AREMA

American Railway Engineering and Maintenance-of-Way Association

CHAPTER 5

TRACK[1]

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, 12½″ × 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 Plates[1]

— 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 ½ 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 ⅜ 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.		
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 1⅝ inches center to center. Outer edge of any hole is not closer than ½ inch to the rolled edge for plates up to ⅜ inch in end thickness; or closer than ⅝ inch to the rolled edge for plates greater than ⅜ inch up to ½ inch in end thickness. Outer edge of any hole is not closer than 1 inch to the sheared edge.		

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

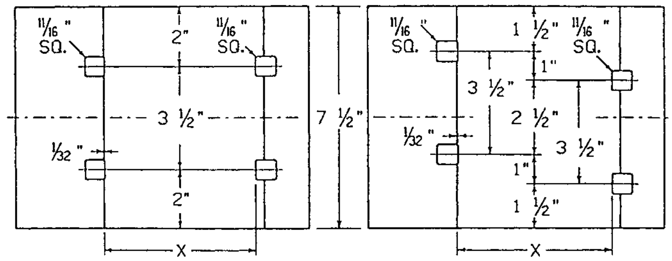
Refer to Table 5-1-3 and Figure 5-1-1 through Figure 5-1-12 for tie plate design.

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 5⅛ Inch Base
2	5-1-2	11 Inch For Use With Rail Having a 5⅛ to 5⅜ Inch Base
3	5-1-3	12 Inch For Use With Rail Having a 5⅜ Inch Base
6	5-1-4	12 Inch For Use With Rail Having a 5½ Inch Base
7	5-1-5	13 Inch For Use With Rail Having a 5½ Inch Base
8	5-1-6	14 Inch For Use With Rail Having a 5½ 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	14¾ Inch For Use With Rail Having a 6 Inch Base
20	5-1-10	15 Inch For Use With Rail Having a 5½ 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	14¾
		12	14
		11	13
119RE, 115RE	5½ inch	20	15
		8	14
		7	13
		6	12
100RE	5⅜ inch	3	12
		2	11
90RA-A	5⅛ 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.



ESTIMATED WEIGHTS IN POUNDS	
PER FOOT	18.60
PER 7 ½"	11.63
PUNCHED	
4 HOLES	11.28
ADD FOR RIBS	
PER FOOT	0.34
PER 7 ½"	0.21

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

FOR USE WITH 9/16" 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.

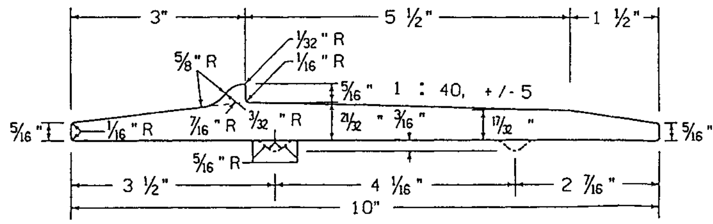
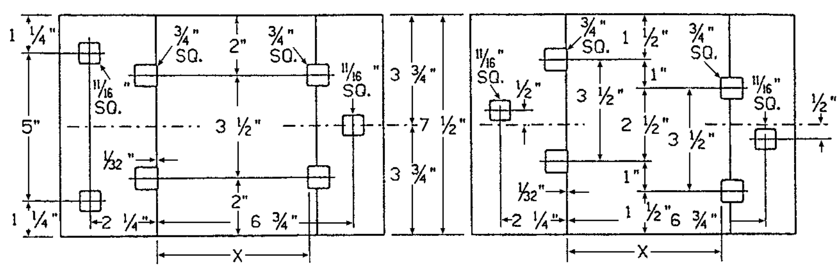


Figure 5-1-1. Plan No. 1 - AREMA 10 Inch Tie Plate for use with Rails Having 4 7/16 to 5 1/8 Inch Rail Base Width



PUNCHING A - 7 SPIKE HOLES
PUNCHING 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	21.58
PER 7 ½"	13.49
PUNCHED	
7 HOLES	12.87
6 HOLES	12.93
4 HOLES	13.05
ADD FOR RIBS	
PER FOOT	0.34
PER 7 ½"	0.21

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 ½" INSTEAD OF 5".

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

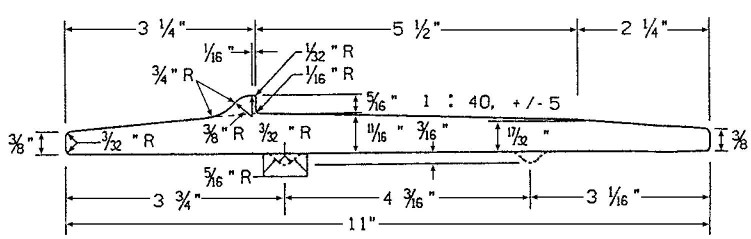


Figure 5-1-2. Plan No. 2 - AREMA 11 Inch Tie Plate for use with Rails Having 5 1/8 to 5 1/2 Inch Rail Base Width

ESTIMATED WEIGHTS IN POUNDS	
PER FOOT	25. 84
PER 7 ¾"	16. 69
PUNCHED	
8 HOLES	15. 86
6 HOLES	15. 99
4 HOLES	16. 12
ADD FOR RIBS	
PER FOOT	0. 34
PER 7 ¾"	0. 22

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

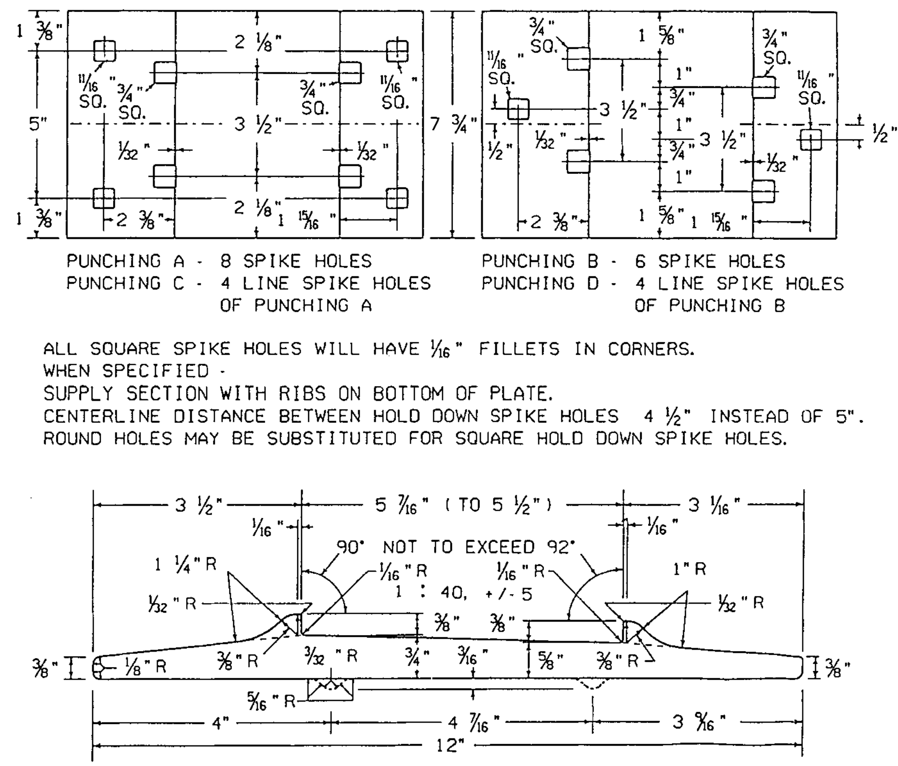


Figure 5-1-3. Plan No. 3 - AREMA 12 Inch Tie Plate for 5⅜ Inch Rail Base Width

ESTIMATED WEIGHTS IN POUNDS	
PER FOOT	25. 95
PER 7 ¾"	16. 76
PUNCHED	
8 HOLES	15. 94
6 HOLES	16. 06
4 HOLES	16. 19
ADD FOR RIBS	
PER FOOT	0. 34
PER 7 ¾"	0. 22

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

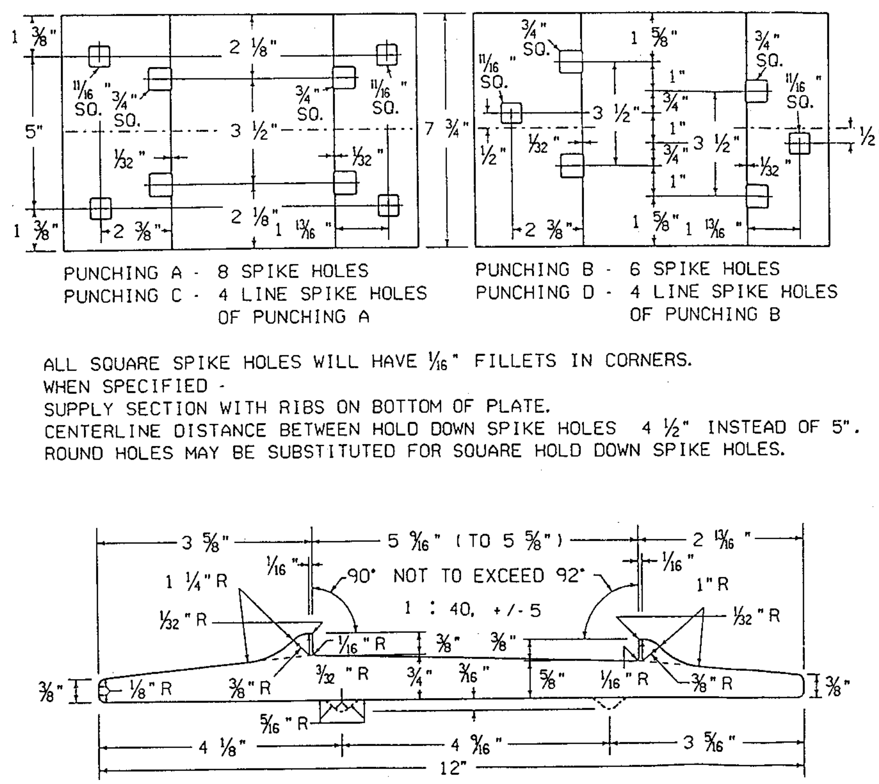
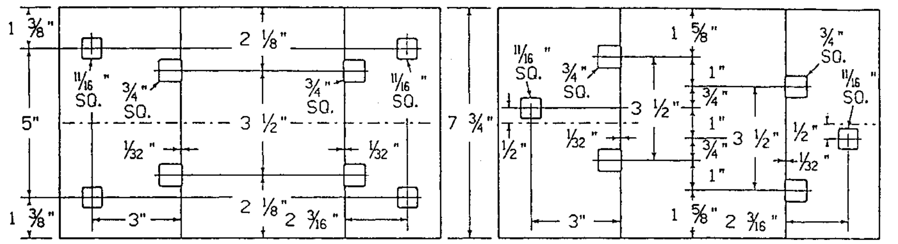


Figure 5-1-4. Plan No. 6 - AREMA 12 Inch Tie Plate for 5½ Inch Rail Base Width



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	31.84
PER 7 ¾"	20.56
PUNCHED	
8 HOLES	19.60
6 HOLES	19.74
4 HOLES	19.89
ADD FOR RIBS	
PER FOOT	0.34
PER 7 ¾"	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 ½" 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.

