anchors are needed, a minimum of 8 anchors per track length (4 per rail) should be applied.

¹ References, Vol. 14, 1913, pp. 107, 1066; Vol. 37, 1936, pp. 467, 1018; Vol. 49, 1948, pp. 362, 639; Vol. 54, 1953, pp. 1080, 1404; Vol. 63, 1962, pp. 489, 752; Vol. 88, 1987, pp. 57. Rewritten 1987.

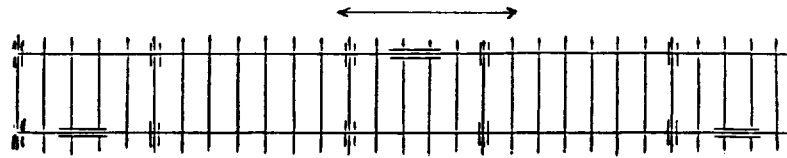


DIAGRAM 1

For Light Density Lines
16 anchors per 39-foot length of track
8 anchors placed to resist movement in each direction.

NOTE: Anchor location to be adjusted for joint spacing.

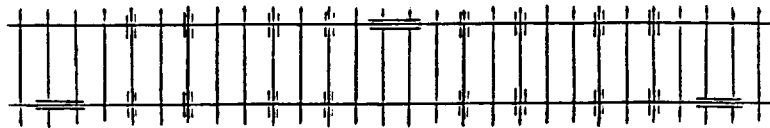


DIAGRAM 2

For Heavy Density Lines
32 anchors per 39-foot length of track
16 anchors placed to resist movement in each direction.

NOTE: Anchor location to be adjusted for joint spacing.

Figure 5-5-3. Anchor Locations in Track Carrying Rail Traffic of About Same Density in Each Direction

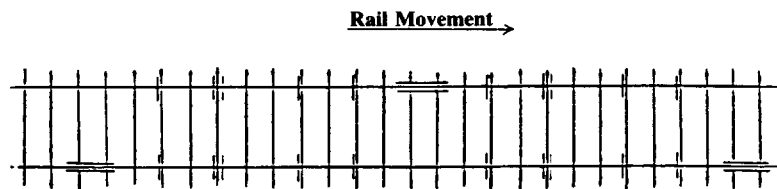


DIAGRAM 3

For Average Conditions
16 anchors forward and 4 back-up anchors per 39-foot
length of track to resist movement primarily in one direction.

NOTE: Anchor location to be adjusted for joint spacing.

Figure 5-5-4. Anchor Locations in Tracks where the Longitudinal force Exerted through the Rail is Primarily in one Direction

5.4.3 CONTINUOUS WELDED RAIL (CWR) (1988)

- a. To provide effective anchoring to resist temperature induced stresses and longitudinal stresses due to train movement in CWR territory, every other tie should be box anchored throughout the full length of the welded rail string. Whenever any discontinuity in the CWR is encountered such as rail joints, turnouts, grade crossings, and railroad crossings, all ties should be box anchored for 200 feet in both directions. On those railroads that consider a field weld without safety straps to be a discontinuity, all such ties should be similarly box anchored for 200 feet in each direction.
- b. Where CWR joins conventional jointed rail, all ties except those supporting the rail joint should be box anchored for 200 feet in each direction.
- c. On curves, additional rail anchors may be required.

5.4.4 TURNOUTS (1988)

- a. Every tie in each track of the turnout should be box anchored wherever possible, i.e. when anchors are applied to one rail, anchors are also required on the opposite rail of the same track. Rail anchors should be applied on the gage side of the rail except where insufficient clearance restricts the use of the anchor or application tool, in which case anchors may be applied from the field side of the rail where clearance permits.
- b. In addition to the mainline, the diverging track should be anchored a sufficient distance to prevent rail movement from disturbing the switch point and frog.
- c. In jointed track territory on the approach ahead of the head block, all cross ties should be box anchored for a minimum distance of 78 feet. On each track beyond the turnout, all cross ties should be box anchored for 78 feet.
- d. In CWR territory, every cross tie should be box anchored for 200 feet ahead of the head block and 200 feet behind the frog on each welded track on each side of the turnout. Turnouts in other than mainline track should be anchored as required.

5.4.5 OPEN DECK BRIDGES (1988)

NOTE: See Chapter 15, Steel Structures, Part 8, Miscellaneous, Section 8.3, Anchorage of Decks and Rails on Steel Bridges, for anchoring rails on steel bridges.

When open deck bridges are not equipped with rail anchors both approaches should have additional anchoring. For jointed track, the number of rail anchors that would normally be applied to the track over the length of the bridge should be used to box anchor additional ties from both ends of the bridge. In CWR territory, every tie should be box anchored for a distance of 200 feet on each approach to open deck bridges. Rail anchors may be placed on open deck bridges only with the special permission of the Chief Engineer.

SECTION 5.5 TRACK BOLT TENSION PRACTICE (2014)

5.5.1 PURPOSE (2014)

The purposes of providing tension in track bolts are:

- a. To draw the joint bars into place when first applied. An initial bolt tension when bars are first applied of from 20,000 to 30,000 lb per bolt is of value in overcoming the roughness of the fishing surfaces, thereby providing a proper seating of the bars.
- b. To hold the joint bars in place throughout actual service conditions and to produce an integral action of the two bars of a joint in resisting bending in the vertical or horizontal planes. A minimum bolt tension of 10,000 lb per bolt for the long-toe joint bar, or 5,000 lb per bolt for the short-toe joint bar is sufficient to accomplish these purposes.
- c. To provide sufficient reserve tension to carry over the period between retightening. This requires that the applied tension shall be high enough to withstand the loss in bolt tension under traffic for the period between retightening and still be sufficient at the end of the period to ensure proper action of the joint bars. Bolt tension loss is relatively rapid immediately following the application of joint bars until the mill scale has disappeared from the fishing surfaces, and averages from 5,000 to 10,000 lb per bolt the first month. After the second month, the rate of bolt tension loss averages from 500 to 1,000 lb per bolt per month. Loss of tension is not uniform at each joint and some bolts may lose twice the above amounts; others lose scarcely any. Bolt tension loss is principally due to a decrease in distance between the two bars of a joint as a result of fishing surface wear. This decrease varies from joint to joint and averages approximately 0.015 inch per year. Traffic density has little effect on this decrease except that on very heavy traffic density lines the decrease at the mid-length of the bars may average 0.025 inch to 0.030 inch per year. The use of spring washers is recommended and will help to maintain bolt tension as this inward movement of the joint bars occurs.
- d. To provide necessary joint bar support without unduly restricting slippage of the rail ends with temperature change. The slippage resistance of a rail end within its joint bars is affected by the amount of bolt tension. Thus in general, high bolt tension produces high joint bar restraint.

5.5.2 PRACTICES (2014)

The following practices are recommended to accomplish these purposes:

- a. The applied bolt tension should be within a range of 20,000 to 30,000 lb per bolt for the initial tightening and within a range of 15,000 to 25,000 lb for subsequent retightening.
- b. Track bolts should be retightened after 1 to 3 months and as necessary thereafter.
- c. Corrosion resistant lubricant should be applied to bolt threads prior to the application of the nuts. This will reduce the variation in thread friction and promote the uniformity of tension obtained.
- d. Track bolt fastening sequence - Bolts are to be applied from the middle going outward alternating sides of the joint. For a 6 hole joint, tightening sequence would be as follows - 3,4,2,5,1,6. See [Figure 5-5-5](#).

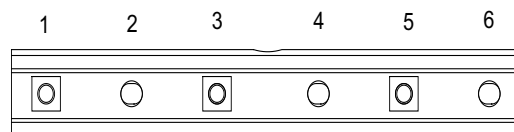


Figure 5-5-5. Example of a 6 Hole Joint

- e. Threaded fasteners should be loaded to maintain the design clamping force. Generally, torque (twisting force) is used to properly pre-load a threaded fastener. [Table 5-5-5](#) lists recommended torque values to lubricated track bolts to achieve recommended tension.

Table 5-5-5. Recommended Minimum Torque Values

Grade 5		Grade 8	
Diameter	FT/LBS of Torque	Diameter	FT/LBS of Torque
7/8"	375	7/8"	500
1"	490	1"	750
1-1/8"	705	1-1/8"	1050

- f. Bolts to be applied to joints should be of the recommended dimension as referenced in Table 4-3-1.

SECTION 5.6 GAGE¹ (1980)

5.6.1 GENERAL (1988)

- a. The gage tool shall indicate standard track gage.
- b. The rail shall be held to gage while line spikes are being driven.
 - (1) The rail shall be properly seated in the tie plates with the edge of the rail base and the field shoulder of the tie plates aligned and in contact.
 - (2) A minimum of two rail holding spikes is required. These spikes shall be so staggered that all outside spikes are on the same side of the tie and inside spikes on the opposite side of the tie.
 - (3) The rail and tie plates shall be spiked to each tie in accordance with the standard of the railway.
- c. Within proper limits, a slight variation of gage from the standard is not seriously objectionable, provided that the variation is uniform and constant over long distances. For new track construction, see [Part 4, Track Construction](#).
- d. Wide gage, due to rail worn within permissible limits, shall be corrected by regaging or by interchanging the low and high rails, or by replacing the rail.
- e. Under ordinary conditions, where speed does not dictate otherwise, it is not necessary to regage track if the increase in gage is not more than 1/2 inch (12 millimeters) provided such increase is uniform.

NOTE: Old spike holes should be plugged when regaging.

- f. Gage rods, gage plates, rail braces, or inner guard rails may be used on curves where it is difficult to maintain gage.

¹ References, Vol. 5, 1904, pp. 533, 563; Vol. 6, 1905, pp. 749, 757, 759; Vol. 7, 1906, pp. 654, 662; Vol. 10, 1909, part 1, pp. 398, 467; Vol. 11, 1910, part 2, pp. 934, 944; Vol. 12, 1911, part 1, pp. 402, 465; Vol. 16, 1915, pp. 732, 1145; Vol. 37, 1936, pp. 467, 1017; Vol. 41, 1940, pp. 556, 867; Vol. 53, 1952, pp. 770, 1123; Vol. 54, 1953, pp. 972, 1398, Vol. 63, 1962, pp. 489, 753.

SECTION 5.7 TAMPING¹ (1984)

5.7.1 TAMPING TOOLS (1988)

- a. Tamping tools should have sufficient head and face area, based on manufacturer's specifications, to compact ballast under the tie and should be repaired or replaced when worn.
- b. Tamping tools should be chosen on the basis of their durability, availability, type of ballast to be tamped, and the amount of ballast to be placed under the tie.

5.7.2 METHODS OF TAMPING (1988)

- a. Tamping tools should be inserted simultaneously on opposite sides of the same tie to prevent the tie from cocking, to insure that the ballast under the tie is completely compacted and that the rail is firmly seated on the tie plate.
- b. When using power tampers in tandem, the machines should be of the same type and have identical tamping heads to produce uniform compaction.
- c. In all tamping, ties should be tamped from 12 inches inside of the rail to the end of the tie. Tamping should not be permitted at the center of the tie to avoid centerbound track.
- d. Regardless of the kind of ballast or the kind of power tamper used, two tamping tools should always be worked opposite each other on the same tie.
- e. The track should be raised to true surface and the ties tamped to a tight bearing against the raised rail. For spot tamping, tamping picks, ballast forks, ballast spades, shovels, tamping bars, or power tampers may be used.
- f. After all tamping operations, the cribs must be properly filled in and the track finished in accordance with the standard ballast section.

SECTION 5.8 WAYSIDE LUBRICATION OF RAIL ON CURVES² (1992)

5.8.1 GENERAL (1992)

- a. Lubrication is recommended where there is excessive wear on the rail or noise abatement is desired.
- b. Lubrication can be accomplished through the use of train actuated devices which dispense lubricant to passing wheel flanges for rolling distribution or in special cases, manual application of lubricant may be necessary.
- c. Lubricators should be located and installed in accordance with manufacturer's recommendations. Lubricators should be located prior to entering the body of the curve. Physical characteristics such as crossings, station platforms or other obstructions must then be given consideration. Location of lubricators also depends on whether a single or series of curves is to be protected. For a single curve, the degree of curve determines the need for protection. For a series of curves, the spacing between lubricators is based on tabulating total units by one of the following methods:

- (1) Curve units.

¹ References, Vol. 3, 1902, pp. 58, 67; Vol. 5, 1904, pp. 532, 536; Vol. 6, 1905, pp. 755, 759; Vol. 42, 1941, pp. 579, 836; Vol. 53, 1952, pp. 770, 1123; Vol. 54, 1953, pp. 972, 1398; Vol. 85, 1984, p. 24. Reapproved with revisions 1984.

² References, Vol. 93, 1992, p. 58.

- (2) Included central angle.
- (a) *Curve Units*. One curve unit is 1 foot of 1 degree curve. To find the number of curve units in a curve, the length, including spirals, is multiplied by the degree of curve. For example: a five (5) degree curve which is 1,000 feet long contains 5,000 curve units.
 - (b) *Included Central Angle*. This is the sum of the central angles of a series of curves. The central angle of a curve is found by multiplying the degree of curvature by the length of curve (in feet) divided by 100. For example: a five (5) degree curve with a length of 2,000 feet contains one hundred (100) degrees of central angle.
 - (c) Locations may be adjusted considering rail wear observations and operating conditions.
- d. Grease travel distances may be affected by: grades, tonnage, speed, type of grease, weather, and curvature.
 - e. Dispersion of grease should be regulated to stay on the gage face of the rail and off the top of the rail.
 - f. Lubrication of both high and low rails of curves is recommended.
 - g. Lubricator inspection should be frequent enough to insure proper operation. The curve rail should be examined to determine that coverage is adequate.
 - h. Track gage should be maintained and checked frequently at lubricator locations to provide good wheel flange/rail contact.
 - i. Alternative methods of rail lubrication (i.e. on board locomotive, hyrail) are available. Application of the lubricants should be at a frequency to achieve the objectives of [paragraph a](#).
 - j. The following characteristics should be considered in choosing a lubricant:
 - Mobility (i.e. carry)
 - Lubricity (i.e. friction reduction) and
 - Retentivity (i.e. durability)
 - Viscosity (i.e. temperature adjusted).

SECTION 5.9 WELDING OF MANGANESE STEEL CASTINGS IN SPECIAL TRACKWORK¹ (2005)

5.9.1 SCOPE (2005)

- a. The following procedure is applicable to the weld repair of imperfections in new austenitic manganese (11-14% Mn) castings, and to the building up and repair of such castings as may be required after periods of service.
- b. Use of proper technique in the welding of manganese trackwork castings is most essential.
- c. Welding of manganese trackwork castings must not be attempted by untrained personnel.
- d. Specific reference is made to The Welding Handbook, Eighth Edition, Volume 4 section covering Austenitic Manganese Steels, published by the American Welding Society (AWS) and AWS D15.2-2003, Section 4, Repair or Fabrication of Components Manufactured from Austenitic Manganese Steel.

¹ References, Vol. 83, 1982, p. 275. Reapproved with revisions 1982.

- e. Welding repairs will not be effective unless good support is maintained under manganese trackwork. In the case of rail bound manganese frogs and crossings, all bolts must be in place and tight. Guard rails must be adjusted and tight. Any irregularities in surface and alignment must be corrected.

5.9.2 WELDING METHODS (2005)

The electric arc is the only welding method recommended for manganese steel casting repair.

5.9.3 ELECTRODES (2005)

- a. Only austenitic manganese (minimum deposit 11% Mn) or stainless steel (nominal 14% Cr and 14% Mn) electrodes or semi-automatic wires should be used. Low phosphorus grades of manganese are recommended. The manganese electrodes are employed for most uses. In special applications, the stainless steel electrodes may provide less deformation under impact than the manganese electrodes. Refer to AWS D15.2-2003, Section 4.2.2 Austenitic Manganese Welding Electrodes, for additional information.
- b. Carbon and low alloy steel electrodes should never be used to weld manganese steel.

5.9.4 LOW HEAT INPUT (2005)

- a. The energy input per unit length of weld should be as low as possible. Use stringer beads; avoid weaving. The weld bead should not be wider than 5/8 inch (16 mm). A wide bead means a slow travel speed. Travel should always be as fast as possible to keep heat build-up low. This is shown by the formula:

$$H = \frac{E \times I \times 60}{S}$$

H = Energy input in joules per inch (mm) of weld

E = Volts

I = Arc current

S = Linear travel speed in inches (mm) per minute

- b. Excess heating will cause the metal to lose its toughness. Welding should be discontinued in an area where base metal temperature exceeds 500 degrees F (260 degrees C) at a point 1 inch (25 mm) from the weld. Temperatures can be determined using a temperature probe. Heat sensitive crayons are not recommended.
- c. There is usually more than one area on a casting requiring repair. This allows the welder to skipweld from one location to another as the metal heats up. (Note that manganese steel has about 1/4 the heat conductivity of carbon steel.)
- d. Preheating and postheating are not recommended for manganese steel trackwork. If the temperature is below 0 degrees F (-17 degrees C), remove the chill only.
- e. In the case of repair of "green" castings in the foundry, where acceptable, the preheat and postheat precautions are not necessary if normal heat treatment of the castings takes place after the welding.

5.9.5 STRESSES (2005)

- a. Direction of successive weld beads should be reversed to minimize build-up of stresses.
- b. Beads should not be started or stopped at edge of castings.

- c. Peening is recommended. Refer to AWS D15.2-2003, Section 4.7.2.4 for further information.

5.9.6 PREPARATION OF WORN AREAS (2005)

- a. Worn areas needing welding are determined by use of a straight edge.
- b. Before welding, all defective areas (fatigued metal, sand pockets, slag inclusions or cracks), along with rust, grease, or other foreign material, must be removed by air-arc scarfing or grinding. Air-arcing will impart less heat than cutting electrodes, and should be used. Oxyacetylene scarfing is not permitted.
- c. All work hardened material must be removed from the wheel contact surfaces. This generally requires removal of metal to a depth of 1/8 inch (3.2 mm) to 3/16 inch (4.8 mm) or more. A round ended punch is a good tool to help compare the hardened and ground surfaces with the unhardened base metal.
- d. Sharp and rolled over edges along the flangeways should be restored to proper AREMA contour before welding is started.

5.9.7 PREPARATION OF DEFECTIVE AREAS (2005)

- a. If defective metal removal endangers safe passage of trains, frogs or crossings must be removed from service and repaired out of track.
- b. After grinding and before welding, base material must be closely examined for hairline cracks using a magnifying glass or dye penetrant. If any are found, they must be V'ed the full length and depth of the crack before welding. Air arcing or grinding should start at the crack end and go towards the edge of the base metal. Air arcing should be done with fast, straight and forward motions as moving too slowly will tend to overheat the base metal.

5.9.8 PRECAUTIONS (2005)

- a. The V'ed areas should be welded first, stopping after root passes to inspect for any new hairline cracks that may develop. If any are observed, they must be removed before further welding takes place. If the root pass is free of new cracks, apply additional weld beads, removing the slag after each pass.
- b. When welding out of track, warping of the casting can be minimized by clamping heel and toe in a fixture with a B\, inch (16 mm) to 1 inch (25.4 mm) thick block placed under the center in order that an upward bow be attained.

5.9.9 FINISHING (2005)

- a. Weld beads should be applied to a slight crown in height so that when finish grinding is completed no surface irregularities will be observed.
- b. All surface irregularities must be removed by grinding to provide a smooth, straight surface. Flangeways must be ground to the proper width and radius using flangeway gage as a reference. The tip of the frog point should be left 3/16 inch (4.8 mm) low, tapering up and back towards the heel of the frog as shown on the Standard AREMA Plan.
- c. Metal flow must be removed periodically from flangeways by grinding, again using proper flangeway gages.

SECTION 5.10 RECOMMENDED PRACTICES FOR SWITCH POINT AND STOCK RAIL CHANGEOUT¹ (1995)

5.10.1 SCOPE (1995)

- a. Track maintenance personnel must frequently inspect turnouts for conditions which can result in derailments or premature wear and failure of components. Switch points and stock rails require particular emphasis, and underlying conditions which can cause rapid wear, degradation, and improper fit must be recognized. In addition, personnel must determine when repair and replacement of these critical components is warranted. Maximum service life must be obtained without risking derailments associated with wheel ramping, chipped or broken points, or improper fit of switch points to stock rails.
- b. [Paragraph 5.10.2](#) below identifies specific conditions which can adversely affect stock rail and switch point performance which, if not addressed in a timely manner, can result in premature wear and deterioration of components and can compromise safe train operation. [Paragraph 5.10.3](#) provides criteria for the repair or replacement of switch points and stock rails. These criteria should be considered as maintenance limits and are generally more conservative and specific as compared with FRA Track Safety Standards related to turnouts and switches. The maintenance limits provided are intended for application to main line operations. Specific limits may be modified to suit yard, branch line, or side track conditions or special situations such as turnouts located in curves.

5.10.2 UNDERLYING CONDITIONS WHICH MAY CAUSE PREMATURE WEAR, DEGRADATION OR IMPROPER FIT OF SWITCH POINTS AND STOCK RAILS (1995)

5.10.2.1 General Turnout Condition

- a. Vertical or horizontal alignment deviations may result in improper support and twisting of stock rails and switch points. Stock rails and switch points must bear uniformly on each switch plate.
- b. Insufficient ballast and poor drainage may result in profile or alignment deviations causing higher rolling stock dynamic forces and further turnout degradation.
- c. Thermal expansion/contraction of rail in the main line or turnout side may result in displacement of the turnout and possible gapping of the switch points. (Refer to [Section 5.4, Rail Anchor Patterns Number of Rail Anchors to Resist Rail Creepage \(1987\)](#).)

5.10.2.2 Switch Stand and Rods

- a. The switch stand may be worn, resulting in lost motion which could cause chipping, premature wear, and improper fit of the points.
- b. Switch throw as measured at the No. 1 rod may deviate from that specified for the turnout design. Improper fit of the switch point to the stock rail will result.
- c. The switch stand spindle may be bent or twisted, with the consequence that the throw of the points may not be properly adjusted.
- d. The switch stand housing may be cracked and will not restrain unwanted movement of the mechanism. The consequence may be that the points will not fit tightly against their respective stock rails.
- e. The crank eye bolt, connecting rod bolt, or connecting rod may be broken. The crank eye bolt hole or connecting rod bolt holes and bolts may also be excessively worn so as to allow unwanted point movement.

¹ References, Vol. 96, p. 30.

- f. The switch lock or lock keeper may be broken, or the lock keeper may be worn to the point where the switch can be thrown with the lock in place.
- g. The baskets of a power switch mechanism may be improperly set. Improper fit of the switch point to the stock rail will be the consequence. (Maintenance is performed by the Signal Department on some railroads.)
- h. For turnouts incorporating long points, the hold down bolts on the auxiliary crank mechanism may be loose or missing. Security and proper fit of the switch points and stock rail may be adversely affected. (Maintenance is performed by the Signal Department on some railroads.)
- i. In spring switches the mechanical switchman may be defective, or require hydraulic fluid and adjustment. (Maintenance is performed by the Signal Department on some railroads.)
- j. The switch clips or clip bolts may be broken or the bolt nuts may be loose or missing. The holes in the switch clip or switch rod, or the special rod bolt may also be excessively worn so as to allow unwanted point movement.
- k. The back rods may be loose such that the points may not be secure.
- l. Bent switch rods with extensions may cause lifting of the switch points.

5.10.2.3 Point of Switch

- a. One or more stops may be loose or missing. The point rail will bend under load causing the tip of the point to shift or pry away from the stock rail.
- b. One or more rail braces may be loose or missing permitting the stock rail to tip outward under load. This may result in a gap between the point and stock rail.
- c. The switch ties may not be sound or may be spike-killed, causing the stock rail to shift away from the point rail and accelerated wear of components.
- d. Incorrect gage at the point may cause accelerated wear of the point rail, and may prevent proper point adjustment.
- e. Undercut stock rails may not be cut in accordance with specifications such that improper fit of the switch point may result.
- f. The switch point tip may not be properly located relative to the stock rail bend or undercut, resulting in rapid point wear.
- g. Overflow of the stock rail or switch point may cause gapping and may result in chipping and breakage.
- h. Bent or damaged switch rods or switch clips may cause switch point rotation.
- i. Fit of manganese insert tips may be compromised when the 5/8 inch distance from the top of the stock rail to the top of the manganese tip is not maintained via regular inspection and grinding during the wear period or life cycle of the manganese tip and stock rail. (Refer to AREMA Portfolio - Plan 220-52.)

5.10.2.4 Heel of Switch

- a. The heel may not be properly supported. The heel of the point rail may deflect downwards under wheel load causing the point to be deflected upwards and be struck by a following wheel.
- b. The heel block may be broken. This may cause the points to drift and may result in misalignment of the point and closure rails.

- c. The heel bolts or bars may be broken or bent causing drifting of the point.
- d. The bolt holes at the heel of the switch may be out of round causing loss of restraint.
- e. The thimbles at the heel may be crushed, resulting in chipping of the points or difficulty in throwing the switch.
- f. Poor tie support conditions may cause the heel block assembly to move under traffic and increase gage.
- g. Over-tightened heel block bolts or shoulder bolts may limit the throw of the switch point.

5.10.3 REPAIR AND REPLACEMENT CRITERIA FOR SWITCH POINTS AND STOCK RAILS (FOR MAIN LINE OPERATIONS) (1995)

- a. Points require repair if chipped or flattened to the extent that they present a face more than 3/16 inch wide for all points closing on the straight stock rail and all points of curved-point turnouts closing on the bent stock rail. Points of straight point turnouts closing on the bent stock rail may present a face up to 5/16 inch wide without requiring repair. If approved by the Chief Engineer, switch points can be repair welded in the field.
- b. When the switch point or stock rail has sustained “flow” of more than 1/8 inch causing the point to stand out from the stock rail, excess metal must be ground off to obtain proper fit.
- c. Make appropriate corrections when the switch point is less than 3/8 inch below the top of the stock rail as measured at the top of the radius at the end of the point. This condition indicates that the stock rail is worn or the point rail is not properly supported or seated.
- d. Make appropriate corrections if the normal 1/4 inch point rail rise above the stock rail has been compromised by point rail wear which could permit the overhanging part of hollowed-out treads of worn wheels to contact the gage face of the stock rail rather than pass over the stock rail in a trailing point move. (See [Figure 5-5-6](#).)
- e. Replace closure rails, stock rails, and switch points if wheel flanges are contacting the tops of splice bars at the heel casting.
- f. Switch points which divert flanges (direct traffic to the turnout side), including switch points in normal position which are against the outer rail on curves must be replaced, rebuilt, or repaired when worn or chipped such that the top at any point is more than 7/8 inch below the plane across the top of the stock rail measured within 6 inches or more from the original end of the switch point.
- g. When wear or chipping on any point rail results in a sloping gage face profile which can cause a wheel flange to ramp on to the running surface of the point or stock rail, the point should be rebuilt or replaced.

5.10.4 GENERAL INFORMATION (2012)

- a. When in signal territory, the Signal Department should be notified in advance when rails, frogs, switch points, or switch stands are changed, rail ends are repaired, or any work is performed that may compromise the integrity of the signal system.
- b. When installing a new switch point, the stock rail should also be renewed or it should be ascertained that the tip of the new switch point is greater than 3/8 inch below the top of a worn stock rail. When installing a new stock rail with a head-worn switch point it should be ascertained that [Paragraph 5.10.3d](#), above, is not violated.

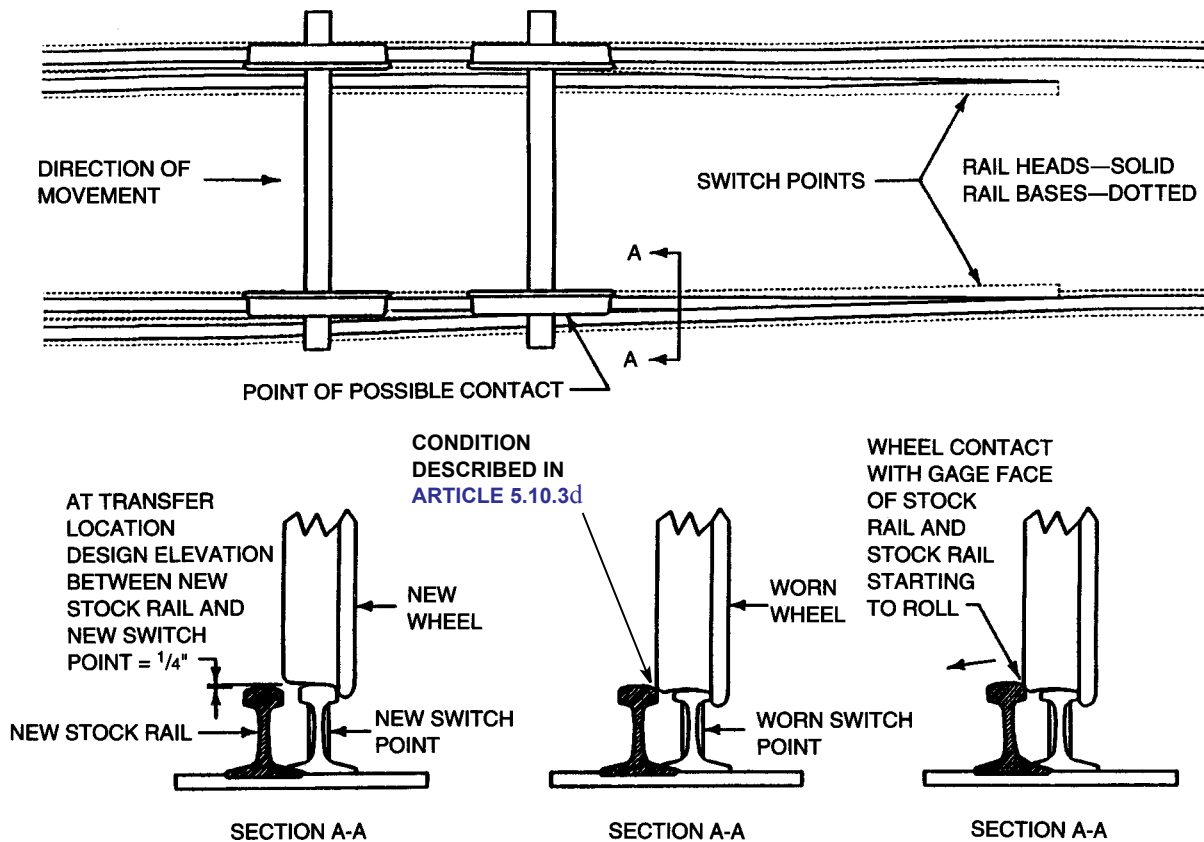


Figure 5-5-6. Rail Rise Corrections

SECTION 5.11 RECOMMENDED PRACTICES FOR THE RENEWAL OF TRACK TIES (2012)

5.11.1 SCOPE (2012)

Locations where ties will be renewed should be based on current tie conditions, track geometry data, track safety standards, track speed, route tonnage, and future operating requirements.

5.11.1.1 Project Planning and Coordination

If possible, at least two months prior to planned tie installation, ensure that members of all affected departments meet at the project site to plan and coordinate the project steps and requirements. Participants should include at the minimum persons responsible for production, track maintenance, bridge maintenance, signal maintenance, and train operations. They should discuss:

- a. Safety precautions and procedures throughout entire work limits.

- b. Lodging, meal and supply facilities adequate and proximate to support the work force.
- c. Lighting requirements for night or tunnel work as well as ventilation requirements for any tunnel work.
- d. Fall protection and retrieval plans for bridge work.
- e. Equipment types to be used and clearing locations identified that accommodate the entire team in a secure and accessible area.
- f. Material supply car staging areas identified to minimize distribution costs and risk.
- g. At-grade road crossing conditions should be evaluated for road and track surface as well as anticipated crossing surface life expectancy.
 - (1) Generally if the crossing surface is not expected to survive until the next tie renewal cycle, its replacement should be included in the current project.
 - (2) Be careful to consider the quantity and magnitude of crossing work anticipated each work day. Road crossing closures (if necessary) should be coordinated with the proper governmental authorities.
 - (3) A portion of crossing work could be completed in advance of the project to ensure maximum tie production and minimal public disruption.
- h. Locations of turnouts, special track work, special tie plates, positive restraint fasteners, lag bolts, concrete and steel ties and if any of these areas will be re-worked within the scope of the project.
- i. Existing maintenance conditions that are to be addressed by the project.
 - (1) Gage deviations - wide or tight gage is ideally addressed by project forces.
 - (2) Rail anchor deficiencies – effective anchors on non removed ties should be driven up tight against the tie and ineffective anchors are to be removed and replaced.
 - (3) Broken and worn tie plates are to be replaced.
 - (4) Insufficient spiking pattern due to standard changes should be corrected.
 - (5) Pads, insulators and clips needed by project forces.
- j. Bridge locations and needed accommodations. Vehicular protection for work over roadways. Removal and reinstallation of ballast curbs and inner metal guardrail.
- k. Signal and communication apparatus such as defect detectors, AEI readers, track wires, etc. should be clearly marked and where possible removed to minimize damage.
- l. Potential equipment obstructions such as retired signal foundations, lubricators and partially buried track material should at minimum be made highly visible or ideally be removed prior to project commencement.
- m. Ensuring adjacent tracks are kept clear wherever possible to provide best possible work area.

5.11.1.2 Marking Ties

- a. Track should be walked so defective ties can visually inspected, identified and marked. Proper marking of ties includes installation of sufficient ties to break up clusters of consecutive poor ties and all defective joint ties.

- b. Marking should be consistent throughout project limits and in a location on ties or rail web that all machine operators can view.
- c. Switch ties needed in tie replacement area should also be measured and marked on web of rail with lengths noted for ordering purposes.

5.11.1.3 Tie Unloading

- a. Ties should not be dropped from rail cars or trucks and should be placed where needed so as to minimize damage prior to installation. Handling minimization is accomplished by unloading the correct amount of ties for a given area close enough to the track so on-track equipment can final place as needed.
- b. Do not unload ties where they will obstruct drainage or pose a tripping hazard.
- c. Consider issuing a train message advising all of material along right of way that could alter customary walking conditions.

5.11.1.4 Ballast Unloading

- a. Sufficient ballast should be unloaded on the track shoulders to provide for the planned track raise and the final surface to comply with current standards.
- b. Additional ballast should be staged at road crossing and turnout locations within the project limits.

5.11.1.5 Tie Positioning

- a. Ties should be laid out at right angles to the track, just ahead or just behind the tie that is to be removed and on the side of track that the team working direction dictates.
- b. Care will have to be taken on high fills as ties can slide or roll down hill and become inaccessible.
- c. Kerf marks on wood ties should be positioned on top.

5.11.1.6 Tie Installation

- a. Ties should be placed in track with the heart wood face down so the tie sheds water. One end of the tie should be stamped, when this stamping is right side up the heart will be down. An alternate method of identifying the top of tie is by positioning the precut 1/8 inch deep saw cut, “kerf” mark (found 6 inches from the end of the tie) facing up.
- b. Track ties will be installed square to the rails. The end of the tie on the line side will be 18” to 18-1/2” from base of rail.
- c. At field welds, new ties will be spaced so that the weld does not fall on a tie.
- d. Tie plates will be installed on all new and existing ties. Broken, damaged, or excessively worn plates must be replaced on ties being changed. Tie plates will be positioned so the field side shoulder bears evenly against the base of the rail and centered on the top of the tie. TIE PLATE SHOULDERS AND SPIKES WILL NOT BE LEFT UNDER THE RAIL.
- e. At insulated joint locations: If a supported insulated joint tie is replaced, an insulated joint tie plate will be used.
- f. Wood or composite ties will be spiked to gage in accordance with AREMA Chapter 5, Part 5, [Section e](#).
- g. Ties are spiked to standard spiking pattern at the time of installation. If positive restraint fasteners are present, the proper tie fastener must be used.

- h. The standard rail anchor patterns are to be maintained per AREMA Chapter 5, Part 5, [Section 5.4](#). Anchors in excess of present standard, except within road crossings, need not be removed. Site specific areas where anchors in excess of standard are required to restrain rail movement are to be maintained.
- i. Temporary speed restrictions are to be placed until track has been stabilized and inspected.
- j. Prior to releasing track to run trains ensure that the entire limits of the work area are inspected. The inspector must inform the Employee-In-Charge that:
 - (1) All equipment and personnel are in the clear and equipment secured.
 - (2) All switches and derails are restored to the proper position and secured.
 - (3) All temporary speed restrictions have been put in place at the proper locations and flagging is completed.
 - (4) All other conditions that would prohibit the safe passage of trains at timetable speed are identified, corrected or protected.

5.11.1.7 Project Clean-up

- a. All project generated ties should be loaded in rail cars for disposition or staged in stockpiles at strategic locations to allow for loading upon arrival of rail cars or trucks. Care should be taken to ensure that stockpiles or loading work do not encumber the visibility of motorists at grade crossings.
- b. All scrap metal in the project limits should be gathered and similarly loaded in rail cars for distribution or otherwise removed from the property.
- c. All debris and material near road crossings, including used asphalt, shall be properly disposed of.
- d. Ensure uneven areas are back-dragged to make as level or even as practicable.
- e. All Communication and Signal apparatus should be restored to service.
- f. All bridges should be restored to standard and tunnel lighting and ventilation equipment stored.
- g. Check right of way signage to ensure project activity did not alter necessary signage (whistle posts, mile posts, speed signs, etc.).
- h. Ensure all project related train messages and speed restrictions are removed.
- i. Inspect culvert inlets and outlets to ensure project activity did not hinder or block proper drainage.

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American Railway Engineering and Maintenance-of-Way Association

Part 6

Specifications and Plans for Track Tools

— 2014 —

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SECTION 6.1 SPECIFICATION FOR TRACK TOOLS¹ (2014)

6.1.1 General (2014)

6.1.1.1 Workmanship

- a. The steel used in the manufacture of all tools shall be free from pipe, porous centers, gross non-metallic inclusions or any other defects.
- b. The chemical composition of percussion tools will be as stated in [Article 6.1.2.3](#).
- c. Unless specifically stated otherwise in the section on non-percussion tools, the chemical composition of non-percussion tools made from carbon steel will be as follows:

Table 5-6-1. Chemical Compositions

Grade	Carbon		Manganese		Phosphorous		Sulfur	
	Min	Max	Min	Max	Min	Max	Min	Max
Carbon	.55	.70	.60	.90		.05		.05

- d. All tools shall be made in a workmanlike manner and shall be free from cracks, seams, laps and other injurious discontinuities. Tools shall be free from burrs and sharp edges not specifically shown on the plans.
- e. Eyes of tools with handle holes must be on center and in true alignment.

6.1.1.2 Finish

6.1.1.2.1 Percussion Tools

The body of the tool will be unpainted. The entire tool will be coated with a transparent lacquer type rust preventative.

6.1.1.2.2 Non-Percussion tools

The body of the tool will be coated with paint, oil or varnish to prevent corrosion. Each polished cutting edge will be oiled or coated with a transparent lacquer type rust preventative.

6.1.1.3 Marking

- a. Each tool shall be legibly marked by stamping the following:
 - (1) The manufacturer's name and/or trademark.
 - (2) A code indicating the production lot.
 - (3) Percussion tools shall be marked with letter "B" indicating grade of steel.

¹ References, Vol. 31, 1930, pp. 555, 1753; Vol. 33, 1932, pp. 582, 815; Vol. 34, 1933, pp. 508, 838; Vol. 35, 1934, pp. 930, 1118, 1122; Vol. 36, 1935, pp. 567, 978; Vol. 37, 1936, pp. 479, 1019; Vol. 41, 1940, pp. 560, 867; Vol. 45, 1944, pp. 337, 620; Vol. 47, 1946, pp. 482, 636; Vol. 54, 1953, pp. 974, 1398; Vol. 55, 1954, pp. 700, 1079; Vol. 58, 1957, pp. 834, 1258; Vol. 62, 1961, pp. 652, 946; Vol. 63, 1962, pp. 490, 755; Vol. 85, 1984, p. 25; Vol. 89, 1989, p. 49; Vol. 94, 1994, p. 81.

(4) For tools manufactured for use in the United States, any information required by the U.S. Department of Labor, Occupational Safety And Health Administration (OSHA). For tools manufactured for use in other countries, the requirements of that country will apply. This pertains primarily to lifting devices used by cranes but may also be required for other tools. The manufacturer will also furnish certified testing and/or other information with each item shipped as needed to comply with OSHA Standards or the requirements of other countries.

(5) If requested by the purchaser, a specific marking indicating the railroad for which the tool was made.

b. The marking shall be located in a position which will not interfere with the quality or performance of the tool, and will not be removed by subsequent redressing.

6.1.1.4 Inspection

a. The inspector representing the purchaser shall have free entry, at all times while the work on the contract of the purchases is being performed, to all parts of the manufacturer's works which concern the manufacture of the materials ordered. The manufacturer shall afford the inspector free of charge, all reasonable facilities and necessary assistance to satisfy the inspector that the material is being furnished in accordance with these specifications. Tests and inspections shall be made prior to shipment at the place of manufacture unless otherwise specified.

b. The purchaser may make tests to govern the acceptance or rejection in the purchaser's laboratory or elsewhere. Such tests shall be made at the expense of the purchaser.

c. Rejection—Material represented by samples which fail to conform to the requirements of these specifications will be rejected.

d. Material which, subsequent to test and inspection at the manufacturer's plant or elsewhere, shows injurious defects will be rejected and the manufacturer shall be notified.

6.1.1.5 Shipment or Delivery

Tools shall be properly packed for shipment to avoid damage. All bundles and boxes shall be plainly marked with the name of the purchaser, purchaser's order number, the name of the supplier, and the point of shipment.

6.1.1.6 Warranty

The manufacturer shall warrant that all tools are free from defects in material, workmanship and heat treatment, that the tools meet all requirements of this specification, and that any defective tools will be replaced free of cost to the purchaser. Certified test report may be requested by the purchaser.

6.1.2 Percussion Tools (2012)

6.1.2.1 Scope

This section of specifications covers the contouring and metallurgical requirements for the manufacturing, ordering, inspection and acceptance of the following percussion tools.

6.1.2.1.1 Metal to Metal Contact Striking Tools

Spike Maul	Plan No. 3
Double-Face Sledge Hammers	Plan No. 13

6.1.2.1.2 Metal To Metal Contact Struck Tools

A head protector shall be provided for struck tools, if specified by purchaser. The head protector shall encapsulate the struck end of the tool in the event a piece of the tool breaks off while being struck.

Track Chisels	Plan No. 17
Round Track Punch	Plan No. 19
Track Spike Lifter	Plan No. 32
Nut Cutter	Plan No. 35
3 lb. Hot Cutter	Plan No. 36
5 lb. Hot Cutter	Plan No. 37
Drift Pin-Short	Plan No. 38
Drift Pin-Long	Plan No. 39
Spiking Tool	Plan No. 41
Drift Pin Remover	Plan No. 46
Offset Wedge	Plan No. 47
Plug Bond Backout Punch	Plan No. 48

6.1.2.2 Manufacture

6.1.2.2.1 Process

The shock resisting steel shall be made from carbon deoxidized, special quality, fine grain size alloy bar produced in accordance with ASTM A576, Standard Specification For Steel Bars, Carbon, Hot-Wrought, Special Quality.

6.1.2.2.2 Heat Treatment

- a. Each tool classified in [Article 6.1.2.1.1](#) and [Article 6.1.2.1.2](#) shall be hardened by liquid quenching and subsequent tempering in such a manner that the hardness range will be maintained to a sufficient depth to absorb the normal working stresses. This heat treatment shall be such that a fracture test of the tool will exhibit a silky, fine grained appearance according to Shephard Standard No. 6 or finer.
- b. All tools made with alloy steel to be redressed without subsequent heat treatment shall be initially heat treated so that the hardness specified in [Article 6.1.2.3.1](#) is maintained to depth from the end not less than the average cross sectional thickness.

6.1.2.3 Chemical and Hardness Requirements

All striking and struck tools ([Article 6.1.2.1.1](#) and [Article 6.1.2.1.2](#)) shall be made of shock resisting alloy steel of a chemical composition with standard AISI residuals (see [Table 5-6-2](#)).

Table 5-6-2. Chemical Requirements for Striking and Struck Tools

	Carbon		Manganese		Phos.		Sulfur		Silicon		Vanadium		Molybdenum		Nickel		Chromium		Copper		
	Min	Max	Min	Max	Max	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	
Alloy 4140	0.38	0.43	0.75	1.00	0.035	0.04	0.15	0.30	0.00	0.00	0.00	0.00	0.15	0.25	0.00	0.00	0.80	1.10	N/A	N/A	
Grade Alloy "B"	0.51	0.60	0.75	1.00	0.025	0.025	1.80	2.20	0.25	0.45	0.35	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.20	0.20
Grade EN30B	0.28	0.32	0.40	0.60	0.03	0.025	0.20	0.35	0.00	0.05	0.20	0.30	3.75	4.00	1.10	1.40	N/A	N/A	N/A	N/A	

6.1.2.3.1 Hardness

All hardness tests shall be performed according to the latest revision of ASTM Spec. E-18. Frequency of testing should be performed to the requirements in the latest revision of "MIL-STD-105E, Military Standard Sampling Procedure Tables for Inspection Attributes."

- All struck surfaces shall be 44/48 Rockwell "C" Hardness except Drift Pins, see Plans 38 and 39.
- All striking surfaces shall be 51/55 Rockwell "C" Hardness.
- All cutting surfaces shall be 56/60 Rockwell "C" Hardness.
- All punch ends shall be 52/56 Rockwell "C" Hardness except plug bond backout punch, see Plan 48.

6.1.2.4 Hardenability

6.1.2.4.1 Alloy Steel

Composition of the steel shall be such that, in the standard Jominy test, the hardness is greater than 50 Rockwell C at 8/16 inch from the quenched end of the specimen.

6.1.2.4.2 Frequency of Testing

The steel manufacturer shall have conducted a Jominy test from the first, middle and last ingot of each heat of steel purchased.

6.1.2.4.2 Frequency of Testing

The steel manufacturer shall have conducted a Jominy test from the first, middle and last ingot of each heat of steel purchased.

6.1.2.5 Microscopic Inclusion Evaluation

Alloy steel shall meet the following requirements for inclusions.