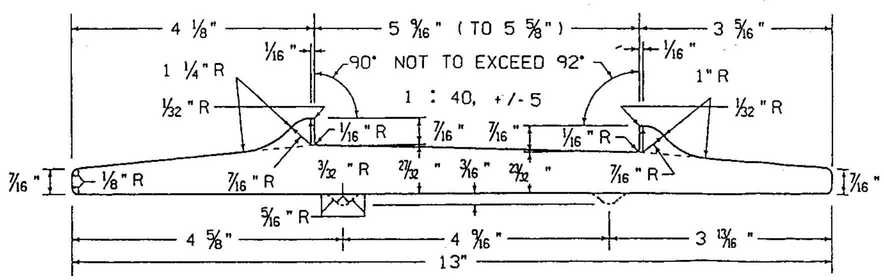
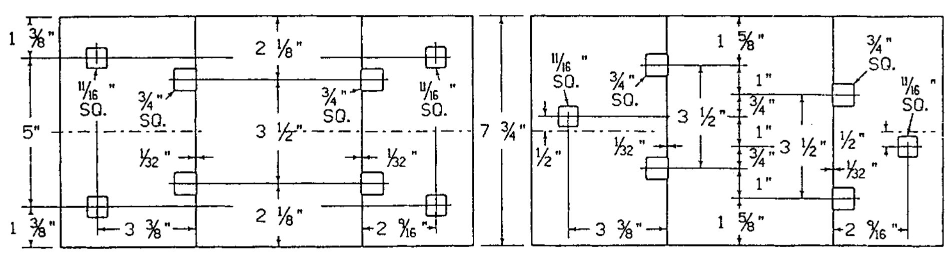


Figure 5-1-5. Plan No. 7 - AREMA 13 Inch Tie Plate for 5½ Inch Rail Base Width



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	37.05
PER 7 ¾"	23.93
PUNCHED	
8 HOLES	22.90
6 HOLES	23.06
4 HOLES	23.21
ADD FOR RIBS	
PER FOOT	0.34
PER 7 ¾"	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 ½" 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.

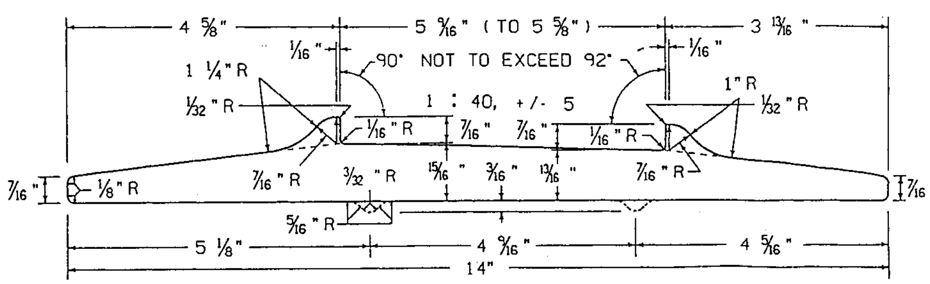


Figure 5-1-6. Plan No. 8 - AREMA 14 Inch Tie Plate for 5½ Inch Rail Base Width

ESTIMATED WEIGHTS IN POUNDS	
PER FOOT	29.92
PER 7 ¾"	19.32
PUNCHED	
8 HOLES	18.41
6 HOLES	18.55
4 HOLES	18.68
ADD FOR RIBS	
PER FOOT	0.34
PER 7 ¾"	0.22

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

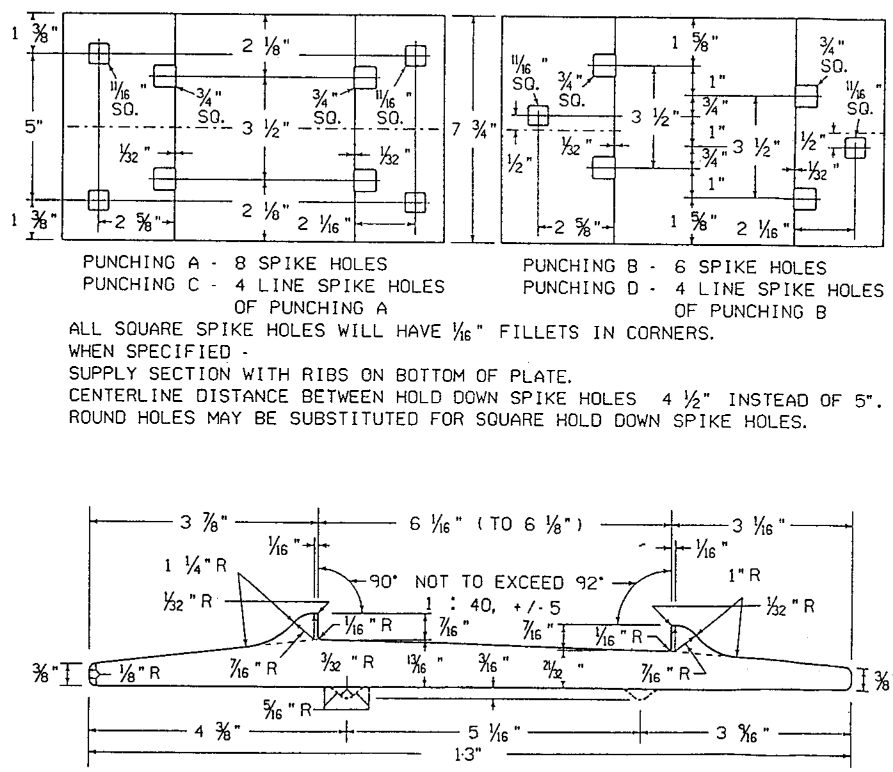


Figure 5-1-7. Plan No. 11 - AREMA 13 Inch Tie Plate for 6 Inch Rail Base Width

ESTIMATED WEIGHTS IN POUNDS	
PER FOOT	34.77
PER 7 ¾"	22.45
PUNCHED	
8 HOLES	21.47
6 HOLES	21.62
4 HOLES	21.77
ADD FOR RIBS	
PER FOOT	0.34
PER 7 ¾"	0.22

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

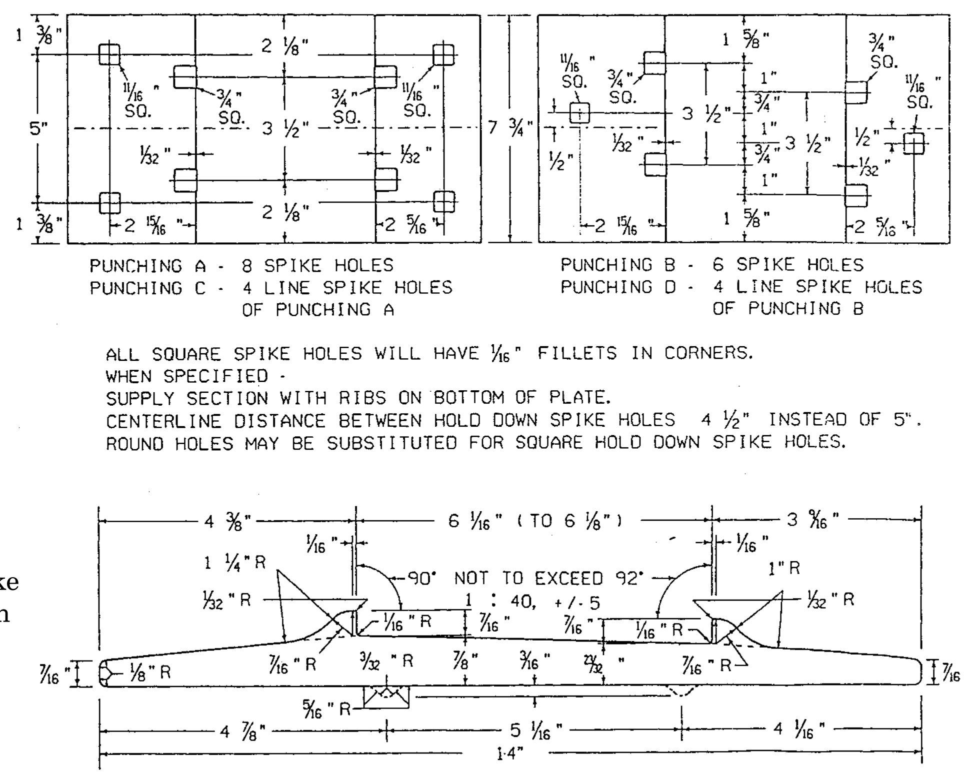
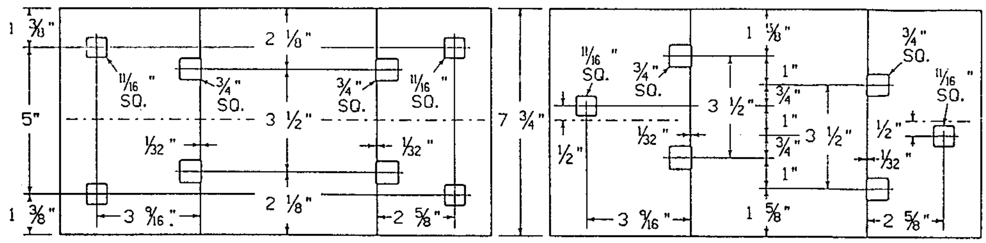


Figure 5-1-8. Plan No. 12 - AREMA 14 Inch Tie Plate for 6 Inch Rail Base Width



ESTIMATED WEIGHTS IN POUNDS	
PER FOOT	37.66
PER 7 ¾"	24.32
PUNCHED	
8 HOLES	23.32
6 HOLES	23.46
4 HOLES	23.60
ADD FOR RIBS	
PER FOOT	0.34
PER 7 ¾"	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 ½" 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.

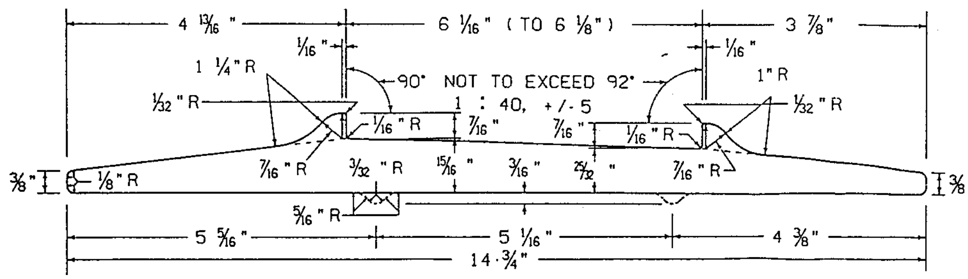
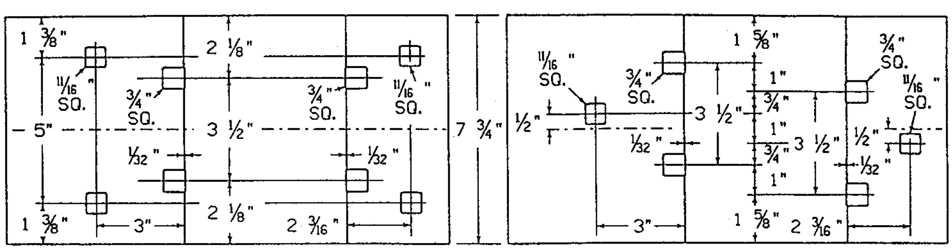


Figure 5-1-9. Plan No. 13 - AREMA 14¾ Inch Tie Plate for 6 Inch Rail Base Width



ESTIMATED WEIGHTS IN POUNDS	
PER FOOT	43.96
PER 7 ¾"	28.39
PUNCHED	
8 HOLES	27.22
6 HOLES	27.40
4 HOLES	27.58
ADD FOR RIBS	
PER FOOT	0.34
PER 7 ¾"	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 ½" 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.

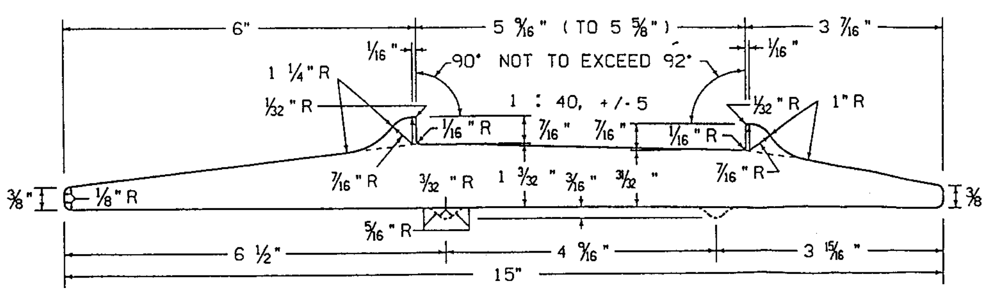
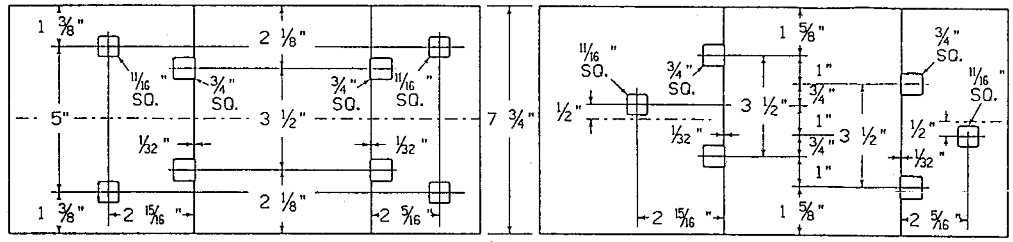


Figure 5-1-10. Plan No. 20 - AREMA 15 Inch Tie Plate for 5½ Inch Rail Base Width for Curves Only



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	47.57
PER 7 ¾"	30.72
PUNCHED	
8 HOLES	29.53
6 HOLES	29.71
4 HOLES	29.89
ADD FOR RIBS	
PER FOOT	0.34
PER 7 ¾"	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 ½" 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.

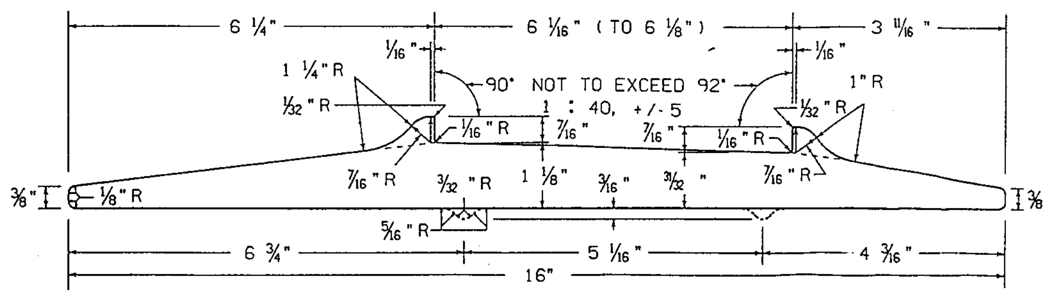
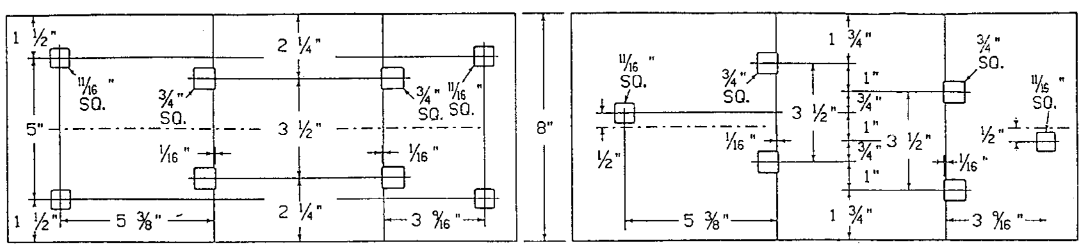


Figure 5-1-11. Plan No. 21 - AREMA 16 Inch Tie Plate for 6 Inch Rail Base Width for Curves Only

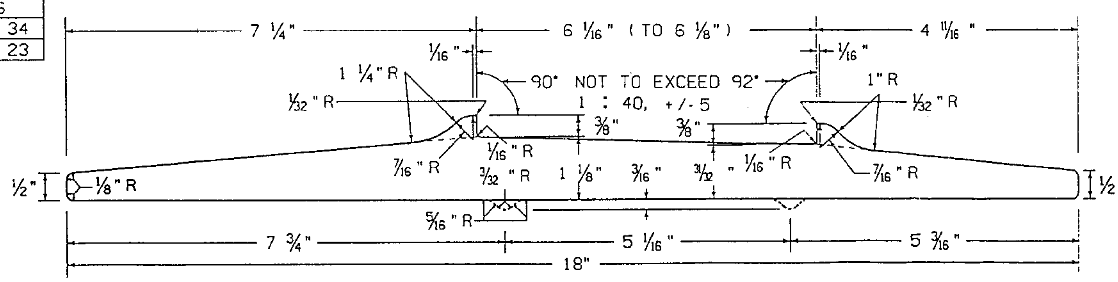


PUNCHING A - 8 SPIKE HOLES
PUNCHING C - 4 LINE SPIKE HOLES OF PUNCHING A

PUNCHING B - 6 SPIKE HOLES
PUNCHING D - 4 LINE SPIKE HOLES OF PUNCHING B

ESTIMATED WEIGHTS IN POUNDS	
PER FOOT	54.53
PER 8"	36.36
PUNCHED	
8 HOLES	35.21
6 HOLES	35.38
4 HOLES	35.55
ADD FOR RIBS	
PER FOOT	0.34
PER 8"	0.23

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 ½" 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 5-1-12. Plan No. 22 - 18 Inch Tie Plate for 6 Inch Rail Base Width

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Part 2

Track Spikes

— 2005 —

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SECTION 2.1 SPECIFICATIONS FOR SOFT-STEEL TRACK SPIKES[1] (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

[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

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.

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 SPIKE[1] (2005)

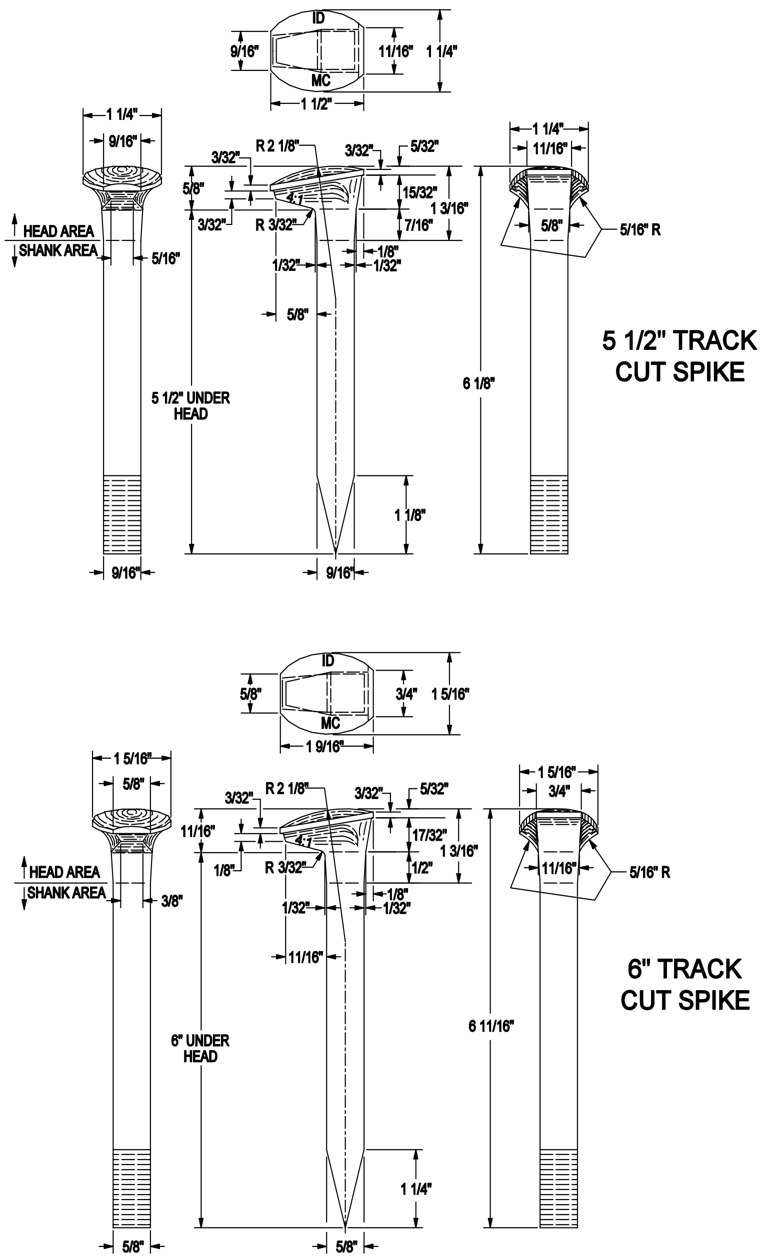

Figure 5-2-1. Track Cut Spike Design

[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

— 2006 —

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SECTION 3.1 SPIRALS[1] (1995)

3.1.1 PURPOSE (1995)

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 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] 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.

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

$$L = 1.63\ (E_u)\ V \qquad \textbf{EQ 1}$$

where:

$L(min)$ = desirable length of spiral in feet
E_u = unbalanced elevation in inches
V = maximum train speed in miles per hour

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.

$$L = 62\ E_a \qquad \textbf{EQ 2}$$

where:

$L(min)$ = desirable length of spiral in feet
E_a = actual elevation in inches

(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:

$$L = 1.22\ E_u\ V \qquad \textbf{EQ 3}$$

where:

$L(min)$ = desirable length of spiral in feet
E_u = unbalanced elevation in inches
V = maximum train speed in miles per hour

(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)

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)

a. In designations for curve points, the first initial represents the alignment on the ride towards station zero, the second that away from station zero.

b. 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

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

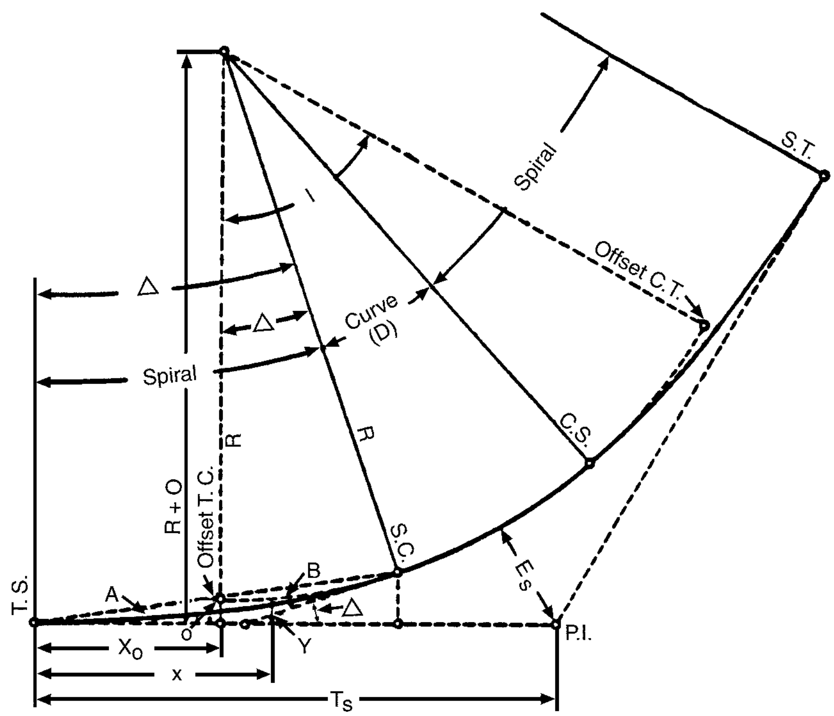

Figure 5-3-1. Spiral Applications

3.1.4 FORMULAS (2005)[1]

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

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

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

$$b = \frac{2}{3}\delta;\ B = \frac{2}{3}\Delta \qquad \textbf{EQ 7}$$

$$y = 0.582\delta s - 0.00001264\delta^3 s \qquad \textbf{EQ 8}$$

$$x = l - 0.003048\delta^2 s \qquad \textbf{EQ 9}$$

$$o = 0.1454\Delta S \qquad \textbf{EQ 10}$$

$$Xo = \frac{1}{2}L - 0.000508\Delta^2 S \qquad \textbf{EQ 11}$$

$$T_s = (R + o)\tan\left(\frac{I}{2}\right) + Xo \qquad \textbf{EQ 12}$$

$$E_s = (R + o)\operatorname{exsec}\left(\frac{I}{2}\right) + o \qquad \textbf{EQ 13}$$

3.1.5 STAKING SPIRALS BY DEFLECTIONS (1965)

a. 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.

b. 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.

c. 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

[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.

curve having the same degree as the spiral at the transit point and a length equal to the distance 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)

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 ½ 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)

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 ½ 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 METHOD[1] (2006)

3.2.1 SCOPE (2006)

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,

[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.

recording the mid-ordinates of the chords spanning each two stations, and designating a reasonable amount of throw to each station.