6.1.2.5.1 Test Specimens

Specimens shall be taken from approximately 4 inch (100 mm) forged, square section taken from the top and bottom of the first, middle and last ingot. The specimen shall be 3/8 by 3/4 inch (9.5 by 19 mm) and shall be taken from an area midway between the center and outside of the test section. Procedures outlined in the latest revision of ASTM Method E 45 shall be followed.

6.1.2.5.2 Examination and Limits

Specimens shall be examined in accordance with the latest revision of ASTM Method E 45, Method D, using the modified JK Chart Fig. 12 of Plate III. The worst field in any specimen shall not exceed the following limits:

Table 5-6-3. Specimen Limits

	A	B	C	D
Thin	3.0	3.0	2.5	2.0
Thick	2.0	2.5	1.5	1.5

6.1.2.6 Nondestructive Test Requirements

To ensure that all tools are free from defects listed in [Article 6.1.1](#), each tool shall be inspected after finished grinding by the supplier according to one of the following procedures:

- Magnetic Particle Inspection in accordance with the latest revision of ASTM Method A-275.
- Liquid Penetrant Inspection in accordance with the latest revision of ASTM Recommended Practice E-165.

6.1.2.7 Design

All tools shall conform substantially when applicable to the dimensions set forth. Dimensions for head contours are shown in Plans A, B or C, D.

6.1.2.7.1 Head Contour

- Heads of tools with a round cross section shall be ground to the corner contours prescribed in Plans A, B or C.
- Heads of tools with a hexagonal or octagonal cross section should also be ground to the corner contours prescribed in Plans A, B or C. In addition, the arcs not tangent to the hexagonal or octagonal corners shall be “blended” into a smooth contour similar to that shown in Plan D.
- Punch ends shall have corner radii according to [paragraph a](#), but with no crown radius.
- All ground surfaces shall be free of decarburization.

6.1.3 Non-Percussion Tools (Materials, Inspection And Physical Tests) (2014)

6.1.3.1 Clay Pick—Plan No. 1

Chemical composition for carbon steel as specified in [Article 6.1.1.1c](#), or alloy steel as specified in AISI 4140. No special tests required.

6.1.3.2 Tamping Pick—Plan No. 2

Chemical composition for carbon steel as specified in [Article 6.1.1.1c](#), or alloy steel as specified in AISI 4140. No special tests required.

6.1.3.3 Spike Maul—Plan No. 3

See percussion tools.

6.1.3.4 Track Wrenches—Plan No. 4

Chemical composition for carbon steel as specified in [Article 6.1.1.1c](#). One wrench to be tested from each lot of 10 dozen or less by applying for 1 minute a load of 400 lb. at a point distant from the jaw end equal to 95 percent of the total length of the wrench without any spreading of the jaw or any permanent set in the handle. If requested by the purchaser, [Article 6.1.2.6](#), Nondestructive Test Requirements, will be adhered to.

6.1.3.5 Lining Bar—Plan No. 5

Chemical composition for carbon steel as specified in [Article 6.1.1.1c](#). One bar to be tested from each lot of 10 dozen or less by applying a load of 350 lb. 9 inch from the end of the handle, with the point suitably secured 6 inch from the end, without leaving a permanent set in excess of 1/4 inch.

6.1.3.6 Rail Tongs—Plan No. 6

Chemical composition for carbon steel as specified in [Article 6.1.1.1c](#). No special tests required.

6.1.3.7 Tie Tongs—Plan No. 7

Chemical composition for carbon steel as specified in [Article 6.1.1.1c](#). No special tests required.

6.1.3.8 Timber Tongs—Plan No. 8

Chemical composition for carbon steel as specified in [Article 6.1.1.1c](#). Three pairs of tongs to be tested from each lot of 10 dozen or less by suspending a load of 300 lb. or 400 lb. work wise in the tongs with the handles in a horizontal position and supported 2 inch from the end. Deflection with 300 lb. weight shall not exceed 1 inch with no permanent set, and with 400 lb. weight deflection shall not exceed 1-1/4 inches with a permanent set not to exceed 1/8 inch.

6.1.3.9 Spike Puller—Plan No. 9

Chemical composition for carbon steel as specified in [Article 6.1.1.1c](#). One puller from each lot of 10 dozen or less to be tested in actual use by pulling a spike with a standard claw bar.

6.1.3.10 Rail Fork—Plan No. 10

Chemical composition for carbon steel as specified in [Article 6.1.1.1c](#). No special tests required.

6.1.3.11 Claw Bar—Plan No. 11

Chemical composition for carbon steel as specified in [Article 6.1.1.1c](#). In the manufacture of claw bars, [Article 6.1.2.6](#), Nondestructive Test Requirements will be adhered to. One bar from each lot of 10 dozen or less to be tested by placing the claws of the bar 1/2 inch under the head of a standard spike, rigidly placed and so located as to hold the bar in a horizontal position while a shock load equivalent to that of a 200 lb. weight falling a distance of 1 foot is applied to the handle at a point 5 inches from its end, without the toes showing any cracks or the handle taking any permanent set.

6.1.3.12 Track Adz—Plan No. 12

Chemical composition for carbon steel as specified in [Article 6.1.1.1c](#). Test one adz in each lot of 10 dozen or less by subjecting cutting edge to 5 normal blows on metal of the same composition as a railroad spike without breakage or serious nicking.

6.1.3.13 Carpenter's Adz—Plan No. 12A

Chemical composition for carbon steel as specified in [Article 6.1.1.1c](#). No special tests required.

6.1.3.14 Double Face Sledge—Plan No. 13

See percussion tools.

6.1.3.15 Tamping Bar—Plan Numbers 14–15

Chemical composition for carbon steel as specified in [Article 6.1.1.1c](#). No special tests required.

6.1.3.16 Tie Plug Driver—Plan No. 16

Material as shown on plan. No special tests required.

6.1.3.17 Track Chisels—Plan No. 17

See percussion tools.

6.1.3.18 Round Track Punch—Plan No. 19

See percussion tools.

6.1.3.19 Track Gage—Plan No. 20

Material as shown on plans. No special tests required.

6.1.3.20 Track Gage with Wood Rod—Plan No. 20-A

Material as shown on plans. No special tests required.

6.1.3.21 Track Shovel—Plan No. 21

6.1.3.21.1 Scope and Design

This specification covers the welded or riveted type with solid shanks. Dimension shall conform to plans, which are made part of this specification. A variation of 1/2 inch more or less from the dimensions shown on the plan for the length of the strap or shank and handle will be allowed. A variation of 1/4 inch more or less from the dimensions shown on the plan for the width or

length of the blade will be allowed, but the total variation in the overall length of shovels shall not exceed 1/2 inch more or less of the dimensions shown on the plan.

6.1.3.21.2 Materials

- a. Blades shall be of carbon or alloy steel, with a Rockwell (Rc) hardness for carbon steel of 45 to 50.
- b. Carbon steel blades shall have a thickness of not less than No. 13 gage and alloy blades shall be not less than No. 14 gage U.S. Standard, the gage to be measured at the point where the hardness is taken. For welded or riveted types, the straps shall be welded or riveted to the blade.

6.1.3.21.3 Handles

Wood handles shall be made of ash and shall conform to Grade AA and be in accordance with the general Specifications for Handles for Track Tools.

6.1.3.21.4 Tests

- a. One shovel from each lot of 10 dozen or less shall be selected. Metal straps (curved to fit the contour of the handle) shall be clamped to the upper and lower parts of the handle. Then, the shovel shall be placed in a prying position, supported at the end of the blade by clamps. The shovel shall be capable of sustaining a load of 200 lb. suspended from the end for a period of 2 minutes without showing any permanent set, fracture or distortion.
- b. Alloy steel shovels which have been given heat treatment to ensure uniformity in hardness shall be subject to shock test to ensure against brittleness. The test shall be made by forcibly striking the blade of the shovel with a hand hammer at several places when placed on an anvil.

6.1.3.22 Ballast Forks—Plan No. 22

6.1.3.22.1 Scope and Design

The dimensions shall conform to the plans, which are made part of this specification. The total variation in the overall length of the forks shall not exceed 1/2 inch more or less of the dimensions shown on plan.

6.1.3.22.2 Material

Forks shall be made of high grade carbon steel. Tines of forks shall show Rockwell (Rc) hardness of 35-45. Straps shall be 0.04 U.S. Standard gage steel.

6.1.3.22.3 Handles

Wood handles shall be made of ash and shall conform to Grade AA and be in accordance with the general Specifications for Handles for Track Tools.

6.1.3.23 Track Tool Handles—Plan Numbers 25-25A

See Specification For Ash And Hickory Handles For Track Tools for material requirements. No special tests required.

6.1.3.24 Scoop—Plan No. 26

6.1.3.24.1 Scope and Design

This specification covers the welded or riveted type with solid shanks. Dimension shall conform to plans, which are made part of this specification. A variation of 1/2 inch more or less from the dimensions shown on the plan for the length of the strap or

shank and handle will be allowed. A variation of 1/4 inch more or less from the dimensions shown on the plan for the width or length of the blade will be allowed, but the total variation in the overall length of scoops shall not exceed 1/2 inch more or less of the dimensions shown on the plan.

6.1.3.24.2 Materials

Blades shall be of carbon or alloy steel, with a Rockwell (Rc) hardness for carbon steel of 45 to 50.

Carbon steel blades shall have a thickness of not less than No. 13 gage and alloy blades shall be not less than No. 14 gage U.S. Standard, the gage to be measured at the point where the hardness is taken. For welded or riveted types, the straps shall be welded or riveted to the blade.

6.1.3.24.3 Handles

Wood handles shall be made of ash and shall conform to Grade AA and be in accordance with the general Specifications for Handles for Track Tools.

6.1.3.24.4 Tests

- a. One scoop from each lot of 10 dozen or less shall be selected and metal straps (curved to fit the contour of the handle) shall be clamped to the upper and lower parts of the handle, after which the shovel shall be placed in a prying position, supported at the end of the blade by clamps and shall be capable of sustaining a load of 200 lb. suspended from the end for a period of 2 minutes without showing any permanent set, fracture or distortion.
- b. Alloy steel scoops which have been given heat treatment to ensure uniformity in hardness shall be subject to shock test to ensure against brittleness. The test shall be made by forcibly striking the blade of the scoop with a hand hammer at several places when placed on an anvil.

6.1.3.25 Aluminum Track Level And Gage—Plan No. 27

Material as shown on plans. No special tests required.

6.1.3.26 Rail Tongs for use with cranes—Plan No. 31

Material as shown on plans. In the manufacture of the rail tongs, [Article 6.1.2.6, Nondestructive Test Requirements](#), will be adhered to.

a. Design

Rail tongs shall be designed in accordance with ASME BTH-1 (latest revision) for Design of Below-the-Hook lifting devices. In accordance with the above referenced design standard, rail tongs shall be designed as a category B lifting device.

b. Manufacture, Testing and Inspection

Rail tongs shall be manufactured, tested, inspected and maintained in accordance with ASME B30.20-XXXX (year of latest revision) for Below-the-Hook Lifting Devices.

6.1.3.27 Track Spike Lifter—Plan No. 32

See percussion tools.

6.1.3.28 Rail Thermometer—Plan No. 34

Material as shown on plans. No special tests required.

6.1.3.29 Nut Cutter—Plan No. 35

See percussion tools.

6.1.3.30 Hot Cutter (3 Pound)—Plan No. 36

See percussion tools.

6.1.3.31 Hot Cutter (5 Pound)—Plan No. 37

See percussion tools.

6.1.3.32 Drift Pin (Short)—Plan No. 38

See percussion tools.

6.1.3.33 Drift Pin (Long)—Plan No. 39

See percussion tools.

6.1.3.34 Spiking Tool—Plan No. 41

See percussion tools.

6.1.3.35 Rail Tongs for use with Truck Crane—Plan No. 42

Chemical composition for carbon steel as specified in [Article 6.1.1.1c](#). In the manufacture of rail tongs, [Article 6.1.2.6, Nondestructive Test Requirements](#), will be adhered to. Each tong shall be tested by lifting a minimum of 125% of working load limit.

6.1.3.36 Switch Clip Wrench—Plan No. 43

Chemical composition for carbon steel as specified in [Article 6.1.1.1c](#). If requested by purchaser, [Article 6.1.2.6](#), will be adhered to.

6.1.3.37 Nipping Bar—Plan No. 44

Chemical composition for carbon steel as specified in [Article 6.1.1.1c](#). In the manufacture of nipping bars, [Article 6.1.2.6, Nondestructive Test Requirements](#), will be adhered to.

6.1.3.38 Nipping Fork—Plan No. 45

No special tests required.

6.1.3.39 Drift Pin Remover—Plan No. 46

See percussion tools.

6.1.3.40 Offset Wedge—Plan No. 47

See percussion tools.

6.1.3.41 Plug Bond Backout Punch—Plan No. 48

See percussion tools.

6.1.3.42 Aluminum Tie Tongs—Plan No. 50

Material as shown on plans. No special tests required.

6.1.3.43 Ball Pein Hammer—Plan No. 51

See percussion tools.

6.1.3.44 Cribbing Tool---Plan No. 52

Material as shown on plans. No special tests required.

SECTION 6.2 SPECIFICATIONS FOR ASH AND HICKORY HANDLES FOR TRACK TOOLS¹ (2010)

6.2.1 MATERIAL (1980)

- a. Before manufacturing tool handles, the manufacturer shall ascertain which of the following kinds of ash or hickory will be accepted. Other woods will not be accepted unless specifically ordered.
- b. Ash for fork, hoe, rake, scoop, shovel, and scythe handles.
 - Black ash (*Fraxinus nigra*).
 - Green ash (*Fraxinus pennsylvanica lanceolata*).
 - Oregon ash (*Fraxinus oregona*).
 - White ash (*Fraxinus americana*).
- c. Hickory for adz, axe, canthook, chisel, hammer, hatchet, jack, maul, pick, punch and sledge handles.
 - Bitternut hickory (*Hicoria cordiformis*).
 - Mockernut hickory (*Hicoria alba*).
 - Nutmeg hickory (*Hicora myristicaeformis*).
 - Pignut hickory (*Hicoria glabra*).
 - Shagbark hickory (*Hicoria ovata*).
 - Shellbark hickory – Bigleaf (*Hicoria laciniosa*).
 - Water hickory (*Hicoria aquatica*)

¹ References, Vol. 43, 1942, pp. 519, 767; Vol. 47, 1946, pp. 484, 636; Vol. 54, 1953, pp. 975, 1399; Vol. 58, 1957, pp. 834, 1258; Vol. 63, 1962, pp. 490, 755. Reapproved without change 1962.

6.2.2 PHYSICAL REQUIREMENTS (1980)

- a. Except as hereinafter provided, all tool handles shall be seasoned to a moisture content not exceeding 12%, and shall be free of injurious characteristics that may impair their serviceability, such as decay, cross grain, abrupt grain dip, holes, large knots, splits, heavy stain, warp, and lightweight wood.
- b. Any tool handle may be either all heartwood, all sapwood, or a mixture of both.

6.2.3 DESIGN (1980)

Tool handles shall conform to the design and dimensions shown on AREMA plans which form a part of these specifications, with an allowable variation of 1/4 inch over or under in length and 1/16 inch over or under in all other dimensions.

6.2.4 MANUFACTURE (1980)

- a. Tool handles shall be cut square at the ends, uniform in size and shape for each type, smoothly finished, and waxed. Lacquered, painted, or stained handles are not acceptable.
- b. The manufacturer shall legibly impress into each accepted handle, at a location and in a manner that will not weaken the handle and at a location designated by the purchaser, whatever grade, maker, or ownership symbol may be required by the purchaser.

6.2.5 INSPECTION (1980)

- a. Handles will be inspected at points of manufacture, shipment, or destination, in suitable and convenient places satisfactory to the purchaser.
- b. Inspectors representing the purchaser shall have free entry to the works of the manufacturer at all times while work on the contract of the purchaser is being performed, and shall have all reasonable facilities (including adequate light) afforded them, free of cost, to satisfy them that the handles being supplied are in accordance with these specifications.
- c. Inspectors will make a reasonably close examination of each handle and acceptance or rejection will be based on visual inspection and the judgment of the inspector. He will not determine the exact weight and density of each handle, but in case of question, one or both of these characteristics may be accurately measured for conformance with the requirements for each grade. Exactness of size and shape will be checked by accurate measurements of handles taken at random.
- d. Each handle will be judged independently, without regard for the decisions on others in the same lot.
- e. The inspector shall have his identifying designation legibly branded into the grasp end of each accepted tool handle.

6.2.6 TYPES OF BLEMISHES AND DEFECTS (1980)

Following is a list of blemishes and defects. Definitions for these effects are listed in the Glossary at the back of this chapter.

cross grain	abrupt grain dip	slight grain dip	hole
pin knot	small knot	medium knot	
split	light stain	medium stain	
small streak	medium streak	large streak	

6.2.7 DELIVERY (1980)

Accepted handles shall be shipped in accordance with the instructions in the order covering them, securely packed in containers marked with the name, type, grade, and quantity of the material therein and with the name of the shipper and the number of the purchaser's contract or order.

6.2.8 GRADE CLASSIFICATION (1984)

Grade classifications are found in [Table 5-6-4](#).

Table 5-6-4. Grade Classifications

Grade Symbol	Color	Maximum Number of Annual Rings per Inch of Radius	Minimum Weight per Cu Ft Lb	Maximum Slope of Grain	Admissible Blemishes and Defects
AA	White, red or brown, or brown, red, and white; but dark brown or dark red only within 10" from tool end.	15	43	1 in 12	1 slight grain dip; tight pin knots and small streaks at least 12" apart; light stain.
AB	White, red or brown, or brown, red, and white; but dark brown or dark red only with 10" from each end.	18	36	1 in 12	1 small tight knot at each end; 2 slight grain dips and 2 tight pin knots at least 6" apart; medium stain; 2 small streaks.
HA	Red or white or red and white.	17	55	1 in 50	Light stain; medium streaks
HB-1	Red or white or red and white.	22	46	1 in 50	Medium stain; large streak bird pecks or tight knots not more than 1/4" in average diameter, in the eye end or first third of the grasp end.
HB-2	Red or white or red and white	27	46	1 in 20	Medium stain; slight grain dip; large streak; bird pecks or tight knots, the sum or whose average diameters does not exceed 1/4" in the eye end or the first third of the grasp end.

6.2.9 USE CLASSIFICATION (2010)

Use classifications are found in [Table 5-6-5](#).

Table 5-6-5. Use Classifications

Handle	Handle Grade Symbol	Number of Tool Plan
Adz - 34"	HA	12 and 12A
Axe - 36"	HA	–
Chisel (Track) 24", 36"	HB-2	17
Drift Pin Remover - 36"	HB-2	46
Fork (Ballast)	AA	22
Hot Cutter (3 lb) 24", 36"	HB-2	36
Hot Cutter (5 lb) 24", 36"	HB-2	37
Maul (Spike) 36"	HA	3
Nut Cutter - 24", 36"	HB-2	35
Pick - 36"	HA	1 and 2
Punch (Round Track) 24", 36"	HB-2	19
Scoop	AA	26
Shovel (Track)	AA	21
Sledge - 36"	HA	13
Spiking Tool - 24", 36"	HB-2	41
Track Spike Lifter - 36"	HB-2	32

SECTION 6.3 RECOMMENDED LIMITS OF WEAR FOR TOOLS TO BE RECLAIMED¹ (1962) R(2013)

6.3.1 GENERAL (1962) R(2013)

- a. Dashed lines and notes indicating the limits of wear of tools to be reclaimed are shown on the plans of the following tools: Nos. 1, 2, 3, 5, 12, 12A, 13, 14, 15, 17, 19, 32, 35, 36, 37, 41, 46, 48 and 51.
- b. For reclaiming alloy track tools, company forces should be limited to grinding methods; where it is advisable to reclaim them by heating methods, due to the numerous and continuous changes in alloy they should be returned to the manufacturer who is familiar with their precise metallurgical content.

¹ References, Vol. 42, 1941, pp. 587, 836; Vol. 43, 1942, pp. 522, 767; Vol. 52, 1951, pp. 519, 817; Vol. 54, 1953, pp. 975, 1399; Vol. 58, 1957, pp. 834, 1258; Vol. 63, 1962, pp. 490, 755. Reapproved without change 1962.

SECTION 6.4 INSULATION FOR TRACK TOOLS STANDARD SPECIFICATIONS¹ (1989)

6.4.1 GENERAL (1989)

6.4.1.1 Scope

This specification covers the requirements for self-amalgamating sealant tape; heat shrinkable environmental sealing boots and thick wall tubing to be used for insulating track tools.

6.4.1.2 Type

- a. The products specified in this section shall be compatible with each other.
- b. Each product shall be furnished in sizes and quantities specified and manufactured in accordance with these specifications.

6.4.2 TECHNICAL REQUIREMENTS (1989)

6.4.2.1 Material

- a. Self-amalgamating sealant tape shall be a cross-linked Butyl based tape that fuses to itself in ambient temperatures. It shall be formulated so that it can be stretch orientated to at least four times its original length, allowing conformance to irregular shapes. The tape shall be supplied with a release paper backing, which allows at least a 1.16 inch overlap to avoid roll contamination and ease of release.
- b. Environmental boots shall be heat shrinkable cross-linked blends of polyolefin and elastomers which provide low moisture permeability, weather resistance and resistance to ozone attack.
- c. Environmental boots shall include an adhesive system that provides an effective environmental seal that meets or exceeds the requirements of ANSI C119.1 for 600V rated systems.
- d. Heat shrinkable tubing and end caps shall be a cross-linked blend of modified polyolefin and elastomers. A sealant shall be applied inside the tubing and end caps which remains flexible for the life of the system. This sealant shall provide both environmental sealing and waterproofing. The tubing shall provide a shrink ratio of at least 3:1 and the end caps at least 2:1.
- e. The sealant system shall provide an effective environment seal to cable jacketing material, including standard plastic and elastomeric materials, yet will strip cleanly from most metallic substances, while resisting water ingress.

6.4.2.2 Properties

- a. The properties for self-amalgamating sealant tape are found in [Table 5-6-6](#) and are a requirement.
- b. The properties for environmental boots are found in [Table 5-6-7](#) and are a requirement.
- c. The properties for heat shrinkable tubing and end caps are found in [Table 5-6-8](#) and must be adhered to.

6.4.2.3 Sizes

- a. The size selection chart for self-amalgamating sealant tape is found in [Table 5-6-9](#). The size, length and quantity manufactured shall be as specified.

¹ References, Vol. 90, 1989, p. 49. Adopted 1989.

Table 5-6-6. Self-Amalgamating Sealant Tape Required Properties

Properties	Test Method	Typical Values
Physical Properties		
Water Absorption	ASTM D-570-81	0.5%
Specific Gravity	ASTM D-792-66 Method A1	1.49
Adhesion:		
Lap Shear XLPE to XLPE	ASTM D-1002-72	8-10 psi
Elongation	ASTM D-142, Method A 412-80	350-400%
Electrical Properties		
Dielectric Strength (125 mil sample)	ASTM D-149-81	250 v/mil
Volume Resistivity	ASTM D-257-78	10 ¹⁴ (min)
Dielectric Constant	ASTM D-150-81	4.9
Dissipation Factor	ASTM D-150-81	0.06
Thermal Properties		
Maximum Service Temperature	C-792-75	265°F
Low Temperature Flexibility	ASTM-3111-76	-40°F on 1/2" mandrel
Chemical Properties		
Corrosivity	ASTM D-2671-80	Non-corrosive 16 hrs @ 150°C
Chemical Resistance	ASTM D-2671-80	Resistant to: alcohol, ketones, acids, alkalis. Non-resistant to: Mineral spirits, naptha, hydrocarbons.
Fungus Resistance	ASTM G-21	Rating 0

Table 5-6-7. Environmental Boots Required Properties

Properties	Test Method	Results
Physical Properties		
Tensile Strength, psi	ASTM D-412 Method A	1500 (min)
Ultimate Elongation (%)	ASTM D-412 Method A	440 (min)
Hardness - Shore "D"	ASTM D-2240	55 ±5
Water Absorption (%)	ASTM D-570 24 hours	0.1% (max)
Specific Gravity	ASTM D-792 Method A1	1.22 ±12
Electrical Properties		
Dielectric Strength 125 mil	ASTM D-149	350 (min)
125 mils (v/mil)		
Dielectric Constant (1 kHz)	ASTM D-150	4.5
Volume Resistivity (ohm-cm)	ASTM D-257	10 ¹⁴ (min)

Table 5-6-8. Heat Shrinkable Tubing and End Caps Required Properties

Properties	Test Method	Results
Physical Properties		
Tensile Strength, psi	ASTM D-412 Method A	1800(min)
Ultimate Elongation (%)	ASTM D-412 Method A	400% (min)
Hardness - Shore "D"	ASTM D-2240	48 ±5
Water Absorption (%)	ASTM D-570	0.1% (max)
Specific Gravity	ASTM D-792 Method A1	1.08 ±.08
Chemical Properties		
Corrosivity	ASTM D-2671 Method A	Non-corrosive 16 hrs @ 175°C
Fungus Resistance	ASTM G-21	Rating 0
Oil Resistance – 24 hrs @ 25°C	ASTM D-412	Rating 0
Hydraulic Fluid Mil H5606 °C	% Original Strength	90 (min)
	% Original Elongation	100 (min)
Diesel Fuel	% Original Strength	100 (min)
	% Original Elongation	120 (min)
Electrical Properties		
Dielectric Strength 125 mils (v/mil)	ASTM D-149	350 (min)
Dielectric Constant (1 khz)	ASTM D-150	3.4 (min)
Volume Resistivity (ohm-cm)	ASTM D-257	10 ¹⁴ (min)
Dissipation Factor (1 khz)	ASTM D-150	0.005 nominal

Table 5-6-9. Self-Amalgamating Sealant Tape Size Selection

Width (Inches)	Length (Feet)	Thickness (Inches)
1	25	1/16 (min)
3-3/4	10	1/8 (min)

- b. The size selection for environmental boots is found in [Table 5-6-10](#). The size, length and quantity manufactured shall be as specified.
- c. The size selection for heat shrinkable tubing and end caps with sealant is found in [Table 5-6-11](#) and [Table 5-6-12](#). The size, length and quantity manufactured shall be as specified. Tubing shall be supplied up to and including 60 inch lengths with sealant applied. The recovered inside diameter dimensions are reduced by the flow of the sealant.

Table 5-6-10. Environmental Boots Size Selection

Expanded Diameter (Inches)	Recovered Diameter (Inches)	Nominal Length (Inches)	Recovered Wall Thickness (Inches)
0.75	0.37	3.0	0.10
1.50	0.70	3.5	0.10
2.50	1.20	4.0	0.10
3.60	2.20	4.0	0.14
4.50	2.20	6.0	0.16

Table 5-6-11. Heat Shrinkable Tubing Size Selection

Expanded Diameter (Inches)	Recovered Diameter (Inches)	Recovered Wall Thickness (Inches)
0.40	0.15	0.060
0.75	0.22	0.090
1.10	0.37	0.105
1.50	0.50	0.120
1.70	0.50	0.120
2.00	0.75	0.155
2.70	0.90	0.155
3.00	1.25	0.155
4.00	1.75	0.155
4.50	1.75	0.155

Table 5-6-12. End Caps with Sealant Size Selection

Nominal Length (Inches)	Min Expanded ID (Inches)	Max Rec ID (Inches)	Nominal Recovered Wall (Inches)
3.250	1.150	0.500	0.095
3.500	1.500	0.750	0.100
3.750	2.000	1.000	0.105
4.500	2.500	1.250	0.110

6.4.2.4 Tolerances

Tolerances shall be as stated in the pertinent test method under the properties part of this specification.

6.4.2.5 Manufacture

- a. Tubing and end caps can be black in color for ultraviolet protection. Other colors available (without ultraviolet protection) are green, white and red.
- b. All insulated tools shall be clean, without burrs or rough edges and have a uniform cross section throughout and finished in a first class, workmanlike manner.

6.4.2.6 Drawings

The manufacturer shall submit for approval to the railroad, shop drawings of each product to be manufactured. Such drawings shall consist of scale and full-size drawings showing in detail all dimensions, kind and quantity of materials, specifications and any other information required for the fabrication of each product. No work indicated by such shop drawings required for the fabrication of said item is to commence until the manufacturer has received written approval of the submitted drawings.

6.4.3 INSPECTION AND SHIPMENT (1989)

6.4.3.1 Inspection

The manufacturer shall have adequate facilities for the inspection of each product by a representative of the railroad during the course of manufacturing.

6.4.3.2 Testing and Acceptance

If the product offered by the manufacturer is not a standard catalog item in production for at least three (3) years the vendor will, prior to delivery, submit for approval seven (7) copies of notarized certified test reports from a recognized independent laboratory (approved by the railroad) that the material lot to be supplied is in accordance with the specifications contained herein.

6.4.3.3 Packing

Each product shall be carefully prepared for shipment to prevent any damage in transit. Any item found damaged in shipment will be rejected by the railroad and shall be removed.

6.4.4 INSPECTION AND USE (1989)

- a. Tools must be inspected before each use to ensure that there has been no damage to the insulation. Tools with damaged insulation must not be used.
- b. Tools should be stored in location free of oils and grease to ensure proper protection of the insulation.

SECTION 6.5 PLANS FOR TRACK TOOLS¹ (2014)

6.5.1 GENERAL (2014)

- a. For the plans for track tools refer to [Table 5-6-13](#) and [Figure 5-6-1](#) through [Figure 5-6-46](#).
- b. For the chemical specifications for carbon steel track tools refer to [Article 6.1.1.1c](#).
- c. For the chemical specifications for alloy steel track tools, refer to [Article 6.1.2.3](#).

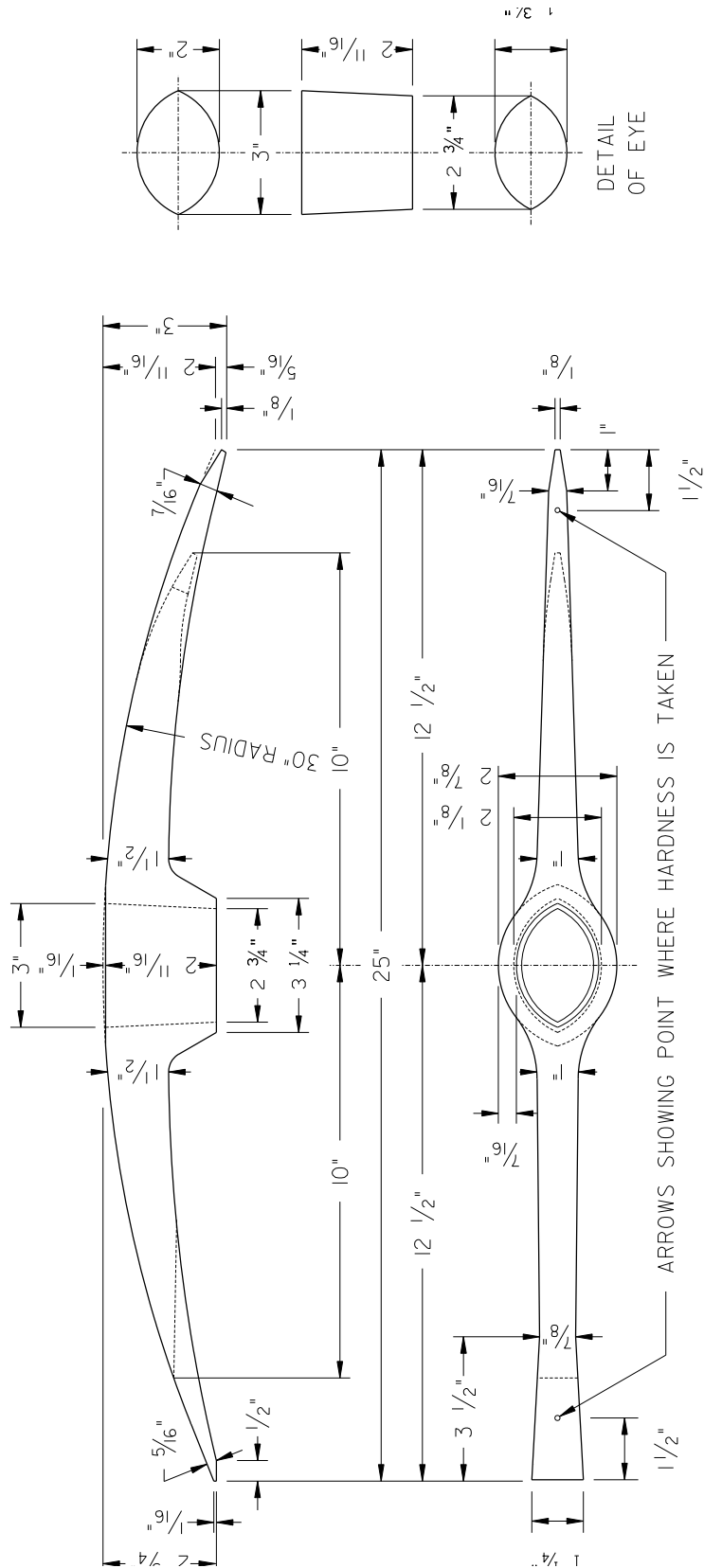
Table 5-6-13. Plans for Track Tools (2014)

Plan Number	Description	Grade of Steel	Hardness
1-02	*Clay Pick	Carbon or Alloy	425-500 BHN
2-02	*Tamping Pick	Carbon or Alloy	425-500 BHN
3-08	*Spike Maul	Alloy	51-55 Rc
4-07	Track Wrenches	Carbon	375-450 BHN
5-02	Lining Bar	Carbon	300-375 BHN
6-02	Rail Tongs	Carbon	
7-10	Tie Tongs	Carbon	
8-10	Timber Tongs	Carbon	
9-10	Spike Puller	Carbon	375-450 BHN
10-03	Rail Fork	Carbon	275-350 BHN
11-10	Claw Bar	Carbon	300-375 BHN
12-07	*Track Adz	Carbon	375-450 BHN
12A-07	*Carpenter's Adz	Carbon	
13-08	*Double Faced Sledge	Alloy	51-55 Rc
14-02	Chisel End Tamping Bar	Carbon	425-500 BHN
15-02	Spear End Tamping Bar	Carbon	425-500 BHN
16-02	Tie Plug Driver	Carbon	
17-08	*Track Chisel	Alloy	44-48 Rc (Head) 56-60 Rc (Point)
19-11	*Round Track Punch	Alloy	44-48 Rc (Head) 52-56 Rc (Point)
20-12	Track Gage—Pipe Center	See Plan	
20A-08	Track Gage—Wood Center	See Plan	
21-08	Track Shovel	Carbon or Alloy	45-50 Rc
22-08	Ballast Fork	Carbon	35-45 Rc
25-03 & 25A-03	Track Tool Handles		

¹ References, Vol. 31, 1930, pp. 562, 1753; Vol. 33, 1932, pp. 582, 815; Vol. 34, 1933, pp. 508, 838; Vol. 35, 1934, pp. 936, 1118, 1122; Vol. 37, 1936, pp. 458, 1019; Vol. 39, 1938, pp. 405, 793; Vol. 40, 1939, pp. 544, 760; Vol. 41, 1940, pp. 564, 867; Vol. 42, 1941, pp. 587, 836; Vol. 43, 1942, pp. 522, 767; Vol. 45, 1944, pp. 338, 620; Vol. 47, 1946, pp. 483, 636; Vol. 50, 1949, pp. 569, 789; Vol. 51, 1950, pp. 650, 855; Vol. 52, 1951, pp. 519, 817; Vol. 54, 1953, pp. 975, 1399; Vol. 55, 1954, pp. 701, 1079; Vol. 57, 1956, pp. 685, 1066; Vol. 58, 1957, pp. 832, 1258; Vol. 62, 1961, pp. 652, 946; Vol. 63, 1962, pp. 490, 755; Vol. 67, 1966, pp. 409, 732; Vol. 68, 1967, p. 359; Vol. 69, 1968, p. 358; Vol. 72, 1971, p. 161; Vol. 94, p. 83.

Table 5-6-13. Plans for Track Tools (2014) (Continued)

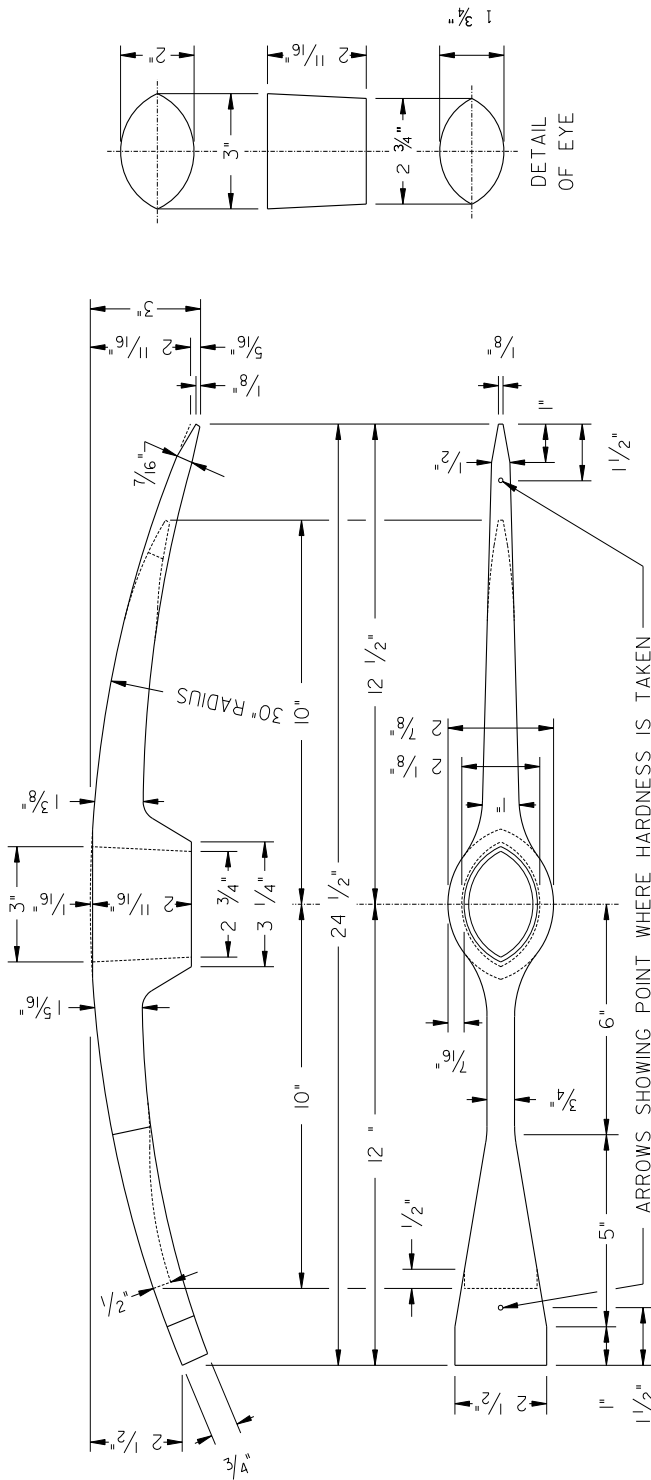
Plan Number	Description	Grade of Steel	Hardness
26-08	Scoop	Carbon or Alloy	45-50 Rc
27-08	Aluminum Combination Track Level and Gage (Insulated)		
31-12	Rail Tongs For Use With Cranes	See Plan	See Plan
32-08	Track Spike Lifter	Alloy	44-48 Rc (Head) 44-48 Rc (Claw)
34-02	Rail Thermometer		
35-08	*Nut Cutter	Alloy	44-48 Rc (Head) 56-60 Rc (Point)
36-08	*3 Pound Hot Cutter	Alloy	44-48 Rc (Head) 56-60 Rc (Point)
37-08	*5 Pound Hot Cutter	Alloy	44-48 Rc (Head) 56-60 Rc (Point)
38-06	Drift Pin (Short)	Alloy or EN30B	32-37 Rc (Overall)
39-06	Drift Pin (Long)	Alloy or EN30B	32-37 Rc (Overall)
41-08	*Spiking Tool	Alloy	44-48 Rc (Head) 52-56 (Point)
42-05	Rail Tongs For Use With Truck Crane	See Plan	
43-97	Switch Clip Wrench	Carbon	375-450 BHN
44-97	Nipping Bar	Carbon	300-375 BHN
45-09	Nipping Fork	See Plan	330-400 BHN
46-11	*Drift Pin Remover	Alloy	44-48 Rc (Head)
47-08	Offset Wedge	Alloy	44-48 Rc
48-09	Plug Bond Backout Punch	See Plan	44-48 Rc (Head) 48-52 (Point)
50-10	Aluminum Tie Tongs	See Plan	300-350 BHN
51-12	Ball Pein Hammer	Alloy	51-55 Rc
52-14	Cribbing Tool	See Plan	
*When specified, track tools will be furnished with properly fitted AREMA handles.			



NOTE :

1. TOLERANCE -
2% ON LENGTH
5% ON CROSS SECTION
2. CURVATURE OF BACK SHALL BE CONTINUOUS AND OF 30" RADIUS EXCEPT WHERE FLATTENED OVER THE EYE.
3. RADIUS TO BE COINCIDENT WITH THE CENTER LINE OF EYE.
4. FURNISH IN CARBON STEEL OR AISI/SAF 4140
5. BRINELL: 425 - 500 FOR CARBON STEEL AND AISI/SAE ALLOY STEEL.
6. RECLAIM LIMITS:
DASHED LINES INDICATE OUTLINE (MINIMUM) OF TOOLS AS RECLAIMED.
7. DOUBLE POINTED PICK SHALL BE FURNISHED WHEN SPECIFIED.
8. APPROXIMATE WEIGHT 7 POUNDS.

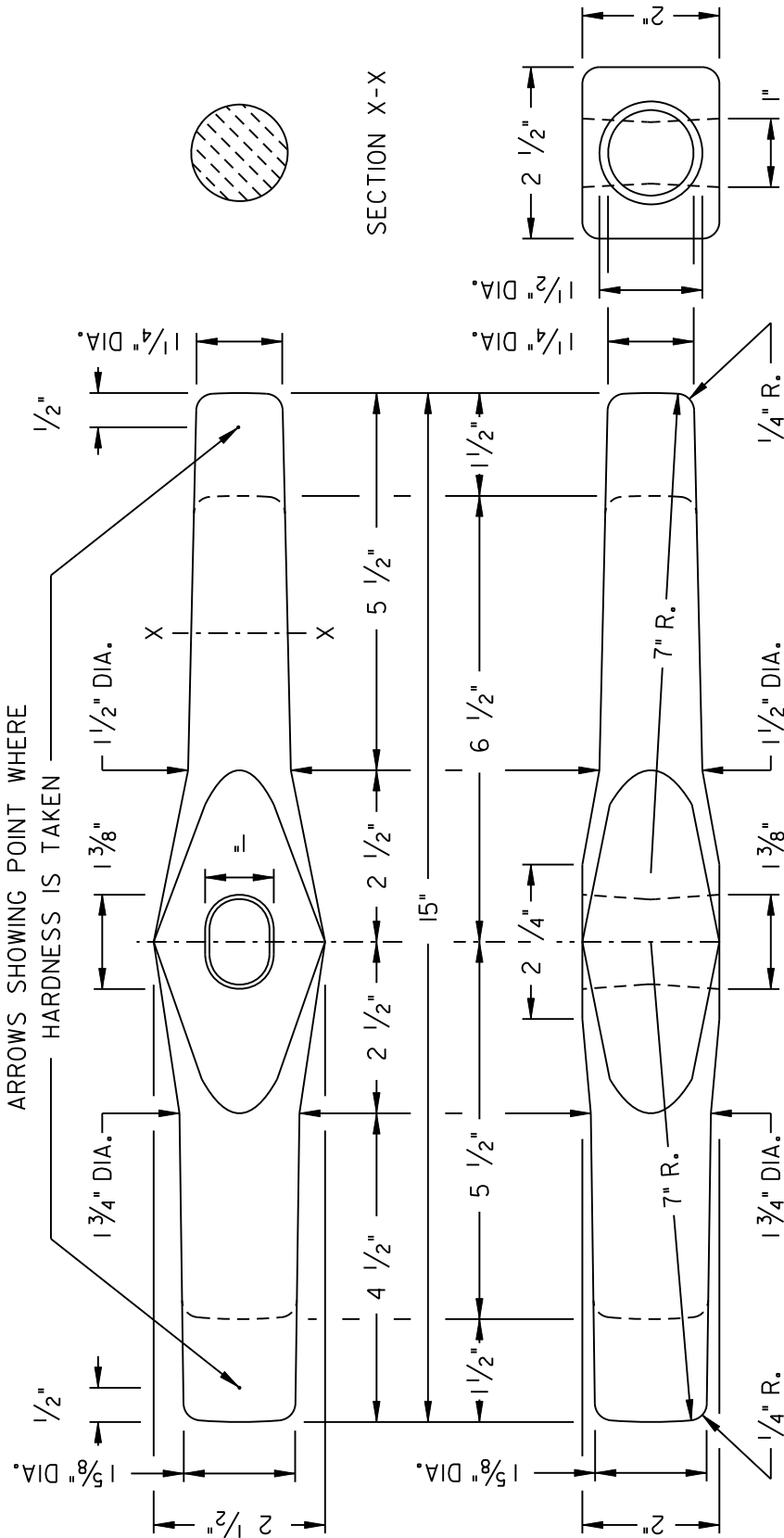
Figure 5-6-1. Plan 1-02 - AREMA Clay Pick



NOTE :

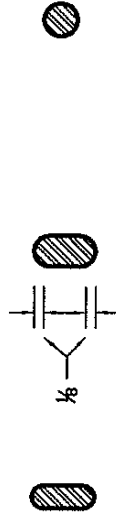
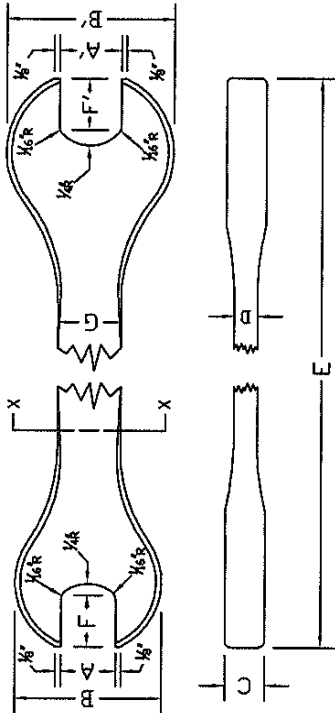
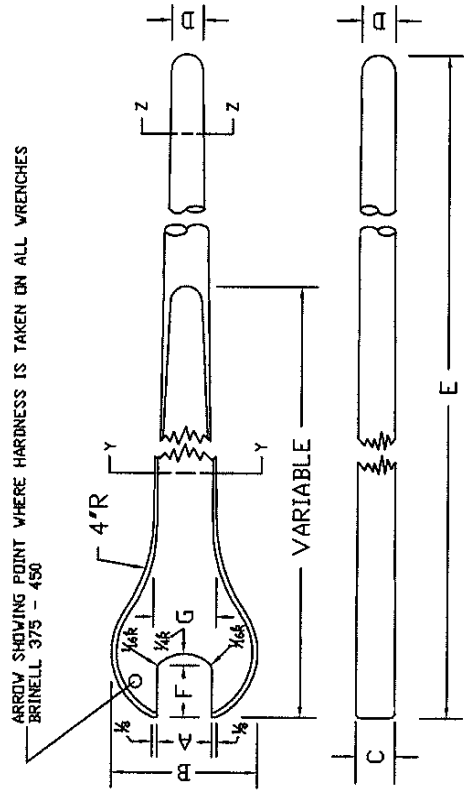
1. TOLERANCE -
2% ON LENGTH
5% ON CROSS SECTION
2. CURVATURE OF BACK SHALL BE CONTINUOUS AND OF 30° RADIUS EXCEPT WHERE FLATTENED OVER THE EYE.
3. RADIUS TO BE COINCIDENT WITH THE CENTER LINE OF EYE.
4. FURNISH IN CARBON STEEL OR AISI/SAE 4140 ALLOY STEEL.
5. BRINELL: 425 - 500 FOR CARBON STEEL AND AISI/SAE 4140 ALLOY STEEL.
6. RECLAIM LIMITS:
DASHED LINES INDICATE OUTLINE (MINIMUM) OF TOOLS AS RECLAIMED.
7. APPROXIMATE WEIGHT 8 POUNDS.