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.

(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 the mid-ordinate.

3.2.2 TOOLS REQUIRED (1965)

A strong fish line or chord of 62-ft length and a 50-ft steel tape; marking crayon; a suitable rule graduated to inches and tenths thereof with the graduations beginning at the extreme end of the rule or scale; and a pad of forms (described later).

3.2.3 PROCESS (1965)

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. This point is Station 0 and should be so marked.

b. The station 31 ft back along the tangent is Station –1.

c. Beginning at Station –1, lay off with steel tape and mark each 31-foot point and number consecutively as Stations –1, 0, 1, 2, 3, etc., and continue the stationing at least two stations beyond the point of tangent, 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. Beginning at Station 0, measure mid-ordinates in tenths of inches from the outside rail to the line joining Stations –1 and 1. This is entered in Col. 2 of the same form. Proceed around the curve to the P.T., measuring the mid-ordinate at each station and entering on the form.

e. Take track centers at frequent intervals where there is more than one track and record any obstacle which might affect lining, noting same in Col. 9 of the sample form shown in Table 5-3-1.

f. Column descriptions:

(1) Col. 1 is for station numbers.

(2) Col. 2 is for measured mid-ordinates in inches and tenths thereof.

(3) Col. 3 is for revised mid-ordinates.

(4) Col. 4, headed Difference, shows the difference between the ordinates in Cols. 2 and 3.

(5) Cols. 5 and 6 are explained by the headings.

(6) Col. 7 is for the full throw which is double the figure shown in Col. 6.

Negative throw indicates that the track at that station is to be thrown in, while positive throw indicates that the track is to be thrown out.

(7) Col. 8 is obtained by subtracting algebraically the full throw from one-half the gage, 28.25″.

(8) Col. 9 is also for revised superelevation to be used on the curve, and, of course, is contingent upon the maximum speed of trains running over this curve.

g. By inspection of measured ordinates in Col. 2, the beginning and ending of the spiral curves can be located as nearly correct as possible.

h. 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.

i. In Col. 4 are entered 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.

j. In Col. 5 are entered the algebraic sums of the differences (shown in Col. 4) up to and including stations being entered. The operation is performed in sequence as indicated by arrows.

k. 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. The operation is also performed in the order shown by the arrows.

l. In the example, computations based on selected revised spiral ordinates in subcolumn A Table 5-3-1, carried through to Col. 6, indicate a half-throw of 31 or a full-throw of 6.2 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 subcolumn B and the curve ordinate of 45 is carried out through Station 11. This gives too great a throw in the positive direction.

m. Therefore, interpolate a spiral between those used in subcolumns A and B, and enter these new spiral ordinates in subcolumn 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.

n. Sum up in Col. 2 the measured ordinates from Stations 24 to 32, incl., in the original spiral, which total 190. The sum of the measured ordinates from Stations 0 to 23, incl., is 922, bringing the total sum of measured ordinates to 1112. The sum of the revised ordinates from Stations 0 to 23, incl., is 921. To assure that Col. 5 will end in 0, the sum of the revised spiral ordinates from stations 24 to 32, incl., must equal 191. Such revised spiral ordinates are entered in subcolumn "C."

o. Carrying the calculations through to Col. 6, the sum of differences check out 0, but the final half-throw is + 17, indicating that the trial spiral ends in a parallel tangent. To end in the original tangent, both Cols.

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

5 and 6 must balance; therefore, an adjustment of the revised ordinates is necessary and is made according to the following rule.

p. 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.

q. 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, let us 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 × (Sta 24 – Sta 22). Let us 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 subcolumn "D," carrying out these computations again to Col. 6, the final half-throw becomes 0 and the ordinates are balanced.

r. 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.

s. In working out string lining problems considerable assistance can be gained by platting 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 platting 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.

t. When tabulations are completed and the curve staked, a copy of the form should be given the track foreman to enable him to apply the proper superelevation at the various stations as the track is lined.

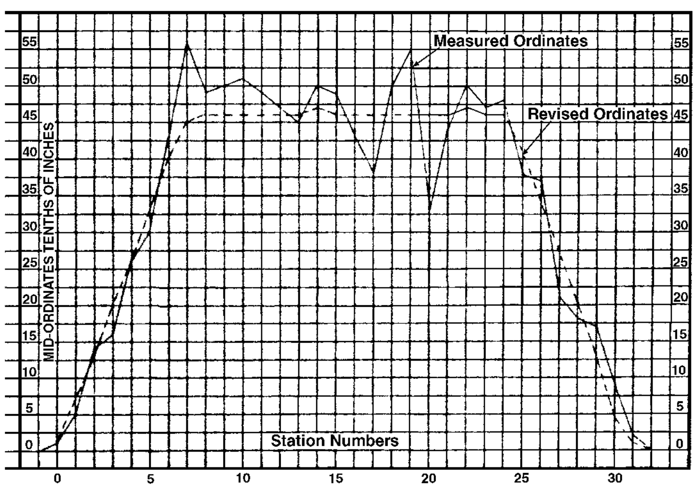

Figure 5-3-2. Platting Mid-ordinates

SECTION 3.3 ELEVATIONS AND SPEEDS FOR CURVES[1] (1962)

3.3.1 ELEVATION OF CURVES (1962)

a. The approximate formula:

$$e = \frac{Bv^2}{32.16R} \qquad \textbf{EQ 14}$$

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,

$$E = 0.0007\ V^2D$$

where:

E = Equilibrium elevation in inches of the outer rail (center to center of rails, or 4′ -11½″)
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.

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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.

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 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 $4\frac{1}{2}$ 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

E = Equilibrium Elevation for Various speeds on Curves																	
D = Degree of Curve	V = Speed in Miles per Hour																
	10	20	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100
0° 30′	0.04	0.14	0.32	0.43	0.56	0.71	0.88	1.06	1.26	1.48	1.72	1.97	2.24	2.53	2.84	3.16	3.50
1° 00′	0.07	0.28	0.63	0.87	1.12	1.42	1.75	2.12	2.52	2.96	3.43	3.94	4.48	5.06	5.67	6.32	7.00
1° 30′	0.11	0.42	0.95	1.29	1.68	2.13	2.63	3.18	3.78	4.44	5.15	5.91	6.72	7.59	8.51	9.48	10.50
2° 00′	0.14	0.56	1.26	1.72	2.24	2.84	3.50	4.24	5.04	5.92	6.86	7.88	8.96	10.12	11.34	12.64	
2° 30′	0.18	0.70	1.58	2.14	2.80	3.54	4.38	5.29	6.30	7.39	8.58	9.84	11.20				
3° 00′	0.21	0.84	1.89	2.57	3.36	4.25	5.25	6.35	7.56	8.87	10.29	11.81					
3° 30′	0.25	0.98	2.21	3.00	3.92	4.96	6.13	7.41	8.82	10.35							
4° 00′	0.28	1.12	2.52	3.43	4.48	5.67	7.00	8.47	10.08								
5° 00′	0.35	1.40	3.15	4.29	5.60	7.09	8.75	10.59									
6° 00′	0.42	1.68	3.78	5.15	6.72	8.51	10.50										
7° 00′	0.49	1.96	4.41	6.00	7.84	9.92											
8° 00′	0.56	2.24	5.04	6.86	8.96	11.34											
9° 00′	0.63	2.52	5.67	7.72	10.08												
10° 00′	0.70	2.80	6.30	8.58	11.20												
11° 00′	0.77	3.08	6.93	9.43													
12° 00′	0.84	3.36	7.56	10.29													

"E" in Inches = $0.0007V^2D$

SECTION 3.4 SPEEDS OF TRAINS THROUGH LEVEL TURNOUTS[1] (1956)

a. Table 5-3-3 and Table 5-3-4 show speeds through level turnouts giving riding conditions equivalent to those obtained in traversing a curve elevated 3 inches less than that required for equilibrium.

b. Speeds through turnouts with either straight or curved switch points are calculated from the equation $E = 0.0007 V^2 D - 3$ (see Section 3.3, Elevations and Speeds for Curves (1962)), 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 length of the switch points.

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.

Table 5-3-3. Turnouts with Straight Switch Points (AREMA)

Turnout Number	Length of Switch Points	Speed in Miles Per Hour	
		Lateral Turnouts	Equilateral Turnouts
5	11′-0″	12	16
6	11′-0″	13	19
7	16′-6″	17	23
8	16′-6″	19	27
9	16′-6″	20	28
10	16′-6″	20	28
11	22′-0″	26	37
12	22′-0″	27	38
14	22′-0″	27	38
15	30′-0″	36	51
16	30′-0″	36	52
18	30′-0″	36	52
20	30′-0″	36	52

[1] References, Vol. 15, 1914, pp. 594, 1063; Vol. 37, 1936, pp. 469, 1017; Vol. 42, 1941, pp. 578, 836; Vol. 44, 1943, pp. 440, 670; Vol. 48, 1947, pp. 553, 885; Vol. 54, 1953, pp. 1082, 1404; Vol. 57, 1956, pp. 767, 1072. Rewritten 1956.

Table 5-3-4. Turnouts with Curved Switch Points (AREMA)

Turnout Number	Length of Switch Points	Speed in Miles Per Hour	
		Lateral Turnouts	Equilateral Turnouts
5	13′-0″	12	17
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
18	39′-0″	44	63
20	39′-0″	50	70

SECTION 3.5 MINIMUM TANGENT LENGTHS REQUIRED BETWEEN REVERSE CURVES FOR YARD OPERATIONS[1] (1984)

3.5.1 NO SPIRAL AND NO SUPERELEVATION (1984)

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

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 5-3-5.