Figure 5-6-2. Plan 2-02 – AREMA Tamping Pick



- ARROWS SHOWING POINT WHERE HARDNESS IS TAKEN
- NOTE:
1. TOLERANCE -
 - 2 % ON LENGTH
 - 5 % ON CROSS SECTION
 2. EYE TAPERED TO CENTER -
 - 4 DEGREES ON LONG DIAMETER
 - 3 DEGREES ON SHORT DIAMETER
 3. FURNISH IN GRADE B ALLOY STEEL.
 4. ROCKWELL C - 51/55
 5. CONTOUR GRIND HEAD PER AREMA PLANS A, B, AND D.
 6. DASHED LINES INDICATE OUTLINE (MINIMUM) OF TOOLS AS RECLAIMED.
 7. APPROXIMATE WEIGHT 10 POUNDS.

Figure 5-6-3. Plan 3-08 – AREMA Spike Maul



SECTION X-X SECTION Y-Y SECTION Z-Z

NOTE

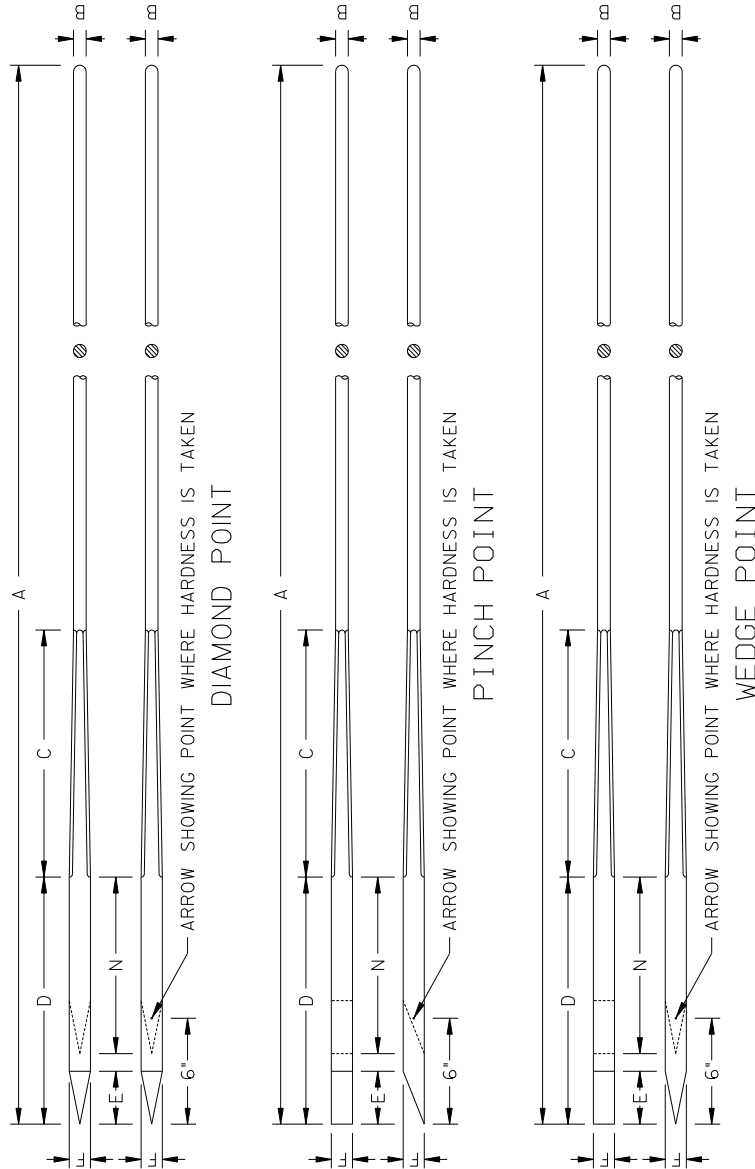
1. Width of nut shall be stamped plainly in $\frac{3}{4}$ " characters on one side of head near each jaw.
2. Tolerance --
2% on length
5% on cross section
3. Single end wrench will be furnished with end tapered for last $\frac{1}{2}$ " to $\frac{1}{2}$ " diam. at end when specified.
4. All wrench jaws shall be milled to dimensions shown.

BOLT SIZES	SINGLE END - DIMENSIONS IN INCHES									
	WIDTH OF NUT	A	B	C	D	E	F	G		
$\frac{3}{4}$	$\frac{1}{4}$	1.257	1.330	3/2	1 1/2	3/4	30	1 1/4	1 1/2	
$\frac{7}{8}$	$\frac{1}{2}$	1.445	1.519	4	1 1/2	3/4	36	1 1/4	1 1/2	
1	$\frac{1}{2}$	1.634	1.709	4	1 1/2	7/8	42	1 1/4	1 1/2	
$1\frac{1}{8}$	$\frac{1}{2}$	1.822	1.898	4 1/2	1 1/2	7/8	48	1 1/4	1 1/2	
$1\frac{1}{4}$	2	2.011	2.088	4 1/2	1	7/8	48	1 1/4	1 1/2	
$1\frac{1}{2}$	2 1/2	2.199	2.277	5	1	7/8	54	1 1/4	1 1/2	

BOLT SIZES	DOUBLE END - DIMENSIONS IN INCHES									
	WIDTH OF NUT	A	B	C	D	E	F	G		
$\frac{3}{4}$ & $\frac{7}{8}$	$1\frac{1}{4}$ & $1\frac{1}{2}$	1.330	1.445	3 1/2	4	1 1/2	36	1 1/4	1 1/2	
$\frac{7}{8}$ & 1	$1\frac{1}{2}$ & $1\frac{3}{4}$	1.519	1.634	4	4 1/2	1 1/2	42	1 1/4	1 1/2	
1 & $1\frac{1}{8}$	$1\frac{3}{4}$ & $1\frac{1}{2}$	1.709	1.822	4	4 1/2	1 1/2	48	1 1/4	1 1/2	
$1\frac{1}{8}$ & $1\frac{1}{4}$	$1\frac{1}{2}$ & 2	1.898	2.011	4 1/2	4 1/2	1 1/2	48	1 1/4	1 1/2	
$1\frac{1}{4}$ & $1\frac{1}{2}$	2 & 2 1/2	2.088	2.199	4 1/2	5	1 1/2	48	1 1/4	1 1/2	

* C = $\frac{1}{8}$ ON $\frac{1}{8}$ END, 1 ON $\frac{1}{4}$ END

Figure 5-6-4. Plan 4-13 - AREMA Track Wrenches

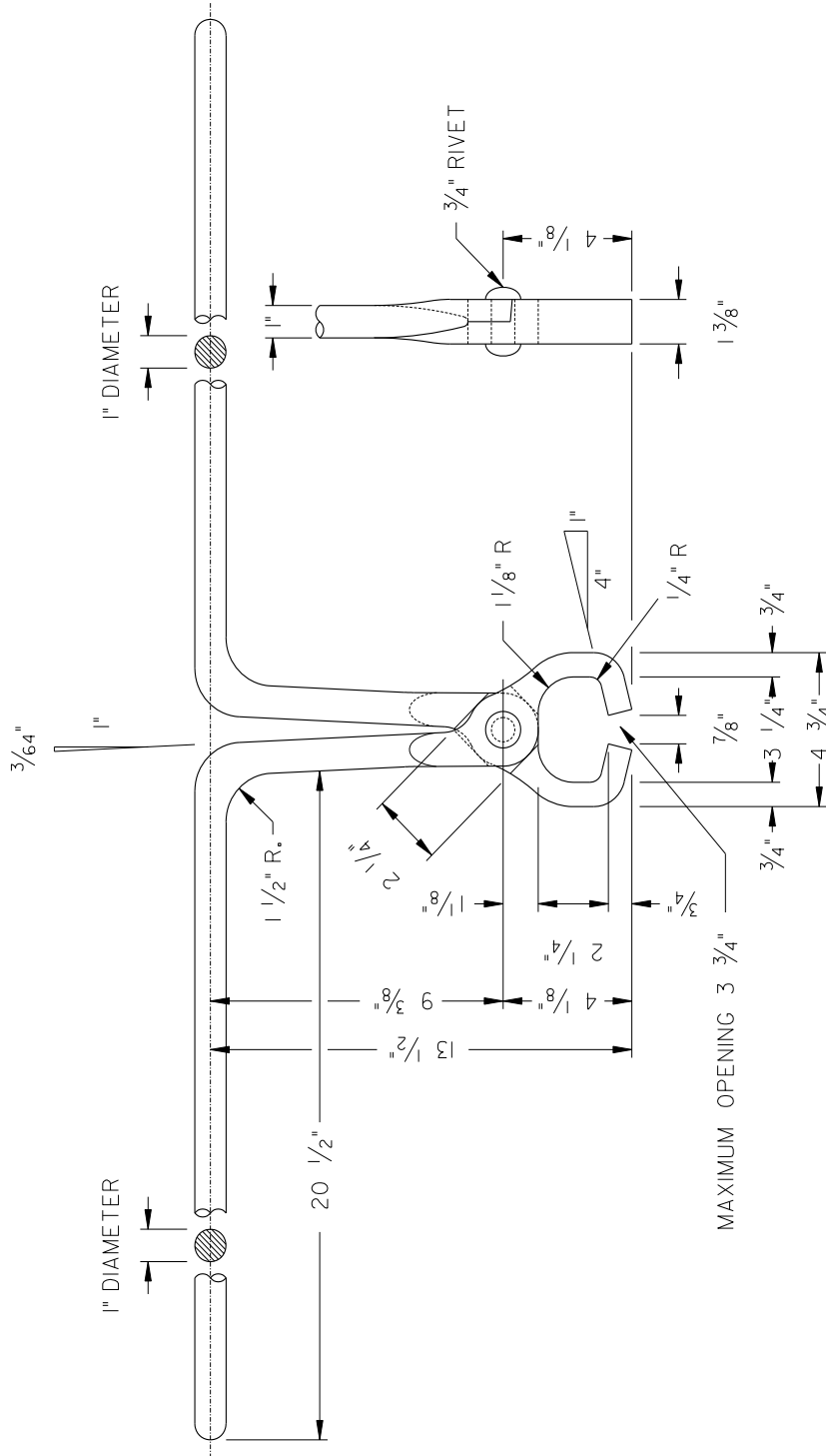


NOTE:

1. FURNISH IN CARBON STEEL.
2. TOLERANCE: 2 % ON LENGTH.
5 % ON CROSS SECTION.
3. HARDNESS: BRINELL 300 - 375.
4. RECLAIM LIMITS: DASHED LINES INDICATE OUTLINE (MINIMUM) OF TOOLS AS RECLAIMED.
5. SPECIFY TYPE OF POINT AND LENGTH OF BAR ON REQUISITION.

SCHEDULE OF DIMENSIONS							
APPROX. WEIGHT	A	B	C	D	E	F	N
18 LB.	5'-0"	3/4"	14"	14"	3"	1 1/4"	10"
22 LB.	5'-4"	7/8"	14"	14"	3"	1 3/8"	10"
26 LB.	5'-6"	7/8"	14"	14"	3"	1 1/2"	10"

Figure 5-6-5. Plan 5-02 – AREMA Lining Bar

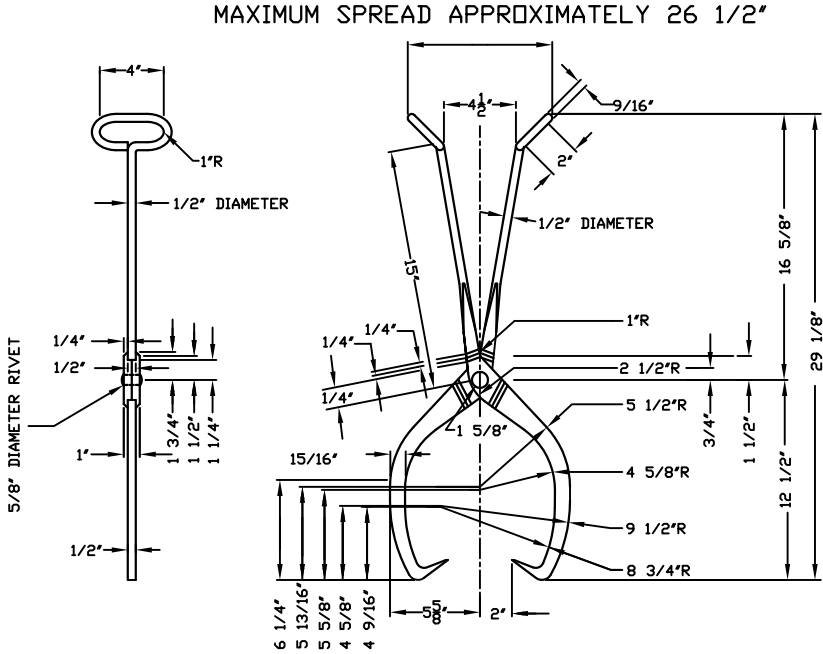


NOTE:

1. TOLERANCE -
 2 3/4 ON LENGTH
 5 3/8 ON CROSS SECTION

2. TOOL TO BE FURNISHED IN CARBON STEEL.
3. NO HARDNESS TESTS REQUIRED.
4. APPROXIMATE WEIGHT 18 POUNDS.

Figure 5-6-6. Plan 6-02 – AREMA Rail Tong



JAW OPENING - 4" MINIMUM 15-1/2" MAXIMUM

NOTE:
 FURNISH IN CARBON STEEL, NO HARDNESS TEST REQUIRED
 TOLERANCE-
 2% ON LENGTH
 5% ON CROSS SECTION
 APPROXIMATE WEIGHT 10 POUNDS
 STANDARD - PEAVEY POINTS TO BE FINISHED BY GRINDING

IF SPECIFIED BY PURCHASER, FURNISH WITH:
 1. HANDLES FROM 1/2" X 1" BARS INSTEAD OF 9/16" ROUNDS
 2. REPLACEABLE POINTS

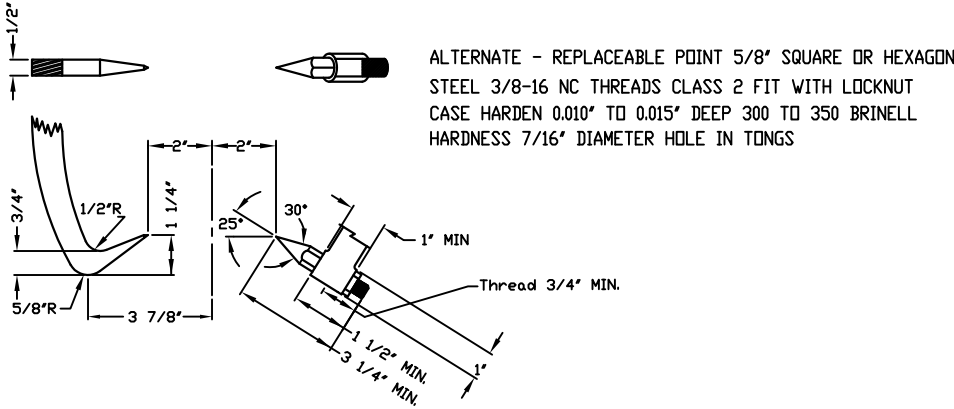
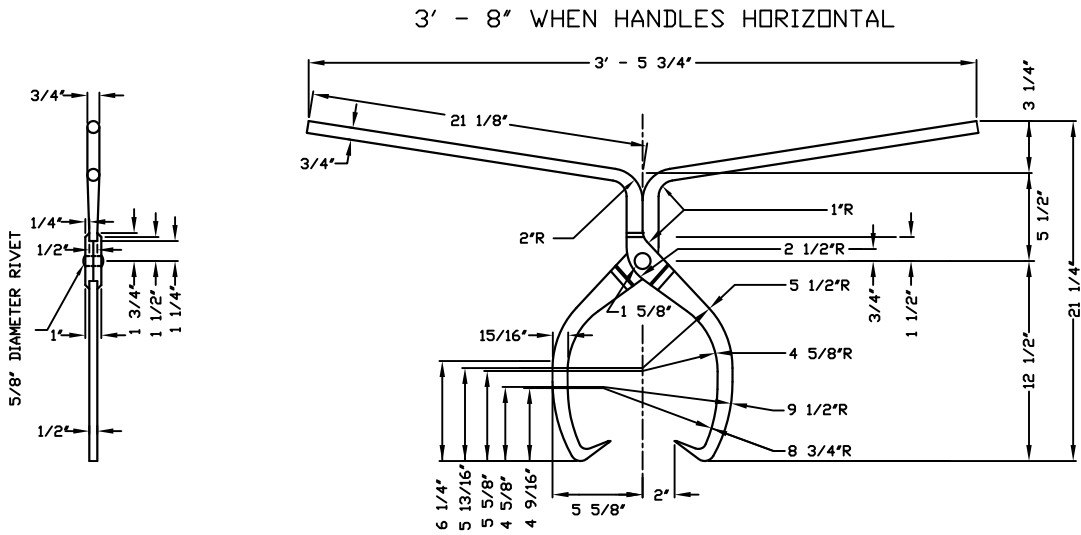


Figure 5-6-7. Plan 7-10 – AREMA Tie Tongs



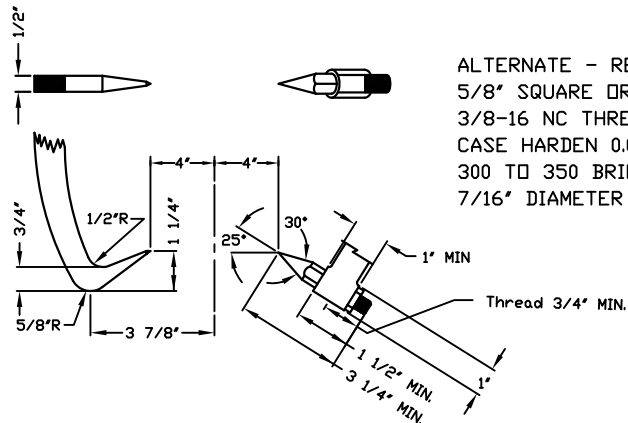
JAW OPENING - 4" MINIMUM 15-1/2" MAXIMUM

NOTE:

FURNISH IN CARBON STEEL
 NO HARDNESS TESTS REQUIRED
 TOLERANCE-

IF SPECIFIED BY PURCHASER, FURNISH
 WITH REPLACEABLE POINTS

2% ON LENGTH
 5% ON CROSS SECTION
 APPROXIMATE WEIGHT 12.2 POUNDS
 STANDARD - PEAVEY POINTS
 TO BE FINISHED BY GRINDING



ALTERNATE - REPLACEABLE POINT
 5/8" SQUARE OR HEXAGON STEEL
 3/8-16 NC THREADS CLASS 2 FIT WITH LOCKNUT
 CASE HARDEN 0.010 TO 0.015 DEEP
 300 TO 350 BRINELL HARDNESS
 7/16" DIAMETER HOLE IN TONGS

Figure 5-6-8. Plan 8-10 – AREMA Timber Tongs

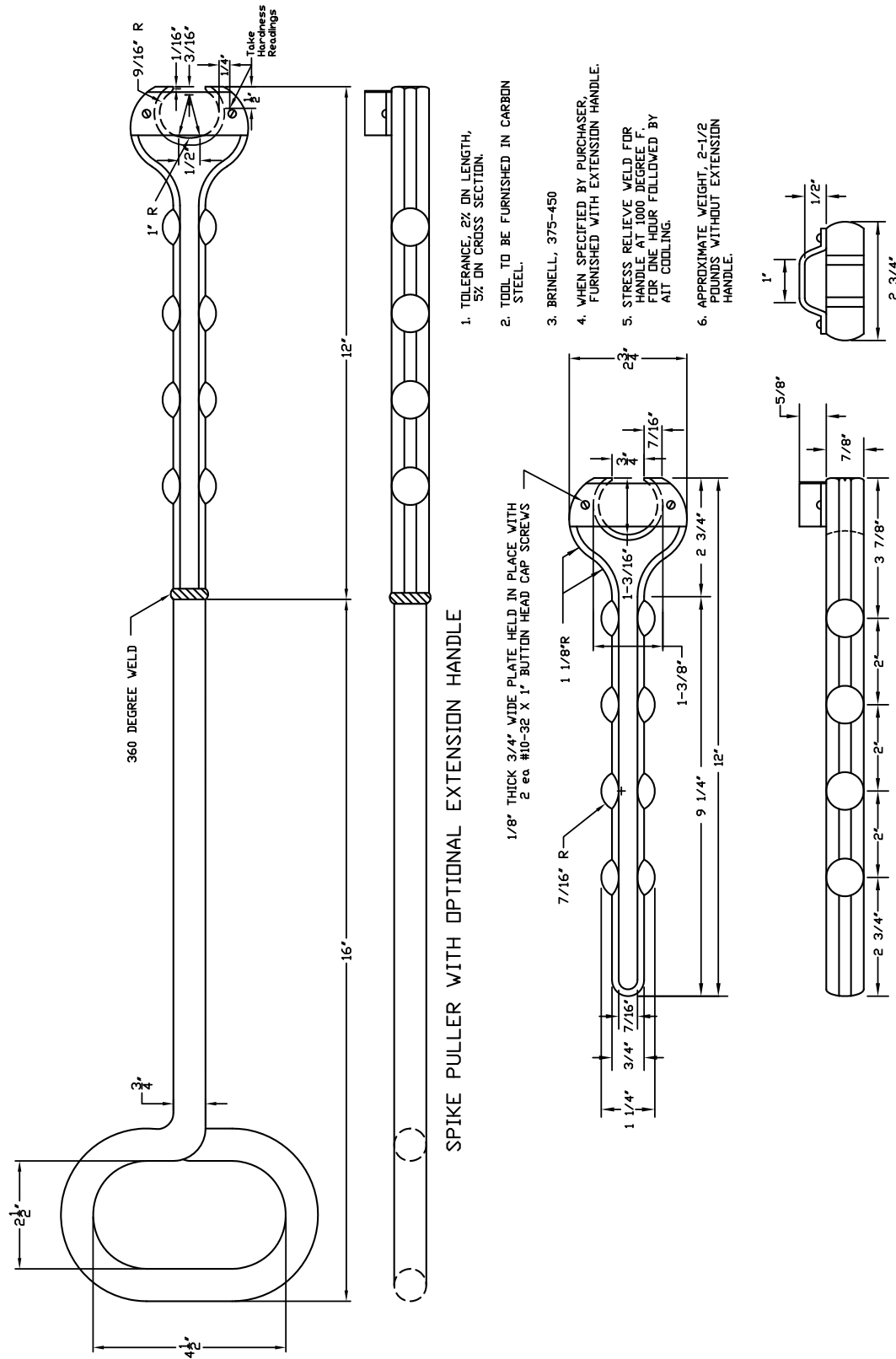


Figure 5-6-9. Plan 9-10 – AREMA Spike Puller

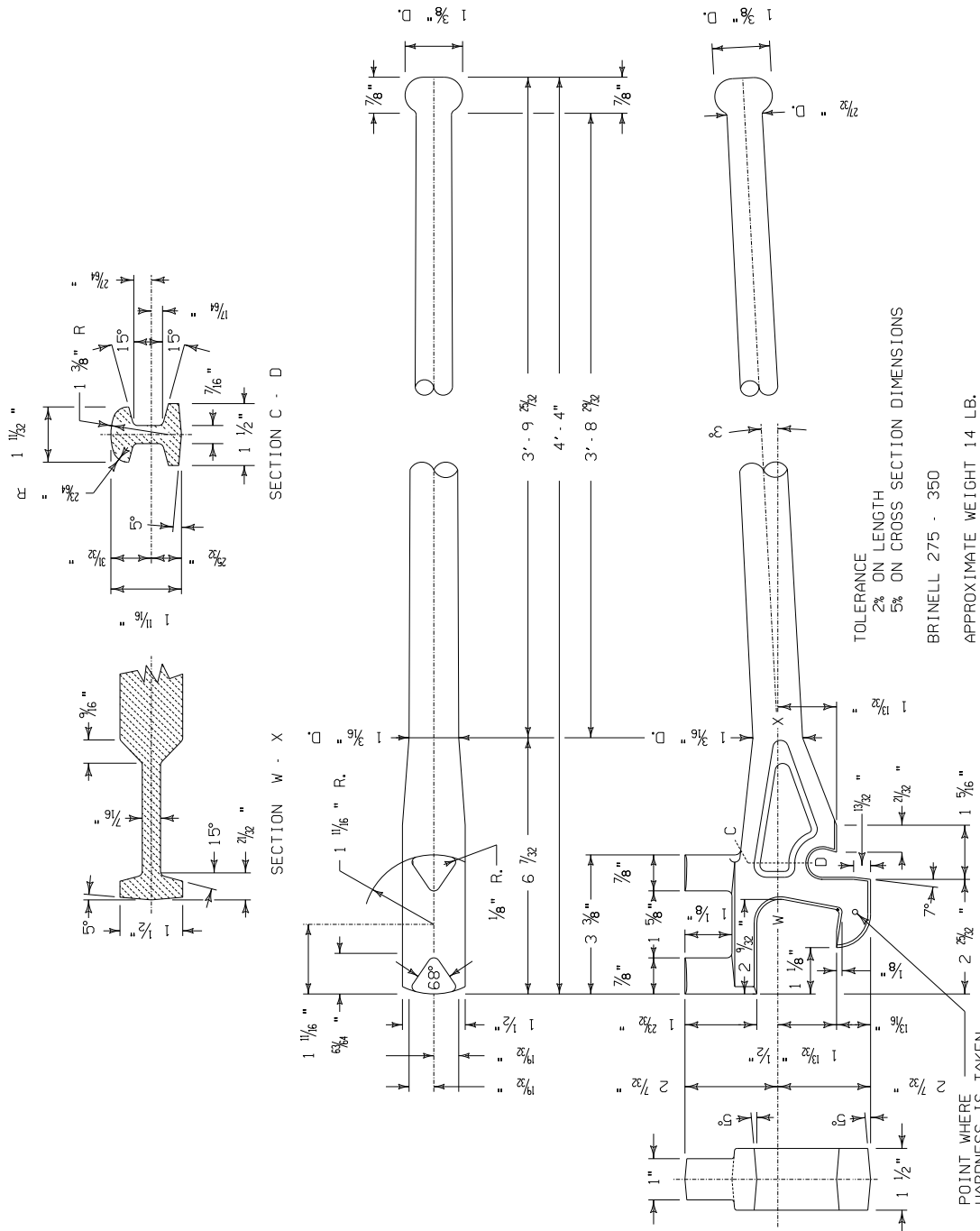
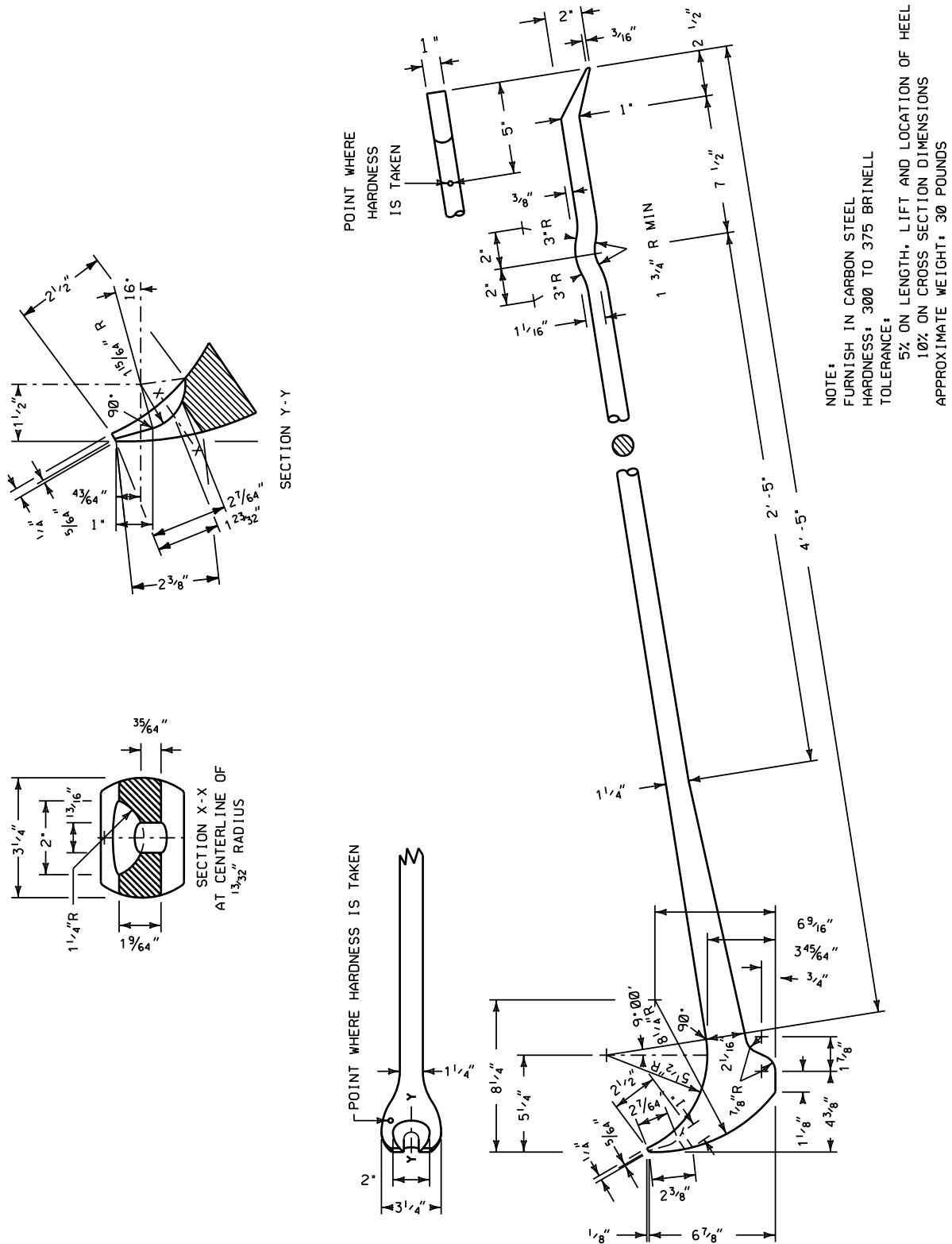


Figure 5-6-10. Plan 10-03 – AREMA Rail Fork



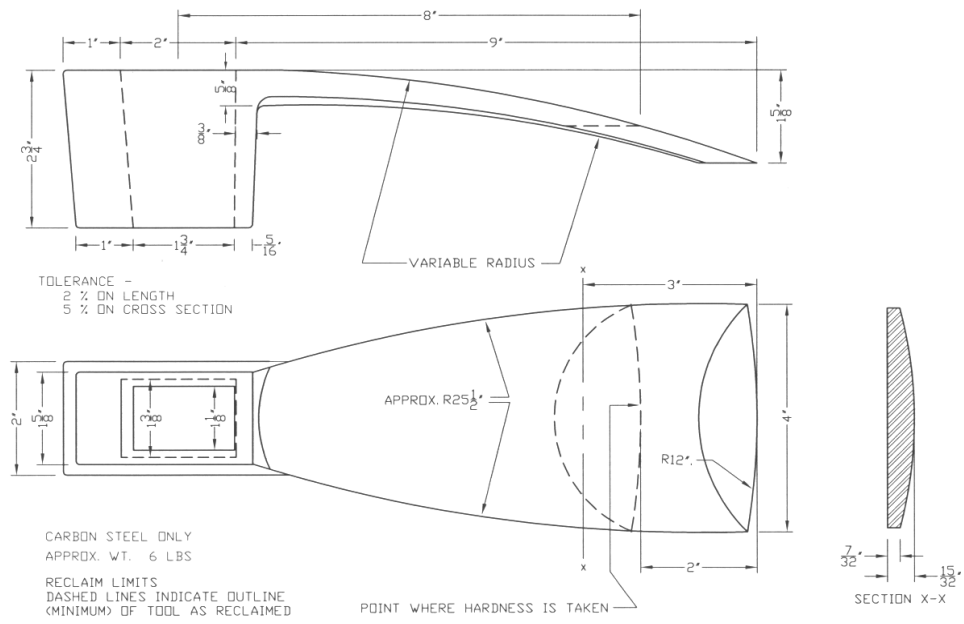


Figure 5-6-12. Plan 12-07 – AREMA Track Adz

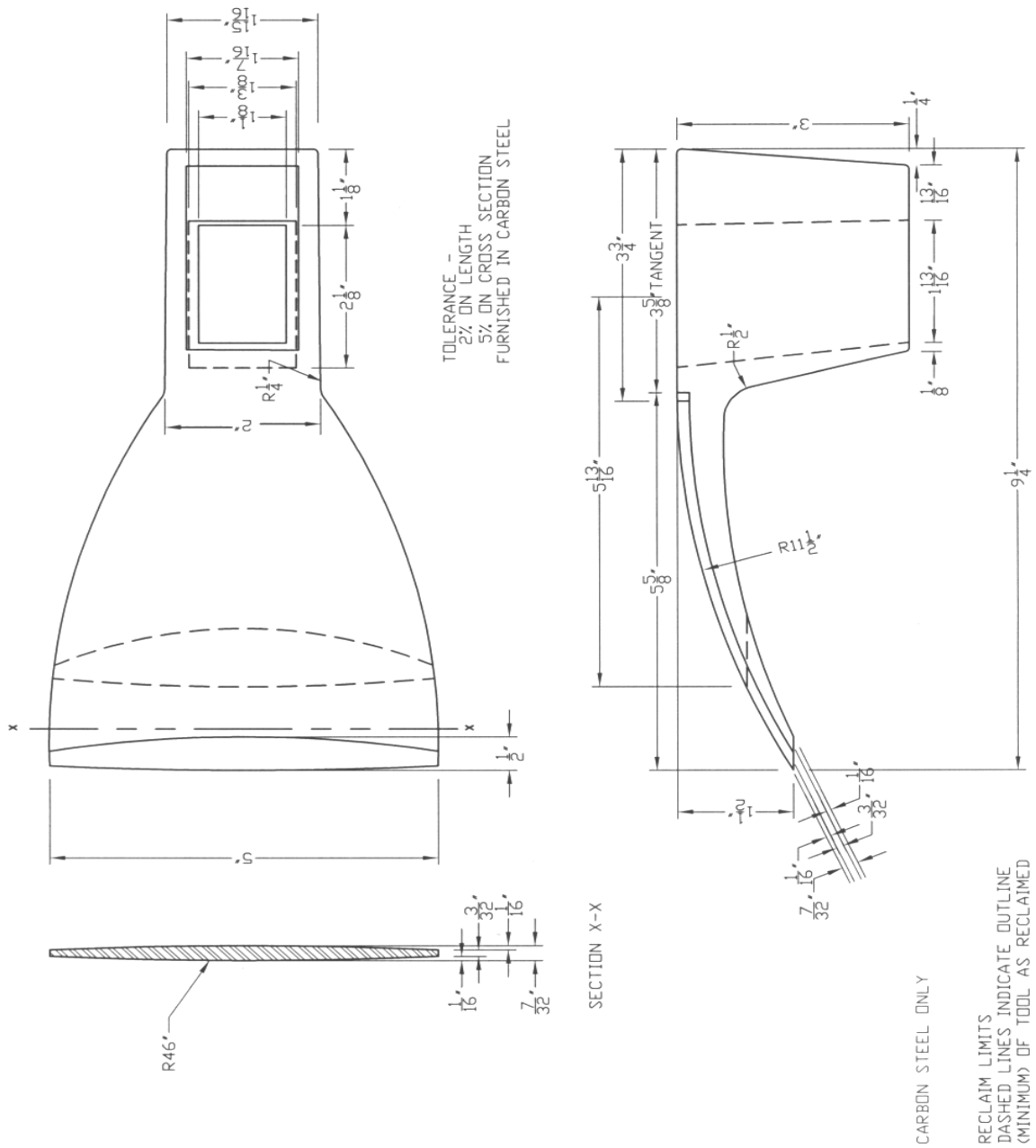
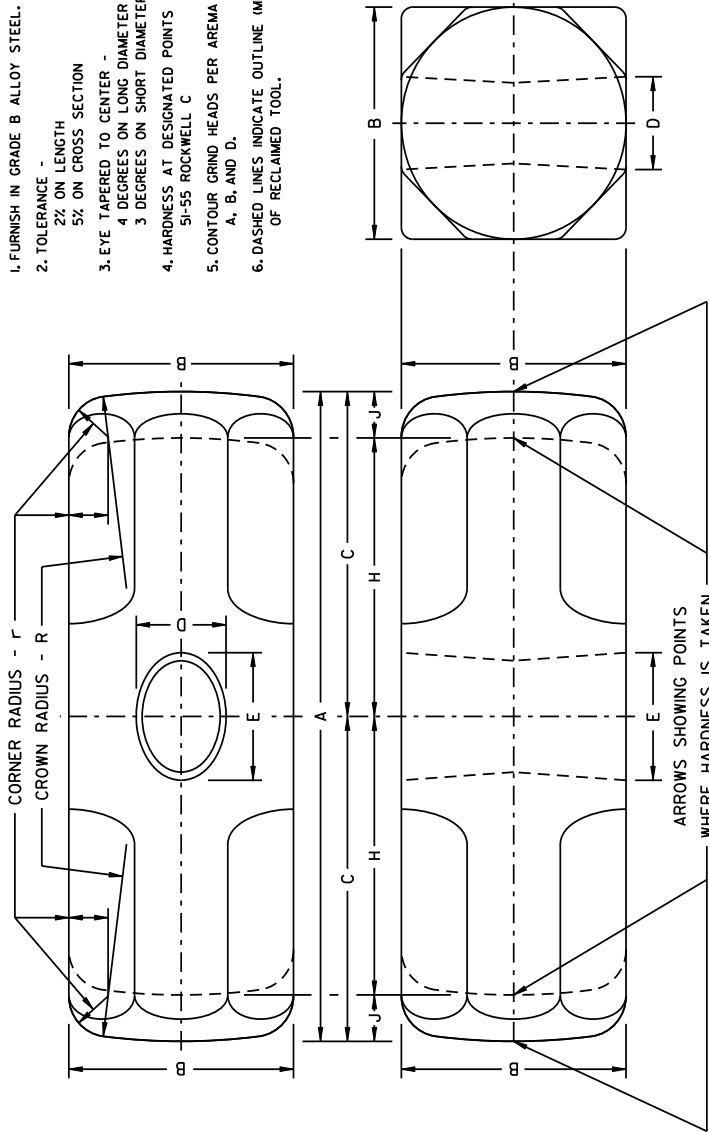


Figure 5-6-13. Plan 12A-07 – AREMA Carpenter’s Adz

- NOTES:
1. FURNISH IN GRADE B ALLOY STEEL.
 2. TOLERANCE -
2% ON LENGTH
5% ON CROSS SECTION
 3. EYE TAPERED TO CENTER -
4 DEGREES ON LONG DIAMETER
3 DEGREES ON SHORT DIAMETER
 4. HARDNESS AT DESIGNATED POINTS -
5I-55 ROCKWELL C
 5. CONTOUR GRIND HEADS PER AREMA PLANS
A, B, AND D.
 6. DASHED LINES INDICATE OUTLINE (MINIMUM)
OF RECLAIMED TOOL.



APPROXIMATE WEIGHT IN POUNDS	LENGTH OF HEAD IN INCHES	WIDTH ACROSS FLATS AT FACE IN INCHES	CENTERLINE OF EYE TO FACE IN INCHES	WIDTH OF EYE IN INCHES	LENGTH OF EYE IN INCHES	RADIUS OF CROWN ON FACE IN INCHES	CORNER RADIUS IN INCHES	CENTERLINE OF EYE TO HARDNESS AND WEAR POINT IN INCHES	FACE TO HARDNESS AND WEAR POINT IN INCHES
	A	B	C	D	E	R	r	H	J
1	4 1/4	1 1/4	2 1/8	5/8	3/4	7	1/4	2	1/4
2	4 3/8	1 3/8	2 3/16	3/4	1	7	1/4	2	1/4
2 1/2	4 1/2	1 1/2	2 1/4	3/4	1	7	1/4	2	1/4
3	4 3/4	1 5/8	2 3/8	3/4	1	7	1/4	2 1/8	1/4
4	5 1/4	1 3/4	2 5/8	3/4	1	7	3/8	2 3/8	1/4
6	6	2 1/8	3	1	1 3/8	7	3/8	2 3/4	1/4
8	6 1/2	2 1/4	3 1/4	1	1 3/8	7	3/8	2 3/4	1/2
10	7	2 1/2	3 1/2	1	1 3/8	7	3/8	3	1/2
12	7 1/2	2 5/8	3 3/4	1	1 3/8	7	3/8	3 1/4	1/2
16	8 1/2	2 7/8	4 1/8	1	1 3/8	7	1/2	3 1/2	1/2
20	9	3 1/8	4 1/2	1 1/4	1 1/2	7	1/2	3 7/8	1/2

Figure 5-6-14. Plan 13-08 – AREMA Double Faced Sledge

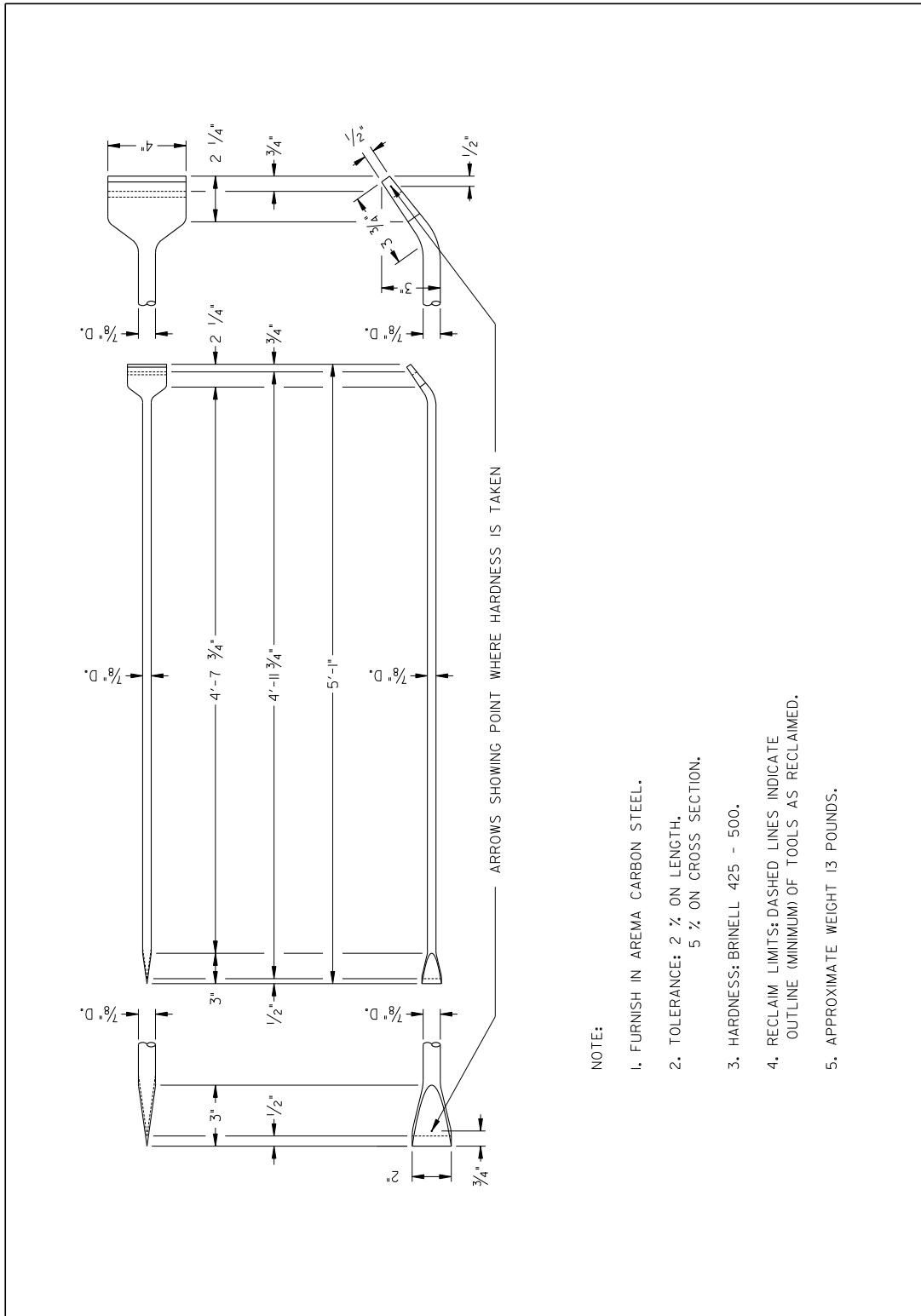
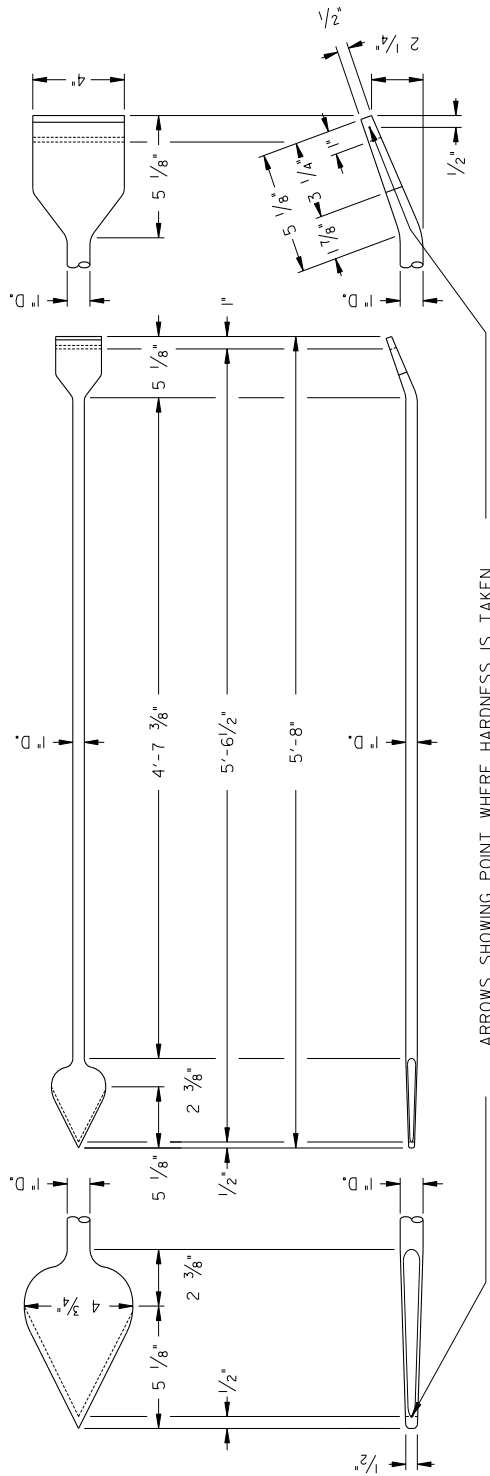


Figure 5-6-15. Plan 14-02 – AREMA Chisel End Tamping Bar

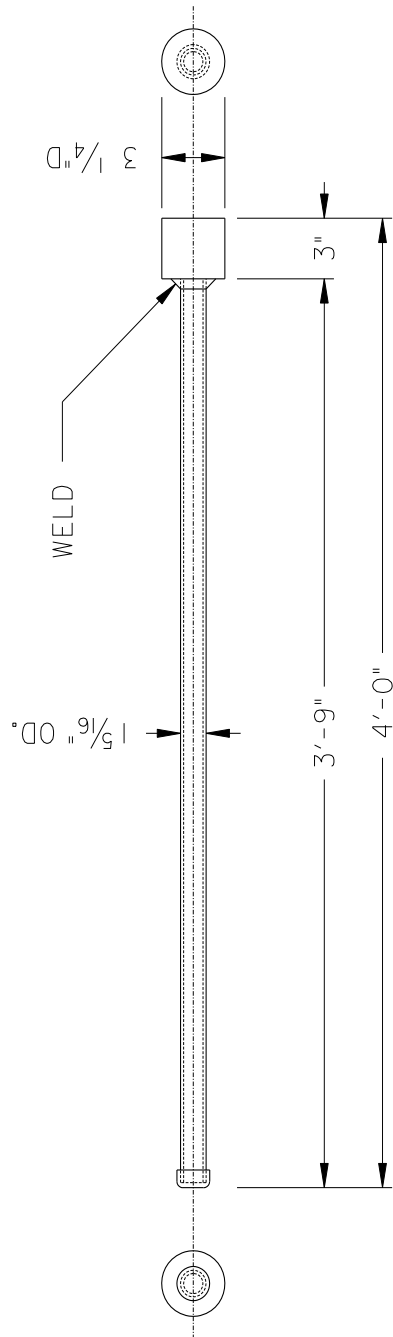


ARROWS SHOWING POINT WHERE HARDNESS IS TAKEN

NOTE:

1. FURNISH IN AREMA CARBON STEEL.
2. TOLERANCE: 2 % ON LENGTH,
5 % ON CROSS SECTION.
3. HARDNESS: BRINELL 425 - 500.
4. RECLAIM LIMITS: DASHED LINES INDICATE
OUTLINE (MINIMUM) OF TOOLS AS RECLAIMED.
5. APPROXIMATE WEIGHT IS POUNDS.