Table 5-3-5. 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

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

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)

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 econmically 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/sec^2)

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

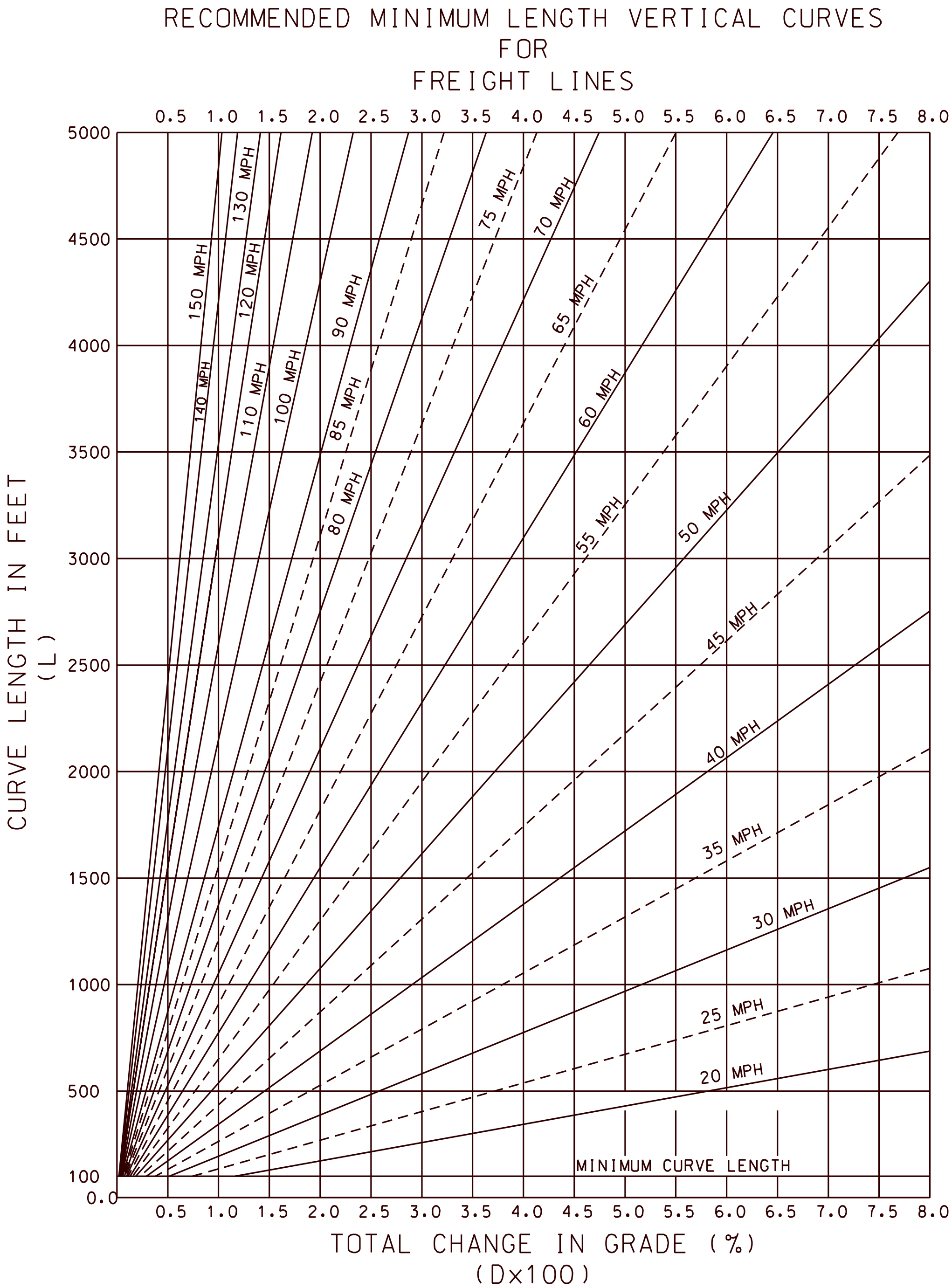
h. The minimum distance between vertical curves shall not be less than 100 ft.

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.

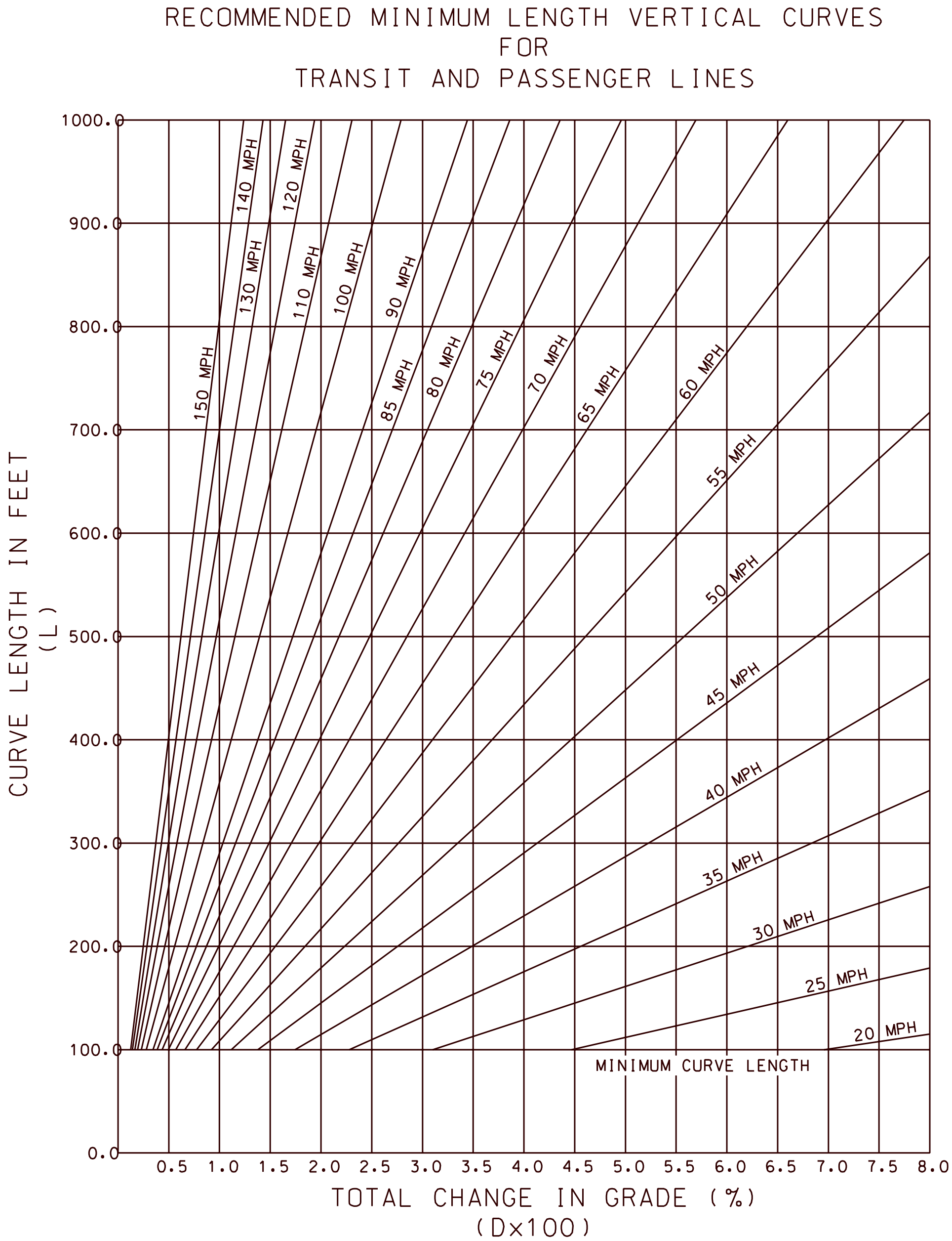
NOTE: Values for various speeds and change in gradients have been graphed for reference.



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

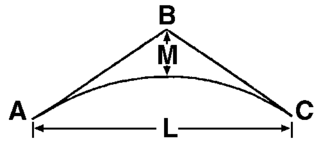


FORMULA: $L = (D \times V^2 \times K)/A$

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

l. 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 –

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

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

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

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

Example Calculation for Passenger and Transit Operations

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

A = 0.60 feet/sec/sec vertical acceleration (Passenger and Transit)
D = Absolute value of ((-.005) - (+.005)) = 0.01
K = 2.15 conversion factor to give L in feet
V = 75 MPH design speed

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

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

SECTION 3.7 COMPENSATED GRADIENTS (1999)

3.7.1 PROPOSED AREMA STANDARDS FOR COMPENSATED GRADIENTS (1999)

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. This corresponds to the resistance created by standard three piece trucks on non-lubricated curves.

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

SECTION 3.8 PERMANENT MONUMENTS[1] (1962)

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 a transit.

[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

— 1984 —

TABLE OF CONTENTS

SECTION 4.1 SPECIFICATIONS FOR TRACK CONSTRUCTION[1] (1984)

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.

[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.

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:

- 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 ⅛ 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′-8½″ between points ⅝ 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 (1962), 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) (1980)

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.

b. The railway company will specify the length of the strings of CWR to be laid and the number, length and location of buffer rails to be used.

c. Prior to laying of CWR, the maximum and minimum rail temperatures in the areas shall be determined and recorded by railway.

d. It is the railway company's responsibility to establish the desired laying temperature. The Contractor shall record the temperature of each rail laid. When it is not possible to lay rail at the desired laying temperature, the contractor shall make the necessary adjustment at a later date. All adjustments shall be made as per instructions of a railway company representative. Buffer rails, in any length between 30 and 37 feet, may be used if permitted by the railway. (For recommended practices, refer to Part 5, Track Maintenance – Section 5.3, Temperature Expansion for Laying Rails (1967).)

e. When laying CWR in new track construction, the rail ends should be laid without expansion gap, and Paragraph 4.1.1o will not apply.

f. Paragraph 4.1.1u will not apply when using CWR.

g. 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.

h. The contractor should apply all rail anchors immediately behind the laying of CWR. The rail should be anchored in accordance with the AREMA recommendations contained in Part 5, Track Maintenance– Section 5.4, Rail Anchor Patterns Number of Rail Anchors to Resist Rail Creepage (1987). Ballast must be unloaded and all cribs filled as soon as rail anchors have been applied. The track should be surfaced and tamped as soon as possible after the laying of the CWR.

4.1.3 APPENDIX II – MINIMUM SPECIFICATIONS FOR INDUSTRIAL TRACK CONSTRUCTION (1984)

a. Industrial track will be considered as track in yard territory and servicing either a light or heavy industry, with speed limit of 10 mph.

b. Tie Requirements – use treated mixed 6 inch grade ties no less than 8′-0″ long, and spaced at maximum of 24 inches c.c.

c. Rail – new or relay rail with no more than 3⁄8 inch head wear. No rail less than 90 #, with properly drilled holes, should be used. Joint batter not in excess of 3⁄16 inch.

d. Tie Plates – new or relay tie plates must be used on all ties. All plates must have same cant.

e. Spikes – 5⁄8″×6″ new or used cut 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. No superelevation shall be used.

g. Maximum curvature of 12 degrees should be used. If sharper curvature is required, approval of servicing railroad will be necessary.

h. Maximum recommended grade is 2%. If steeper grade is required, approval of servicing railroad will be necessary.

i. Turnouts – use #7 or greater. If smaller turnout is required, approval of servicing railroad will be necessary.

   (1) Box anchor every third switch tie across.

   (2) Suggest use of appropriate switch point guard on turnout side switch point with heavy traffic.

   (3) Refer to AREMA Portfolio of Trackwork Plans as to track duty requirements and construction details.