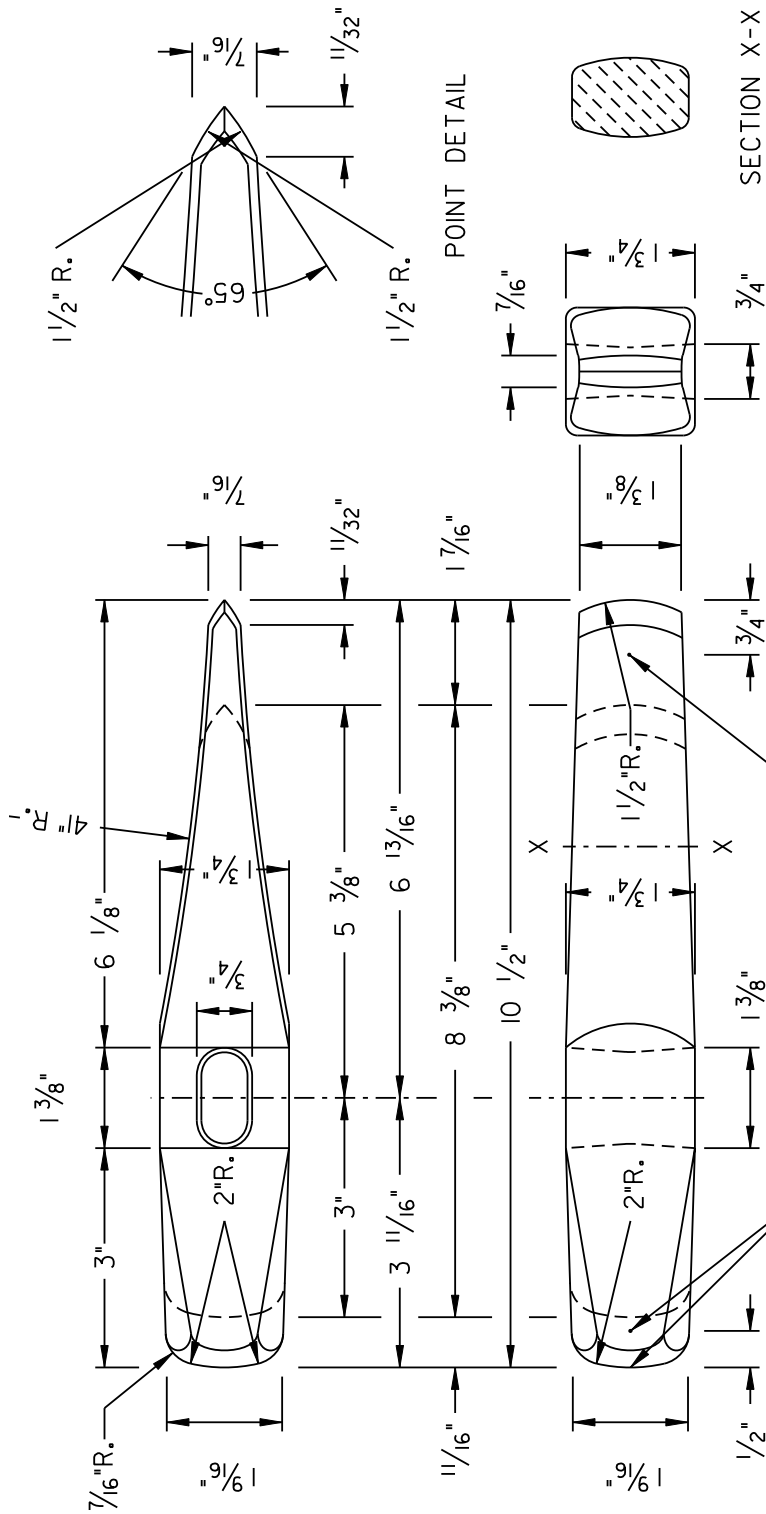
Figure 5-6-16. Plan 15-02 – AREMA Spear End Tamping Bar



NOTE:

1. MATERIAL: HANDLE - STANDARD WEIGHT PIPE WITH CAP.
BLOCK - ROLLED ROUND STEEL.
2. TOLERANCE: 2 % ON LENGTH.
5 % ON CROSS SECTION.
3. REMOVE ALL SHARP EDGES BY GRINDING.
4. APPROXIMATE WEIGHT 13.5 POUNDS.

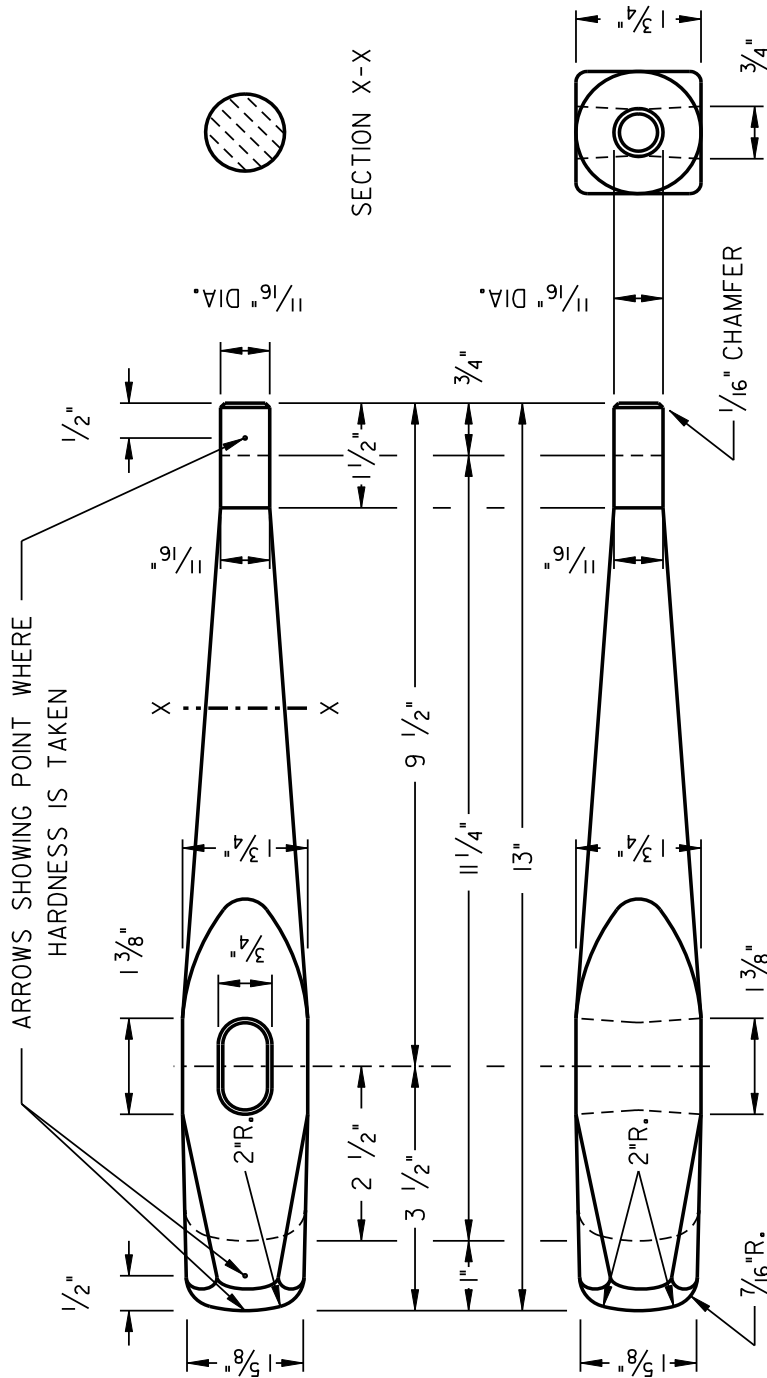
Figure 5-6-17. Plan 16-02 – AREMA Tie Plug Driver



NOTE: WHERE HARDNESS IS TAKEN

- 1. TOLERANCE -
 - 2 % ON LENGTH
 - 5 % ON CROSS SECTION
- 2. EYE TAPERED TO CENTER -
 - 4 DEGREES ON LONG DIAMETER
 - 3 DEGREES ON SHORT DIAMETER
- 3. FURNISH IN GRADE B ALLOY STEEL.
- 4. ROCKWELL C -
 - POINT 56/60
 - HEAD 44/48
- 5. CONTOUR GRIND HEAD PER AREMA PLANS A, C, AND D.
- 6. DASHED LINES INDICATE OUTLINE (MINIMUM) OF TOOLS AS RECLAIMED.
- 7. APPROXIMATE WEIGHT 5 1/2 POUNDS.

Figure 5-6-18. Plan 17-08 – AREMA Track Chisel



- NOTE:
1. TOLERANCE -
2 % ON LENGTH
5 % ON CROSS SECTION
 2. EYE TAPERED TO CENTER -
4 DEGREES ON LONG DIAMETER
3 DEGREES ON SHORT DIAMETER
 3. FURNISH IN GRADE B ALLOY STEEL.
 4. ROCKWELL C -
POINT 52/56
HEAD 44/48
 5. CONTOUR GRIND HEAD PER AREMA
PLANS A, C, AND D.
 6. DASHED LINES INDICATE
OUTLINE (MINIMUM) OF TOOLS
AS RECLAIMED.
 7. APPROXIMATE WEIGHT 5 1/2 POUNDS.

Figure 5-6-19. Plan 19-11 – AREMA Round Track Punch

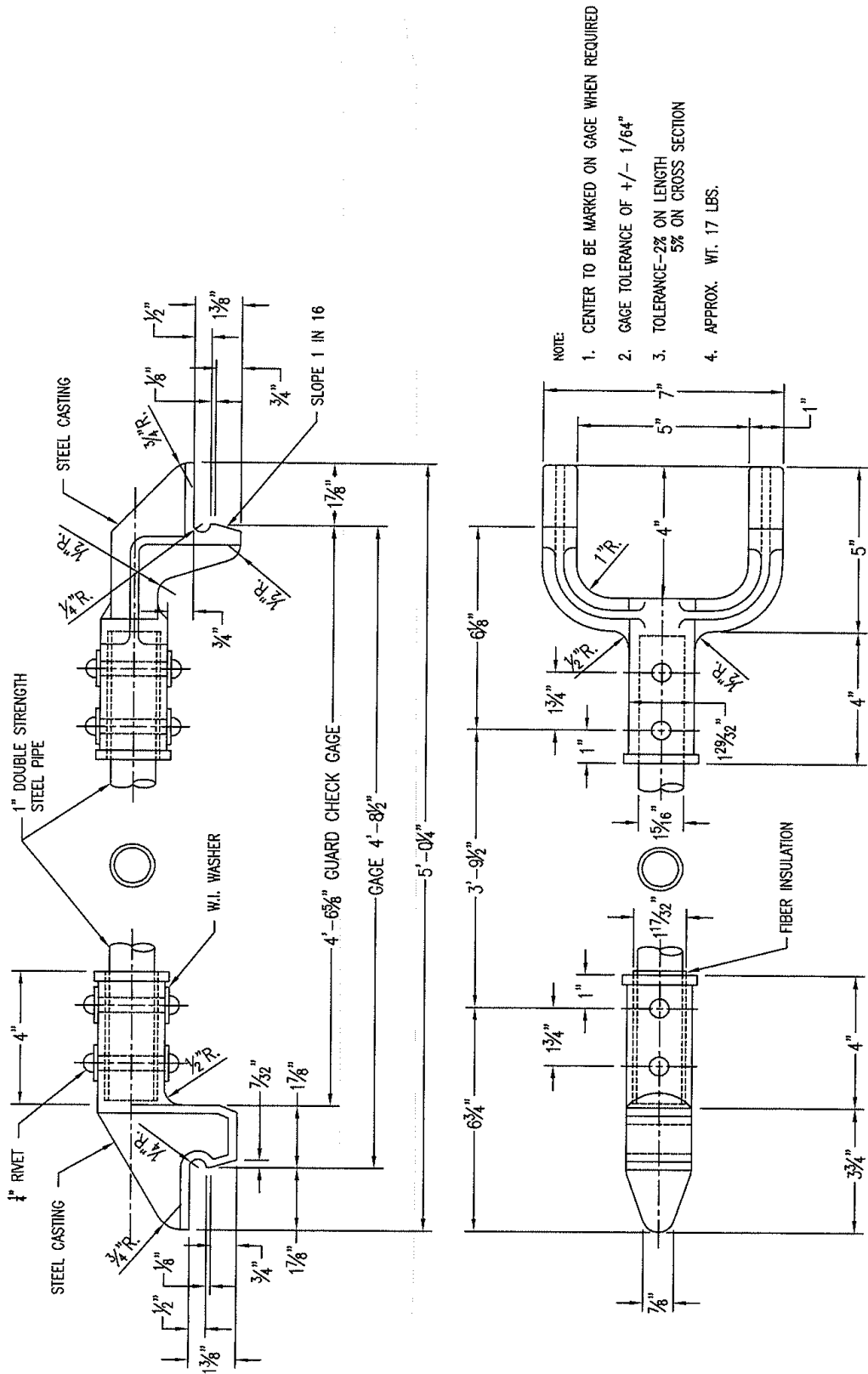


Figure 5-6-20. Plan 20-12 – AREMA Track Gage – Pipe Center

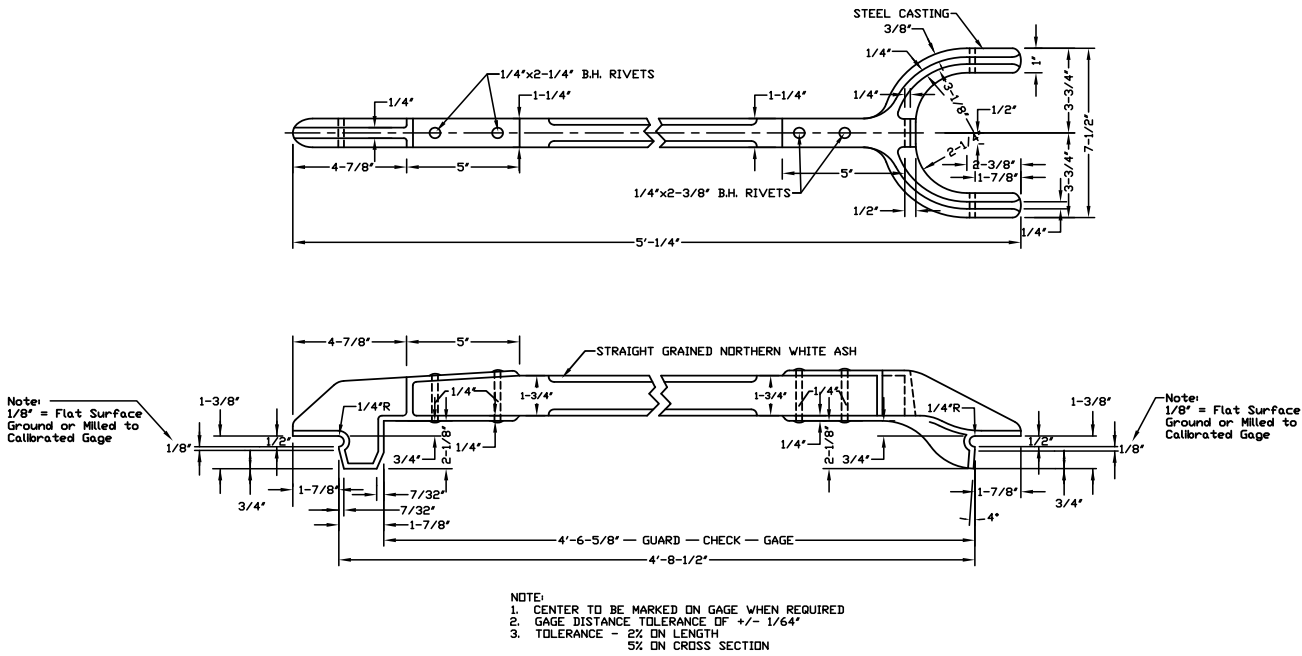


Figure 5-6-21. Plan 20A-08 – AREMA Track Gage – Wood Center

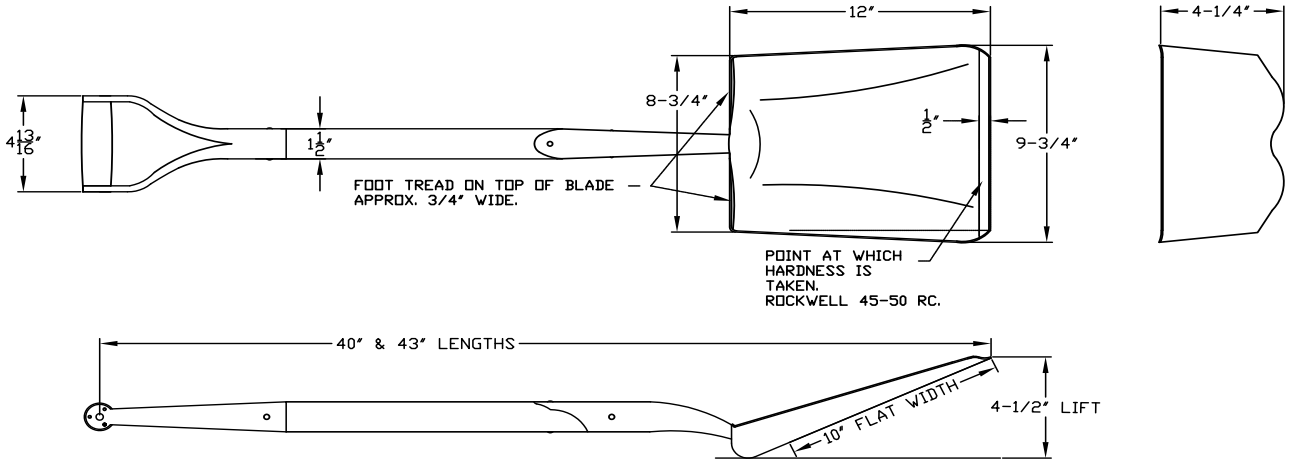


Figure 5-6-22. Plan 21-08 – AREMA Track Shovel

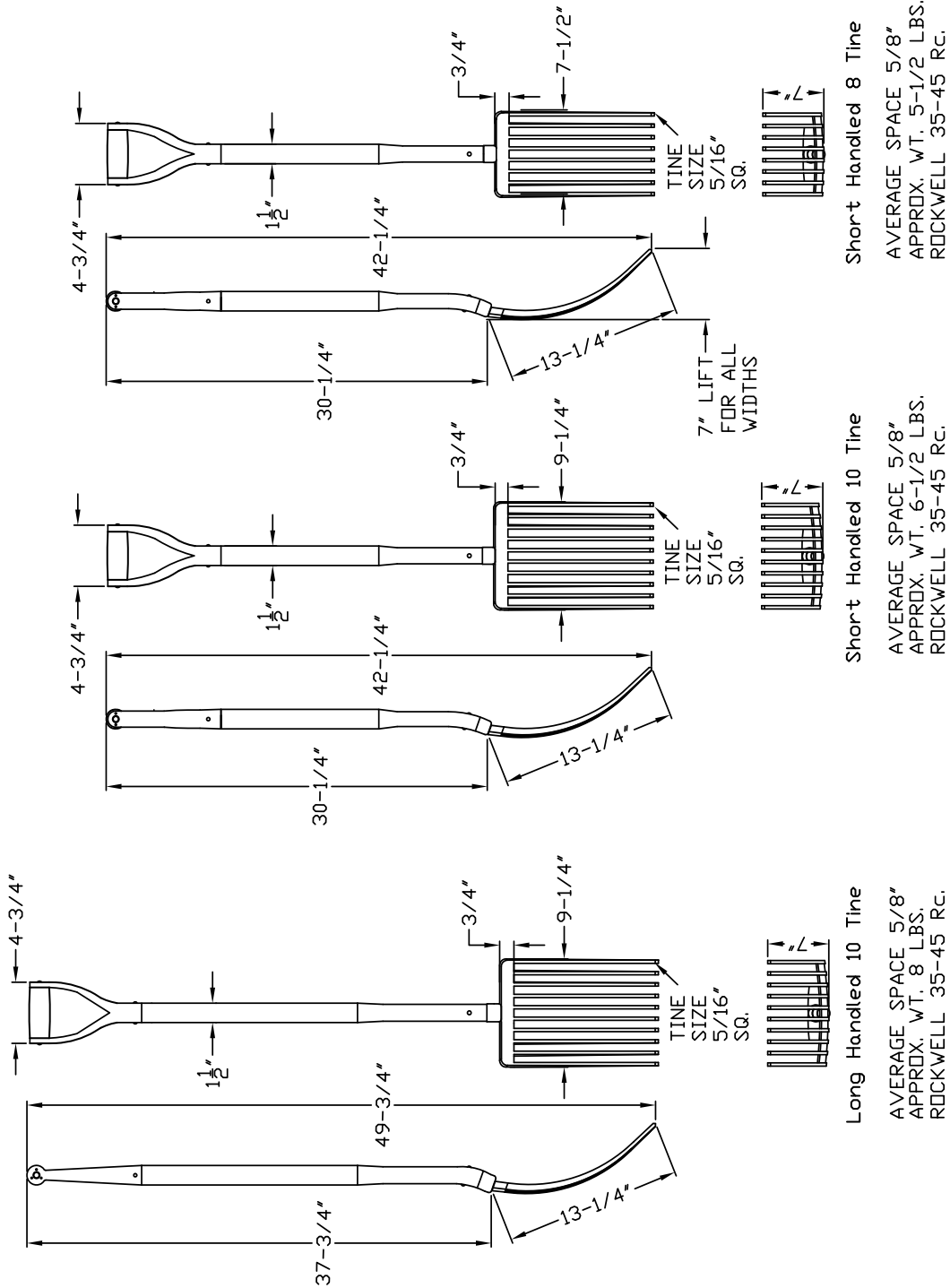


Figure 5-6-23. Plan 22-08 – AREMA Ballast Fork

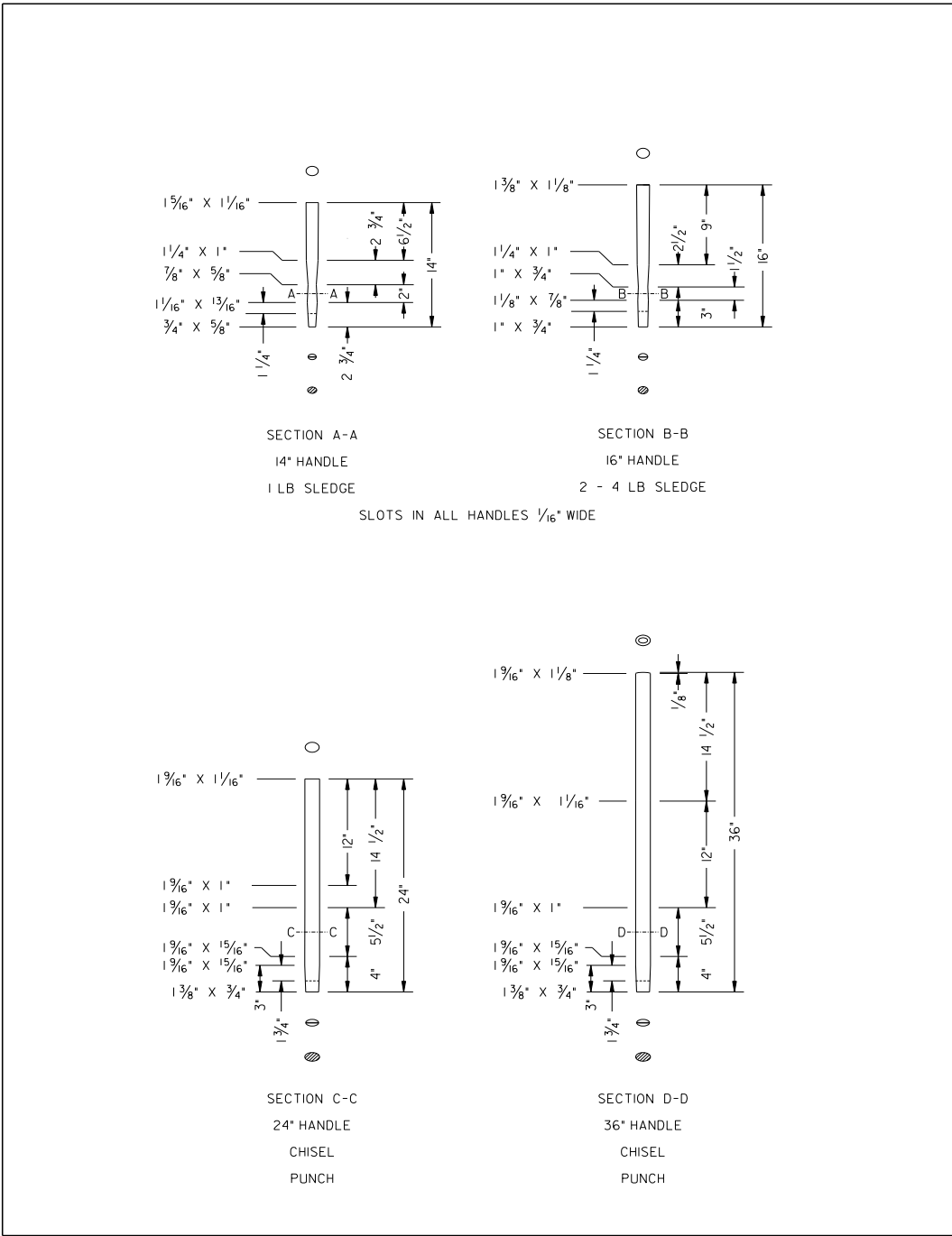


Figure 5-6-24. Plan 25-03 – AREMA Track Tool Handles

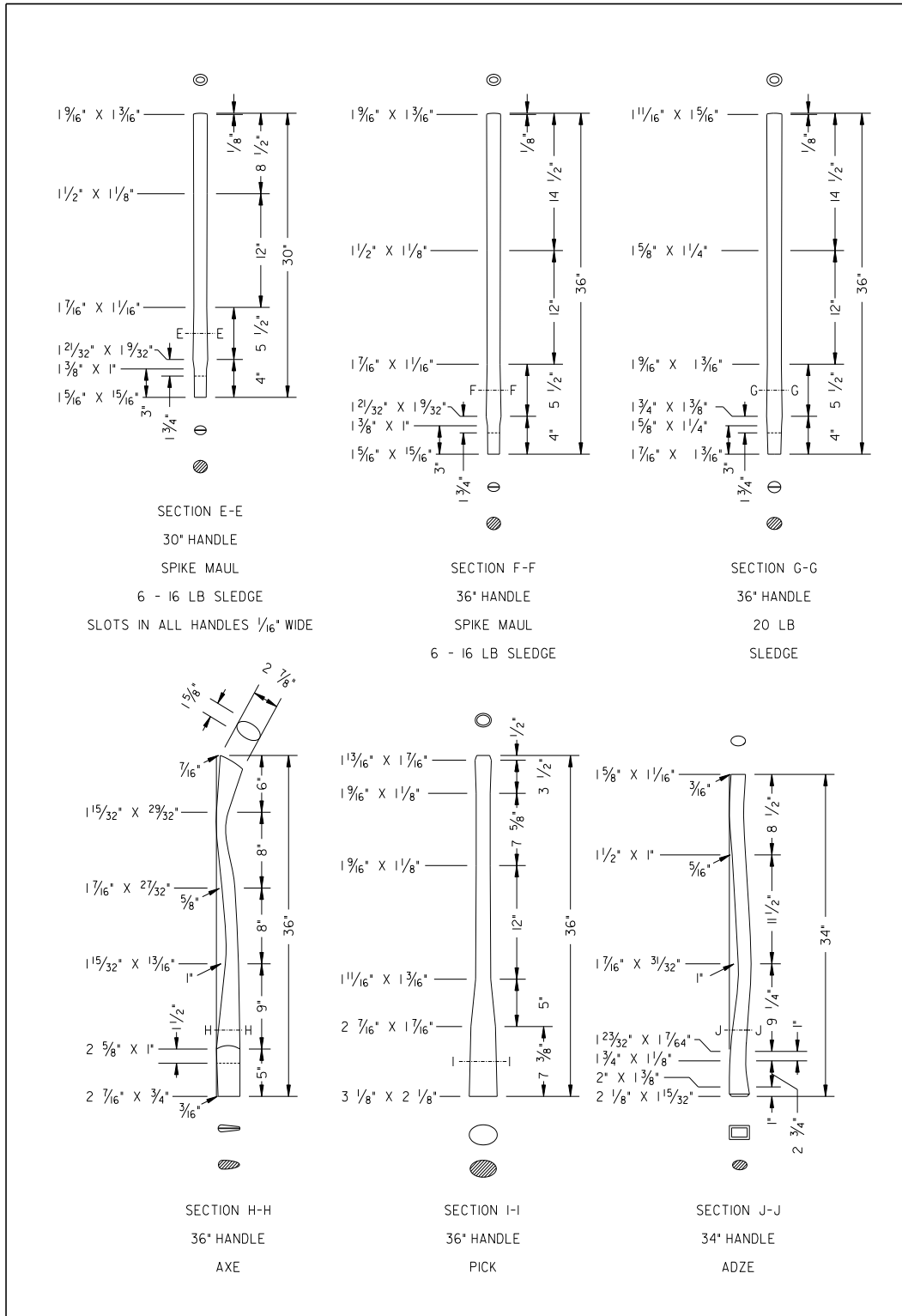


Figure 5-6-24A. Plan 25A-03 – AREMA Track Tool Handles

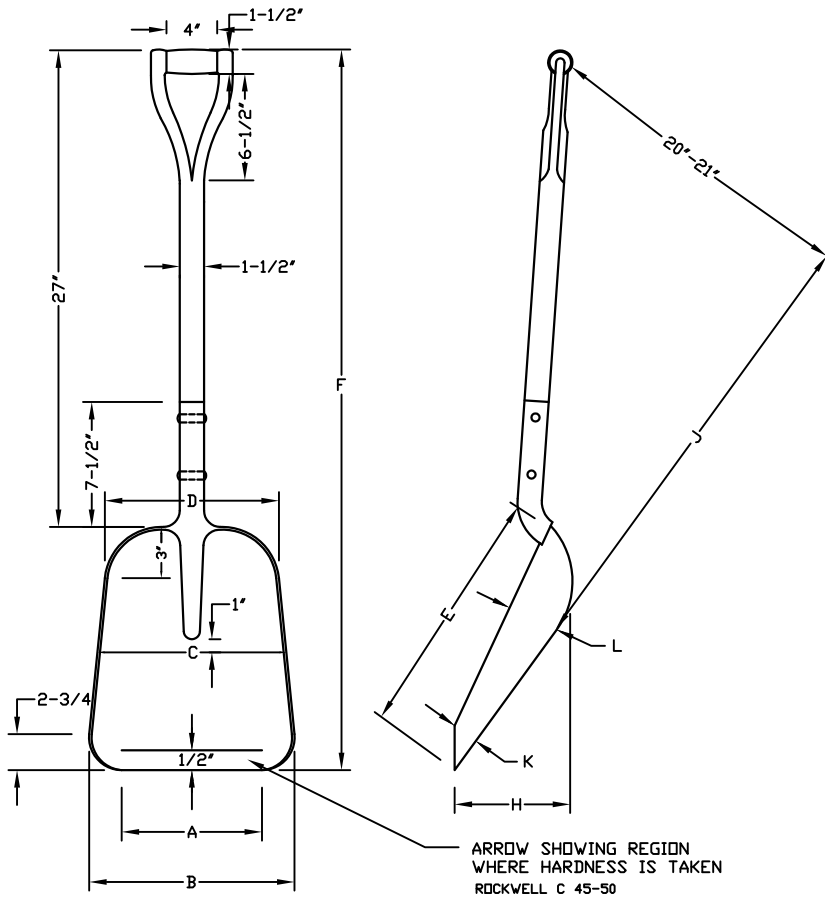


TABLE OF DIMENSIONS- SIZES No 2, 4 AND 6

SIZE	A	B	C	D	E	F	H	J	K	L
2	10-1/2	11-3/4	11	9	15	40-3/4	7	35	1-3/8	3-3/8
4	11	12	11-1/4	9-1/4	16	41-3/4	7-3/8	36	1-5/8	3-5/8
6	11-1/2	12-1/4	11-1/2	9-1/2	17	42-3/4	7-5/8	37	1-7/8	3-7/8

TOLERANCE + OR - 1/4"

Figure 5-6-25. Plan 26-08 – AREMA Scoop

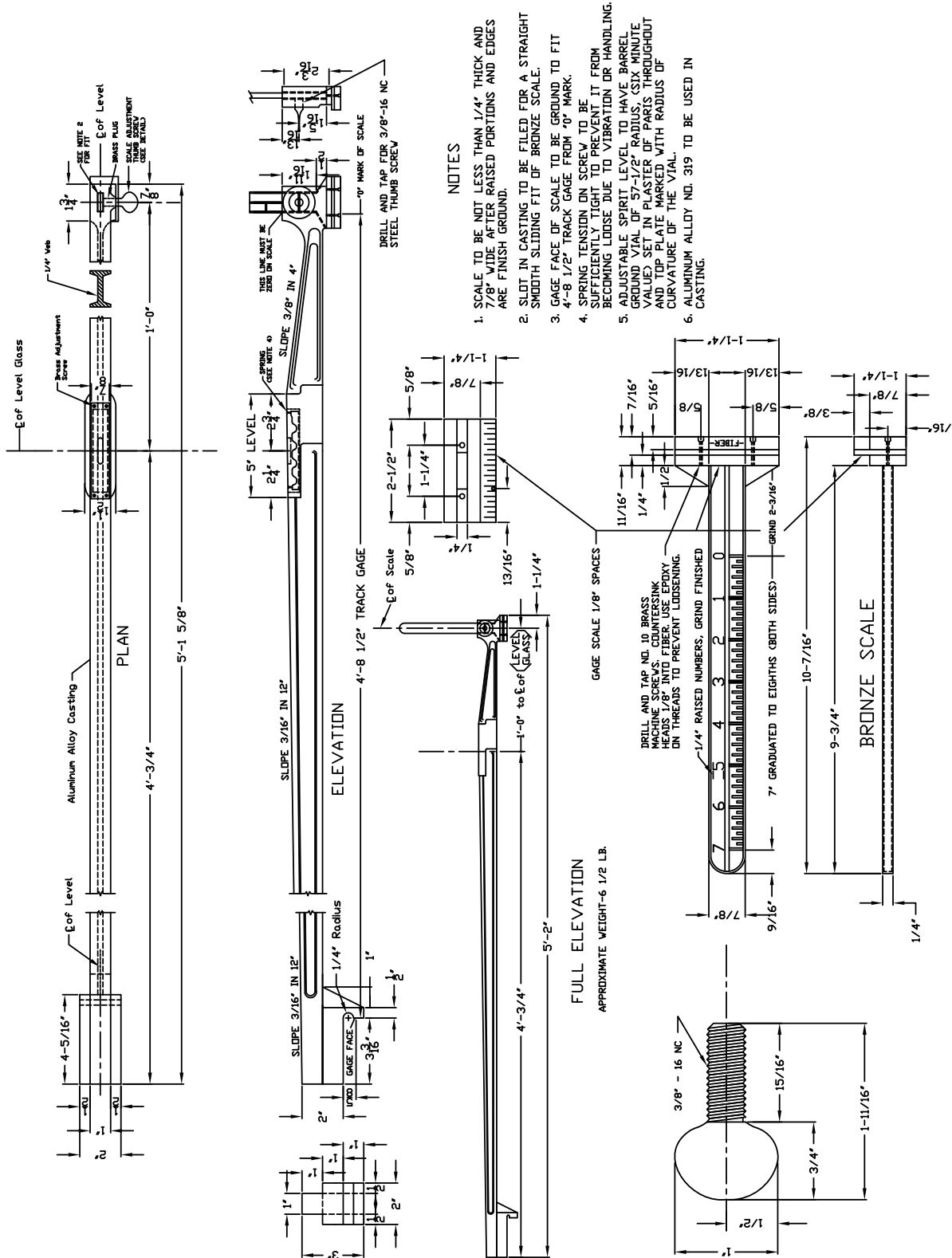
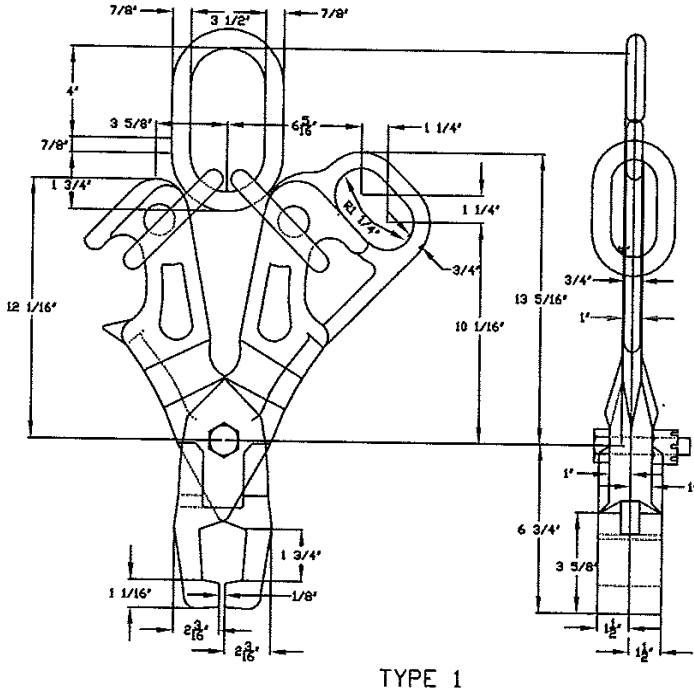
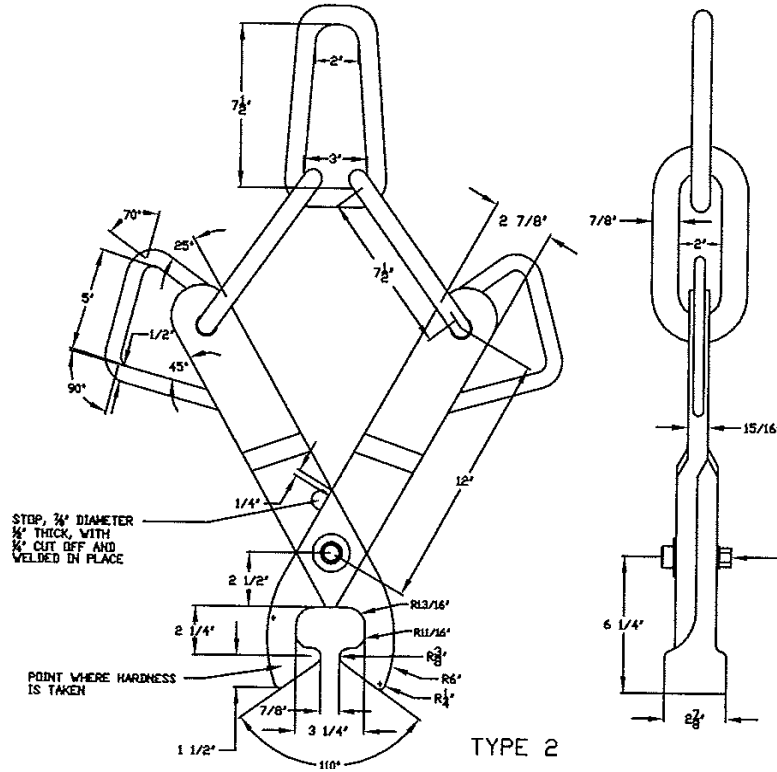


Figure 5-6-26. Plan 27-08 – AREMA Aluminum Combination Track Level and Gage (Insulated)



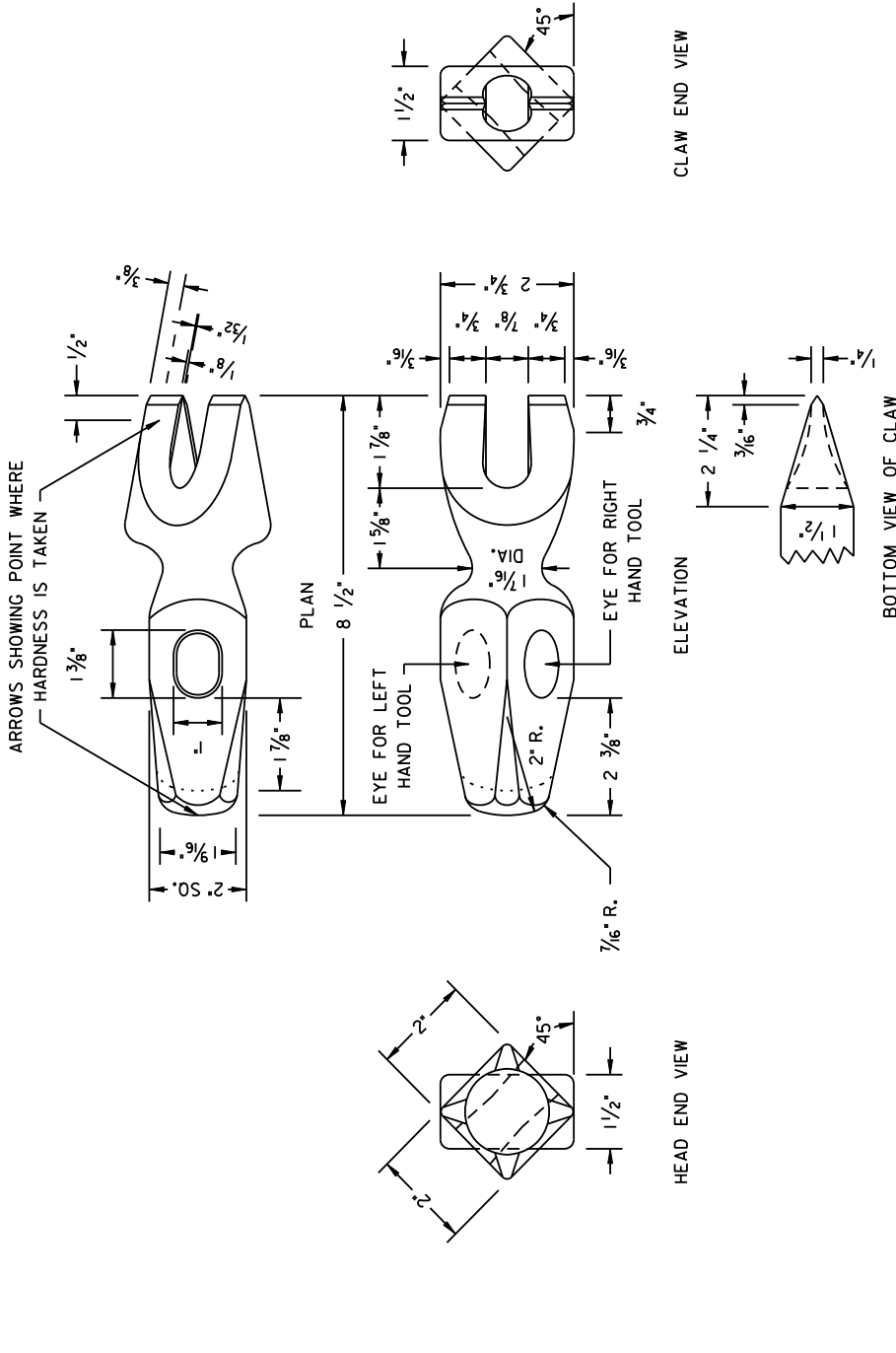
- NOTES
1. MATERIAL - HEAT TREATED ALLOY STEEL
 2. LIFTING RING - 7/8" DIAMETER BAR, MILD STEEL
 3. OBLONG LINK - 7/8" DIAMETER BAR, MILD STEEL
 4. JAW SPREAD - APPROXIMATELY 6 3/4"
 5. LIFTING CAPACITY - 3TON MAX TO BE STAMPED ON TONGS.
 6. APPROXIMATE WEIGHT - 56 POUNDS



- NOTES
1. MATERIAL - 4140 STEEL
 2. MASTER LINK - 7/8" DIAMETER
 3. CONNECTING LINKS - 7/8" DIAMETER
 4. HANDLE - 1/2" DIAMETER MILD STEEL WELDED TO ARM
 5. JAW SPREAD - 6 3/4" MINIMUM
 6. HARDNESS - 34/40 ROCKWELL C
 7. LIFTING CAPACITY - 3 TON MAX TO BE STAMPED ON TONGS.
 8. APPROXIMATE WEIGHT 40 POUNDS

- 1- 1" SHOULDER BOLT X 2" LONG
- 1- 1" WASHER
- 1- 3/4" WASHER
- 1- 3/4" NUT TACK WELDED TO BOLT

Figure 5-6-27. Plan 31-12 – AREMA Rail Tongs for Use with Cranes



- NOTE:
1. TOLERANCE -
 - 2 7/8" ON LENGTH
 - 5 7/8" ON CROSS SECTION
 2. EYE TAPERED TO CENTER -
 - 4 DEGREES ON LONG DIAMETER
 - 3 DEGREES ON SHORT DIAMETER
 3. FURNISH IN GRADE B ALLOY STEEL.
 4. ROCKWELL C - CLAW AND HEAD 44/48
 5. CONTOUR GRIND HEAD PER AREA PLANS A, B, AND D.
 6. DASHED LINES INDICATE OUTLINE (MINIMUM) OF TOOLS AS RECLAIMED.
 7. APPROXIMATE WEIGHT 6 POUNDS, 5 OUNCES.
 8. HAND OF TOOL. DRAWING IS FOR A RIGHT HAND TOOL. THE CLAW OPENING IS TO THE RIGHT FOR A TOOL IN THE WORKING POSITION. WHEN SPECIFIED BY PURCHASER, THE EYE MAY BE PLACED IN OPPOSITE FACE FOR A LEFT HAND TOOL. THE CLAW OPENING IS TO THE LEFT FOR A TOOL IN THE WORKING POSITION.

Figure 5-6-28. Plan 32-08 – AREMA Track Spike Lifter

1. THERMOMETER SHALL HAVE A SUITABLE WEATHER RESISTANT CASE BETWEEN 1 1/2" AND 3" IN DIAMETER, AND BETWEEN 3/8" AND 3/4" IN THICKNESS.
2. THERMOMETER SHALL HAVE A BREAK RESISTANT LENS.
3. THERMOMETER SHALL HAVE A BLACK TEMPERATURE SCALE WITH BLACK NUMERALS, A RED INDICATOR HAND AND A CONTRASTING FACE. NUMERALS SHALL BE AS LARGE AS POSSIBLE FOR EASY READABILITY. SCALE GRADUATIONS WILL BE IN 2 DEGREE INCREMENTS AND 10 DEGREE MARKED INTERVALS.
4. THERMOMETER SHALL HAVE A BI-METALLIC SENSING ELEMENT PRE-CONDITIONED AND TESTED FOR PERMANENT CALIBRATION FOR ACCURACY TO WITHIN PLUS OR MINUS OF 2 % OF FULL SCALE RANGE.
5. THERMOMETER SENSING ELEMENT SHALL REACH SENSING EQUILIBRIUM WITHIN 3 MINUTES.
6. THERMOMETER SHALL HAVE A MAGNET OR MAGNETS ON THE BACK SIDE OF CASE STRONG ENOUGH TO SUSTAIN ITS OWN WEIGHT IN ANY POSITION.
7. CORNERS OF THE THERMOMETER CASE TO BE ROUNDED WHERE PRACTICABLE.

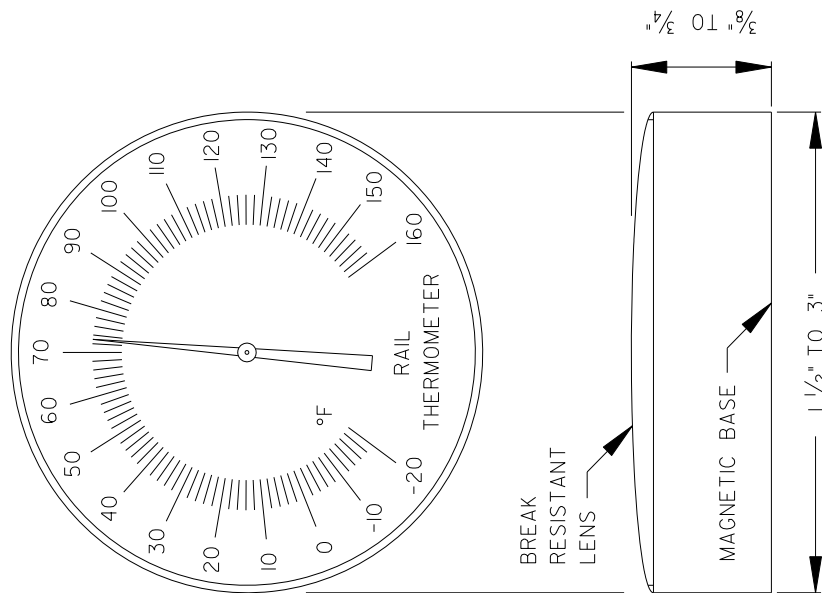
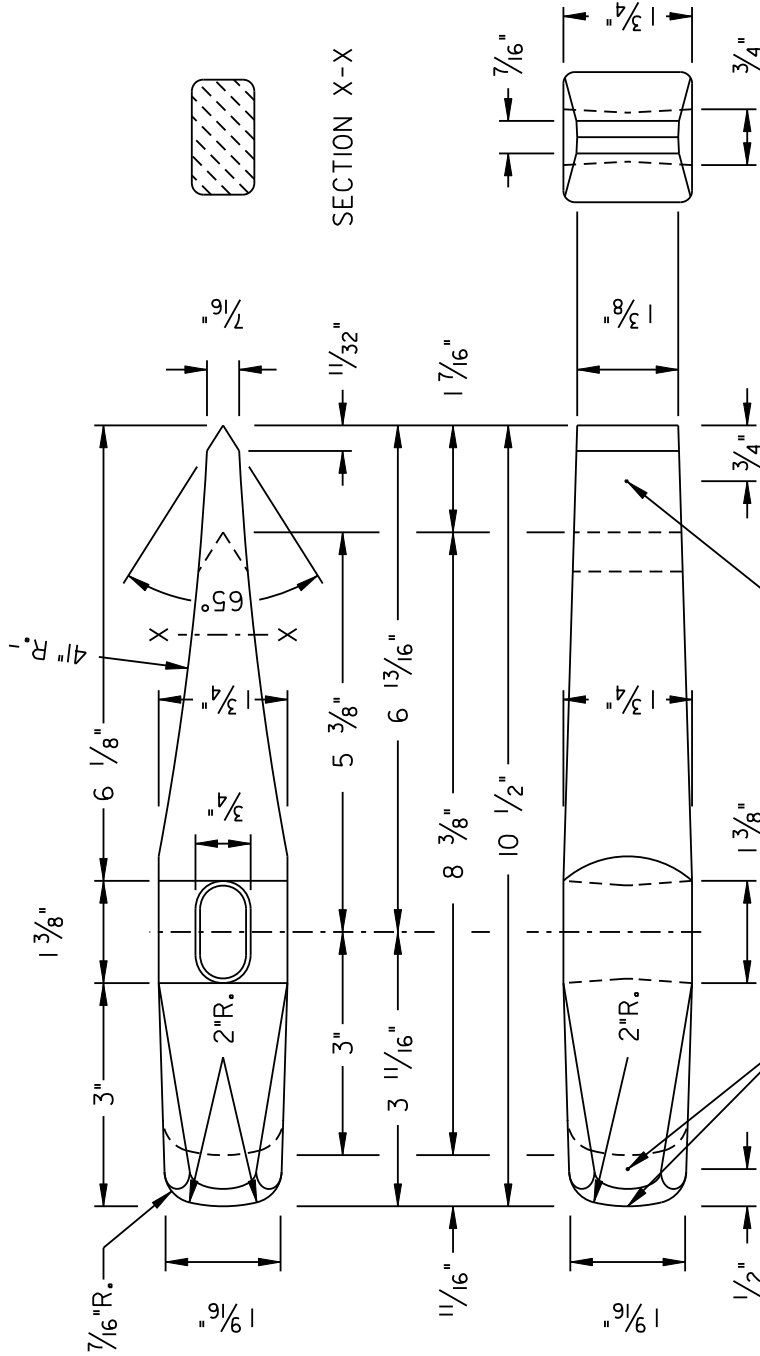


Figure 5-6-29. Plan 34-02 – AREMA Rail Thermometer

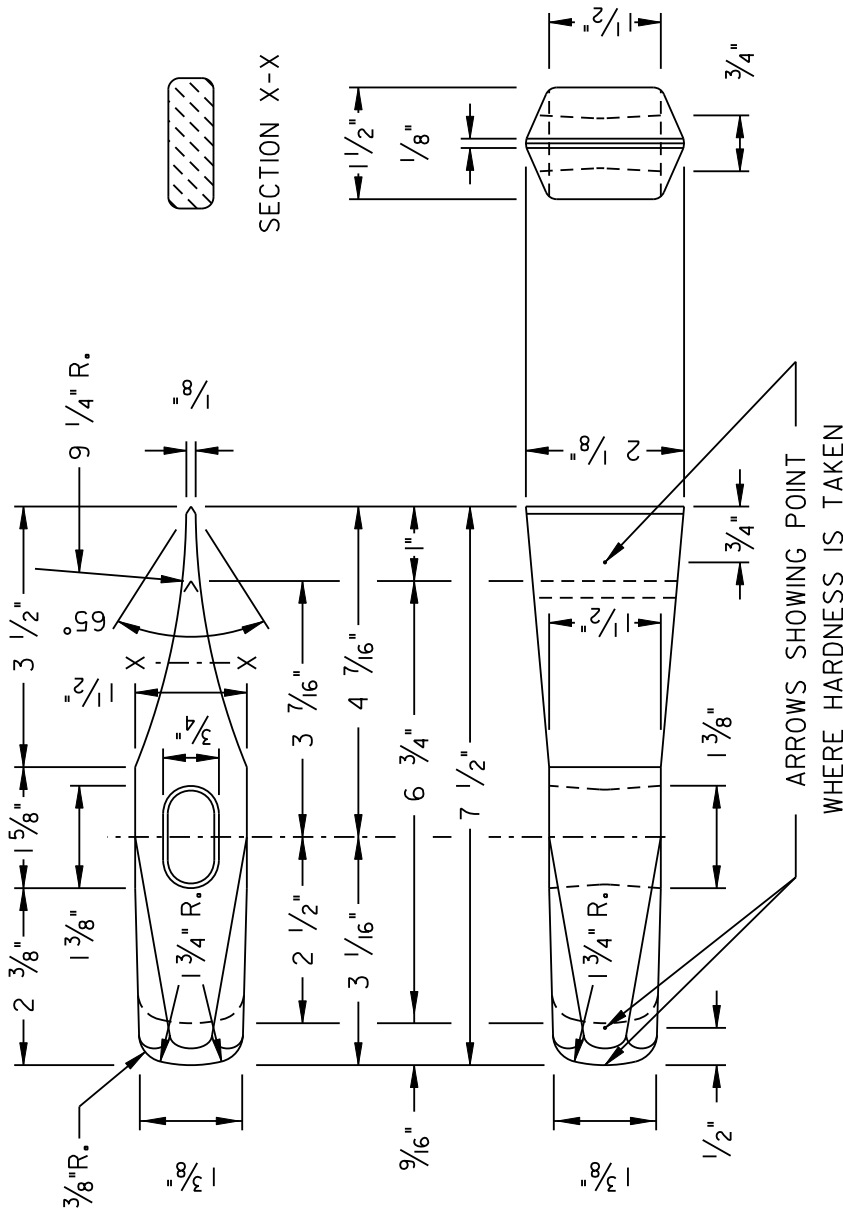


ARROWS SHOWING POINT WHERE HARDNESS IS TAKEN

NOTE:

1. TOLERANCE -
2 % ON LENGTH
5 % ON CROSS SECTION
2. EYE TAPERED TO CENTER -
4 DEGREES ON LONG DIAMETER
3 DEGREES ON SHORT DIAMETER
3. FURNISH IN GRADE B ALLOY STEEL.
4. ROCKWELL C -
POINT 56/60
HEAD 44/48
5. CONTOUR GRIND HEAD PER AREMA PLANS A, C, AND D.
6. DASHED LINES INDICATE OUTLINE (MINIMUM) OF TOOLS AS RECLAIMED.
7. APPROXIMATE WEIGHT 5 1/2 POUNDS.

Figure 5-6-30. Plan 35-08 – AREMA Nut Cutter



- NOTE:
1. TOLERANCE -
 - 2 % ON LENGTH
 - 5 % ON CROSS SECTION
 2. EYE TAPERED TO CENTER -
 - 4 DEGREES ON LONG DIAMETER
 - 3 DEGREES ON SHORT DIAMETER
 3. FURNISH IN GRADE B ALLOY STEEL.
 4. ROCKWELL C -
 - POINT 56/60
 - HEAD 44/48
 5. CONTOUR GRIND HEAD PER AREMA PLANS A, C, AND D.
 6. DASHED LINES INDICATE OUTLINE (MINIMUM) OF TOOLS AS RECLAIMED.
 7. APPROXIMATE WEIGHT 3 POUNDS.

Figure 5-6-31. Plan 36-08 – AREMA 3 Pound Hot Cutter

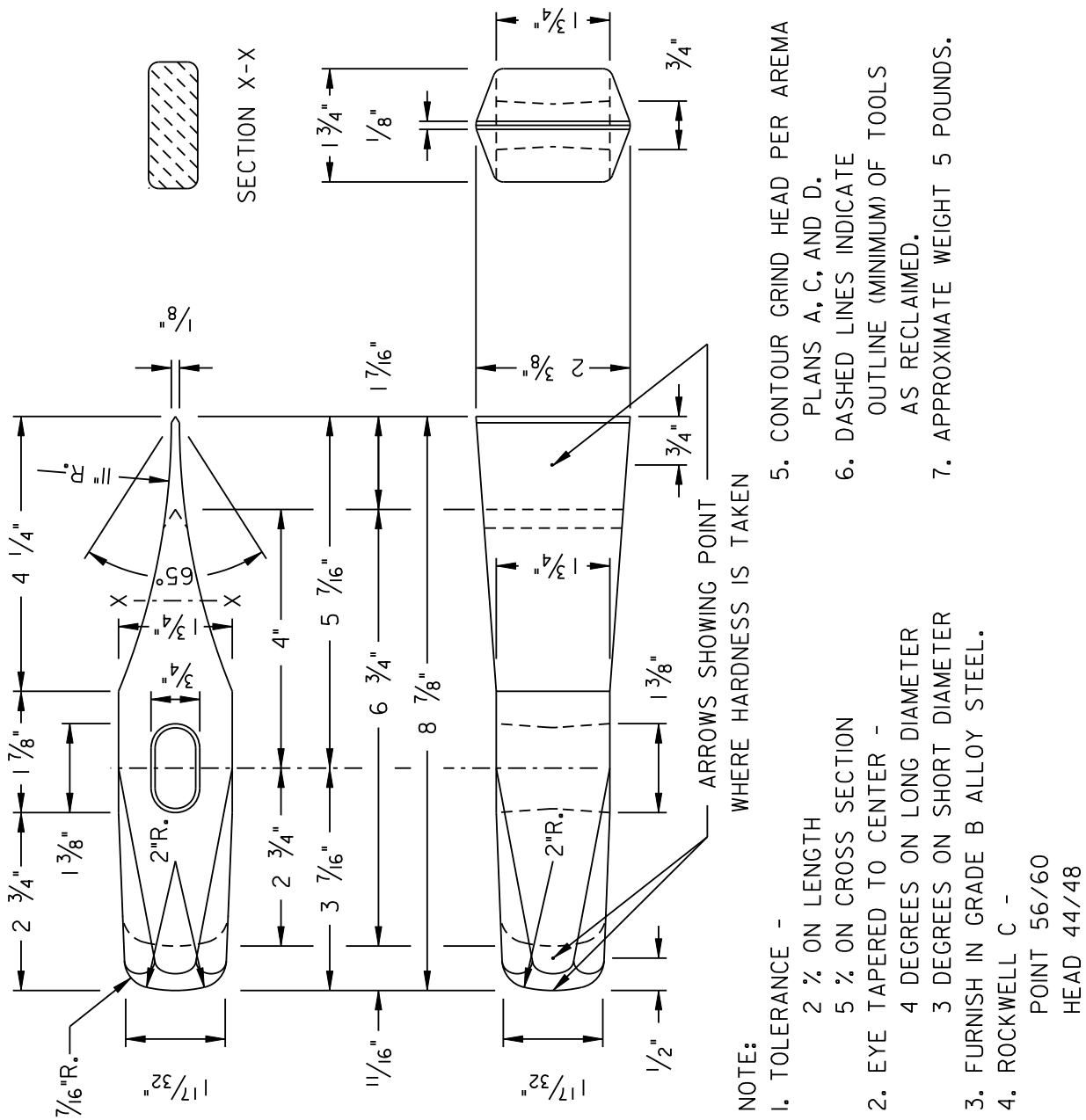
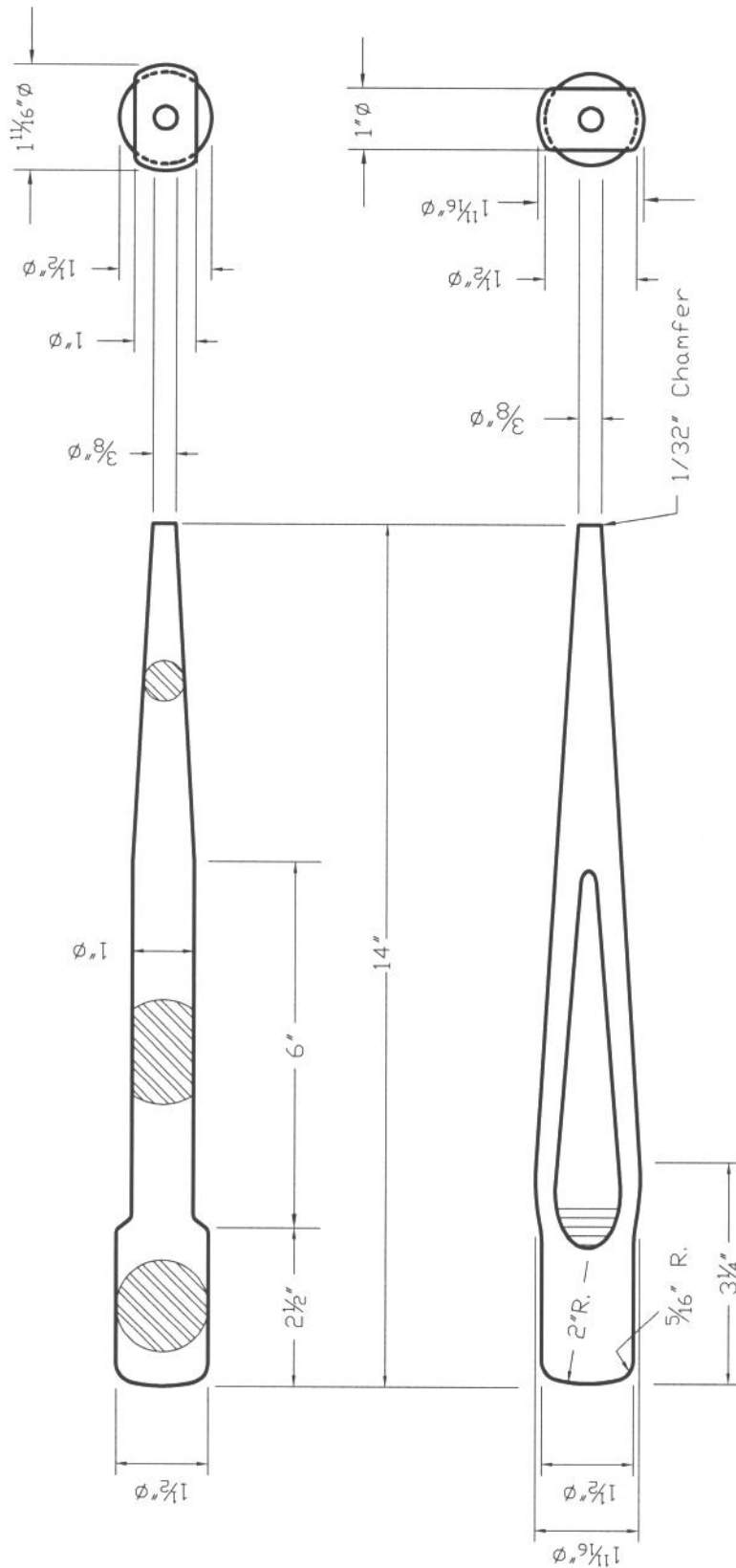
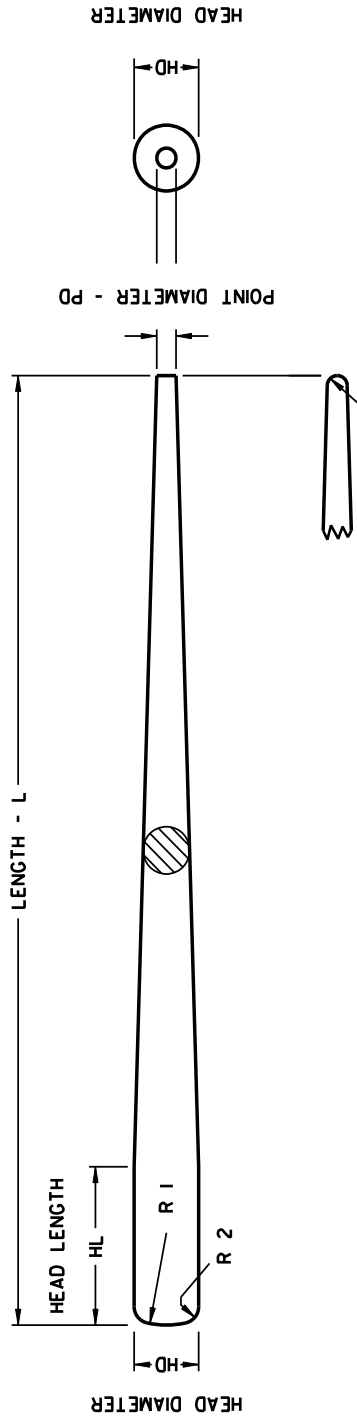


Figure 5-6-32. Plan 37-08 – AREMA 5 Pound Hot Cutter



- NOTES:
1. TOLERANCE -
2% ON LENGTH
5% ON CROSS SECTION
 2. TOOL TO BE FURNISHED IN
9260 (GRADE B) OR EN30B
 3. HARDNESS, ROCKWELL C - 32 / 37.
 4. CONTOUR HEAD PER AREMA
PLANS A-03, C-83, AND D-83.

Figure 5-6-33. Plan 38-06 – AREMA - Drift Pin (Short)

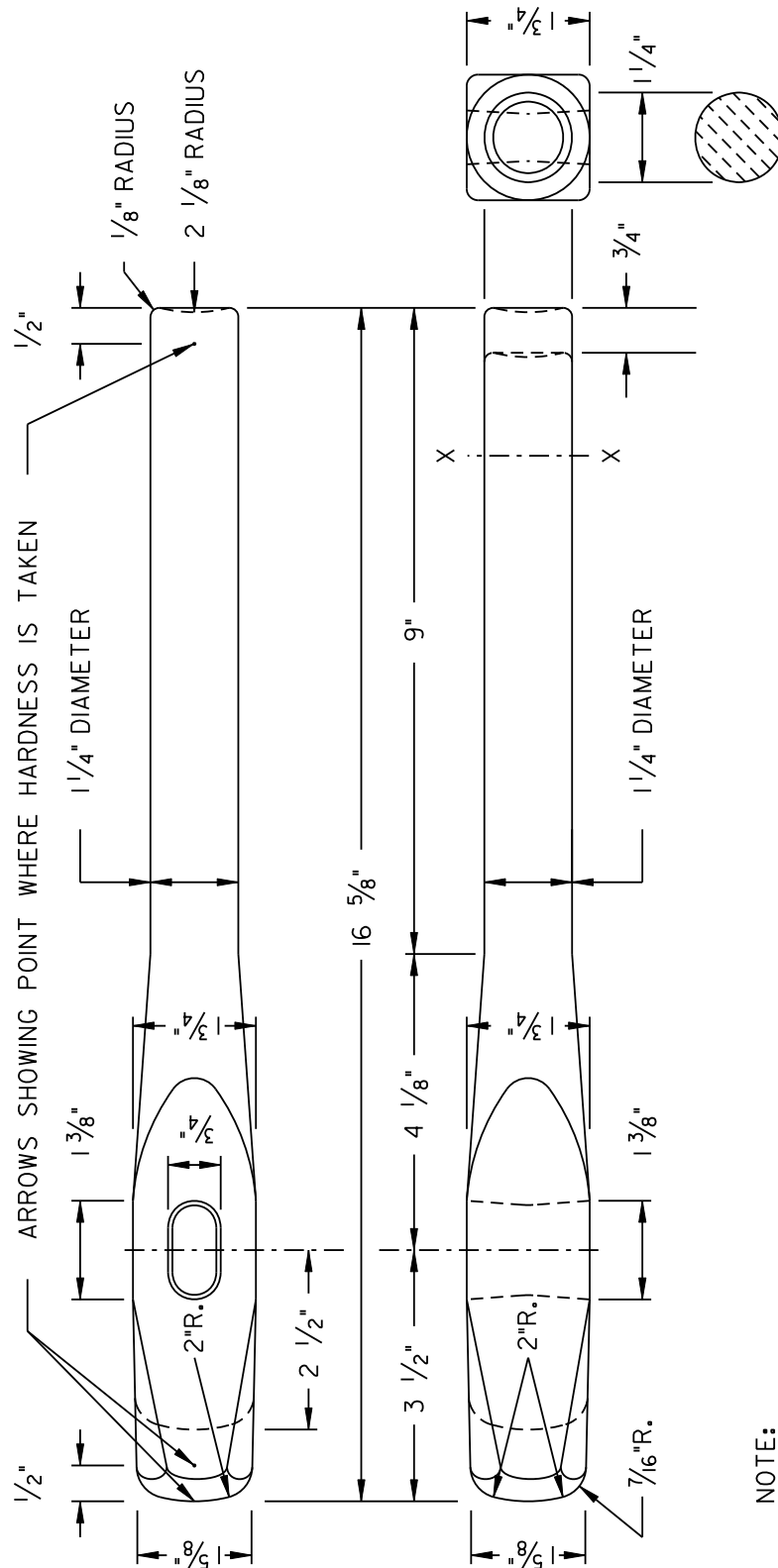


ALTERNATE POINT DETAIL
TO BE FURNISHED WHEN A POINT
RADIUS IS SPECIFIED IN THE TABLE
OF DIMENSIONS

- NOTES:
1. TOLERANCE -
2 1/2% ON LENGTH
5% ON CROSS SECTION
 2. TOOL TO BE FURNISHED IN
ALLOY STEEL
9260 GRADE B OR
EN30 B
 3. ROCKWELL C - SEE TABLE
 4. CONTOUR GRIND HEAD PER AREA
PLANS A, C, AND D.

LENGTH L	HEAD LENGTH HL	HEAD DIAMETER HD	CENTER RADIUS R 1	CORNER RADIUS R 2	POINT DIAMETER PD	POINT RADIUS R 3	OVERALL ROCKWELL HARDNESS
18"	3"	1 1/4"	1 3/4"	5/16"	3/8"	NONE	32/37
19"	3"	1 1/2"	2"	5/16"	3/8"	3/16"	32/37
26"	2"	1 1/2"	2"	5/16"	7/8"	NONE	32/37
26"	2"	2"	2"	5/16"	7/8"	NONE	32/37

Figure 5-6-34. Plan 39-09 – AREMA - Drift Pins (Long)



- NOTE:
1. TOLERANCE -
 - 2 % ON LENGTH
 - 5 % ON CROSS SECTION
 2. EYE TAPERED TO CENTER -
 - 4 DEGREES ON LONG DIAMETER
 - 3 DEGREES ON SHORT DIAMETER
 3. TOOL TO BE FURNISHED IN GRADE B ALLOY STEEL.
 4. ROCKWELL C - POINT 52/56 HEAD 44/48
 5. CONTOUR GRIND HEAD PER AREMA PLANS A, C, AND D.
 6. DASHED LINES INDICATE OUTLINE (MINIMUM) OF TOOLS AS RECLAIMED.
 7. APPROXIMATE WEIGHT 6 POUNDS.

Figure 5-6-35. Plan 41-08 – AREMA Spiking Tool

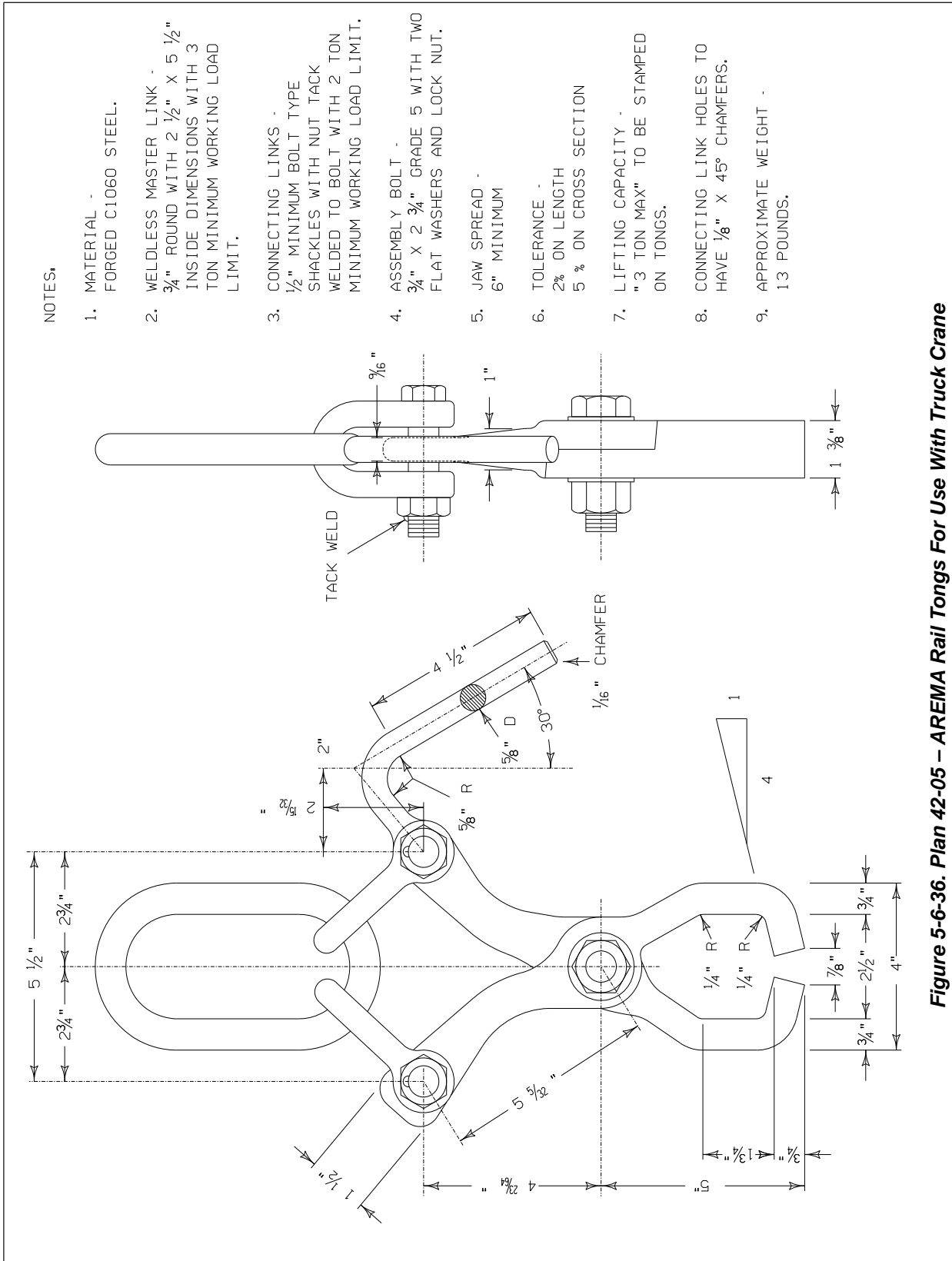


Figure 5-6-36. Plan 42-05 – AREMA Rail Tongs For Use With Truck Crane

1. WIDTH OF NUT SHALL BE STAMPED PLAINLY IN 3/4" CHARACTERS ON TOP SIDE OF HEAD NEAR THE JAW.
2. TOLERANCE - 2% ON LENGTH
5% ON CROSS SECTION
3. ROUND CORNERS AT WRENCH END TO 1/16" RADIUS.

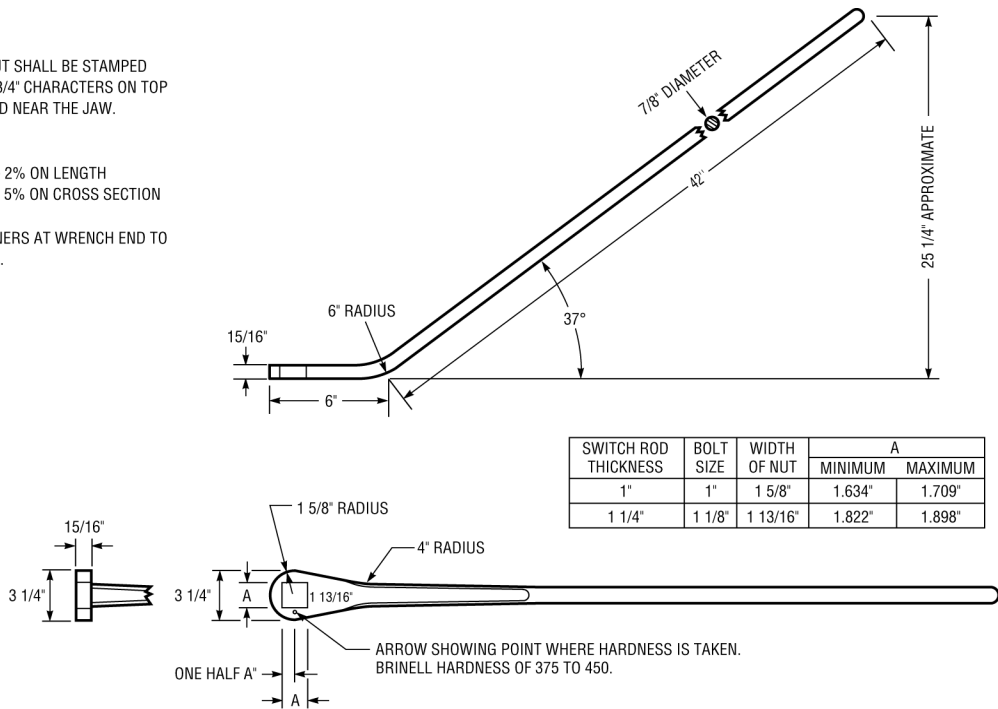
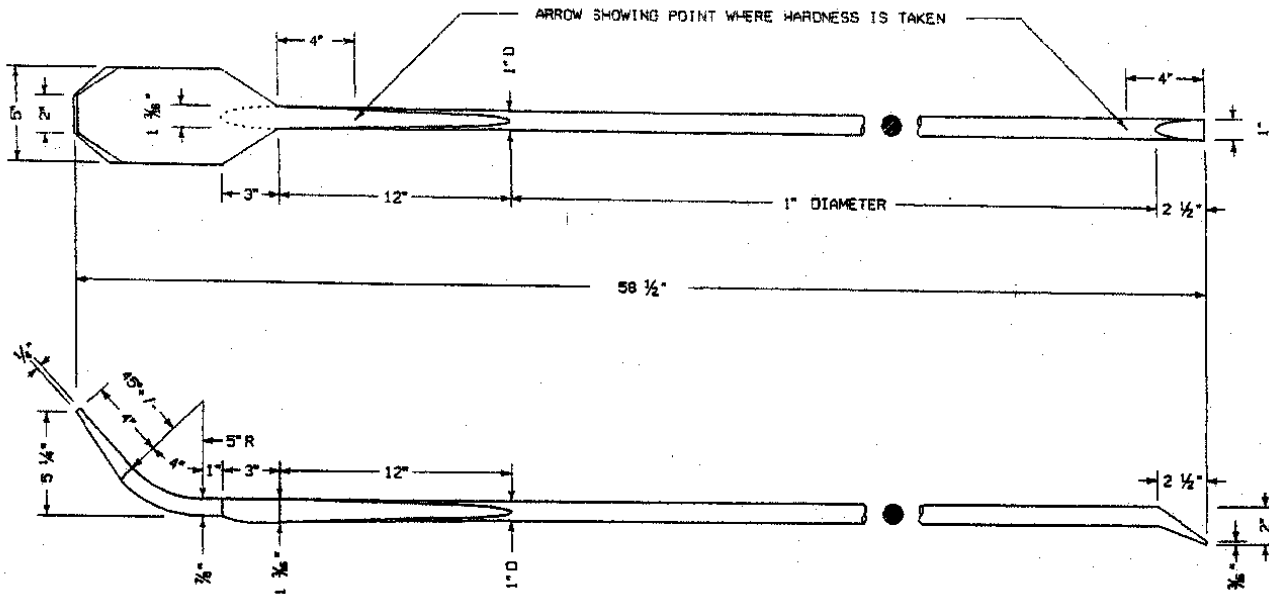


Figure 5-6-37. Plan 43-97 – AREMA Switch Clip Wrench



NOTE:

1. FURNISH IN AREMA CARBON STEEL
2. TOLERANCE: 2% ON LENGTH
5% ON CROSS SECTION
3. HARDNESS: BRINELL 300 - 375
4. APPROXIMATE WEIGHT: 21 POUNDS