   (4) Suggest 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. Same tie shall be box-anchored across.

k. Rail Joints – use 4-hole, 24 inch or 6-hole, 36 inch joint bars fully bolted with lock washers. Refer to Table 5-5-2, for proper expansion requirements when laying rail. The rail-joint bar contact surface should be lubricated upon installation.

l. Ballast – use AREMA #5 size stone, ballast furnace slag or equivalent. 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 for trainmen or as required by local Commissions.

m. Necessary gaging shall be done at the time rail is laid and, unless otherwise provided, gage shall be 4′-8½″ between points ⅝ inch below the top of rail on the two inside edges of the rails.

n. Crossings – use flange timbers on each side of rail. Flange ways should be sealed with bituminous material to insure water will not drain into track crossing. Rail joints should be avoided in crossing area.

o. Appliances such as derails, wheel stops and bumping posts will be installed as required by the serving railroad.

SECTION 4.2 PROPER USAGE OF THE VARIOUS TYPES OF FROGS[1] (1970)

4.2.1 SPRING-RAIL FROGS (1984)

a. May be used in main track where traffic is predominantly on the main track side of the frog.

b. May be used in yard tracks but only when rigid frogs are not available.

4.2.2 RAIL-BOUND MANGANESE STEEL FROGS (1984)

Shall be used on heavy-traffic lines where traffic is approximately equal on both sides of the frog.

[1] References, Vol. 67, 1966, pp. 412, 733. Reapproved with revisions 1970.

4.2.3 SOLID MANGANESE STEEL FROGS (1984)

May be used as alternate to rail-bound manganese steel frogs.

4.2.4 SELF-GUARDED FROGS (1984)

a. Shall be used in yard tracks.

b. May be used in main track where speed does not exceed 30 mph.

NOTE: Guard rails may be used with self-guarded frogs when conditions justify.

4.2.5 BOLTED RIGID FROGS (1984)

May be used in yard and industry tracks where traffic is light on both sides of frog, but only when self-guarded frogs are not available, or when desirable to utilize available second-hand frogs.

AREMA

American Railway Engineering and Maintenance-of-Way Association

Part 5

Track Maintenance

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SECTION 5.1 SPECIFICATIONS FOR LAYING RAIL[1] (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.

[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.

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.

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, Preservation of Track Fixtures (1960).

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	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

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 RAIL[1] (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.

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[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 56½ 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:

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

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

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:

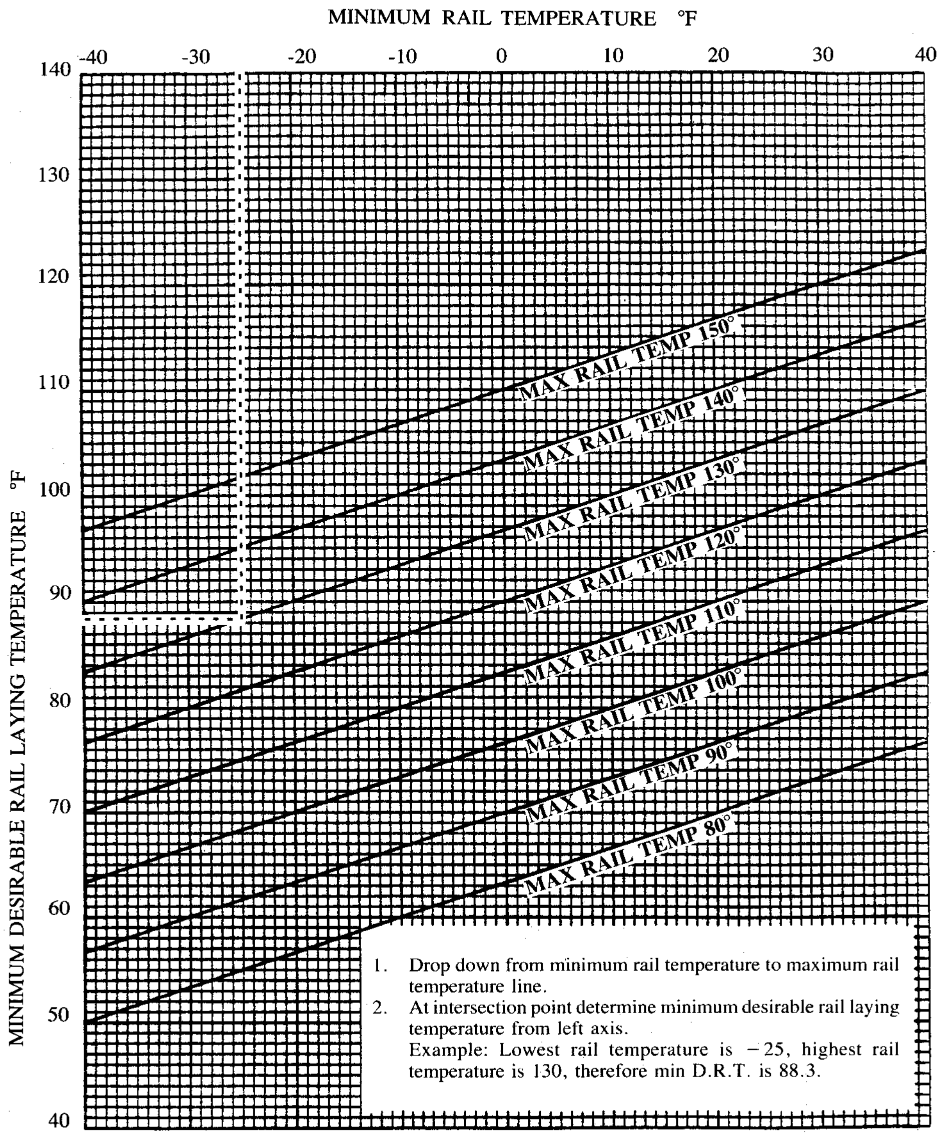

Figure 5-5-1. Minimum Rail Laying Temperature

(1) A reliable contact-type pyrometer should be used in order to determine the rail temperature immediately.

(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).

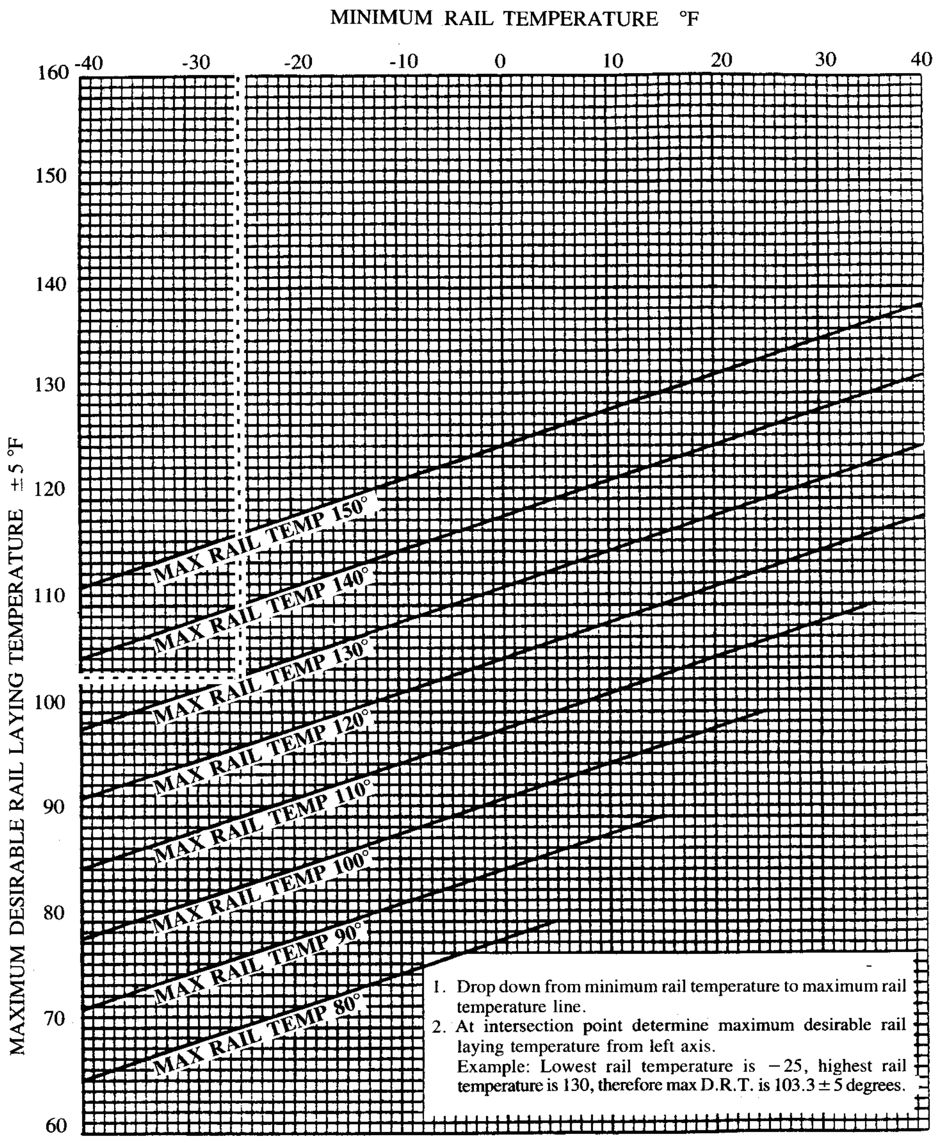

Figure 5-5-2. Maximum Rail Laying Temperature

s. Drive spikes should be installed in accordance with the practice of the railroad. (Use of machine(s) recommended.)

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 4.5, Recommended Repair of Defective or Broken Rail in CWR.)

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

w. If field welding of strings is to be done, all CWR should be laid or adjusted to the preferred laying temperature beforehand.

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 3.14 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 4.5 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.

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)

SECTION 5.3 TEMPERATURE EXPANSION FOR LAYING RAILS[1] (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 CREEPAGE[1] (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.

[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.

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.

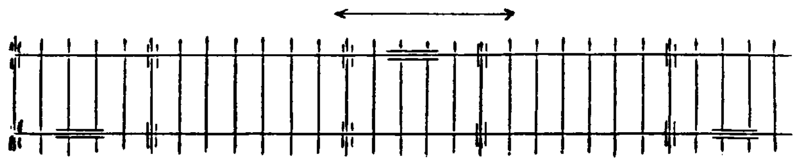

DIAGRAM 1

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.

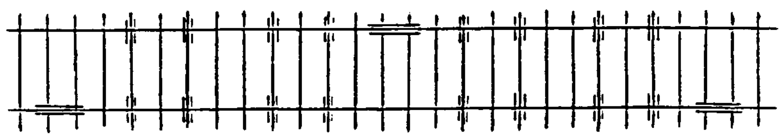

DIAGRAM 2

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

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.

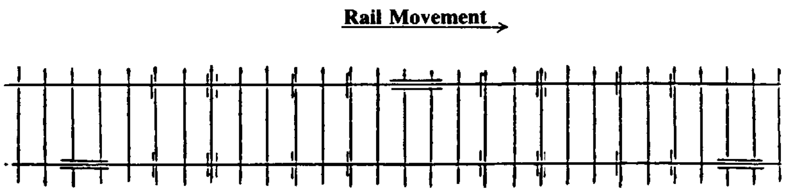

DIAGRAM 3

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

5.4.4 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[1] (1962)

5.5.1 PURPOSE (1988)

The purposes of providing tension in track bolts are:

a. To draw the joint bars into place when they are 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 tightenings. This requires that the applied tension shall be high enough to withstand the loss in bolt tension under traffic for the period between tightenings and still be sufficient at the end of the period to insure 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 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 (1988)

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 tightenings.

b. Track bolts should be retightened as required, preferably from 1 to 3 months after the joint bars are applied, and at intervals of 1 year thereafter. More frequent tightening is unnecessary and therefore uneconomical. Less frequent tightening requires too high an applied bolt tension to carry over the longer period.

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.

[1] References, Vol. 46, 1945, pp. 567, 802, 819; Vol. 54, 1953, pp. 1066, 1403; Vol. 63, 1962, pp. 489, 753. Reapproved without change 1962.