Figure 5-6-38. Plan 44-97 – AREMA Nipping Bar

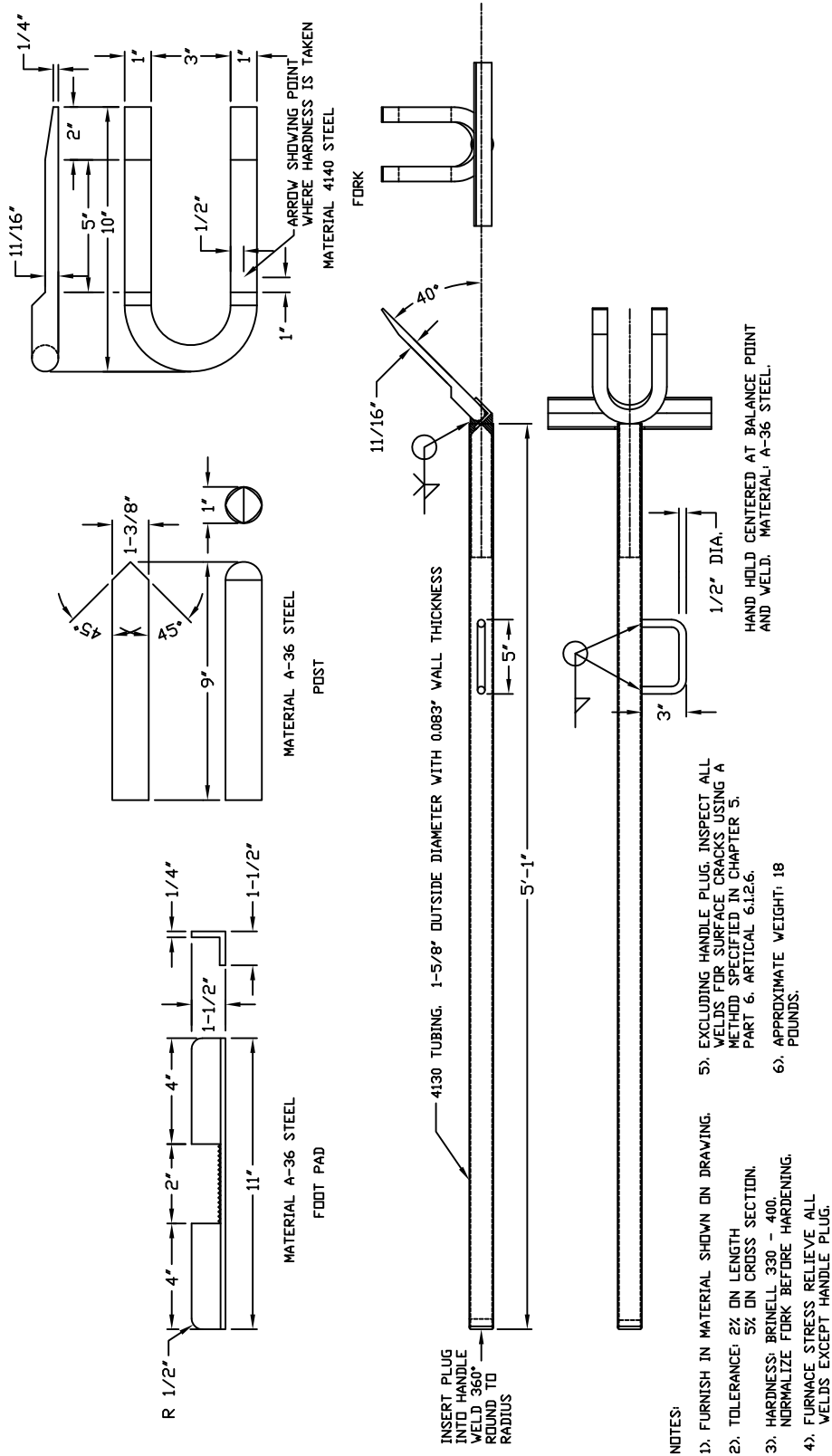


Figure 5-6-39. Plan 45-09 - AREMA Nipping Fork

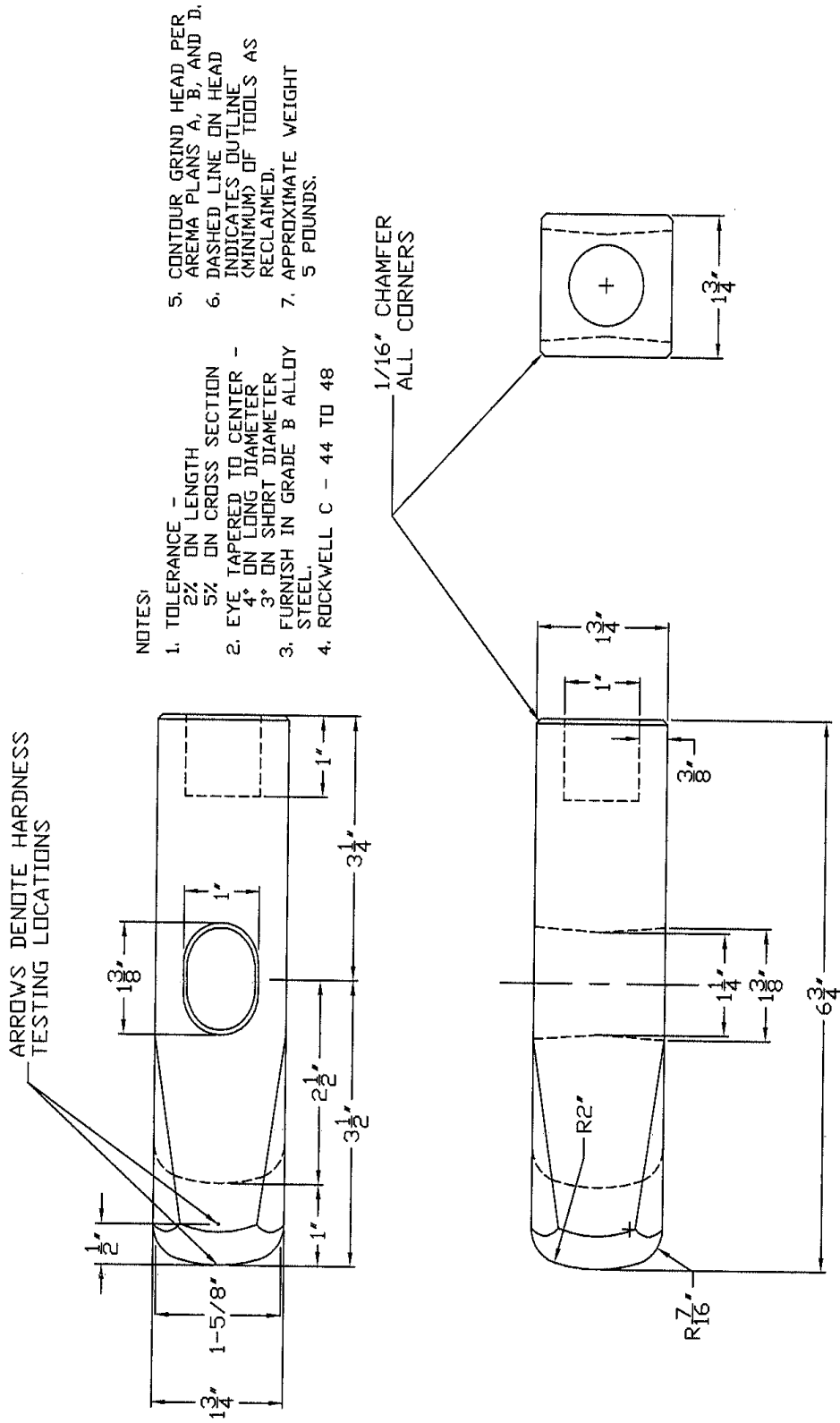


Figure 5-6-40. Plan 46-11 - AREMA Drift Pin Remover

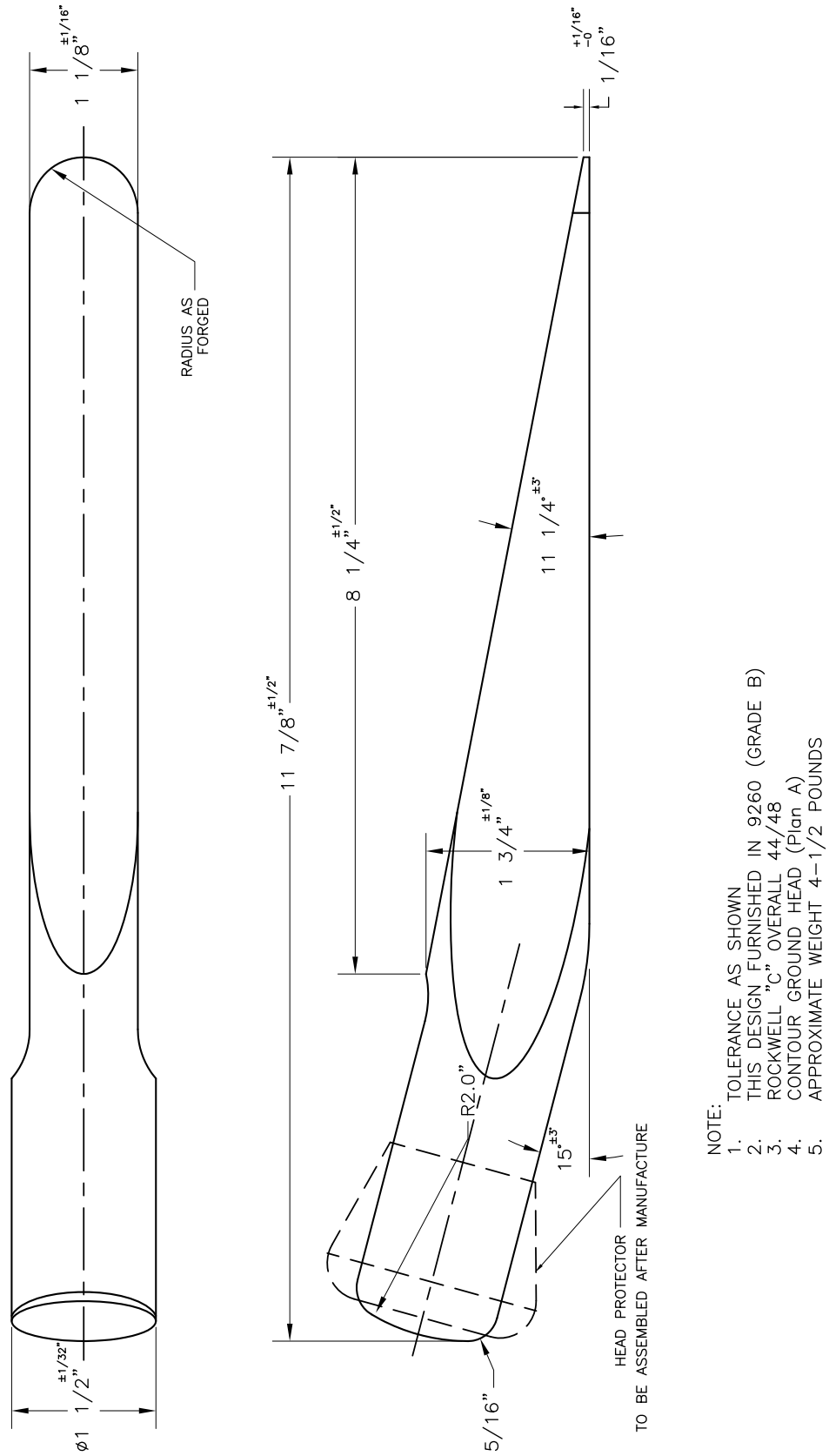
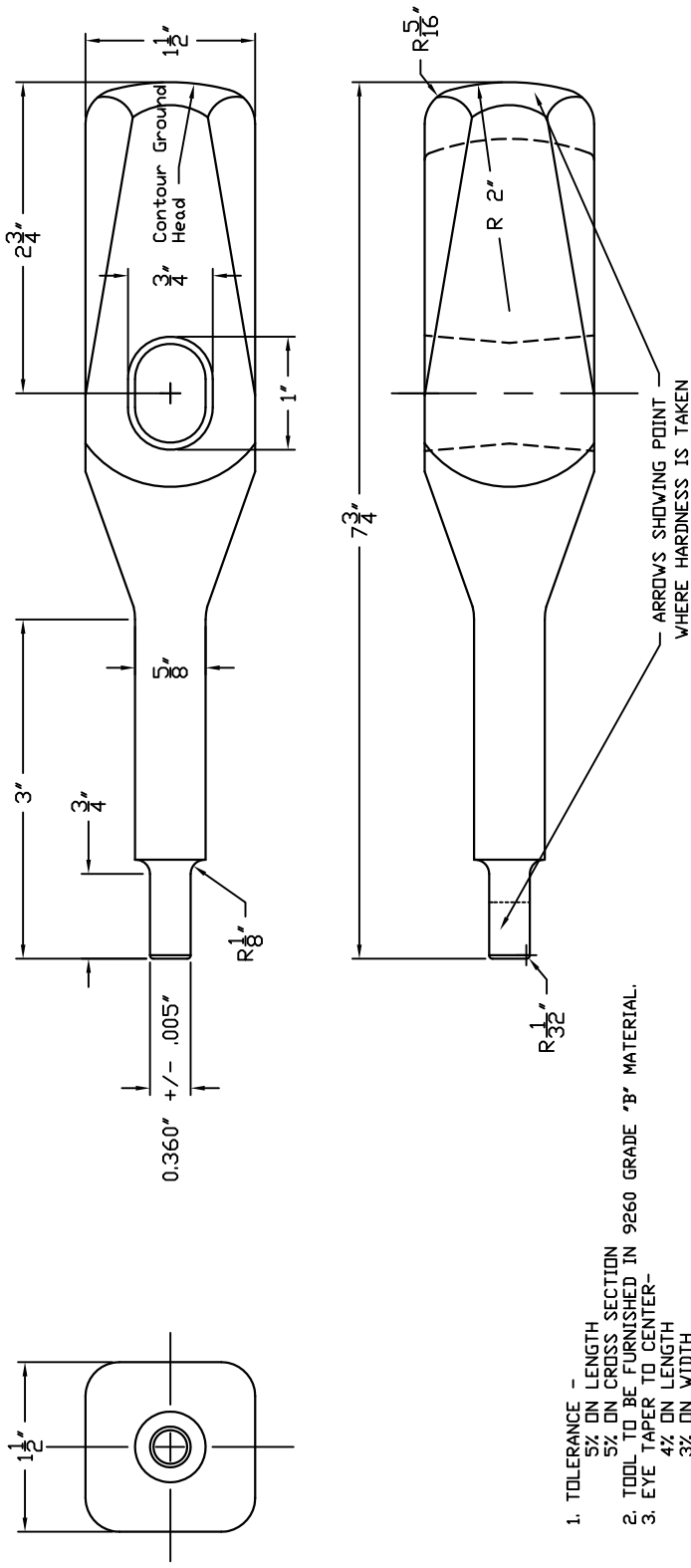


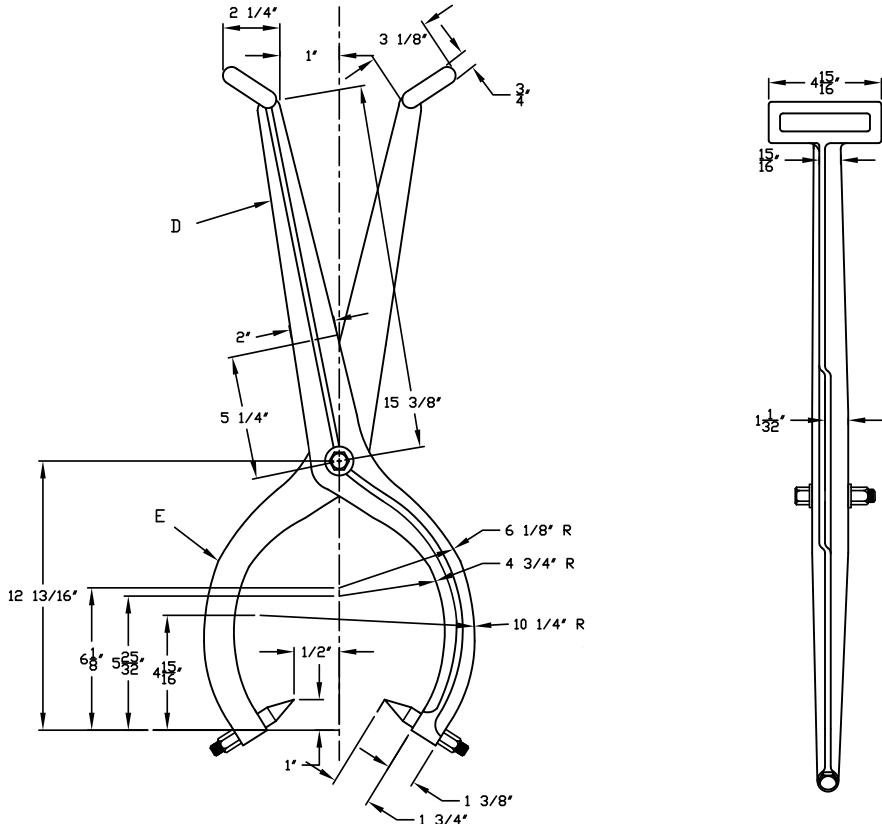
Figure 5-6-41. Plan 47-08 - AREMA Offset Wedge



1. TOLERANCE -
5% ON LENGTH
5% ON CROSS SECTION
2. TOOL TO BE FURNISHED IN 9260 GRADE "B" MATERIAL.
3. EYE TAPER TO CENTER -
4% ON LENGTH
3% ON WIDTH
4. ROCKWELL C -
POINT 48/52 RC
HEAD 44/48 RC
5. CONTOUR GRIND HEAD PER AREMA
PLANS A, C, AND D.
6. DASHED LINES INDICATE OUTLINE (MINIMUM) OF TOOLS
AS RECLAIMED
7. APPROXIMATE WEIGHT 5-1/2 POUNDS.

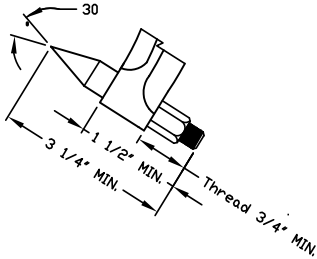
Figure 5-6-42. Plan 48-09 AREMA Plug Bond Backout Punch

MAXIMUM SPREAD APPROXIMATELY 26-1/2"



NOTES:

- A). TONG HALVES MADE OF AA535 ALUMINUM.
- B). POINTS MADE OF MILD STEEL CASE HARDENED & ASSEMBLED WITH 3/8" LOCK NUT.
- C). ASSEMBLED WITH 3/4" X 3-1/2" HEX HEAD GRADE 5 BOLT, 2 WASHERS & LOCK NUT.
- D). MARK IN THIS LOCATION: "LA104", "FOR HAND USE ONLY" AND "YEAR/MONTH" CODE
- E). APPROXIMATE WEIGHT 9 POUNDS



- REPLACEABLE POINT**
- 1). 5/8" SQUARE OR HEXAGON STEEL
 - 2). 3/8"-16 NC THREADS CLASS 2 FIT WITH LOCK NUT CASE HARDEN 0.010" TO 0.015" DEEP 300 TO 350 BRINELL HARDNESS
 - 3). 7/16" DIAMETER HOLE IN TONGS.

Figure 5-6-43. Plan 50-10 AREMA Aluminum Tie Tongs

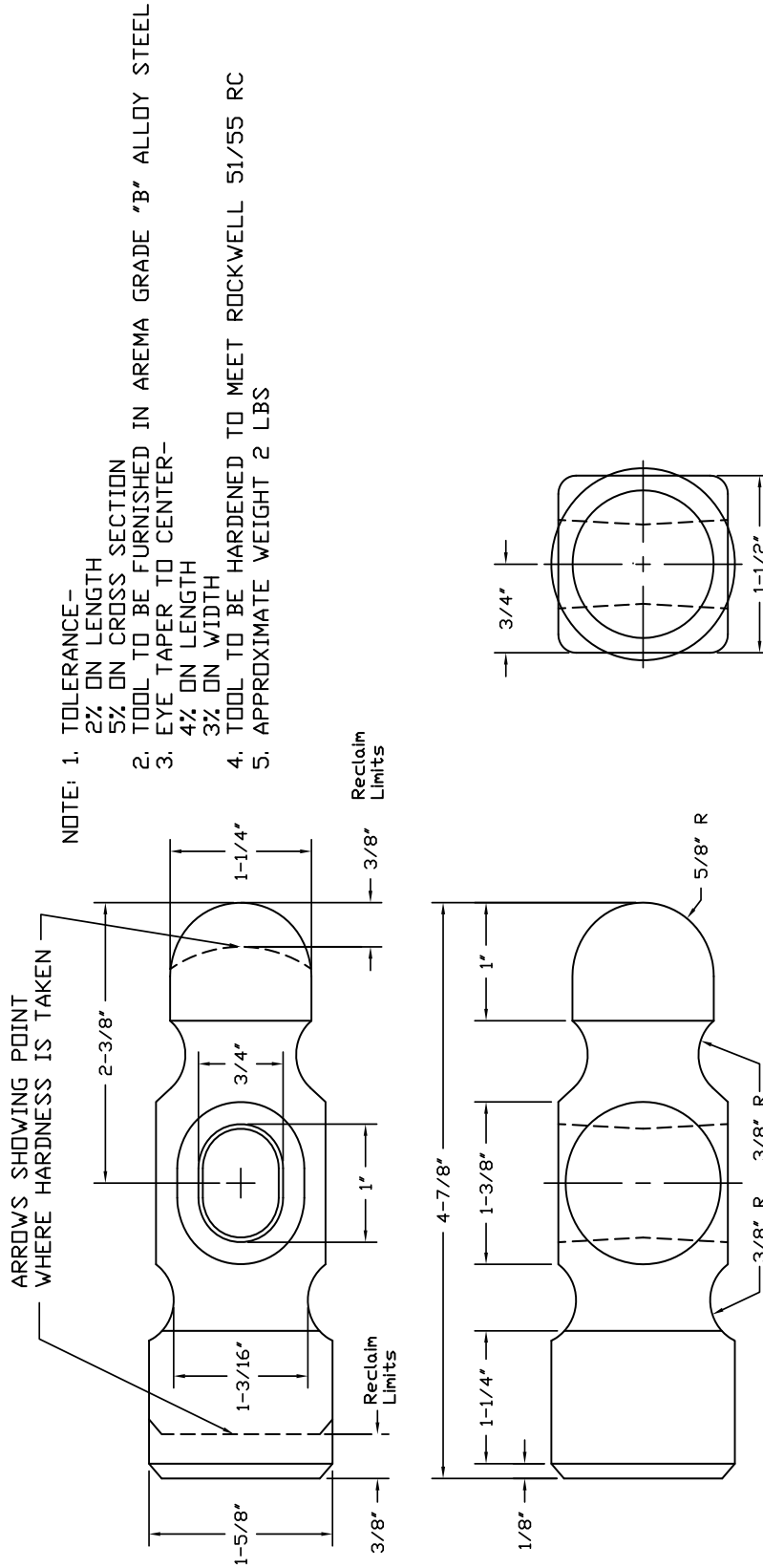


Figure 5-6-44. Plan 51-12 AREMA-Ball Pein Hammer

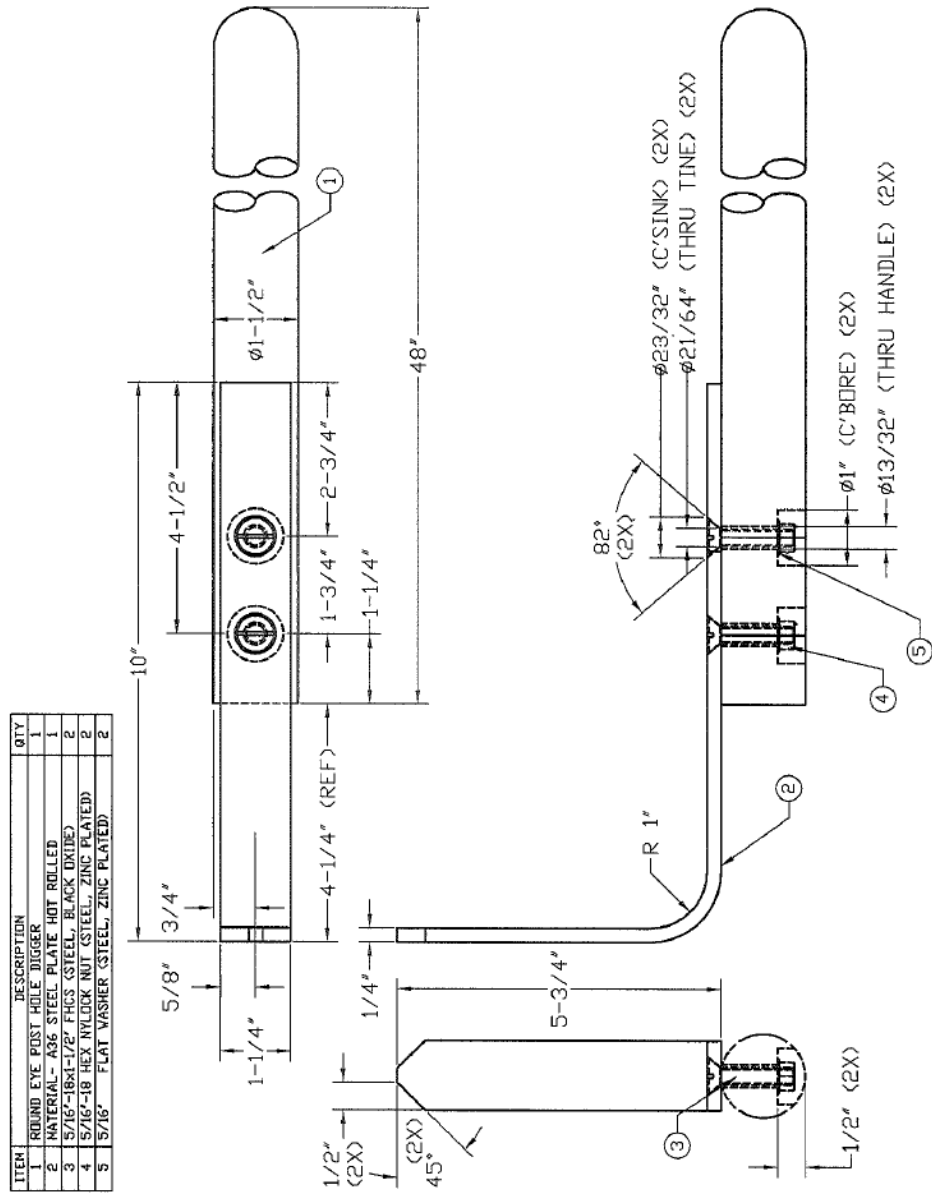


Figure 5-6-45. Plan 52-14 AREMA-Cribbing Tool

6.5.2 HAND TOOL CONTOUR DIMENSIONS (2009)

For the hand tool contour dimensions refer to [Table 5-6-14](#).

Table 5-6-14. Plan A-AREMA Hand Tool Contour Dimensions

Type of Tool	Plan Number	Tool Size	Stock Diameter of Head (See Note 1)	Radius of Crown on Face	Corner Radius	Dimensions Indentation	Also See Plan Numbers
			In inches	In inches	In inches	In inches	
			D	R	-	C	
Spike Maul	3	–	1-1/4	7	1/4	–	B and D
		–	1-5/8	7	1/4	–	
Double Faced Sledge	13	1 lb	1-1/4	7	1/4	–	B-83 and D
		2 lb	1-3/8	7	1/4	–	
		2-1/2 lb	1-1/2	7	1/4	–	
		3 lb	1-5/8	7	1/4	–	
		4 lb	1-3/4	7	3/8	–	
		6 lb	2-1/8	7	3/8	–	
		8 lb	2-1/4	7	7/16	–	
		10 lb	2-1/2	7	7/16	–	
		12 lb	2-5/8	7	7/16	–	
		16 lb	2-7/8	7	1/2	–	
20 lb	3-1/8	7	1/2	–	–		
Track Chisel	17	–	1-9/16	2	7/16	7/32	C and D
Round Track Punch	19	–	1-5/8	2	7/16	7/32	C and D
Track Spike Lifter	32	–	1-9/16	2	7/16	7/32	C and D
Nut Cutter	35	–	1-9/16	2	7/16	7/32	C and D
Hot Cutter	36	3 lb	1-3/8	1-3/4	3/8	3/16	C and D
Hot Cutter	37	5 lb	1-17/32	2	7/16	7/32	C and D
Drift Pin - Short	38	14"	1-1/2	2	5/16	5/16	C and D
Drift Pin - Long	39	18"	1-1/4	1-3/4	5/16	5/16	C and D
		19"	1-1/2	2	5/16	5/16	
		26"	1-1/2	2	5/16	5/16	
		26"	2	2	5/16	5/16	
Spiking Tool	41	–	1-5/8	2	7/16	7/32	C and D
Drift Pin Remover	46	5 lb	1-3/4	2	7/16	7/32	C and D
Offset Wedge	47	4-1/2 lb	1-1/2	2	5/16	7/32	C and D
Plug Bond Backout Punch	48	5-1/2 lb	1-1/2	2	5/16	–	C and D

Note 1: Distance across flats, if tools are hexagons or octagons

6.5.3 METHOD FOR ESTABLISHING THE CORNER CONTOUR OF HAND TOOL STRIKING FACES (1984)

Refer to [Figure 5-6-46](#) when establishing the tool contact face contour according to the following steps:

- Draw tool head centerline C/L .
- Draw line AC , representing the side of the tool head. Except in tapered tools, this line is parallel to C/L at a distance of $D/2$. D is the stock diameter of the tool or with hexagons and octagons the distance across the flats.
- Draw arc AA' with a radius of R .
- Draw line EE' parallel to line AC at a distance (r) equal to the corner radius to be used.
- Draw arc BB' parallel to arc AA' at a distance equal to the corner radius. The radius of this arc (R') is equal to the crown radius minus the corner radius.
- Draw arc SP with a radius r from point O , the intersection of line EE' and arc BB' . The resultant arc is tangent to arc AA' and line AC at points S and P , respectively.

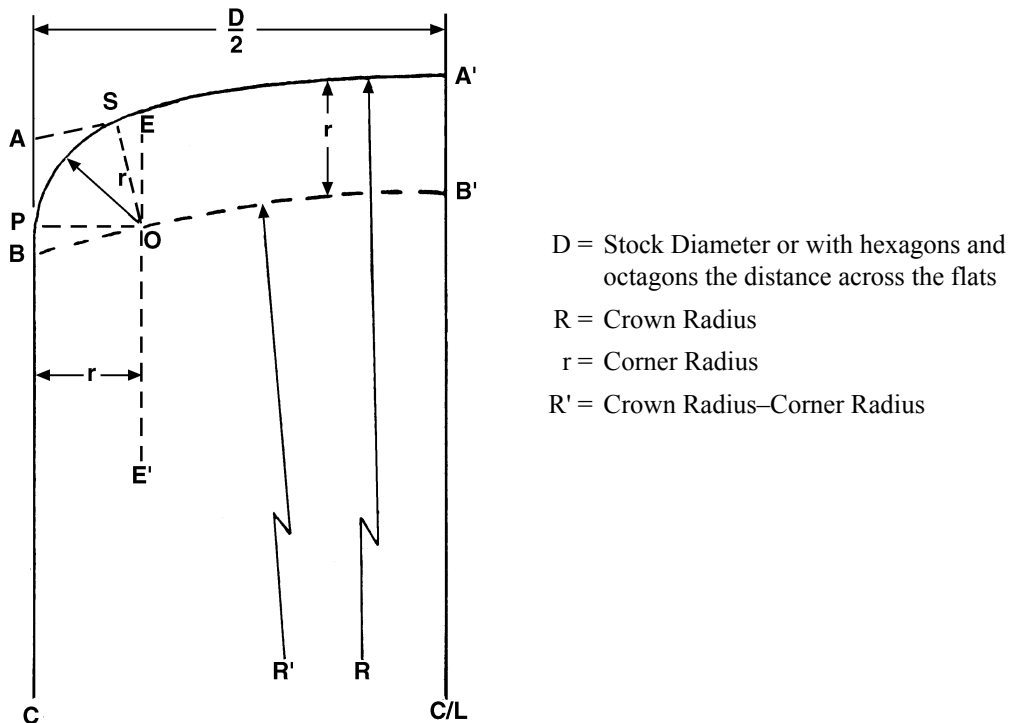
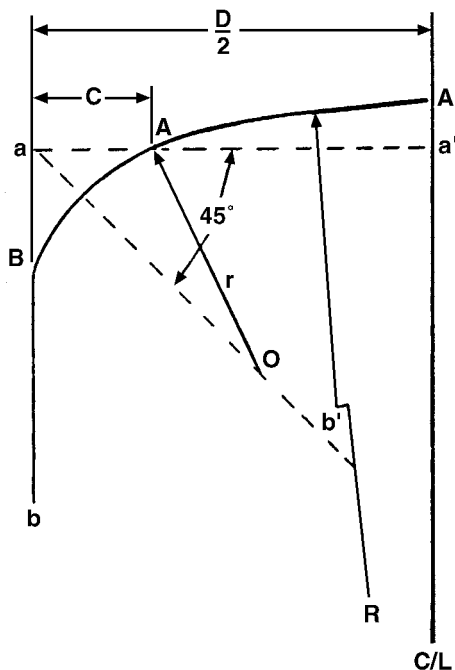


Figure 5-6-46. Plan B-83 – AREMA Contour of Hand Tool Striking Faces

6.5.4 METHOD FOR ESTABLISHING THE CORNER CONTOUR OF HAND TOOL STRUCK FACES (3/4 INCH STOCK AND OVER) (1984)

Refer to [Figure 5-6-47](#) when establishing the tool contact face contour according to the following steps:

- Draw tool head centerline C/L .
- Draw line ab , representing the side of the tool head, parallel to C/L at a distance of $D/2$. D is the stock diameter of the tool or with hexagons and octagons the distance across the flats.
- Draw line aa' perpendicular to C/L .
- Draw line ab' at a 45 degree angle from line aa' .
- On line aa' , locate point A , which is the distance C (Corner indentation shown in [Table 5-6-14](#)) from point a .
- From point A , locate point O on line ab by scribing an arc of radius r (the corner radius).
- From point O scribe the corner arc BA with radius (r).
- From point A locate the center of struck face arc AA' by scribing arc of radius R (crown radius) so that it intersects C/L .
- From this point of intersection scribe arc AA' with radius R .



D = Stock Diameter or with hexagons and octagons the distant across the flats.
 R = Crown Radius
 r = Corner Radius
 C = Corner Indentation

Figure 5-6-47. Plan C-83 – AREMA Contour of Hand Tool Struck Faces

6.5.5 CONTOUR BLENDING OF CORNERS (1984)

Refer to [Figure 5-6-48](#) for the contour blending of corners.

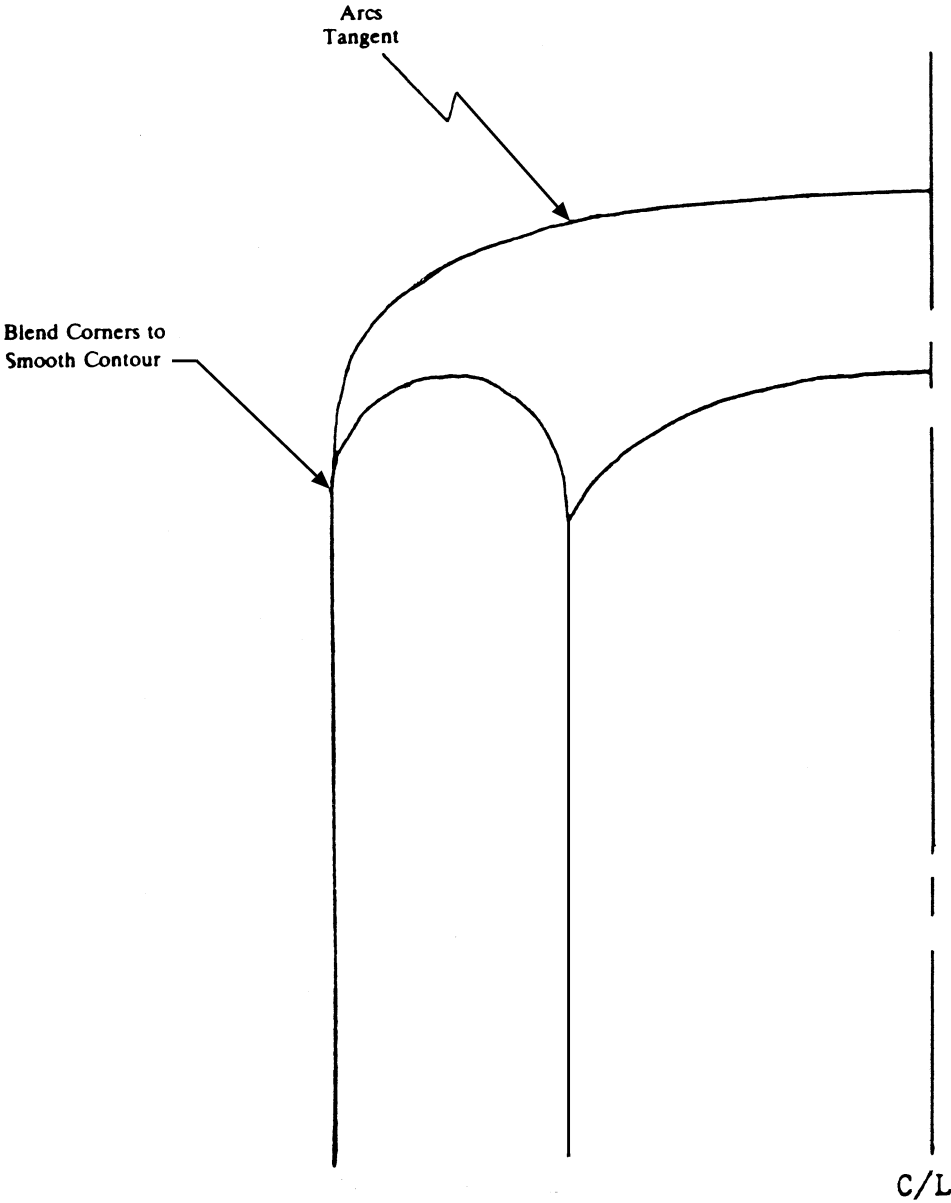


Figure 5-6-48. Plan D-83 – AREMA Contour Blending of Corners

SECTION 6.6 RECOMMENDED PRACTICES FOR USING, REDRESSING, SHARPENING AND REPLACING HANDLES IN TRACK TOOLS¹ (2004)

6.6.1 INTRODUCTION (1994)

- a. Striking and struck track tools such as spike mauls and sledge hammers are the most used hand tools in the maintenance of track. These and other tools are subject to severe service and require constant attention to ensure that they are in a safe condition to use.
- b. Proper use of these tools requires the following of a few basic rules in conjunction with the appropriate safety rules.
 - (1) A hammer swing should end up with the hammer face parallel with the surface being hit. Avoid glancing blows, over strikes and under strikes.
 - (2) Use a spike maul only to drive spikes.
 - (3) Never strike one hammer with another hammer.
 - (4) Match the hammer to the job. Don't use a sledge to drive small nails. If another tool is being struck, the face of the hammer should be larger than the face of the tool being hit.
 - (5) Make sure the handle is tight and not damaged.
 - (6) Check the striking or struck face for cracks or mushrooming. Check the cutting end for cracks and sharpness. Redress, sharpen, or replace tool depending on severity of condition that is present.
 - (7) Redress frequently to reduce the amount of grinding required to keep the tool in good working condition.

6.6.2 TOOL DESIGN AND MANUFACTURE (2004)

- a. AREMA track tools may be made from one of two types of steel.
 - Carbon steel.
 - Alloy steel, grade B.

See [Table 5-6-1](#) and [Table 5-6-2](#) for the chemical composition of these steels.
- b. The chemical composition of AREMA alloy steel is designed to allow field dressing of tools without the need of subsequent heat treating. AREMA alloy also has the highest resistance to spalling. Carbon steel tools can be sharpened in the field but should not be redressed. [Table 5-6-13](#) is a list of track tools and the type steel that can be used in their manufacture.
- c. The ends of tools are hardened as specified in [Table 5-6-13](#). The distance back from the original end of the tool that this hardness extends is “not less than the average cross sectional thickness.” The degree of hardness depends on the use the tool end is to receive.
 - Struck surfaces: Rockwell C hardness 44 to 48.
 - Striking surfaces: Rockwell C hardness 51 to 55.

¹ References, Vol. 94, (1994), p. 83.

- Cutting surfaces: Rockwell C hardness 56 to 60.
 - Punch ends: Rockwell C hardness 52 to 56.
 - Drift pins: Rockwell C hardness 32 to 37 overall.
- d. Striking and struck faces are contour ground. The original shape of striking and struck faces was to have a radius ending in a 45 degree bevel which extended to the side of the tool. The corner between the radius and the bevel was apt to spall if a glancing blow was struck. The bevel was replaced with a second radius. The radii used with various track tools are given in [Article 6.1.2.7.1](#). It is difficult to use this information to redress tools in the field but a commercial template is available.

6.6.3 REDRESSING OF TOOLS (1994)

- a. The first thing to do in redressing a tool is to give it a good visual inspection.
- (1) Look for the manufacturer's brand. If not found, discard the tool. Look for the letter "B" to indicate "AREMA Grade B Steel." If not found, the tool is made of other than grade B alloy steel and cannot be field redressed without subsequent heat treatment but it may be sharpened.
 - (2) Will the tool be usable after redressing or will so much grinding have to be done that the hardened end will be lost or the shape of the tool changed to the point where it will no longer serve its intended purpose? Refer to [Section 6.3, Recommended Limits of Wear for Tools to be Reclaimed \(1962\) R\(2013\)](#) for tool details or use a template.
 - (3) Look at the striking and struck end for spalls and cracks. If present, will the tool be returned to its original shape after grinding? If not, discard the tool.
 - (4) Check the condition of the eye for the handle. Usually, wear is not a problem in this area but look for cracks. At times, tools are abused by using the flat near the eye for striking which may lead to cracking. If cracks are found discard the tool.
 - (5) Discard any tool which has electric welding arc strikes on it or has indications of being repaired by oxy-acetylene welding.
 - (6) Replace the handle if it has cracks, slivers and other defects that cannot be sanded out.
- b. Redressing of tools has a few basic rules.
- (1) **ALWAYS WEAR EYE PROTECTION.**
 - (2) The tool must be returned to its original shape. Get a new tool of the type that is being redressed to act as a reference if the shape is in question or use a template.
 - (3) A stationary belt sander or bench grinder may be used. Use a medium or fine grit abrasive belt or grinding wheel.
 - (4) The grinding temperature must be kept low. If the grinding temperature is not controlled, the hardness may be changed in one of two ways. The section may have the hardness removed or a hard, brittle area created. The first case may lead to mushrooming. The second may cause chipping and spalling. Keep water handy and dip the tool frequently to control the heat. Discard the tool if it is overheated during grinding. If the tool turns a bluish color, it indicates overheating.
 - (5) If the handle requires replacement, remove the old handle before redressing. It is usually easier to redress a tool without a handle.

- (6) Redressing should be done in the long dimension of the tool whenever practicable. (From eye toward head.) Belt or wheel direction should be away from head.
- (7) Adjustable work rests should set to rigidly support the tool being worked.
- (8) Vary the grinding location of the tool being redressed frequently to avoid overheating the steel. Dip tool in water to cool as necessary.
- (9) All cracks and spalls must be removed. Dye penetrant testing kits are available to check for cracks.
- (10) Check shape of head against new item or with template to determine if the proper contour has been restored.
- (11) Repairing or altering tools by field welding is prohibited.

6.6.4 SHARPENING OF TOOLS (1994)

- a. Sharpening of cutting edges requires caution.
 - (1) **ALWAYS WEAR EYE PROTECTION.**
 - (2) A stationary belt sander or bench grinder may be used. Use a medium or fine grit abrasive belt or grinding wheel.
 - (3) Sharpening should be done in the long dimension of the tool whenever practicable. (From eye toward edge.) Belt or wheel direction should be away from edge. Get a new tool of the type that is being sharpened to act as a reference if the shape is in question or use the cutting edge guide of the template.
 - (4) The steel is thinner in this section and is easier to overheat. Keep water handy and dip the tool frequently to control the heat. If the tool turns a bluish color, it indicates overheating.
 - (5) Another error to watch for is making the edge too thin. The end shape and dimensions of track tools are shown in [Section 6.3, Recommended Limits of Wear for Tools to be Reclaimed \(1962\) R\(2013\)](#). Avoid undercutting the edge. The cutting edge should go straight back from the point or may have a light “barrel” shape. This gives more steel behind the point to resist chipping.
 - (6) The working end of drift pins and back out punches should be ground flat and square to the long axis of the tool.
 - (7) When sharpening, the tool should be held at the desired angle and moved across the face of the belt or wheel. Adjustable work rests should be set to the proper angle. Pressure of the tool against the belt or wheel must be controlled to prevent overheating. Belt or wheel direction should be away from the cutting edge. (From eye toward edge.)

6.6.5 REPLACING HANDLES (1994)

- a. The following procedure should be used to replace tool handles.
 - (1) **ALWAYS WEAR EYE PROTECTION.**
 - (2) Remove old handle by sawing close to the tool.
 - (3) Place the tool on a proper support and drive out the part of handle remaining in the eye from the side opposite the wedges.
 - (4) Clean the eye. Check inside the eye for pieces of the old handle and for any damage to the tool.

- (5) Select the correct replacement handle. Do not use a handle if it is not the right size or shape.
- (6) Partially insert the handle into the eye to check for a proper fit. Check to see if the handle and tool come into contact on the entire circumference of the eye.
- (7) Lubricate the eye portion of the handle. Waterless hand cleaner or a wax crayon may be used.
- (8) Place tool on a proper support so eye portion of handle can be driven through the tool to ensure a tight fit. Drive the handle on tight. Be careful not to drive the handle to point where the back side of the tool cuts deeply into the handle. This will damage the handle and could lead to the handle failing. The collar of the handle should be approximately 1/4 to 1 inch from the tool.
- (9) After the handle has been seated properly, cut off the excess of the handle sticking out from the eye flush with the tool.
- (10) Open the slot in the tool handle in the eye of the tool with a chisel or similar tool.
- (11) Drive a wood wedge into slot as deeply as is possible. Trim or file off wedge flush with tool.
- (12) Drive steel wedge in center of eye. The steel wedge may be either circular or flat. If flat, it is to be driven at right angle to wood wedge. Drive wedge flush with tool. Be careful of glancing blows that might cause the steel wedge to chip or mushroom.
- (13) The above instructions apply to drive on handles. For slip on handles used with tools such as picks and adzes, drive out the old handle, slip head onto new handle, and tap firmly on a solid base until a tight fit is achieved.
- (14) Handles made from material other than wood are available and may be an acceptable substitute. Handles made of other materials have both advantages and disadvantages. Other materials may have better durability, a distinctive “feel” to users, a different method of installation and greater initial cost. Users should investigate and decide which material is most economical for use on their property.

SECTION 6.7 RECOMMENDED PRACTICES FOR USE OF POWERED HAND TOOLS ON TRACK (2013)

6.7.1 SCOPE (2013)

These minimum recommended practices cover the safe use and care regarding powered hand tools for railway construction and maintenance. The use of the term “tool” or “machine” are used interchangeably throughout this section to refer to any hand held powered tool.

6.7.2 GENERAL SAFETY (2013)

DANGER

OPERATOR MANUALS MUST BE KEPT IN PROXIMITY TO THE TOOL AND AVAILABLE TO THE OPERATOR AT ALL TIMES. SEE OPERATOR MANUAL FOR SPECIFIC SAFETY AND USE INSTRUCTIONS FOR SPECIFIC TOOLS. DO NOT OPERATE THE TOOL UNTIL PROPERLY TRAINED, HAVE READ AND UNDERSTAND THE OPERATING MANUALS AND INSTRUCTIONS FOR USE OF THE TOOL.

Track

ALWAYS WEAR REQUIRED PERSONAL PROTECTIVE SAFETY EQUIPMENT AND/OR SAFETY APPAREL AS REQUIRED BY THE OPERATING AUTHORITY, APPLICABLE TO THE JOB, AND THE TOOL BEING USED.

NEVER WEAR LOOSE OR FRAYED CLOTHING THAT CAN GET TANGLED IN THE TOOL OR BE CARELESS WITH HANDS, FEET OR OTHER BODY PARTS AROUND THE WORKING PARTS OF THE TOOL.

NEVER USE A TOOL FOR A PURPOSE OTHER THAN FOR WHAT IT WAS DESIGNED.

OPERATE GAS POWERED TOOLS IN WELL VENTILATED AREAS. FAILURE TO DO SO MAY RESULT IN PERSONAL INJURY AND/OR DEATH.

ENSURE ALL TOOL OPERATION HAS CEASED PRIOR TO HANDLING, OR MOVING TO ANOTHER LOCATION.

DO NOT ADJUST OR REPAIR ANY POWERED HAND TOOL WHILE RUNNING OR CONNECTED TO THE POWER SOURCE.

INSPECT ALL POWERED HAND TOOLS PRIOR TO USE FOR FLUID LEAKS, FUEL LEAKS, AND APPROPRIATE PROTECTIVE GUARDS. DO NOT USE DAMAGED OR DEFECTIVE EQUIPMENT. FAILURE TO DO SO MAY RESULT IN PERSONAL INJURY AND/OR DEATH.

REMOVE DAMAGED/DEFECTIVE TOOLS FROM SERVICE USING APPROPRIATE OUT OF SERVICE TAG AND NOTIFICATION OF SUPERVISORY PERSONNEL.

PERSONNEL SHOULD FOLLOW ADDITIONAL PRECAUTIONS RELATING TO THE SPECIFIC WORK AREA, LOCAL, STATE, AND FEDERAL SAFETY REGULATIONS.

WARNING

Since some tools may throw sparks, the operator must ensure all personnel not directly involved in the work are located in a safe zone to prevent injury. Make sure the work area is clear of debris or other hazards.

When using a tool with an abrasive product, take additional precautions to prevent fires. Fire extinguisher, and/or other designated fire extinguishing equipment should be readily available at all times.

The operator must be familiar with their surroundings and conduct a thorough job briefing to identify prohibited work areas such as unsafe grades, poor footing areas, vehicular traffic and overhead hazards.

Clear the work area of any combustibles prior to operating any tool producing sparks.

CAUTION

Care should be exercised during lifting to prevent or reduce injuries.

Operators should familiarize themselves with the weight and handling requirements of the tool prior to use.

Do not transport or store a cut-off machine with abrasive wheel mounted on the machine. Keep dirt, oils, and contaminants off of abrasive wheels and store in approved clean containers. Tools may generate heat; caution should be used when handling.

- **General**

Ensure that the machine does not exceed the Maximum Operating Speed (MOS) or rated Revolutions Per Minute (RPM) for the abrasive wheel being employed.

WHEN CHANGING ABRASIVES, FOLLOW THE MANUFACTURERS INSTRUCTIONS FOR SAFETY AND OPERATION, USE ONLY THOSE THAT COMPLY WITH ANSI STANDARDS. BEFORE USING, RUN NEW SAW BLADES FOR ONE MINUTE AT FULL SPEED TO CHECK FOR DEFECTS OR VIBRATION.

TO AVOID PERSONAL INJURY OR EQUIPMENT DAMAGE, ALL TOOL REPAIR, MAINTENANCE OR SERVICE MUST BE PERFORMED BY AUTHORIZED AND PROPERLY TRAINED PERSONNEL.

All tools should be designed to minimize operator fatigue or stress.

- **Handles and lifting points**

Whenever practical, handles should be designed to minimize vibrations transmitted to the operator. In the event anti-vibration handles are not practical, it is recommended the operator wear vibration-reducing work gloves.

Whenever practical adjustable carry handles should be incorporated into the design to accommodate varying body heights.

If the tool requires multiple personnel to lift or move, the tool should have sufficient lifting points for each person and/or a center lifting point. Lifting points should be clearly distinguishable. Weights should be labeled on heavy tools where appropriate or specified by the customer.

- **Pinch points**

Pinch points should be clearly labeled. See operator's manual for pinch points, labels and decal placement.

6.7.3 HYDRAULIC TOOLS (2013)

6.7.3.1 General Safety Precautions

Inspect hydraulic hoses daily for cracks, nicks, cuts, etc. Replace or repair any hose that has exposed wire reinforcement. Check tool, hoses, couplers and connectors daily for leaks. DO NOT feel for leaks with bare hands, contact with a leak may result in serious personal injury.

When working in electrified territory, the use of non-conductive hydraulic hose is recommended.

Always disconnect the hydraulic tool from the power source prior to any adjustment or repair.

CHECK POWER SOURCE DAILY TO CONFIRM NORMAL OPERATING PARAMETERS. NEVER EXCEED OPERATING PARAMETERS FOR FLOW OR PRESSURE FOR THE TOOL BEING USED. PERSONAL INJURY OR DAMAGE TO THE TOOL CAN RESULT.

Ensure hydraulic oil is warmed to proper operating temperature prior to use.

DO NOT carry the tool by the hydraulic hose ends (pigtailed). Ensure tool operation has ceased prior to moving tool.

When using hydraulic tool in an area of extreme heat sources, care should be taken to prevent contact with hydraulic oil and hoses.

Hydraulic hoses pose a slip, trip, and fall hazard. Instruct all personnel to the potential hazard.

De-energize hydraulic circuit prior to connecting or disconnecting tools or changing abrasives or cutters.

6.7.4 GASOLINE POWERED TOOLS (2013)

6.7.4.1 General Safety Precautions

Refuel gasoline powered tools in a well-ventilated area away from combustible material and away from sparks, open flames, or other heat sources. Do Not smoke while refueling.

Take precaution when handling fuel; keep in mind the risk of fire, explosions and inhaling of fumes.

Never refuel the machine while the engine is running, or when the engine is hot.

Make sure there is sufficient ventilation when refueling, or mixing fuel with oil.

Always remove tools from work area prior to refueling. Move the machine a safe distance away from the refueling area prior to starting.

Store fuel, or fuel mixtures only in an approved container designed for that purpose.

Never start the tool until the following have been verified:

- Spilled fuel has been cleaned up.
- Fuel has not contaminated or soaked into clothing, protective apparel, or gloves.
- Bare skin, if exposed to fuel, has been washed.

Store gasoline powered tools and fuel in a well-ventilated area.

Move the machine a safe distance or at least 10 feet from the fueling point before starting the engine. Ensure that the gas cap is properly tightened on the machine and fuel container. Check machine and fuel lines for leaks.

Always carry the machine with the engine stopped, rotating parts stopped and muffler away from body.

Always turn off the machine prior to moving to and from the rail.

Keep handles clean and dry and free of oil, dirt, and fuel.

Operate gas powered machines only in well ventilated areas to avoid carbon monoxide exposure.



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Part 7

Rail Anchors¹

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SECTION 7.1 RECOMMENDED PRACTICES FOR RAIL ANCHORS² (2013)

7.1.1 SCOPE (2013)

These recommended practices define the manufacturing requirements for drive-on and spring-type rail anchors, both new and remanufactured, which either may be applied manually or with standard anchor machines that readily can be adapted to the anchor being considered. (For the purpose of this recommended practice, remanufactured anchors are defined as used drive-on

¹ References, Vol. 85, 1984, p. 26; Vol. 91, 1990, pp. 54-57.

² Revised 1990.

or spring-type anchors which have been reformed to restore performance to the requirements described herein, except where specifically noted.)

7.1.2 FUNCTION (2013)

Rail anchors transmit static and dynamic longitudinal forces in the rail to the cross tie.

7.1.3 DESIGN (2013)

Rail anchors shall be designed:

- a. To function during their service life without damage to the rail base due to longitudinal forces, application forces, or vibratory action.
- b. To be able to resist longitudinal and torsional forces exerted by skewed ties without damage to the base of rail.
- c. To be capable of being applied tightly against the tie either manually or by machine.
- d. For easy application, removal and successive reapplication without appreciable loss of holding power as required per slip test in [Article 7.1.4](#).
- e. Rail anchors shall have sufficient bearing area and depth to minimize the possibility of the anchor damaging or becoming embedded in the tie under pressure and to prevent the anchor from overriding the tie.

7.1.4 SLIP TEST (2013)

- a. Rail anchor slippage shall be determined by applying a gradually increasing load directly to the end of the rail; the anchor, applied perpendicular to the rail base, shall be resisted by a fixed metal block positioned 5/8 inch below the base of the rail. The test can also be performed with the rail fixed and the load applied to the anchor by a moving metal block 5/8 inch below the rail base. In the interest of safety, the fixture should have clamps or other engagement which will prevent the rail and anchor from slipping off the fixed block while the load is being applied, but which will not restrain the rail from slipping through the anchor. The rail used in conducting the test shall meet dimensional specifications in the width and thickness of the base for the intended rail to be restrained.
- b. The rail shall be preloaded to 500 pounds to allow the anchor to take its initial set including anchor lean. The location of the anchor at the drive-on or applied side of the rail base shall be marked or fixed by a calibrated dial gauge or other measuring device. The load shall be increased at a rate not to exceed 1.0 inch per minute or 10,000 pounds per minute until it reaches 6,000 pounds (for rail sections less than 110 RE use 5,000 lbs.) where it shall be held for one minute before measuring slippage, which shall not exceed a total of 1/16 inch.
- c. Upon satisfactory completion of each test, the anchor being tested shall be removed, reapplied at a different location on the rail base, and shall meet the foregoing criteria for a second and a third successive test.
- d. Slip tests shall be made as frequently as necessary by the manufacturer according to their internal test plan, or as required by the purchaser, during production to ensure rail anchors meet the above criteria.

7.1.5 FRACTURE TEST (2013)

- a. Anchors from each production batch, or remanufactured anchors from each production batch of each anchor design submitted by the purchaser for remanufacturing shall be randomly selected and subject to fracture tests. The test shall be repeated three successive times according to the manufacturer's test plan on the same anchor with no fractures allowed.

- b. For drive-on anchors the test shall require a 275 ft-lb impact on the jaw of the anchor placed upright over a 30 degree angle wedge.
- c. For spring-type anchors the test shall require a force of sufficient magnitude to spread the anchor, without breaking to a permanent dimension which exceeds the width of the rail base plus 0.05 inch, on which it is to be applied, by 6%. This measurement shall be made between points, in the same plane parallel to the rail base, where the anchor normally comes in contact with the rail base.

7.1.6 RETESTS AND REJECTION (2013)

- a. Should a sample fail the fracture or slip test, a retest consisting of two anchors randomly selected from the same production lot shall be made. If both of these samples meet the test requirements, the anchors from that lot shall be accepted.
- b. If either new anchor retest sample fails the fracture or slip test, all of the anchors in the production lot shall be rejected. Following rejection these anchors must be segregated from the production process, properly marked and may be scrapped or reheat-treated at the manufacturer's discretion. Any reheat-treated anchors subsequently shall be tested using the original criteria.
- c. If either remanufactured anchor retest sample fails the fracture or slip test, it shall be rejected. Following rejection these anchors may be scrapped or reheat-treated at the manufacturer's discretion. Any reheat-treated anchors subsequently shall be tested using the original criteria.

7.1.7 DIMENSIONS (2013)

The manufacturer shall carry out dimensional checks on 2 of every 500 anchors produced per line to assure compliance with all dimensional requirements. If either of these two anchors fail to conform, the manufacturer must take immediate remedial action to inspect, identify and segregate all nonconforming anchors from the production process as per their inspection and test plan. The foregoing dimensional checks will apply to remanufactured anchors only as related to those areas of the anchors which require reforming in order for the anchor to meet the requirements of this recommended practice. The remanufacturer shall not be held responsible for the dimensional configuration or tolerances as related to original anchor design.

7.1.8 WORKMANSHIP (2013)

The finished rail anchors shall not be marred or deformed and shall be free of detrimental defects, such as, laps, cracks, seams and decarbonized or burned steel. It is recognized that remanufactured anchors may have defects that have resulted from previous service or application. Only those anchors having defects which may impair function that resulted from previous service or from the reforming process need be culled unless otherwise specified by the purchaser. All anchors to be remanufactured shall be cleaned of oil, grease, or other residue so as to improve inspection and performance.

7.1.9 IDENTIFICATION (2013)

Each new rail anchor shall be hot-stamped to show the rail section or base size and other information including the year of manufacture for traceability. Remanufactured anchors shall be identified as such by means of hot or cold stamping. The original manufacturer's identification as to rail section and year of manufacture will remain on the anchor.

7.1.10 PACKAGING (2013)

Unless otherwise specified all new or remanufactured anchors shall be packaged per customer specifications. All anchors within each package shall be for the same rail size and shall be of the same type of anchor. All packages shall be securely bound to ensure it will not reopen during handling and shipping.

7.1.11 TAGGING (2013)

Each package shall have securely affixed to the outside a product identification tag which shows the date of manufacture, type of anchor and the rail sizes covering the anchors contained in that package.

7.1.12 SHIPPING TAG (2013)

Each load shall have securely affixed to not less than 10% of its packages tags which show consignee name and address, customer order number, manufacturer's order number and quantity of anchors in that shipment.

7.1.13 INSPECTION (2013)

When specified, the inspector representing the purchaser shall have free entry to the manufacturer's facilities and shall be provided, on a no charge basis, all reasonable accommodation and documentation to satisfy that the products being furnished are in accordance with the purchaser's specifications. The plant manager shall be notified prior to the inspection so that the facilities, materials and product shall be available for inspection.

7.1.14 ACCEPTANCE (2013)

To be accepted, the rail anchors offered must fulfill all the requirements of these recommended practices.

SECTION 7.2 RECOMMENDED PRACTICES FOR RAIL ANCHOR APPLICATION AND MAINTENANCE (2013)

7.2.1 GENERAL (2013)

- a. Anchor shall be applied to the rail sections for which they are designed.
- b. Rails having reduced base width and/or flange thickness on account of wear, corrosion, or rolling variations may require custom manufactured anchors for satisfactory performance. The anchor manufacturer's representative shall provide appropriate measurements of rail base or sample rails to aid in optimizing rail anchor design.
- c. Where the minimum recommended quantity of anchors is not sufficient to restrain the rail, additional anchors can be applied.
- d. The base of the rail shall be reasonably clean and cribs open for proper anchor application.
- e. Whenever possible, anchors shall be applied against sound ties, preferably those with vertical sides. Anchors must be applied so as to have full bearing against the tie or tie plate. Before applying anchors which bear against the tie plate, the tie plate should be properly centered on tie. Anchors should be applied from the gage side of the rail when possible.
- f. When rail or ties are renewed or respaced, anchors shall be properly repositioned.
- g. Anchors shall be uniformly spaced along the rail length. To avoid tie skewing they must be installed on the same side of each tie on both rails.
- h. Care shall be taken when applying rail anchors to ensure that they are properly seated and not overdriven. The manufacturer's instructions or recommendations must be followed.

- i. Anchors must be applied and removed with the proper tools. Machines used to apply anchors must be properly adjusted, and adjustment must be checked daily or at more frequent intervals if necessary.
- j. Anchors shall not be installed:
 - (1) At ties which support rail joints.
 - (2) Where they will interfere with bond wire, boot legs, insulated joints, or other signal or track appliances.
 - (3) Within a minimum of 2 inches from the edge of any field weld to prevent nicks or gouges within the heat affected zone of welds.
- k. Rails shall be properly anchored immediately after adjustment to recommended neutral temperature. When necessary, trains must be operated at reduced speed until track is anchored at proper temperatures.
- l. Sufficient anchors shall be applied and maintained through both tracks of turnouts, and on each side of turnouts to reduce rail movement. Additional anchors may be required to reduce rail movement at locations where gradients exist or where train braking or acceleration is common. Sufficient rail anchors shall be applied on all tracks approaching any railroad or road crossings to prevent rail movement.
- m. Damaged or ineffective anchors shall be replaced.
- n. Anchors which become displaced shall be repositioned. Cause of rail movement shall be determined and additional anchors installed as necessary. When repositioning anchors by manual means they should be removed and applied rather than slid along the rail.

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Part 8

Highway/Railway Grade Crossings¹

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¹ References, Vol. 51, 1950, pp. 200, 800; Vol. 54, 1953, pp. 487, 1306; Vol. 62, 1961, pp. 359, 904; Vol. 75, 1974, p. 2; Vol. 84, 1983, p. 94; Vol. 88, 1987, p. 78.

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SECTION 8.1 GENERAL AND INTRODUCTION (2006)

8.1.0 SCOPE (2006)

The fact that design values and practices for new construction or for the reconstruction of highway/railway at-grade crossings are presented in this Part does not imply that existing non-conforming crossings are unsafe, nor does it mandate the initiation of improvement projects. For projects involving rehabilitation, restoration, replacement, renewal, resurfacing or maintenance of existing tracks through crossings, crossing surfaces or roadway approaches to crossings, where major revisions to alignment, elevation or profile are deemed impractical or beyond the reasonable scope of the work being undertaken, existing design values may be retained, particularly if a site investigation indicates the existing design features are performing in a satisfactory manner for the normally anticipated traffic exercising due care. Absent other compelling factors, the cost of full reconstruction of these facilities solely to conform to the recommended practices contained herein, particularly on lower volume roadways, will often not be justified.

8.1.1 DEFINITIONS (2006)

For purposes of this Part the following definitions shall apply:

The terms “construction” and “constructed” refer to newly created facilities or the relocation of existing facilities to a substantially altered location or alignment.

The terms “reconstruction” and “reconstructed” refer to improvements undertaken for the primary purpose of increasing roadway or railway system capacity, such as widening the roadway or adding additional lanes, or the laying of additional tracks.

The terms “rehabilitation”, “restoration”, “replacement”, “renewal”, “resurfacing” and “maintenance” all refer to lesser improvements; work undertaken for the purpose of system preservation; or to maintain or restore facilities or features to a prior status, capacity or utility; and include the replacement of components other than in-kind when comparable materials are considered functionally obsolete, are not readily available, or when necessary or desirable to comply with changes in the track owner’s or operating railroad’s standard practices or procedures applicable to such work.

The terms “highway”, “roadway” and “street” may be used interchangeably and are presumed to have the same meaning irrespective of ownership, maintenance responsibility, or governing authority.

SECTION 8.2 GUIDELINES FOR THE DESIGN, CONSTRUCTION OR RECONSTRUCTION OF HIGHWAY/RAILWAY AT-GRADE CROSSINGS (2013)

8.2.0 DESIGN-GENERAL (2006)

The decision to construct a new roadway facility at-grade across an existing line of railroad, especially a main line, or a new rail facility across an existing roadway, should not be taken lightly. While acknowledging the motoring public frequently has real and legitimate needs to have access across rail lines, careful consideration should be given to balancing public necessity, public convenience and safety.

In urban areas, and even many rural areas, it is frequently not necessary, and seldom in the best interests of either the public or the railroad, for every roadway or street to extend across the railroad. Quite often, traffic on some number of roadways in relatively close proximity can be channeled to a single point of access across the railroad without unduly sacrificing convenience. This common point of access can then be engineered, or re-engineered, to improve operations and reduce potential conflicts for each respective mode. Whenever it is deemed necessary to establish a new crossing in an area where other crossings already exist, consideration should be given to closing one or more existing crossings.

While it is necessary for the design of highway/railway at-grade intersections to recognize and accommodate the unique characteristics of each traffic mode, many of the basic strategies and recommended practices for the design of the intersection and appurtenances are not unlike those traditionally employed in the practice of roadway/roadway intersection design.

Each intersection approach, including through and across the intersection itself, should be designed and constructed so as to comply, as near as practicable, with the generally accepted design criteria (such as typical section, grade, profile, structural integrity, etc.) for the speed, traffic density and intended function of the respective route (References 2, 5, 8); however, since railroad design criteria relative to horizontal and vertical curvature, gradient and superelevation tend to be more restrictive than the corresponding criteria for roadway pavements, it is typically necessary and generally more economical to first establish the governing track geometrics and then design or adjust the roadway geometrics accordingly.

To the extent that economics may be a factor in highway/railway intersection design, especially when deciding whether an existing or proposed intersection should be at-grade or grade separated, such analyses should not be based solely on initial construction costs, but should additionally consider life cycle costs associated with maintenance, delays to traffic and potential collisions (both train involved and non-train involved), irrespective of whether said costs may be incurred by the track owner and/or operating railroad, the roadway agency or the traveling public. Generally, whenever a new roadway is proposed to be constructed or an existing roadway reconstructed across a rail line, or a new rail line is to be constructed across a roadway, and absent other consideration of rail or roadway system design requirements and/or the presence of potentially favorable terrain, if the crossing exposure index (the product of the average daily number of train movements and the projected average daily number of roadway vehicles over the crossing) exceeds 70,000 in rural areas or 290,000 in urban areas, further analysis of the economic feasibility of grade separation is indicated (Reference 7).

8.2.1 ROADWAY DESIGN AND GEOMETRICS (2013)

8.2.1.1 Crossing Location

The roadway designer should ascertain the speed, frequency and nature of train operations at or in the vicinity of a proposed crossing and endeavor to avoid crossing tracks at-grade where the crossing would be frequently blocked by standing or slow moving trains. Such locations to avoid would include at or in the vicinity of rail yards and terminals, switching leads, tracks used for meeting or passing trains, where helper engines are often used, and areas where trains are frequently held short of

yards, terminals, interlockings or switch tracks specifically to avoid blocking other crossings. When it is necessary to cross tracks at such locations, grade separation of the roadway and railroad is highly recommended. Existing highway/railway at-grade crossings in such locations should be eliminated by closure or grade separation whenever possible. Care should also be taken to avoid crossing tracks at-grade wherever turnouts, crossovers, rail crossings or railroad bridges would fall within the limits of or in close proximity to the crossing. New highway/railway at-grade crossings should never be established across designated high-speed rail lines or tracks equipped with electrified "third rails". Other railway related factors which should be considered in selecting the location of an at-grade crossing are track curvature and superelevation, track gradient, number of tracks and others as may be relevant to the design of intersections and the selection of appropriate system(s) of highway traffic control devices at the crossing. (References 3, 4 & 5)

8.2.1.2 Roadway Alignment

To the extent practicable, the roadway alignment should be tangent in the immediate vicinity of the railroad and intersect the track(s) at or nearly at right angles. The number of traffic lanes and the width of the roadway section, including shoulders, should be uniform on both sides of the crossing and, preferably, for at least 100 feet on either side. Bi-directional center turn lanes should be eliminated in the immediate vicinity of any highway/railway at-grade crossing by installing a raised median instead, designating for use in one direction only, or striping out entirely. Additional shoulder or embankment width should be provided in the immediate vicinity of the crossing as/if required for proper placement of crossing traffic control devices per the *Manual on Uniform Traffic Control Devices* (MUTCD) (Reference 4). Parking lanes should be eliminated in the crossing vicinity as needed to preclude parked vehicles from blocking approaching motorists' view of the crossing traffic control devices and/or an approaching train. Curb cuts, driveways and other public access to the roadway within close proximity to the crossing should be restricted. Consideration should be given to pedestrians and bicyclists, where practical, and to persons with disabilities. The alignment of newly constructed or reconstructed sidewalks or paths should be adjusted to cross the track(s) as nearly at a right angle as possible to minimize the possibility of bicycle tires or the small wheels on the front of wheelchairs from becoming caught in the flangeway.

8.2.1.3 Roadway Approach Pavement

Any crown or superelevation in the roadway section should be eliminated at or tapered into the crossing to match the grade and profile of the railroad track. Portland cement concrete pavements should be terminated a sufficient distance from the outer edge of the crossing surface, giving due consideration to both future track and crossing surface maintenance as well as the type and width of equipment to be used to compact asphaltic concrete material in the resultant "gap" between the rigid pavement and the crossing surface (See Article 8.4.10 of this Chapter). Poured in place Portland cement concrete pavements should not be used between tracks where track centers are 25 feet or less. The use of under-pavement headers is not recommended; however, if the pavement design selected includes provision for headers, the headers should be constructed a sufficient distance from the ends of the track cross-ties so as not to interfere with future track and crossing surface maintenance and replacement operations.

8.2.1.4 Crossing Elevation

When constructing or reconstructing the roadway approaches to a highway/railway grade crossing, or the track through the crossing, the elevation of the crossing should be established by mutual agreement between both the roadway's and railroad's engineers, giving due consideration to any anticipated settlement of the track under traffic following any re-ballasting or surfacing. Where multiple tracks exist, the tops of rails of all tracks should be brought to the same plane where practicable.

8.2.1.5 Roadway Approach Grades

When constructing or reconstructing the roadway approaches to a highway/railway grade crossing, the roadway surface should be constructed to be level with said plane through the tops of rails for a distance of at least 24 inches (preferably 60 inches or more) beyond the outer rail of the outermost track in each direction. The top of rail plane should be connected to the grade line of the roadway in each direction by vertical curves of such length as is consistent with the design criteria normally applied to the functional classification of the roadway under consideration. (Reference 5) It is desirable that the surface of the roadway be not more than 3 inches above or 3 inches below the elevation of the top of rail plane, as extended, at a point 30 feet from the outermost rail, measured at right angles thereto. Particular care should be taken to provide a roadway profile that will allow

any reasonably anticipated low clearance vehicular traffic to traverse the crossing without hanging up on the crossing or rails. If such profile is not practicable or feasible, it is recommended the governing roadway authority restrict and sign the crossing and roadway accordingly. The profiles of newly constructed or reconstructed sidewalks shall comply with the Americans with Disabilities Act (ADA) guidelines, if practicable.

8.2.1.6 Traffic Control Devices

Allowing for and providing appropriate system(s) of highway traffic control devices at and in the vicinity of highway-rail grade crossings, in accordance with the provisions of the Manual on Uniform Highway Traffic Control Devices, (MUTCD) Reference 4, is an integral part of the design of new or reconstructed crossings. Active grade crossing warning devices shall comply with the applicable portions of the AREMA *Communications and Signals Manual of Recommended Practices* and *MUTCD*. Care must be taken to coordinate the design and operation of any highway traffic control devices at the highway-rail grade crossing with other traffic control devices or systems at nearby highway-highway intersections so as to avoid queuing vehicles on or afoul of the highway-rail crossing and to allow any such traffic to clear the crossing in the event of a train movement. It should be noted that changes to an adjacent highway-highway intersection such as the addition of lanes, installation of a traffic control signal or construction of a roundabout may affect driver behavior at the highway-rail grade crossing. (See also Sections 8.6 and 8.7 of this Chapter and section 8C.09 of *MUTCD*.) Designs for roadways carrying two-way traffic and having three (3) or more traffic lanes (including turn lanes) in the same direction across a highway-rail grade crossing should provide for non-mountable raised center medians extending at least 50 feet (200 feet preferred) on either side of the crossing and of sufficient width to allow for the placement of additional crossing traffic control devices in the median (see AREMA *Communications and Signals Manual of Recommended Practices* Part 3 and *MUTCD* for additional information on requirements for minimum clearances). All public highway-rail grade crossings should be additionally equipped with advance warning signs, and all paved approaches to public highway-rail grade crossings should have pavement markings installed, in accordance with the recommendations of the MUTCD. Typically, such advance warning signs and pavement markings are the responsibility of the roadway authority. (References 1, 3, 4, 6)

8.2.1.7 Drainage Ditches and Culverts

Railroad trackbeds are commonly designed with shallow side ditches primarily intended to drain the trackbed itself. Wherever a roadway approach to a highway/railway crossing conflicts with the trackside drainage, a culvert or other drainage structure of appropriate material and size (15-inch minimum diameter) should be installed under the roadway approach at an elevation which permits unrestricted flow. Such culverts should also be of sufficient length and/or equipped with flared ends or headwalls to preclude collapse of the roadway shoulder at or around the culvert ends, including provision for such additional shoulder width as may be required to properly place traffic control devices. It should be noted such trackside ditches were generally not designed as interceptors for area-wide drainage, thus should not be presumed to be an adequate outlet for the roadway drainage.

8.2.1.8 Track Structure Through Highway/Railway Crossings

The track structure through the limits of a new or reconstructed highway/railway grade crossing should be constructed or reconstructed in accordance with [Section 8.4](#) of this Chapter.

8.2.1.9 General Safety Regulations, Insurance, Flagging and Right-of-Entry Permits

Whenever performing roadway work on railroad owned property or within 50 feet of an existing railroad track, the roadway authority and/or its contractor(s) should confer, in advance, with the operating railroad and/or track owner relative to the operating railroad's and/or track owner's respective requirements for safety, flagging, insurance, right-of-entry permits (if required) or other as may pertain to the performance of the proposed work, and should be prepared to comply with same.

8.2.2 RAILWAY DESIGN AND GEOMETRICS (2013)

8.2.2.1 Track Location

While the railroad engineer tends to have limited flexibility to adjust the design elements (alignment, grade and elevation) of a new or relocated track specifically to accommodate a highway/railway grade crossing, to the extent any such flexibility does exist, every reasonable effort should be made to accomplish a comparable result. (Refer to [Article 8.2.0](#) of this Chapter.) If it is not feasible to alter the track layout to sufficiently mitigate any resulting undesirable crossing features, then, to the extent practical, consideration should be given to adjusting, relocating or possibly closing the road. Depending upon the type of rail facility being designed and the nature and volume of traffic on the roadway, number of lanes, etc., grade separation may be appropriate.

8.2.2.2 Crossing Location

To the extent practical, newly constructed or reconstructed tracks should be designed to intersect the roadway at or nearly at a right angle and, preferably, at a location where the roadway is tangent. The location(s) of any turnouts or crossovers should be adjusted to avoid falling within the limits of, or unduly close to, the roadway and to minimize the number of tracks in the crossing. If multiple tracks are to be constructed "side by side" within the limits of the roadway, the elevations of the tops of rails should all fall as nearly as practical in the same plane. Except where train-operating speeds will be relatively low, sharp curves in the track in close proximity to the crossing should be avoided where possible. To the extent practicable, efforts should be made to avoid a condition where any required track superelevation runs opposite the grade of the roadway. If the highway/railway crossing is to be in close proximity to a railroad bridge, the bridge should be of a ballast deck design to facilitate future adjustments, as may be required, to the elevation and profile of the tracks(s) through the limits of the highway/railway crossing.

8.2.2.3 Track Elevation

The elevation of newly constructed or reconstructed tracks through a highway/railway at-grade crossing should be established by mutual agreement by the railroad's and roadway's engineers and arrangements made to adjust, to the extent practical, the roadway approaches so as to conform with [Articles 8.2.1.4](#) and [8.2.1.5](#) of this Chapter.

8.2.2.4 Traffic Control Devices

Where newly constructed or reconstructed tracks cross a public roadway at-grade, arrangements should be made to install appropriate system(s) of highway traffic control devices at and in the vicinity of the highway-rail grade crossing, in accordance with the provisions of the MUTCD and subject to any applicable State or local agency requirements and approvals. (See [Article 8.2.1.6](#) of this Chapter).

8.2.2.5 Drainage

Where newly constructed or reconstructed tracks cross an existing roadway at-grade, care should be taken to avoid compromising the roadway drainage by placing culvert pipes or other appropriate drainage structures as/if needed in the roadway side ditches under the track. Any culvert pipes under the track(s) should conform to the requirements of [Part 4](#) of Chapter 1 of this Manual as to material specifications and depth of cover.

8.2.2.6 Track Structure Through Highway/Railway Crossings

The track structure through the limits of a new or reconstructed highway/railway grade crossing should be constructed or reconstructed in accordance with [Section 8.4](#) of this Chapter.

8.2.2.7 Highway Work Zone Traffic Control, Insurance, and Permits

Whenever performing track or crossing surface work through the limits of a public roadway, the operating railroad, track owner and/or railroad contractor should confer, in advance, with the roadway authority relative to their requirements for a

Temporary Traffic Control Plan or other work zone traffic control (see *MUTCD* Part 6 and Section 8A.08), insurance, permits (if required) or other as may pertain to the performance of the proposed work within the limits of the roadway, and should be prepared to comply with same (see [Article 8.4.1](#) of this Chapter, however, relative to full roadway closure).

SECTION 8.3 GUIDELINES FOR THE REHABILITATION OR MAINTENANCE OF HIGHWAY/RAILWAY AT-GRADE CROSSINGS (2013)

8.3.1 ROADWAY APPROACH REHABILITATION AND MAINTENANCE (2013)

8.3.1.1 General

Projects involving rehabilitation, restoration, replacement, renewal, resurfacing or maintenance of existing roadway approaches to a highway/railway grade crossing should be planned and executed, to the extent reasonably practicable, to conform to the provisions of [Article 8.2.1](#) of this Chapter; however, whenever doing so would require revisions to the roadway alignment, elevation or profile which are deemed impractical or beyond the reasonable scope of the work being undertaken, such work should conform with the applicable standards and practices of the governing roadway authority and/or regulatory agency having jurisdiction for the scope of work being performed. Any such roadway approach work not being performed concurrent with the rehabilitation, restoration, replacement or renewal of the crossing surface should be planned and executed such that the resulting roadway surface conforms, as nearly as practical, to the elevation and profile of the existing track(s) and crossing surface(s).

8.3.1.2 Coordination with Railroad

Should projects involving rehabilitation, restoration, replacement, renewal, resurfacing or maintenance of existing roadway approaches to a highway/rail grade crossing require adjustments to the crossing surface (crossing width, track elevation, or other) or to other railroad owned or maintained facilities, it is incumbent upon the roadway engineer or roadway authority to communicate such plans to the respective railroad operating company or track owner sufficiently in advance of the work to allow for proper and timely coordination, including reaching a mutual agreement as to scope of work, materials to be used, work schedule(s) and division of costs.

When the nature of these adjustments impacts the compliance with *MUTCD*, State, local or railroad standards, corrective action should be taken. Where extensive corrective action is required, a diagnostic team may be convened to assure compliance with all applicable standards. Examples of adjustments requiring corrective action include:

- a. Roadway geometric changes affecting width, crossing angle or elevation of the traveled way, such as:
 - (1) Lateral clearances of traffic control devices including crossbuck assemblies or active warning devices
 - (2) Vertical Clearances affecting overhead flashing light signals or height of gate arms
 - (3) Modifications impacting the effectiveness of curbing
 - (4) Modification or addition of lanes requiring changes or additions to traffic control devices
 - (5) Modification or addition of shoulders requiring changes or additions to traffic control devices
 - (6) Conversion of existing pavement width for alternative uses requiring changes or additions to traffic control devices
 - (7) Changes to the width or crossing angle of the traveled way requiring adjustments to railroad signal circuits

- b. Addition or modification of sidewalks or pathways
- c. Addition or modification of guardrails or barriers
- d. Improvements to roadways that affect the traffic volume or patterns
- e. Addition or Modification of utilities in the vicinity of the crossing

8.3.1.3 General Safety Regulations, Insurance, Flagging and Right-of-Entry Permits

Article 8.2.1.9 of this Chapter is incorporated herein by reference.

8.3.2 TRACK AND CROSSING SURFACE REHABILITATION AND MAINTENANCE (2006)

8.3.2.1 General

Projects involving rehabilitation, restoration, replacement, renewal, resurfacing or maintenance of existing track(s) and/or crossing surface(s) through a highway/railway grade crossing should be planned and executed, to the extent reasonably practicable, to conform to the provisions of Article 8.2.2, Section 8.4 and Section 8.5 of this Chapter; however, whenever doing so would require revision(s) to the track alignment, track elevation and/or track profile which are deemed impractical or beyond the reasonable scope of the work being undertaken, such work should conform with the applicable standards and practices of the operating railroad, track owner and/or regulatory agency having jurisdiction for the scope of work being performed. Any such track or crossing surface work not being performed concurrent with the rehabilitation, restoration, replacement or renewal of the roadway approaches should be planned and executed such that the resulting crossing surface conforms, as nearly as practical, to the elevation of the existing roadway approaches or arrangements made to correspondingly adjust the roadway approaches. When such adjustment(s) consist of placing tapered overlays on the roadway approaches, such tapered overlays should typically extend, perpendicular to the railroad, at least 10-feet beyond the outside edge of the crossing surface or end of tie for each 1-inch of track raise above the pre-existing pavement elevation, or as otherwise deemed practical considering pre-existing conditions.

8.3.2.2 Coordination with Roadway Authority

Should projects involving rehabilitation, restoration, replacement, renewal, resurfacing or maintenance of existing track(s) and/or crossing surface(s) through a highway/railway grade crossing require adjustments to the roadway approaches, it is incumbent upon the railroad engineer or person in charge of the work to communicate such plans to the respective roadway authority sufficiently in advance of the work to allow for proper and timely coordination, including reaching a mutual agreement as to scope of work, materials to be used, work schedule(s) and division of costs.

8.3.2.3 Highway Work Zone Traffic Control, Insurance, and Permits

Article 8.2.2.7 of this Chapter is incorporated herein by reference.

SECTION 8.4 THE TRACK STRUCTURE AS CROSSING FOUNDATION (2013)

8.4.1 GENERAL (2006)

Where roadways and railroad tracks intersect at grade, the track structure itself (ties, rail, ballast, etc.) serves as the foundation for the crossing surface which, in effect, is essentially an extension of the roadway surface across the tracks. Thus, in addition to its customary function of carrying and supporting rail traffic, it must also carry and support the roadway traffic. While the weight of roadway vehicles is often a fraction of the weight of rail vehicles, the impact effects of such roadway loading,

especially from heavy trucks, can be considerable. As such, the track through an at-grade crossing should be engineered and constructed with this additional loading in mind. Particularly on lighter density, low speed tracks, if extending the life of the crossing and/or reducing the need for maintenance is a concern, it is often advisable to construct the track through the limits of the crossing with heavier materials than may be specified for the remainder of the track.

It should also be recognized that conventionally constructed railroad trackage, particularly in North American freight service, by design, experiences considerably greater deflection under load than typical roadway pavements. Also, the differing level of live loads experienced by these respective structures often results in correspondingly different rates of subsidence. As such, where roadways and railways intersect at-grade, particular attention should be paid to the interface of the track and the roadway pavement along the vertical plane coincident with the ends of the track cross-ties.

Considering the current state of the practice relative to constructing, reconstructing, replacing, renewing and/or rehabilitating conventional railroad trackage, it should be recognized by rail and roadway personnel alike that attempts to do other than nominal highway/railway grade crossing maintenance within the limits of an existing roadway absent a full roadway closure are highly likely to result in less than satisfactory results requiring more frequent track and/or crossing maintenance and repeated roadway traffic disruptions. Thus, whenever such work is being undertaken, every effort should be made by the roadway authority to allow full closure of the roadway during the reasonable progress of such work.

8.4.2 DRAINAGE (2006)

In situations where the grade of the roadway approach descends toward the crossing, provisions shall be made to intercept surface and subsurface drainage and direct it laterally so that it will not be discharged on the track or pond adjacent to the track. Surface ditches shall be installed. All drainage areas should be cleaned and sloped away from the crossing in both directions along the track and the roadway. If required, subdrains with suitable inlets and the necessary provisions for clean-out shall be made to drain the subgrade thoroughly and prevent the formation of water pockets. This drainage shall be connected to a storm sewer system, if available; if not, suitable piping, geotechnical material and/or French drains shall be installed to carry the water a sufficient distance from the roadbed(s). Where gravity drainage is not available, a nearby sump may provide an economical outlet, or the crossing may be sealed and the roadbed stabilized by using asphalt sub-ballast or its equivalent.

8.4.3 SUBGRADE (2006)

The track subgrade should be cleaned of any old contaminated ballast and bladed to a uniform plane (with at least a $\frac{1}{4}$ " per foot cross slope for drainage) a minimum of 12 inches below the bottom of tie, extending at least 20 feet beyond each end of the crossing and at least 1 foot (3 to 5 feet preferred) beyond the ends of the ties. In addition, it is recommended the subgrade be over-excavated to allow for a minimum of 6 inches of well compacted sub-ballast material to be installed below the ballast. A compacted layer of hot mix asphalt, typically 4 or more inches thick, may be substituted for the sub-ballast.

8.4.4 GEOTECHNICAL FABRIC (2006)

A geotechnical fabric may be used between the subgrade and ballast section. If used, it should extend at least 20 feet beyond the end of the crossing, and if a rail joint falls within these limits, at least 5 feet beyond the rail joint. If practical, the geotechnical fabric should extend under the roadway surface 10 feet or more each way from the centerline of track.

8.4.5 BALLAST (2012)

Clean ballast conforming to AREMA [Chapter 1](#), of at least the same quality or better as that specified by the track owner or operating railroad for the track beyond the limits of the crossing, should be placed between, on the ends, and under the ties and sub-ballast.

8.4.6 TIES (2013)

New treated (nominal 7"x 9") hardwood, concrete, steel, or composite ties, conforming to the specifications contained in [Chapter 30](#) of this Manual for use in heavy haul freight service, should be used through the crossing and a minimum of 20 feet beyond each end of the crossing. Length, surface plane, spacing and type of ties should conform to the type of grade crossing surface materials being used and the respective surface material manufacturer's recommendations. Ties must uniformly support the crossing surface material.

8.4.7 TIE PLATES, SPIKES, ANCHORS (2007)

All ties through the crossing and at least 20 feet beyond each end of the crossing should be fully plated with double shoulder tie plates. Unless an elastic fastener system is used, all ties should be spiked with at least 3 line-holding spikes (double spiked on gage side of rail) per tie plate and at least 2 plate holding spikes per tie plate and all ties through the crossing should be fully box anchored. Optional placement of tie pads is acceptable with cut spike fastener systems. It is recommended that elastic fasteners through rail crossings be treated with a corrosion resistant treatment.

8.4.8 RAIL (2006)

The rail section should, at a minimum, be 115 lb through the crossing area, and so laid to eliminate all joints within the crossing and for a distance of at least 1 foot for each MPH of maximum authorized train speed, but in no case less than 20 feet, beyond each end of the crossing. Where necessary, long rails shall be used or the rail ends welded to form continuous rail. If active grade crossing signals requiring an island circuit are present, there should be no joints within the island circuit. Any insulated joints required within the limits herein specified should be glued, bonded joints. The use of non-control cooled rail and rail sections known to have a higher tendency of developing head and web separation failures (e.g., 112 lb., 131 lb., etc.) should be avoided through highway/railway grade crossings. Similarly, the use of rails turned sideways (mudrails) or other rigid materials should not be used as flangeway fillers in highway/railway grade crossings as these also increase the likelihood of developing head and web separation failures in the running rails.

8.4.9 LINING AND SURFACING TRACK (2006)

Rails should be spiked to line and the track mechanically tamped and surfaced to grade and alignment as described in [Articles 8.2.1.4, 8.2.1.5 and 8.2.2.3](#) of this Chapter.

8.4.10 REMOVING AND REPLACING TRACK (2006)

Where the track structure is to be constructed or replaced through the limits of an existing roadway, the pavement should be cleanly saw cut a minimum of 42 inches, and desirably 60 inches or more, from the outer ends of the ties, and the roadway pavement and base excavated to a depth consistent with the depth of ballast removal. Once the track panel has been placed, ballast section constructed and track surfaced and lined, a separation fabric may be placed to protect the ballast section. Appropriate roadway base stone should then be placed in lifts and firmly compacted with an appropriate roller or vibratory compactor prior to reestablishing the roadway pavement. This will aid in preventing the settlement which often occurs adjacent to the crossing surface.

SECTION 8.5 CROSSING SURFACE MATERIAL SELECTION AND INSTALLATION (2006)

8.5.1 CROSSING SURFACE MATERIALS (2006)

Any crossing surface material may be used on any crossing at the discretion of the track owner or operating railroad, or as recommended by a diagnostic evaluation of the crossing, however, the use of unconsolidated crossing materials (ballast, dirt,

gravel) should generally be avoided at public crossings or on main tracks. Specifications and plans concerning the crossing surface material and usage should conform to the manufacturer's recommendations and/or the track owner's or operating railroad's specifications and plans and, where applicable, to the standards of the governing roadway authority. Manufactured crossing surface materials should be designed and fabricated to be substantially flush with the tops of rails when newly installed, giving due consideration to the rail height, tie plate thickness, fastening system, and anchor system and whether tie pads are to be used. Grade crossing surface systems, including any flangeway (gage or field side) filler material components, must be electrically non-conductive so as not to interfere with train control or crossing signals.

8.5.2 WIDTH OF CROSSING (2006)

The crossing shall be of such width as prescribed by law, but in no case shall the width be less than that of the adjacent traveled way plus 1 foot on each side as measured perpendicular to the roadway. Where sidewalks are present and the separation between the edge of the traveled way and near edge of the sidewalk is less than 8 feet, the sidewalk crossing surface shall be of the same type as the roadway crossing surface and shall be continuous to the back of the sidewalk.

8.5.3 FLANGEWAY WIDTH AND DEPTH (2006)

For newly constructed or newly reconstructed highway/railway crossings, flangeways not less than 3 inches in width should be provided. This width may be reduced at the discretion of the operating railroad if the track is used exclusively by transit or other captive (non-interchange) equipment. Flangeways shall be at least 2 inches in depth unless approved by the operating railroad.

SECTION 8.6 LOCATION OF PARALLEL RAILWAYS AND HIGHWAYS (2013)

8.6.1 GENERAL (2009)

- a. Instances occur where new highways may need to be constructed parallel to existing railroads, or new rail lines may need to be constructed parallel to existing highways. The closer such facilities are to each other, the greater the potential for highway-rail conflicts caused by either a desire for rail service by a user located on the other side of the highway, or property owners on the other side of the rail line desiring access to the highway. The former will result in rail spurs being constructed across the highway at-grade, the latter in perceived need for additional roadway crossings of the rail line at-grade.
- b. To reduce conflicts and inconveniences, the following principles are recommended for the guidance of railroads, highway agencies, planners, and developers. These principles provide guidance for new or expanded road and rail facilities located and designed with proper attention to capacity, operations and safety. The purpose of these recommended practices is to reduce and minimize the construction of highways and railroads with less-than-desirable criteria or in close proximity to one another.
- c. Even though there may be no immediate plans for land use changes in the area in question, but topographic or other factors do not preclude development, consideration should be given to factors which would affect or encourage future development. Adequate space for such activities should be reserved between the highway and the railroad to accommodate such uses.
- d. It is also desirable to locate railroad tracks and parallel highways sufficiently distant from each other in the vicinity of highway-rail grade crossings to avoid negatively impacting grade crossing safety and operations. Allowances should be made for future grade separation of the highway-rail crossing, or, where such grade separation is not likely to be feasible or warranted, then as needed to address any anticipated present or future needs for highway storage distance, accommodation of traffic queues, and coordination of traffic control between the highway-rail crossing and any adjacent highway-highway intersections.

8.6.2 TRAFFIC IMPACT STUDIES (2009)

- a. Railroad marketing and industrial development departments are often aware of present and future business potential on a site or sites which may be developed. Upon request, rail planning, operating and engineering personnel can work in partnership with community and regional transportation planners to define potential needs for rail access; room for switching operations; car loading and storage; and lead tracks or other rail improvements to accommodate present and future rail users on a site.
- b. State Highway and Transportation agencies, and many local jurisdictions, require a site “traffic access and impact study” as a condition of issuing licenses or permits to developers who wish to add or remodel facilities which will have access from the street or highway system. This is a tool used to assess the effect a particular development or developments will have on the surrounding transportation network. It specifies what provisions are needed for safe and efficient highway access and smooth traffic flow. The product of the study is a report, prepared by and under the supervision of a registered Professional Engineer, which describes the type of access and the scope of required roadway improvements required to accommodate the development or developments on the site at “build-out”. The report should be prepared in accordance with the latest edition of *Transportation Impact Analyses for Site Development* (ITE Journal February 2006), published by the Institute of Transportation Engineers (ITE); with the latest editions of *Trip Generation* (7th Edition, 2003) and *Trip Generation Handbook* (2nd Edition, 2004), published by the Institute of Transportation Engineers (References 10, 11 & 12) and with the specific requirements of the transportation or planning agency having jurisdiction. Such studies and reports should also consider the likely traffic impacts at nearby highway-rail grade crossings and any resultant needs for safety improvements or alterations thereat.
- c. Where proposed land development will require additional public roadway access across an existing line of railroad to reach a parallel highway, any resultant impacts on existing and future railroad operations must be fully considered. Should creation of a new public highway-rail crossing be required, consideration should be given to grade separation, closing one or more nearby crossings, or locating the proposed development on an alternate site, as determined to be in the best interest of all concerned parties.
- d. Where a community has developed along the main line of a railroad, and there are numerous street crossings of the tracks, the traffic access and impact study should expressly consider the consolidation of crossings and the use of the remaining streets to serve as outlets to the surrounding highway system. The concentration of traffic to a few desirable routes may permit physical improvements to intersections, traffic signalization, highway-rail grade separation, or other projects which may not otherwise be justified.

8.6.3 GENERAL DESIGN CRITERIA (2013)

- a. The recommended practices for the design of the railroad facilities can be found in this Manual and the AREMA *Portfolio of Trackwork Plans*.
- b. The criteria for the design of the highway facilities can be found in the publication, *A Policy for Geometric Design of Highways and Streets*, also called the “Green Book”, published by the American Association of State Highway and Transportation Officials (AASHTO) (Reference 5); and state or local agency design directives and manuals. The chosen design should reflect the results of the access and impact study.
- c. The requirements for highway traffic control devices approaching or at a public highway-rail or pathway-rail grade crossing can be found in the *Manual on Uniform Traffic Control Devices* (MUTCD) published by the Federal Highway Administration (FHWA) and the AREMA *Communications & Signals Manual of Recommended Practices*. (References 1 & 4)
- d. Where the results of the traffic access and impact study indicate that traffic queues may extend from a signalized intersection to or across a highway-rail grade crossing, the traffic signals should be preempted by the grade crossing warning system in accordance with the MUTCD (see AREMA *Communications & Signals Manual of Recommended*

Practices Part 3 and the latest version of *Preemption of Traffic Signals near Railroad Crossings*, published by ITE (Reference 6)).