SECTION 5.6 GAGE[1] (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 ½ 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.

SECTION 5.7 TAMPING[2] (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.

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[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.

[2] 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.

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 PRESERVATION OF TRACK FIXTURES[1] (1960)

The following is recommended as good practice:

5.8.1 RAIL JOINTS (1988)

a. When assembling rail joints in territory where corrosion is moderate, the rail ends should be protected from corrosion by the application of a brush coat of metal preservative. In territory where corrosion is severe, the bars should also be coated, and end plugs can be used to preserve the bolts. All bolts should be coated with a grease-type preservative when applied. Field end hardening of the rail should be done prior to applying rust preventives to the joints.

   Petrolatum or petrolatum-based compounds with a corrosion inhibitor, will give good protection in the joints.

b. In track where damaging corrosion exists or the joints have become frozen, the spray method of preserving the joints without removing the bars is recommended at suitable intervals. Application to the inside and outside of the joints can be made economically with suitable spray equipment.

c. Petrolatum, asphalt, and petroleum oil-based compounds, preferably containing a wetting agent and a corrosion inhibitor, can be used to control corrosion and prevent or eliminate frozen joints, broken bolts and stripped joints. Best results can be obtained if applied during warm weather.

[1] References, Vol. 24, 1923, pp. 502, 1167; Vol. 37, 1936, pp. 469, 1018; Vol. 49, 1948, pp. 325, 639; Vol. 54, 1953, pp. 972, 1398; Vol. 61, 1960, pp. 954, 1235. Rewritten 1960.

5.8.2 RAIL AND OTHER TRACK MATERIAL, EXCEPT JOINTS (1988)

a. Oil turnout fixtures, except on surfaces where graphite is used.

b. Oil rail, tie plates and spikes when subjected to special corrosive conditions where ultimate life is affected.

c. Oiling of rail, tie plates and spikes can be done by a spray machine.

d. Satisfactory oil for this purpose should conform to the general specifications found in Table 5-5-5.

Table 5-5-5. Asphalt Base Dipping Oil Specifications

Type	Specification
Flash point, min	130 degrees F
Asphalt, 100 penetration, min	45%
Viscosity, Saybolt Universal, 130 degrees F	240 – 350 sec

SECTION 5.9 WAYSIDE LUBRICATION OF RAIL ON CURVES[1] (1992)

5.9.1 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.

(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)

[1] References, Vol. 93, 1992, p. 58.

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. Dispension 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 5.10 WELDING OF MANGANESE STEEL CASTINGS IN SPECIAL TRACKWORK[1] (2005)

5.10.1 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.

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.

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

5.10.2 WELDING METHODS (2005)

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

5.10.3 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.

5.10.4 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 ⅝ 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 ¼ 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.

5.10.5 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.

5.10.6 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.

5.10.7 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.

5.10.8 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 5⁄8 inch (16 mm) to 1 inch (25.4 mm) thick block placed under the center in order that an upward bow be attained.

5.10.9 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 5.11 RECOMMENDED PRACTICES FOR SWITCH POINT AND STOCK RAIL CHANGEOUT[1] (1995)

5.11.1 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 5.11.2 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 5.11.3 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.

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

5.11.2.1 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).)

5.11.2.2 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.

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[1] References, Vol. 96, p. 30.

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.

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.

5.11.2.3 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.)

5.11.2.4 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.

5.11.3 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 5-5-5.)

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.

5.11.4 GENERAL INFORMATION (1995)

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. Items maintained by Signal Department employees are subject to the "Rules and Regulations Governing Railroad Signal and Train Control Systems" issued by the FRA.

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 5.11.3d, above, is not violated.

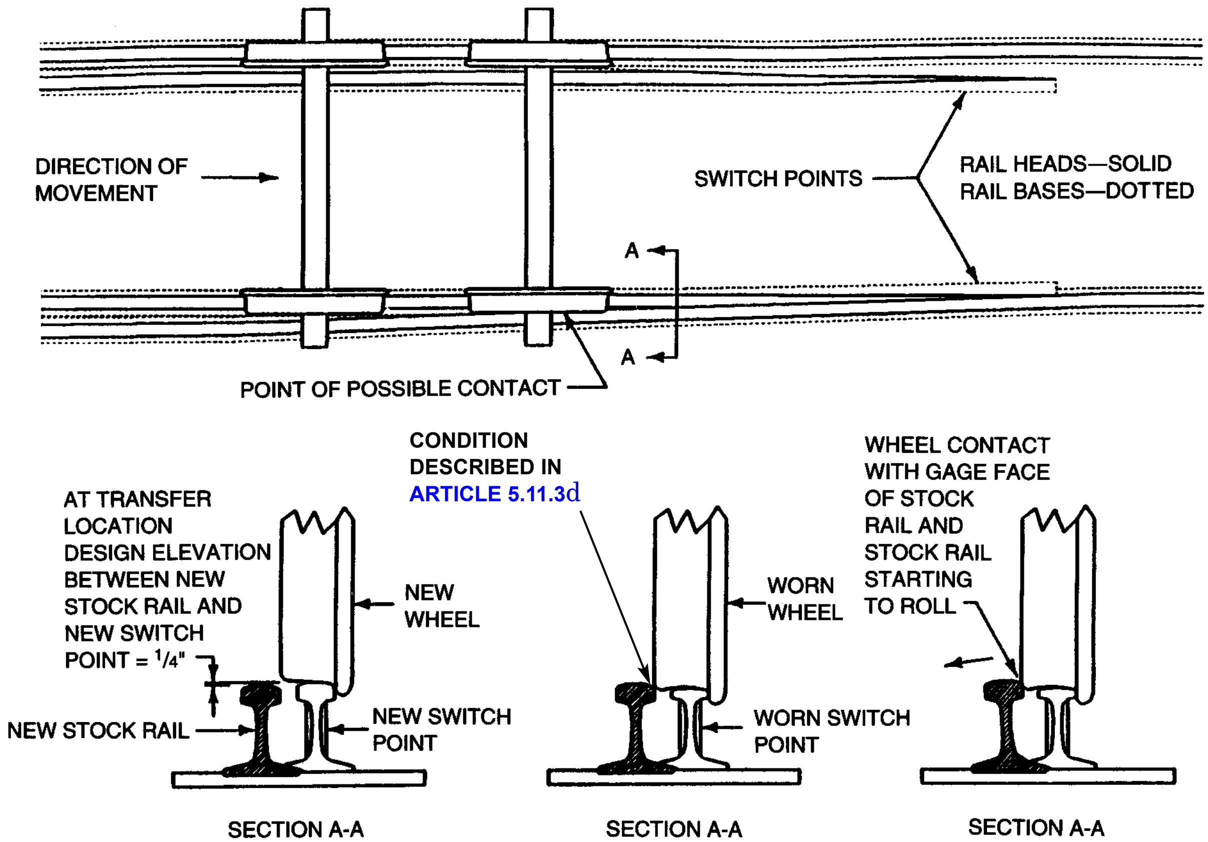

Figure 5-5-5. Rail Rise Corrections

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American Railway Engineering and Maintenance-of-Way Association

Part 6

Specifications and Plans for Track Tools

— 2007 —

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SECTION 6.1 Specification for Track Tools[1] (1997)

6.1.1 General

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

	Carbon		Manganese		Phosphorous		Sulfur	
Grade	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.

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[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.

(3) 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.

(4) 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 (2006)

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. 3-02
Double-Face Sledge Hammers	Plan No. 13-02

6.1.2.1.2 Metal To Metal Contact Struck Tools

Track Chisels	Plan No. 17-02
Round Track Punch	Plan No. 19-02
Track Spike Lifter	Plan No. 32-03
Nut Cutter	Plan No. 35-02
3 lb. Hot Cutter	Plan No. 36-02
5 lb. Hot Cutter	Plan No. 37-02
Drift Pin-Short	Plan No. 38-03
Drift Pin-Long	Plan No. 39-03
Spiking Tool	Plan No. 41-02

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	
Grade	Min	Max	Min	Max	Max	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	0.15	0.25	0.00	0.00	0.80	1.10
Grade	Min	Max	Min	Max	Max	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
Alloy "B"	0.51	0.60	0.75	1.00	0.025	0.025	1.80	2.20	0.00	0.45	0.35	0.50	0.00	0.00	0.00	0.00
Grade	Min	Max	Min	Max	Max	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
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

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.
- 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.

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 $\frac{8}{16}$ 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.

6.1.2.5 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-03, B-83 or C-83, D-83.

6.1.2.7.1 Head Contour

a. Heads of tools with a round cross section shall be ground to the corner contours prescribed in Plans A-03, B-83 or C-83.

b. Heads of tools with a hexagonal or octagonal cross section should also be ground to the corner contours prescribed in Plans A-03, B-83 or C-83. 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-83.

c. Punch ends shall have corner radii according to paragraph a, but with no crown radius.

d. All ground surfaces shall be free of decarburization.

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

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 ¼ 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 1-¼ inches with a permanent set not to exceed ⅛ 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 ½ 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 and the solid shank type with either wood, malleable iron, combination wood metal, or user approved composition handle tops. Dimension shall conform to plans, which are made part of this specification. A variation of ½ 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 ¼ 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 ½ 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 and Tops

This specification covers either wood, malleable iron, combination wood metal, or user approved composition handle tops. 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 ½ 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) harness of 35-45. Straps shall be 0.04 U.S. Standard gage steel.

6.1.3.22.3 Handles

This specification covers either wood, malleable iron, combination wood metal, or user approved composition handle tops. 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 and the solid shank type with either wood, malleable iron, combination wood metal, or user approved composition handle tops. Dimension shall conform to plans, which are made part of this specification. A variation of ½ 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 ¼ 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 ½ 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 and Tops

This specification covers either wood, malleable iron, combination wood metal, or user approved composition handle tops. 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 Spot Board—Plan No. 30

Material as shown on plans. No special tests required.

6.1.3.27 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.

6.1.3.28 Track Spike Lifter—Plan No. 32

See percussion tools.

6.1.3.29 Drive Spike Extractor Socket Wrench—Plan No. 33

No special tests required.

6.1.3.30 Rail Thermometer—Plan No. 34

Material as shown on plans. No special tests required.

6.1.3.31 Nut Cutter—Plan No. 35

See percussion tools.

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

See percussion tools.

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

See percussion tools.

6.1.3.34 Drift Pin (Short)—Plan No. 38

See percussion tools.

6.1.3.35 Drift Pin (Long)—Plan No. 39

See percussion tools.

6.1.3.36 Spiking Tool—Plan No. 41

See percussion tools.

6.1.3.37 Switch Clip Wrench—Plan No. 43

Chemical composition for carbon steel as specified in Article 6.1.1.1c. If requested by the purchaser, Article 6.1.2.6, will be adhered to (see Table 5-6-4).

SECTION 6.2 SPECIFICATIONS FOR ASH AND HICKORY HANDLES FOR TRACK TOOLS[1] (1962)

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).

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[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.

- 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 acquatica)

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 ¼″ 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 ¼″ in the eye end or the first third of the grasp end.

6.2.9 USE CLASSIFICATION (1989)

Use classifications are found in Table 5-6-5.