- e. Highway traffic volumes and operations at non-signalized highway-highway intersections near the rail line should be reviewed for their effect on nearby highway-rail grade crossings and engineering improvements should be identified and considered.
- f. Arterial highways parallel to the tracks and serving residential or commercial areas should be a sufficient distance from any highway-rail grade crossing, as established by the traffic access and impact study, to permit the queuing of traffic at a signalized highway-highway intersection between the railroad and the intersection without occupying the track.
- g. Arterial highways parallel to the tracks should be a sufficient distance from any highway-rail grade crossing to permit grade separation of the highway-rail grade crossing in the future as may be required by additional development or future changes in highway and/or rail traffic.
- h. The number of public highway-rail grade crossings of a main track within a given area should be minimized. It is desirable that such crossings be located no closer than ½ mile apart, measured along the tracks.
- i. Highway-rail grade crossings with steep approach grades within the study area should be identified for potential elimination or correction. Care should be taken during highway or railroad construction or reconstruction that steep approach grades at crossings not be created or made worse.
- j. Highway-rail grade crossings of main-line railroad tracks within industrial facilities are discouraged.
- k. Where possible, industrial facilities, multimodal or bulk terminals, warehousing, or port operations should be located between the through highway and the railroad main line. This will permit the development of the property without having spur or service tracks cross the public highway or street.
- l. Where service or spur tracks must cross a public highway at-grade, the crossing should be made as close to 90 degrees as practical, but not recommended less than 75 degrees. The installation of active traffic control devices and illumination should be considered. The highway-rail grade crossing should be located, or lead, storage or other tracks should be placed, so that switching or car spotting does not require that cars or locomotives be stopped on or near the crossing. The layout of the tracks or the rail operations should be so planned that industry or railroad employees are not required to be on the ground or exposed to traffic at or near the highway.

8.6.4 PHYSICALLY RESTRICTED AREAS (2009)

- a. Where highways must be located adjacent to railroad tracks due to physical restrictions, they shall be designed and constructed so as to not interfere with the railroad roadbed or ballast section. Provision must be made for a subgrade cross section of the track or tracks adequate to encompass space for such items as the following:
 - (1) Railroad wayside signals, sign and appurtenances
 - (2) Crossing traffic control devices
 - (3) Railroad pole lines and catenary structures
 - (4) Buried facilities, such as fiber optics or other communications lines
 - (5) Drainage, including ditches and culverts
 - (6) Utilization of off-track equipment

- (7) Signal cases or bungalows
- (8) Railroad maintenance activities, such as tie and surface operations
- b. Where it is possible that errant highway vehicles may intrude onto the track, barriers meeting the applicable criteria for strength and safety shall be placed to prevent highway vehicles from fouling the track or otherwise damaging railroad facilities or interfering with train operations. The design and placement of barriers must conform to the current edition of the *Roadside Design Guide*, 3rd Edition (2002), published by AASHTO. (Reference 9)
- c. Provisions should be made for snow removal and/or storage, and ice control.

8.6.5 LIMITED ACCESS HIGHWAYS (2009)

- a. A limited access highway may be defined generally as a highway especially designed for through traffic and to which abutting property owners have no right of access. Access may be had only at specified locations.
- b. In some instances these access restrictions are modified to the extent that such access may be had by abutting owners as is reserved pursuant to the map and description of lands to be appropriated. Service highways, to provide access to and from areas adjacent to a limited access highway, may also be provided if they are deemed necessary in the public interest.
- c. Any abutting property owner has an inherent right of entry to and from a public highway. In establishing limited access highways, this inherent right of abutting owners must be acquired from the owner by purchase, gift, agreement or condemnation. A railway as a property owner may therefore assert its right of access to a limited access highway that abuts its property, and seek a form of compensation for such loss of rights.
- d. Highway-rail grade crossings are not permitted on highways designed for access control.
- e. Where no usable property exists between the limited access highway and a parallel line of railroad, and no other reasonable means exists for the railroad to access its property for maintenance purposes, a locked gate access from the limited access highway may be appropriate.
- f. Where usable property does exist between the limited access highway and a parallel line of railroad, the highway designer should endeavor to provide alternate access to the affected property which minimizes the need for at-grade highway-rail crossings.

SECTION 8.7 LICENSE OR EASEMENT APPLICATIONS (HIGHWAY – STREET – ROADWAYS)¹ (2012)

8.7.0 DEFINITIONS (2012)

For purposes of this Part, terms are defined. These terms may apply to aerial, at-grade, or under grade activity.

The term “license or permit” means a written authorization, whereby a certain activity is granted. Usually a license / permit includes conditions and a fee, either a one-time payment or periodic. Licenses / permits may be cancelled by either party, sometimes on short notice, as defined in the license or permit.

¹ References, Vol. 56, 1955, pp. 378, 1045; Vol. 57, 1956, pp. 328, 953; Vol. 58, 1957, pp. 441, 1140; Vol. 63, 1962, pp. 185, 732. Reapproved without change 1962.

The term “easement” means an agreement whereby a property owner authorizes use of some or all of a property. An easement attaches a right of use to the property. Usually an easement includes conditions, fees, and is legally recorded. An easement may have a set time period.

The term “designer” means a party who is in charge of a project that proposes project work.

The term “owner” means a party who owns real property. The owner may be a railroad or other party.

The term “permittee” means a party who seeks or possesses authorization for activity on the real property of an owner.

The terms “engineering agreement” or “preliminary engineering agreement” are used to define an agreement between the railroad and an outside party for the design phase of a project whereby the railroad begins a financial account for its services. This agreement may include right of entry permission. The purpose is to identify how the proposed project affects railroad facilities (such as track, signaling, operations, and safety), identify design criteria (including clearances), and identify other project specific considerations.

The term “construction agreement” is used to define an agreement between the railroad and an outside party for the construction phase of a project whereby the railroad prepares a material and work force account estimate and a scope of work. Conditions set forth in a construction agreement usually identify construction activity; project duration; identification of construction forces, maintenance responsibilities, and flagging/safety requirements; insurance requirements; and may include negotiated agreements, licenses, and other permits.

8.7.1 PURPOSE (2012)

The purpose of this section is to notify the designer who proposes opening, closing, or modifying crossings (at grade or grade separated) that coordination may be necessary with several entities, including but not limited to the railroad, the state public agency in charge of regulating grade crossings, and utility companies. Depending on the nature of the proposed work, agreements, licenses, easements and/or other permits may be required.

Refer to AREMA Chapter 1, [Part 5, Pipelines](#) for additional information regarding crossings of pipelines.

8.7.2 GENERAL (2012)

- a. The real estate department or the public projects department of the railroad is usually the contact point to begin the coordination process with the railroad. The railroad should be provided with a conceptual plan and anticipated project schedule as early as possible in the design process. It may be necessary for the owner and the permittee to enter into an engineering agreement.
- b. Each state may have one or more agencies charged with regulation of public grade crossings. These agencies may be a utility commission, a commerce commission, department of transportation, or a local road authority. Federal requirements should also be considered.
- c. Any entry onto railroad property will require permission of the railroad. Some owners may require right of entry permits that must be obtained prior to entry upon property. Some railroads require all who enter its property to complete railroad safety training.
- d. Utility facilities may be present within the project limits. The designer should be aware that agreements may be in place between the utility company and other parties that include special considerations. The designer should contact the utility company early in the design process to make allowances for proper protection of those facilities.
- e. Temporary use of property for construction purposes must be negotiated with the owner and operating railroad. Use of property for any purpose, including but not limited to, surveying, locating utilities, geotechnical activity, maintenance activities or any temporary or permanent construction, must be negotiated with the owner and operating railroad.

- f. Upon approval of final plans and cost estimate, the appropriate license, easement, permit and/or a construction agreement will be prepared.
- g. Upon regulatory agency approval and execution of the appropriate final agreements, construction can begin.

8.7.3 GENERAL PLANS & SPECIFICATIONS (2012)

8.7.3.1 Design

The designer should not overlook the railroad when gathering initial project information. Valuation mapping (right-of-way, track charts, station maps) and utility agreements from the railroad can provide useful information of property limits, property improvements, and utility locations. Most railroads have design criteria related to clearances, drainage and hydrology, pipe size and material, utility locations, grade crossing surface type and installation, and overpass/underpass structures including column thicknesses and crash walls.

The format and content of project documents will vary depending on the railroad and the public agency with jurisdiction. But, typically, information provided to the railroad for review should include the following:

- a. Plans
 - (1) Information such as railroad property lines; property improvements such as tracks, signals, buildings, and pole lines; and utility locations and depths.
 - (2) USDOT/AAR grade crossing inventory number of each grade crossing within the project limits.
 - (3) Boundary of the property to be used by license, permit, or agreement.
 - (4) Distance to the nearest railroad milepost and milepost number and latitude and longitude coordinates, if available.
 - (5) Centerline of track or tracks.
 - (6) Current and proposed drainage structures.
 - (7) Proposed roadway improvements.
 - (8) Horizontal and vertical clearances from center of nearest track, top of rail (outside rail if track geometry is curved).
 - (9) Permanent and temporary traffic control devices and markings, including signals, foundations, cabinets, overhead wires, and underground conduits.
 - (10) Work zone traffic plans including detours, diversions, closures, flagging, and durations.
 - (11) Phased or staged construction.
 - (12) Location and boundaries of property to be used both temporary and permanent either by license, permit, or agreement. of any construction or temporary license, permit, or agreement areas.
- b. Profiles
 - (1) Roadway centerline profile showing current and proposed grades.
 - (2) Roadway cross slope and transitions.

- (3) Top of rail elevations of each track at road centerline and edges.
- (4) Top of rail elevations within the project limits and at least 500 feet outside of project limits.
- (5) Ditch elevations and grades.
- c. Drainage
 - (1) Details and calculations of current and proposed drainage hydraulics and hydrology.
- d. Sections
 - (1) Cross sections with currently existing ground and proposed track roadbed and ditches.
 - (2) Cross sections with currently existing ground and proposed roadway and ditches.
 - (3) Typical sections of proposed track, roadway, and ditches.
- e. Property
 - (1) If requested, a plat, usually 8.5" x 14", showing property to be used by license, permit, and or easement.
- f. Contract Documents
 - (1) Supplemental special provisions for work on railroad property.
 - (2) Specifications for the portions of work that will affect or occupy railroad property.
- g. Design and Construction Changes
 - (1) Work zone traffic plan changes
 - (2) Shoring plans
 - (3) Demolition plans and schedule
 - (4) Plan revisions or changes
 - (5) Other contract document changes

8.7.3.2 Submittals

The following is a typical sequence of submittals to the railroad, which should be submitted electronically, if possible:

- a. Conceptual plan and project schedule.
- b. License, permit, or agreements with applicable fees.
- c. Initial plans, specifications, and calculations for railroad review.
- d. Final plans, specifications, and calculations.
- e. Final right of way or easement plats.

- f. Design and construction changes submittals.
- g. Construction agreement with insurance certificates and applicable fees.
- h. Request for railroad flagging including dates and durations.

SECTION 8.8 REFERENCES (2009)

1. Current Communications and Signals Manual of Recommended Practices, American Railway Engineering and Maintenance of Way Association (AREMA) Landover, MD.
2. Geometric Design Criteria for Highway-Rail Intersections (Grade Crossings), Institute of Transportation Engineers (ITE), Washington, D.C.: Publication No. IR-110, April, 2001.
3. Guidance on Traffic Control Devices at Highway Rail Grade Crossings, US Department of Transportation, Washington D.C. December, 2002. Ayers, D.J., Unstable track formations respond to bituminous spray treatment, Railway Gazette International 128, n. 7, July 1972, p.263-264.
4. Manual of Uniform Traffic Control Devices, 2003 Edition, (FHWA), Washington, D.C.
5. A Policy on Geometric Design of Highways and Streets, American Association of State and Highway and Transportation Officials (AASHTO), Washington D.C.: 2000 Edition.
6. Preemption of Traffic Signals near Railroad Crossings, Institute of Transportation Engineers (ITE). Washington D.C.: Recommended Practices, Item RP-025A (January 2006).
7. A Procedure for the Provision of Highway-Railroad Grade Separations, TransTech Group, Inc., G. Rex Nicholson, Jr. and George L. Reed, April 2001 (see Proceedings of the 2008 Rail Corridor Safety Conference, A Railroad Runs Through It, May 12-14, 2008). A link to download the full study is: www.TransTechGroupInc.com/paper.
8. Railroad-Highway Grade Crossing Handbook, 2nd Edition Revised (2007) Federal Highway Administration (FHWA), Washington D.C.: Publication No. FHWA-TS-86-215.
9. Roadside Design Guide, (2002) American Association of State and Highway and Transportation Officials (AASHTO), Washington D.C. 3rd Edition.
10. Transportation Impact Analyses for Site Development. Institute of Transportation Engineers, Washington D.C. (ITE) An ITE Proposed Recommended Practice. ITE Journal, (February, 2006).
11. Trip Generation, (2003) Institute of Transportation Engineers (ITE). Washington D.C. 7th. Edition.
12. Trip Generation Handbook, (2004), Institute of Transportation Engineers (ITE) Washington D.C. 2nd Edition.



American Railway Engineering and
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Part 9

Design Qualification Specifications for Elastic Fasteners on Timber Cross Ties

— 2014 —

This Part has now been eliminated. This material can now be found in [Chapter 30, Ties, Appendix](#).

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Part 10

Miscellaneous

— 2012 —

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SECTION 10.1 SPECIFICATIONS FOR STEEL SCREW SPIKES¹ (2012)

10.1.1 SCOPE (2012)

This Specification covers:

- a. Standard Strength Steel Screw Spikes
- b. High Strength Steel Screw Spikes

10.1.2 PROCESS (2012)

- a. The steel shall be made by either Electric-Furnace or Basic Oxygen process.
- b. Each lot of screw spikes shall be made from a uniquely identifiable heat of steel.

10.1.3 MANUFACTURE (2012)

The heads of the spikes shall be formed and the threads rolled hot or cold. Threads may be cut when agreed to by the purchaser.

10.1.4 CHEMICAL COMPOSITION (2012)

The chemical composition shall meet the requirements of [Table 5-10-1](#). The composition may be taken from the ladle analysis of the raw material or from a finished screw.

¹ References, Vol. 62, 1961, pp. 648, 946; Vol. 63, 1962, pp. 490, 755; Vol. 64, 1963, pp. 430, 683. Rewritten 1963.

Table 5-10-1. Screw Spike Chemical Requirements

	Carbon	Phosphorous	Sulfur
Standard Strength	0.18% Min 0.25% Max	0.04% Max	0.05% Max
High Strength	0.40% Min 0.55% Max		
For high strength screws the manufacturer and purchaser may agree on alternate steel compositions			
Copper, when specified for corrosion resistance..... 0.20% -0.35%			

10.1.5 TENSILE PROPERTIES (2012)

- a. Finished screws shall conform to the following minimum requirements for tensile properties:

Standard Strength

Tensile Strength, psi..... 74,000 Min

Yield Strength, psi.....37,000 Min

Elongation, % 18 Min

High Strength

Tensile Strength, psi.....120,000 Min

Yield Strength, psi.....80,000 Min

Elongation, %18 Min

- b. Tensile test shall be made on a specimen prepared from a finished spike. Recommended dimensions are shown in figure 5-10-3. Testing shall be performed according to ASTM F606.
- c. If any test specimen fails because of mechanical reasons, such as failure of testing equipment, operator error, or improper specimen preparation; it may be discarded and another specimen taken.
- d. If the elongation of a tension test specimen is less than that specified in [Article 10.1.5a](#) and any part of the fracture is outside the middle half of the gauge length, a retest is allowed.
- e. Except for heat-treated screws, steel mill cert data may be used for tensile strength with approval of the customer.

10.1.6 BENDING PROPERTIES (2012)

- a. The threaded portion of a spike shall bend 45° around a hardened pin 3 times the spike nominal diameter without cracking on the outside of the bend. Scale should be removed from the outside of the bend area before examination for cracks.

- b. If a bend test fails, only one retest shall be permitted. The retest shall be performed on two random specimens selected from the same lot. If both test specimens meet the specifications, the lot shall be accepted. If either fails, the lot shall be rejected.

10.1.7 NUMBER OF TESTS (2012)

A minimum of three tensile and three bend tests per 10,000 pieces must be performed.

10.1.8 DIMENSIONS (2012)

The purchaser shall specify in the inquiry and order the plan to which the screws are to be manufactured. The following plans cover designs of screw spikes. Other designs may be specified by the purchaser.

- Plan 1S Rectangle Head Screw Spike
- Plan 2S Square Head Screw Spike

10.1.9 FINISH (2012)

The head shall be concentric with and firmly joined to the body of the screw. The material shall be free from injurious defects and shall have a workmanlike finish. Screws shall be provided with plain finish unless a corrosion resistant coating is specified by the purchaser.

10.1.10 MARKING (2012)

Markings shall be raised.

- a. A letter or brand indicating the manufacturer shall be located on the top of the washer of each screw as shown on the plans.
- b. The year and month of manufacture shall be located on the top of the washer of each screw.
- c. High strength screws shall be marked with an “H” of the top of the washer.

10.1.11 INSPECTION (2012)

The inspector representing the purchaser shall have free entry at all times while work on the contract of the purchaser is being performed to all parts of the manufacture's works which concern the manufacture of the material ordered. The manufacturer shall afford the inspector, without charge, all reasonable facilities to verify that the material is being manufactured in accordance with these specifications. All tests and inspections shall be made at the place of manufacture, prior to shipment, unless otherwise specified and shall be so conducted as to not interfere unnecessarily with the operation of the works.

10.1.12 REJECTION (2012)

- a. Material represented by test samples that fail to meet the requirements of Articles 10.1.5 and 10.1.6. shall be rejected.
- b. Material that shows injurious defects subsequent to its acceptance at the manufacturer's works shall be rejected and the manufacturer notified.

10.1.13 PACKAGING (2012)

- a. The purchaser shall specify the type and quantity of packaging in which the screws are supplied.
- b. Each package shall be labeled with the manufacturer, lot identification, quantity, and part number or identification.
- c. When specified by the purchaser, the threads of each screw shall be coated with wax.

SECTION 10.2 PLANS FOR STEEL SCREW SPIKES (2012)

10.2.1 GENERAL (2012)

For steel screw spike plans refer to [Figure 5-10-1](#) through [Figure 5-10-3](#).

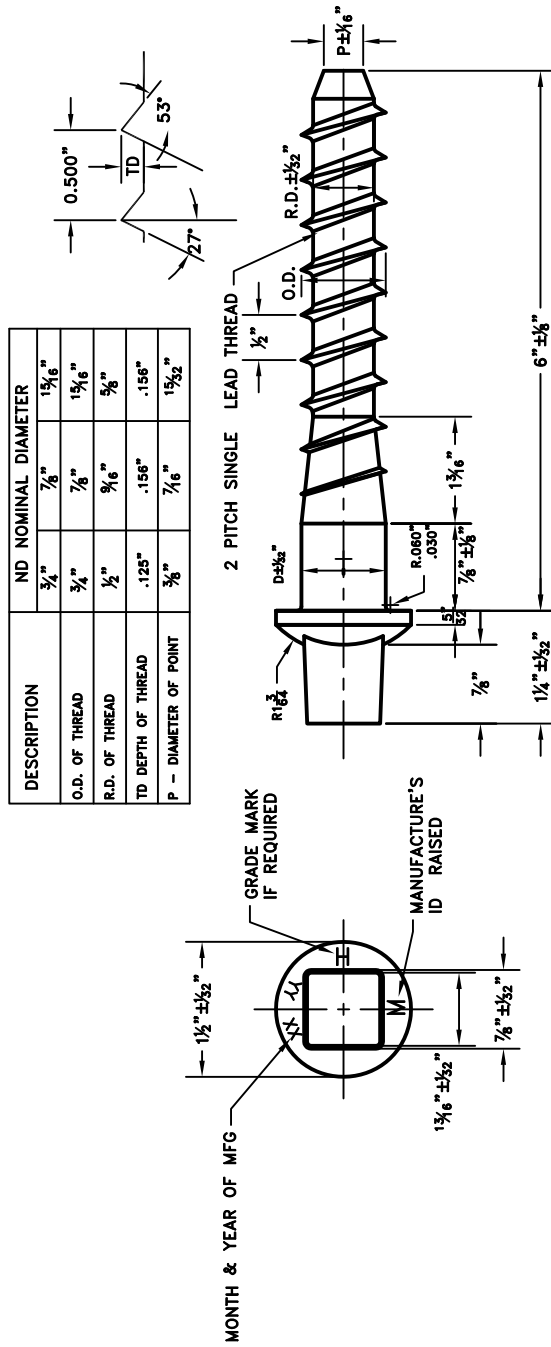


Figure 5-10-2. Plan 2S-12 AREMA Square Head Screw Spike (2012)

D	G	A min	R min
.500" ±.010"	2.000"±.005"	2.250"	.250"
.350" ±.007"	1.400"±.005"	1.750"	.250"
.250" ±.005"	1.000"±.005"	1.250"	.190"

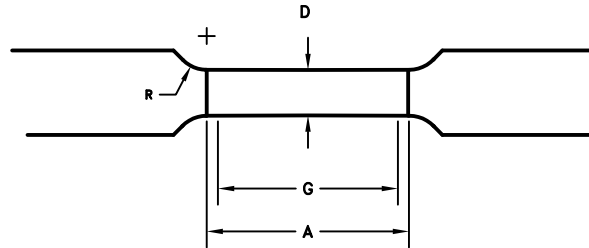


Figure 5-10-3. Recommended Tensile Specimen Dimensions (2012)

SECTION 10.3 RECOMMENDED PRACTICE FOR USE OF ABRASIVE WHEELS (2005)

10.3.1 SCOPE (2005)

These recommended practices cover the safe use, care and protection of abrasive wheels as it relates to railway construction and maintenance.

10.3.2 GENERAL (2005)

It is recommended that the current issue of the American National Standard for Safety Requirements for the Use, Care, and Protection of Abrasive Wheels, B7.1 sponsored by the Unified Abrasives Manufacturers' Association and associated organizations be followed. Issues may be obtained from U.A.M.A. 30200 Detroit Road, Cleveland, OH 44145-1967. All applicable Federal, State and local regulations shall govern operators, equipment and material.

10.3.3 GENERAL SAFETY (2005)

- Every precaution should be taken to prevent fire caused by sparks from abrasive wheels and to check area thoroughly for any smoldering fire before leaving.
- It is recommended that each wheel be speed tested at least the maximum test speed, in accordance with ANSI B7.1 Section 7, Standard Speeds, of the A.N.S.I. standards, and documented with a letter from the manufacturer. Manufacturers must maintain records to substantiate the tests and warranty of same is to be indicated on product labels.
- Always compare the operating speed recommended for the wheel against the machine operating speed. Never operate a wheel over its maximum operating speed. Excessive RPM could result in disintegration of the wheel. The maximum operating speed in RPM will be shown by the manufacturer on the label of each wheel.
- Before applying an abrasive wheel the operator must check to determine that the maximum RPM shown on the wheel will not be exceeded. The RPM of the abrasive machine must be checked by using a tachometer (speed counter). When

the machine RPM is in excess of that shown as the maximum allowable for the particular wheel to be used, the equipment must be adjusted to provide the proper RPMs. In no case will the operator take over the speed control of the abrasive machine engine by hand operation to accelerate it with an abrasive wheel and appurtenances on the spindle. (See ANSI B7.1 Section 7, Standard Speeds)

- e. When a new wheel is being started, allow it to operate at maximum operating speed for at least one minute before being applied to a working surface.
- f. Only the machine operator or helper should stand near an operating abrasive machine, and these people should avoid standing or walking in line with the abrasive wheel, except when necessary to perform their work. (Refer to [Article 10.3.5b.](#))
- g. Always use safety glasses with side shields as a minimum while operating an abrasive machine. Additional appropriate eye and face and respiratory protection may be required.
- h. Handle wheels carefully to prevent dropping or bumping. If an abrasive wheel is dropped or suspected of being damaged, it shall not be mounted.
- i. An inspection should be made for damage to the guard, flanges, or nuts, and to ensure that the spindle has not been sprung out of balance or bent in the event of breakage of an abrasive wheel. Machines should be inspected each day by the operator to see that the arbors, adaptors or other parts are free from wear. (Refer to [Article 10.3.6.](#))
- j. Shut down the grinding machine while moving it from one location to another. Avoid any possible damage to the abrasive wheel.
- k. Frequent inspections should be made for defects in abrasive wheels in use and for irregularities in the grinding machine, such as unusual vibrations or shaking, worn shaft or any unusual increase in engine speed. Wheels showing any visible evidence of cracks or damage should be destroyed.
- l. Any damaged or unsafe abrasive wheels must be destroyed to prevent accidental usage.
- m. Wherever possible, reinforced wheels should be used.
- n. Proper guards must be used to limit extent of damage and injury in the event of wheel failure. (See ANSI B7.1 Section 4, Safety Guards)

10.3.4 WHEEL MARKINGS (2005)

Each abrasive wheel, unless excluded by ANSI B7.1, should be marked with the following minimum information:

- Maximum Operating Speed (rpm)
- Manufacturer Identification
- Manufacture Date
- Manufacturer Product Designation

10.3.5 STORAGE (2005)

NOTE: See ANSI B7.1 Section 2, Handling and Storage

- a. Abrasive wheels must be handled and stored with care. Extreme temperatures will affect the structural integrity of the wheel. Extremes of humidity and moisture can disrupt the balance of a wheel, causing it to fly apart while in use.
- b. Abrasive wheels are extremely fragile in some circumstances, and need special treatment. Wheels should not be dropped or struck, and tools or other material must not be placed on top of abrasive wheels.
- c. Abrasive wheels should be stored in their shipping boxes laying flat on a flat surface until used, or as indicated in ANSI B7.1 Section 2, Handling and Storage, and must be stored in a dry place. Weight of shipping boxes and contents, when feasible, should be limited to approximately 50 pounds.
- d. Abrasive wheels stored or being carried in trucks must not be exposed to water, solvents, oil, dampness or extreme temperatures. Suitable racks, bins or boxes should be provided to prevent damage.
- e. It is recommended that all abrasive wheels should not be used after 2 years from manufacture date. Any recommended shelf life provided by an individual manufacturer will supersede this recommendation. Date, including month and year, of manufacture to be indicated on all wheels.
- f. The opportunity for damaging a wheel in storage increases with time and it is therefore recommended that stock be rotated to use the oldest wheels first.

10.3.6 ABRASIVE WHEEL MOUNTING (2005)

NOTE: See ANSI B7.1 Section 5, Flanges and Section 6 Mounting.

- a. Abrasive wheels must fit freely on the spindles and should not be forced on, nor should they be loose.
- b. A blotter (compressible washer) shall always be used between each flange and the abrasive wheel surface to ensure uniform distribution of flange pressure. Blotters shall cover the entire flange contact area. New blotters shall be used each time a wheel is mounted unless blotters are affixed to the wheel by the grinding wheel manufacturer. Loose blotters shall not be reused when mounting a new wheel or remounting a partly used wheel. Scuffed or damaged blotters shall not be used.
- c. Spindle nuts should only be tightened enough to hold the abrasive wheel firmly to prevent slippage, otherwise the clamping pressure may damage the abrasive wheel. There must be no alterations to an abrasive wheel to force it to fit. Use the proper wheel only.
- d. Bearing surfaces on mounting flanges and washers must be clean and flat. Both flanges, of any type, between which a wheel is mounted, shall be of the same diameter and have equal bearing surfaces. See ANSI B7.1 Section 5, Flanges, for further explanation.
- e. The reducing bushings furnished with some abrasive wheels should not extend beyond the wheel sides.
- f. Where wheels are mounted by means of a central spindle nut and flanges, the spindle should be of sufficient length and should be threaded to a sufficient length so that when the wheel and flanges are mounted there will be room for a full nut on the spindle. The threading should extend well inside the flange, or washers should be placed between the outer flange and the nut.
- g. Threaded nuts, or the central spindle nut, must be threaded in a manner that will tighten the nut as the spindle or wheel rotates.
- h. Closely inspect all abrasive wheels before mounting. If an abrasive wheel is suspect of damage it shall not be used.

10.3.7 OPERATION (2005)

NOTE: See ANSI B7.1 Section 9, General Operating Rules

- a. Operation of grinding machines shall not be at a speed higher than that recommended by the wheel manufacturer. The wheel must have this stamped on the side, and should not be used if this number is absent.
- b. All abrasive wheels should be run at full operating speed for at least 1 minute before grinding. The first contact made with the wheel on the material to be ground should be light to allow the wheel to become heated so as to permit any defects in the wheel to indicate their presence. During this time the grinding machine operator must place himself to one side, out of range of any possible danger if the wheel should break.
- c. Use of excess pressure on the wheel can be detrimental to metal quality. If the grinding speed slows markedly or the work surface gets hot and discolored, pressure must be reduced.
- d. Drive engines, electric motors, or control air supply must not be started or turned on while an abrasive wheel is in contact with any surface.
- e. Never start or operate a grinding machine without the wheel hood or guard in place.
- f. Grind only the material for which the machine and abrasive wheel are designed. Work should NEVER be jammed into the wheel.
- g. Grind only with the flat surface of cup wheels.
- h. Wheels out of balance through wear must be removed from the machine and discarded.
- i. When grinding is completed, the operator must shut down the grinding machine before leaving the equipment. Abrasive wheels should be protected between grinding operations.
- j. When an abrasive wheel breaks, an inspection must be made to assure that the guard and flanges have not been damaged. A full investigation and report of each broken wheel should be made, and in the event of an injury, machine shall be taken out of service pending full investigation.
- k. Proper guards must be used to limit extent of damage and injury in the event of wheel failure. (See ANSI B7.1 Section 4, Safety Guards.)
- l. Some of the causes of wheel breakage on grinding machines are improper mounting of the wheel, worn or distorted flange plates, improper speeds, abusive operation, careless handling and oil or moisture soaked wheels.

10.3.8 GRINDING PRACTICE (2005)

- a. Prescribed types of grinding machines should be used for designated kinds of work. Machines must be sufficiently rigid and substantial to minimize vibration and its adverse effect on the abrasive wheel.
- b. Only persons who have been properly qualified should perform grinding work.
- c. Side grinding should only be performed with abrasive wheels designed for this purpose.
- d. All grinding heads must be equipped with a protection hood or wheel guard.
- e. The removable outside portion of guard for the straight hand pieces used with all flexible shaft grinders must be in place when the hand piece is in use.

- f. The band-type guard used with cup-type abrasive wheels must be positioned so that at no time will the wheel protrude beyond the edge of the guard a greater distance than indicated in [Table 5-10-2](#).

Table 5-10-2. Band Type Guard Positioning

Overall Thickness of Abrasive Wheel in Inches	Maximum Exposure of Wheel Beyond Edge of Guard in Inches
1	1/2
2	3/4
3	1
4	1-1/2

10.3.9 GRINDING EQUIPMENT (2005)

- For surface grinding on rail ends, engine burns and thermite welds, grinders equipped with mechanical vertical feed control are recommended.
- For cross grinding to remove overflow from rail ends or providing clearance between rail ends to avoid chipping, a cross-cut grinder with a 1/8 inch reinforced wheel or flexible shaft grinder with a cross cutting attachment and 1/8 inch wheel are recommended.
- For grinding frogs, railroad crossings, switch points and stock rails, hand-held grinders or flexible shaft attachments may be used. Grinding machines with mechanically fed wheels may be used on frogs, railroad crossings and stock rails. Reinforced wheels should be used wherever possible.

10.3.10 GRINDING RAIL END SURFACE WELDS (2005)

The higher rail end should first be ground to a straight surface as determined by holding an 18 inch straight edge even with the end of the rail. Grinding should not extend beyond the limits of the weld except to make a smooth transition between welded and adjacent rail surfaces. The undamaged adjacent surface of the rail should not be lowered.

10.3.11 GRINDING WELDED ENGINE BURNS AND THERMITE WELDS (2005)

The welded engine burns and thermite welds must be ground to conform to the contour of the existing rail head. Grinding should not extend beyond the limits of the weld except to make a smooth transition between welded and adjacent rail surfaces.

10.3.12 CROSS GRINDING RAIL ENDS (2005)

- On joints where the expansion is 1/16 inch or greater, the 1/8 inch reinforced wheel must be used to grind out all excess or flowed metal in the expansion area.
- On joints where the expansion is 1/16 inch or less, referred to as tight joints, the 1/8 inch reinforced wheel must be used and the grinding made to a depth of 3/16 inch.
- The abrasive wheel must not come into contact with the splice bars or rail head bond wire.

10.3.13 GRINDING FROGS, RAILROAD CROSSING AND SWITCH POINTS (2005)

Grinding should be used for the following purpose:

- a. Preventative grinding: The removal of overflowed metal from flangeways on new track material in order to extend the service life. The grinding may have to be done several times until work hardening has occurred.
- b. Preparation grinding: The removal of spalled, cracked, flowed and work hardened metal prior to welding (cutting torch shall not be used for this purpose.)
- c. Finish grinding: The finish ground frog, railroad crossing and switch point should closely conform to original specifications to produce a smooth surface, proper flangeway and radius. Use gauge to check flangeway clearance and radius.

10.3.14 GRINDING STOCK RAILS (2005)

Grind all overflow off the gage side of the stock rail opposite the switch point contact area. The ground area must extend 4 inches beyond each end of contact area.

10.3.15 RAIL CUTTING (2005)

- a. Abrasive wheels should be stored under cover, not in the same car or storage area where oil is stored, and should not be used when wet, fouled with foreign particles, overheated or glazed. They should be stored in a flat position when carried in trucks.
- b. Injuries are likely to occur if the saw workhead is not oscillated and the abrasive blade gets overheated or warps while sawing a rail.
- c. Any tie plate or rail anchor falling directly under the location of the cut should be removed. There should be sufficient clearance below the location of the cut to prevent abrasive wheel contact with ballast, ground or concrete.
- d. Operators should ease the abrasive wheel onto the rail head and then maintain a constant pressure throughout the entire cut.
- e. Saws shall be firmly attached to the rail to provide safe control and proper alignment while cutting rail. The equipment shall not be used for any other purpose than cutting rail.
- f. To avoid overspeed, sufficient fuel must be in machine to prevent interruption of cutting.

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American Railway Engineering and
Maintenance-of-Way Association

Chapter 5 Glossary

The following terms are used in [Chapter 5 Track](#) and placed here in alphabetical order for your convenience.

Abrupt Grain Dip

Deviation of the fiber out of parallel with the axis of the handle in excess of one-eighth the diameter of the handle where the grain dip occurs

Absolute Value (Sub 5.8)

Absolute value is defined as a positive (>0) value for any given value negative or positive.

Area Width

Overall dimension of the plate parallel to the rail it supports. Tie plates are generally from seven to eight inches wide.

Balance (Sub 5.8)

The superelevation in a curve that equally distributes the vertical forces onto both rails at a designated speed.

Balanced Speed (Sub 5.8)

The velocity through a curve whereby the elevation (superelevation) fully counteracts the centrifugal forces of the train, and vertical forces are equal on each rail.

Central Angle (Sub 5.8)

This is the deflection angle or how many degrees you turn in a curve.

Change in Crosslevel (Sub 5.8)

The mathematical difference between two crosslevel measurements. Adding two opposing values or subtracting two same rail values obtains the change.

Chord (Sub 5.8)

A straight line of specified length between two points on the gage line of the high rail of a curve. A wire or string called a 'stringline' is used in the field to project a chord which is used to measure the mid-chord offset.

Compensated Grade (Sub 5.8)

A compensated grade is a grade adjusted for the resistance due to horizontal curvature.

Compound Curve (Sub 5.8)

A curve with sections of different radii, sometimes connected by a spiral, in the same direction.

Continuous Welded Rail

A number of rails welded together in lengths of 400 feet or longer. (Welded Rail: Rails welded together in lengths of less than 400 feet.)

Coordinate (Sub 5.8)

A coordinate is a set of numbers defining a location and an item being measured.

Cross Grain

Deviation of the fiber out of parallel with the axis of the handle in excess of 1 in 12 for ash and 1 in 20 for hickory.

Cross Level (Sub 5.8)

The relationship in altitude that the two rails of a track has in relation to each other, Where both rail treads are of equal altitude the rack is considered to have zero Crosslevel at that point.

Cross Tie

A transverse component of a track system whose functions are the control of track gage and the transmission of rail loads to ballast.

Curvature (Sub 5.8)

All curves have a value of sharpness called curvature. A higher degree of curvature denotes a sharper curve.

Curved Track (Sub 5.8)

A bend in the alignment of track that is measured by degrees, with most main track curves falling between 1 and 5 degrees.

Degree of Curve (Sub 5.8)

The angle subtended at the center of a simple curve by a 100 foot chord.

Easement Curve (Sub 5.8)

See Spiral Curve.

Eccentricity

The distance from the shoulder to the edge of the tie plate at right angles to the shoulder is larger on the field side than the gage side to compensate for the greater tendency of the field end to cut into the tie. The horizontal distance from middle of the rail seat to middle of the tie plate is the eccentricity.

Elastic Clip

Any rail clip which meets both of the following conditions:

- The rail clip is designed to have constant contact with the top of the rail base (or have constant contact with another fastener component which in turn is in contact with the top of the rail base) and, simultaneously, constant contact with a vertical support device or base structure (a wood tie for this specification) under all expected loads;
- The rail clip is designed to deflect a measurable amount relative to either the rail or tie, or both, from its installed condition under loading, followed by return to the initial installed condition when all loads are removed.

Elastic Fastener

A Rail Fastener which includes an elastic clip to hold the rail, but does not necessarily have a resilient plate between the rail and the tie.

Elastic Rail Fastener

See Rail Fastener

Elevation (Sub 5.8)

- (of grade) The vertical distance of a point above a reference datum. (above sea level for example)
- (of curves) The vertical distance that the outer rail is elevated above the inner rail, - also known as superelevation

Engineer

The purchaser, or the purchaser's designated employee or representative authorized to act on the purchaser's behalf.

Entry Angle (Sub 5.8)

See Switch Angle; the angle between the gage lines of the switch rail and the stock rail at the points of switch.

Equilateral Turnout (Sub 5.8)

A turnout where the diverging angle is divided evenly between each side of the turnout.

Equilibrium (Sub 5.8)

A physical state when the vertical forces acting on each rail are equal.

Field Side (Sub 5.8)

End of tie plate or side of rail designed to be located on the opposite side of the rail from the centerline of track.

Gage Side (Sub 5.8)

End of tie plate or side of rail designed to be located closest to the centerline of track.

Grade (Sub 5.8)

- See Gradient
- At Grade - the crossing of two elements (road, railroad) at the same elevation
- Material - see specifications in that section

Gradient (Sub 5.8)

A change in vertical elevation, usually measured as a percent change from a datum.

Grade Rail (Sub 5.8)

The rail used as control for vertical alignment

Hand Tamper

Any tamping tool that is manually inserted into the ballast. The tool may be activated manually or by a power source.

Hold Down Device

A spike or screw that fastens a rail-supporting plate in proper position on the tie.

Hold Down Holes

Located on the plate away from the rail seat; these holes do not allow spikes to contact the edge of the rail base. Also called "Anchor Spike Holes."

Hole

Holes (including bird pecks) may extend partially or entirely through the piece and be from any cause.

Large Streak

Discoloration over 1/32 inch wide.

Lateral Load (Sub 5.8)

A wheel/rail load, or vector component of that load, that is parallel to the plane across the top of the running rails and perpendicular to the longitudinal axis of the rail.

Lateral Turnout (Sub 5.8)

A handed turnout, the turnout is right or left handed not equilateral. The diverging angle is one side only.

Length

Overall dimension of the plate at right angles to the rail it supports. Tie plates of different length can be used with given rail section with the length chosen based on the traffic density of the track on which it is to be used.

Light Stain

Slight difference in color which does not materially change the appearance of the handle.

Line Holes

Located at the edge of the rail seat, these holes allow the spikes to contact the edge of the rail base.

Line Rail (Sub 5.8)

The rail used as control for horizontal alignment

Longitudinal Load

A load along, or parallel to, the longitudinal axis of a rail.

Medium Knot

Average diameter more than 1/8 inch, but not more than 1/4 inch.

Medium Stain

Pronounced difference in color which does not obscure the grain of the wood.

Medium Streak

Discoloration extending more than one-third the length of the handle, but not over 1/32 inch wide.

Monument (Sub 5.8)

Any marker used to indicate information, location, or point. Monuments are permanent in nature.

Mid-Ordinate (Sub 5.8)

The distance between a chord and the gage line at the center of the chord in curved track. Also, the distance between the center of a chord positioned on the top of a track and the top of rail when measuring profile.

Ordinate(s) (Sub 5.8)

The data resulting from measuring mid-ordinates around a curve.

Out-of-face Tamping (Sub 5.8)

Lifting and tamping the entire track to restore it to a uniform surface and cross level.

Overbalance Speed (Sub 5.8)

The velocity through a curve slower than balanced speed. This may also be expressed as the curve being over elevated for the speed.

Nadal's Criterion

A single wheel limit for wheel climb derailment. The criterion was developed from solving the equilibrium forces of single point wheel flange contact just prior to derailment.

$$L/V = [\tan(\partial) - \mu]/[1 + \mu \tan(\partial)]$$

L – lateral force acting on the rail

V- vertical force acting on the rail

∂ - contact angle between wheel flange and rail (w.r.t. horizontal)

μ - coefficient of friction between wheel and rail

For more information the reader is referred to: [Manual of Standards and Recommended Practices](#), published by the AAR.

Pin knot

Average diameter not more than 1/16 inch.

Power Tamper

Any tamping machine that inserts tamping tools through the use of mechanical, pneumatic, electrical, or hydraulic power systems.

Radius (Sub 5.8)

The distance from the center point of a curve, to a point on the curve. It is ½ diameter of a circle.

Rail Clip

A rail fastener component that provides rail rotational resistance about the longitudinal axis of the rail.

Rail Fastener

Any system of components which fasten a railroad rail to a cross tie or to a support base. (Note: This specification only addresses wood tie supports.)

Rail Seat

The area of the tie plate or resilient fastener that supports the rail.

Rail Seat Cant

Tie plates are generally rolled with the rail seat not parallel to the base of the plate so that the rail head is tilted toward the centerline of track to help offset lateral thrust and provide better wheel bearing on the rail head. The AREMA recommended cant is a ratio of 1:40.

Resilient Rail Fastener

A Rail Fastener which has a designed elastic member between the rail and the tie, generally with the elastic member serving as a tie plate; a Resilient Rail Fastener does not necessarily have an elastic clip as a component.

Reverse Curve (Sub 5.8)

A set of curves with opposing curvature separated by a common tangent point at their junction.

Rigid Clip

Any rail clip that is not an Elastic Clip.

Rolled Width

The dimension of the finished section as it leaves the rolls and is equal to the length of the tie plate.

Sag (Sub 5.8)

A vertical curve which is concave upwards. It is the lowest point of elevation for that curve.

Sheared Length

The dimension to which the finished section is cut and is equal to the width of the tie plate.

Shoulder

A ridge parallel to the rail designed to assist in holding the rail in position. The height of the shoulder is about equal to the thickness of the edge of the rail base.

If a plate has a “Single Shoulder,” the shoulder is located on the field side of the rail seat to resist the outward thrust of the rail. A “Double Shoulder” plate has an additional shoulder on the gage side of the rail seat.

Single shoulder plates may accommodate a desired rail section by adjusting the punching of the spike holes on the gage side to match the width of the rail base. Double shoulder plates are limited to a single rail base width.

Simple Curve (Sub 5.8)

A curve with continuous change in direction of alignment by means of an arc of a single radius.

Skin Lift (Sub 5.8)

Out-of-face tamping of the track where the nominal raise is 1 inch or less.

Slight Grain Dip

Deviation of the fiber out of parallel with the axis of the handle not in excess of one-eighth the diameter of the handle where the grain dip occurs.

Small Knot

Average diameter more than 1/16 inch, but not more than 1/8 inch.

Small Streak

Threadlike discoloration extending not more than one-third the length of the handle.

Spiral Curve (Sub 5.8)

A curve whose degree varies either uniformly or in some definitively determined manner so as to give it a gradual transition between a tangent and a simple curve, which it connects, or between two simple curves.

Split

Lengthwise separation of the wood extending from one surface through the piece to the opposite surface or an adjoining surface

Spot Tamping

Lifting and tamping short sections of track to restore it to proper surface.

Summit (Sub 5.8)

A vertical curve which is concave downwards; it is the highest point of elevation for that curve.

Superelevation (Sub 5.8)

The amount in inches that the line rail (high side of a curve) is elevated over the grade rail (low side of a curve).

Switch Angle (Sub 5.8)

The angle formed between the gage lines of a stock rail and switch point at its point.

Tamping Tool

Any apparatus that is brought in direct contact with the ballast for the purpose of compacting it under the tie.

Tie Plate

A part of the track structure placed under the rail to distribute the wheel load to the tie, cant the rail to the desired angle, assist in maintaining the track to gage and protect the tie. The tie plate has a rail seat, either flat or canted, either a single or double shoulder parallel to the rail it supports, and is punched with holes for spikes or other fasteners. The bottom of the tie plate is usually flat, but ribbed or other designs may be used.

Track Modulus (Sub 5.8)

The modulus of elasticity of rail support defined within the “beam on elastic foundation” theory. Track Modulus is the force required to depress 1 inch of a continuous rail length through a distance of 1 inch. Track Modulus is generally stated in units of “lb/in/in.”

Transit (Sub 5.8)

A surveying instrument.

Transition Curve (Sub 5.8)

See Spiral Curve.

Turnout Number (Sub 5.8)

The number corresponding to the frog number of the frog used in the turnout.

Unbalance (Sub 5.8)

The superelevation in a curve that is less than a calculated value that will otherwise equally distribute onto both rails the vertical force of trains that are traveling at the maximum authorized speed.

Vertical Curve (Sub 5.8)

A vertical curve is used to connect sections of track of different elevations from a grade.

Vertical Load (Sub 5.8)

A wheel/rail load or vector component of that load, perpendicular to the plane across the top of the running rail, through the wheel/rail contact patch.

V-Max (Sub 5.8)

The maximum speed based on a mathematical formula, permitted on a curve based on the average curvature and average superelevation in a designated segment (155 foot maximum).