Table 5-6-5. Use Classifications

Handle	Handle Grade Symbol	Minimum Weigh per Dozen Handles Lb	Number of Tool Plan
Adz-34″	HA	15	12
Axe-36″	HA	17	–
Cant hook	HB-1	–	–
Chisel (Track) 24″	HB-2	–	17
Flatter (3″ Square) 24″	HB-2	–	–
Fork (Ballast)	AA	–	22
Hammer	HA	–	–
Hatchet	HA	–	–
Hoe	AB	–	–
Hot Cutter (3 lb) 24″	HB-2	–	36
Hot Cutter (5 lb) 24″	HB-2	–	37
Jack	HB-1	–	–
Maul (Spike) 36″	HA	15	3
Pick-36″	HA	21	1 and 2
Punch (Round Track) 24″	HB-2	–	19
Rake	AB	–	–
Scoop	AA	–	26
Scythe (Snath) 59″	AA	–	–
Shovel (Track)	AA	–	21
Sledge-36″	HA	14	13
Track Spike Lifter-36″	HB-2	–	32

SECTION 6.3 RECOMMENDED LIMITS OF WEAR FOR TOOLS TO BE RECLAIMED[1] (1962)

6.3.1 GENERAL (1962)

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 and 21.

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 SPECIFICATIONS[1] (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.

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[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 ½″ 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

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.

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

Width (Inches)	Length (Feet)	Thickness (Inches)
1	25	1⁄16 (min)
3¾	10	⅛ (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 TOOLS[1] (2007)

6.5.1 GENERAL (2007)

a. For the plans for track tools refer to Table 5-6-13 and Figure 5-6-1 through Figure 5-6-39.

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 (2007)

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
3-02	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	
7-93	Tie Tongs	Carbon or Alloy	
8-93	Timber Tongs	Carbon or Alloy	
9-94	Spike Puller	Carbon	375-450 BHN
10-03	Rail Fork	Carbon	275-350 BHN
11-97	Claw Bar	Carbon	300-375 BHN
12-07	*Track Adz	Carbon or Alloy	375-450 BHN
12A-07	*Carpenter's Adz	Carbon or Alloy	
13-02	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	
17-02	Track Chisel	Alloy	44-48 Rc (Head) 56-60 Rc (Point)
19-02	Round Track Punch	Alloy	44-48 Rc (Head) 52-56 Rc (Point)
20-62	Track Gage—Pipe Center	See Plan	
20A-62	Track Gage—Wood Center	See Plan	
21-62	Track Shovel	Carbon or Alloy	45-50 Rc
22-62	Ballast Forks	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 (2007) (Continued)

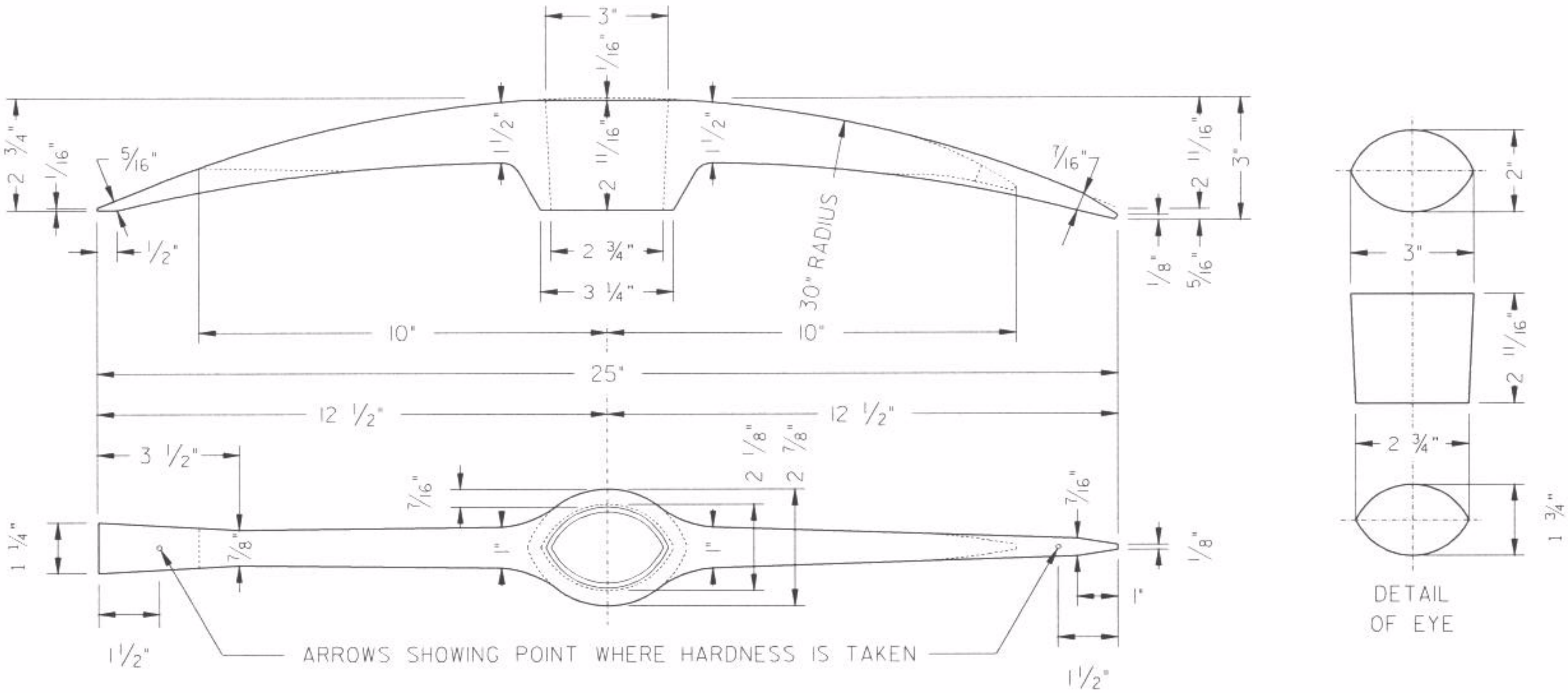
Plan Number	Description	Grade of Steel	Hardness
26-62	Scoop	Carbon or Alloy	45-50 Rc
27-68	Aluminum Combination Track Level And Gage (Insulated)		
30-62	Spot Board	See Plan	
31-97	Rail Tongs For Use With	See Plan	
	Crane (Type 1 And 2)		
32-03	Track Spike Lifter	Alloy	44-48 Rc (Head) 44-48 Rc (Claw)
33-62	Drive Spike Extractor	Carbon	300-350 BHN
	Socket Wrench		
34-02	Rail Thermometer		
35-02	Nut Cutter	Alloy	44-48 Rc (Head) 56-60 Rc (Point)
36-02	3 Pound Hot Cutter	Alloy	44-48 Rc (Head) 56-60 Rc (Point)
37-02	5 Pound Hot Cutter	Alloy	44-48 Rc (Head) 56-60 Rc (Point)
38-06	Drift Pin (Short)	Alloy or EN30 B	32-37 Rc (Overall)
39-06	Drift Pins (Long)	Alloy or EN30 B	32-37 Rc (Overall)
41-02	Spiking Tool	Alloy	44-48 Rc (Head) 52-56 (Point)
43-97	Switch Clip Wrench	Carbon	375-450 BHN
*When specified, the small eyed track tools will be furnished with AREMA handles. The handles are to be properly fitted and wedged.			

Table 5-6-14. Chemical Specification for Carbon Steel Track Tools

Type	Specification
Carbon (Note 1)	0.55 to 0.70
Manganese	0.60 to 0.90
Phosphorous	0.05 max
Sulphur	0.05 max
Note 1: Applies to all carbon steel tools	

Table 5-6-15. Chemical Specifications for AREMA Alloy Steel Track Tools

	Carbon		Manganese		Phos.	Sulfur	Silicon		Vanadium		Molybdenum		Nickel		Chromium	
Grade	Min	Max	Min	Max	Max	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	0.15	0.25	0.00	0.00	0.80	1.10
Grade	Min	Max	Min	Max	Max	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
Alloy "B"	0.51	0.60	0.75	1.00	0.025	0.025	1.80	2.20	0.00	0.45	0.35	0.50	0.00	0.00	0.00	0.00
Grade	Min	Max	Min	Max	Max	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
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



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.

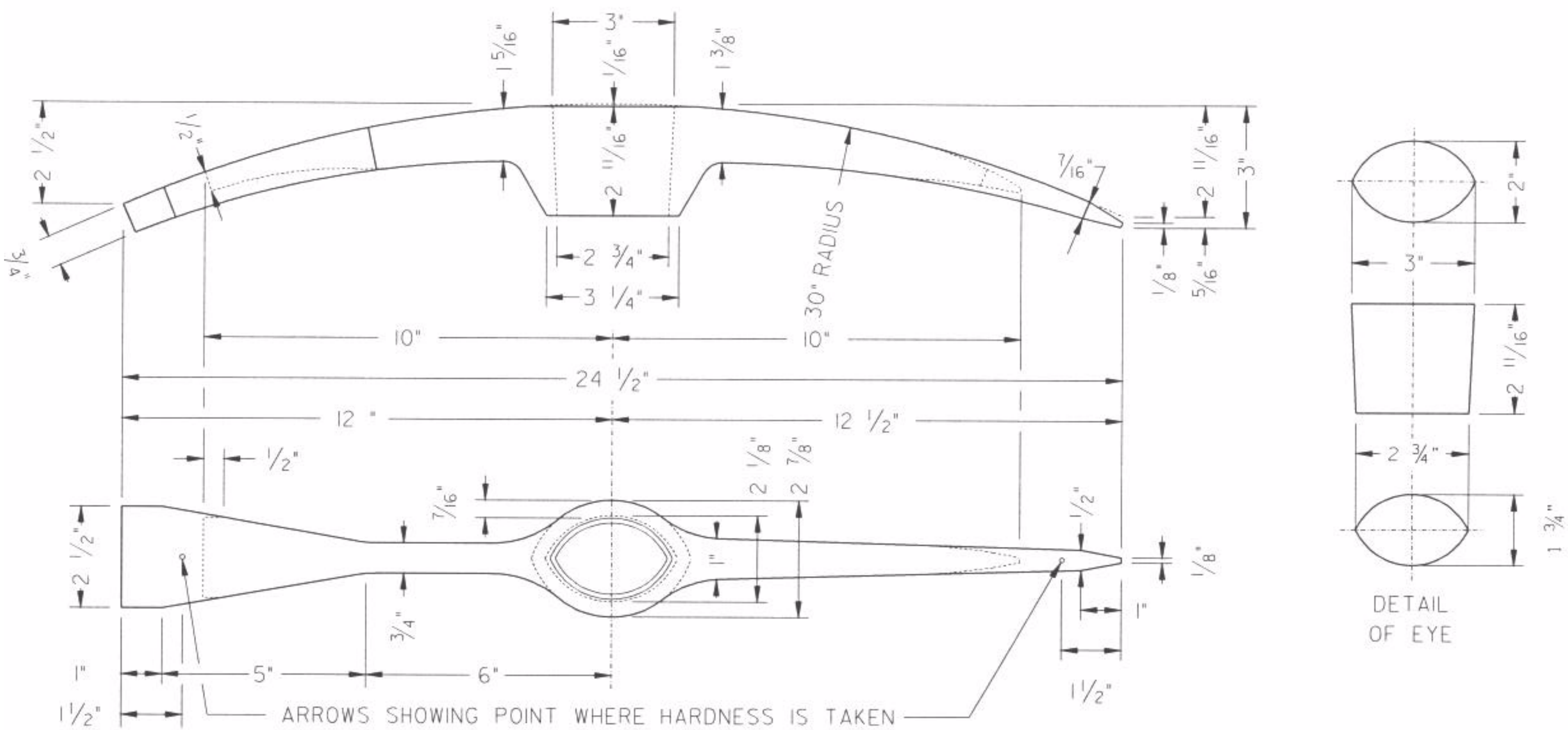
5. BRINELL: 425 - 500 FOR CARBON STEEL AND AISI/SAE ALLOY STEEL.

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.

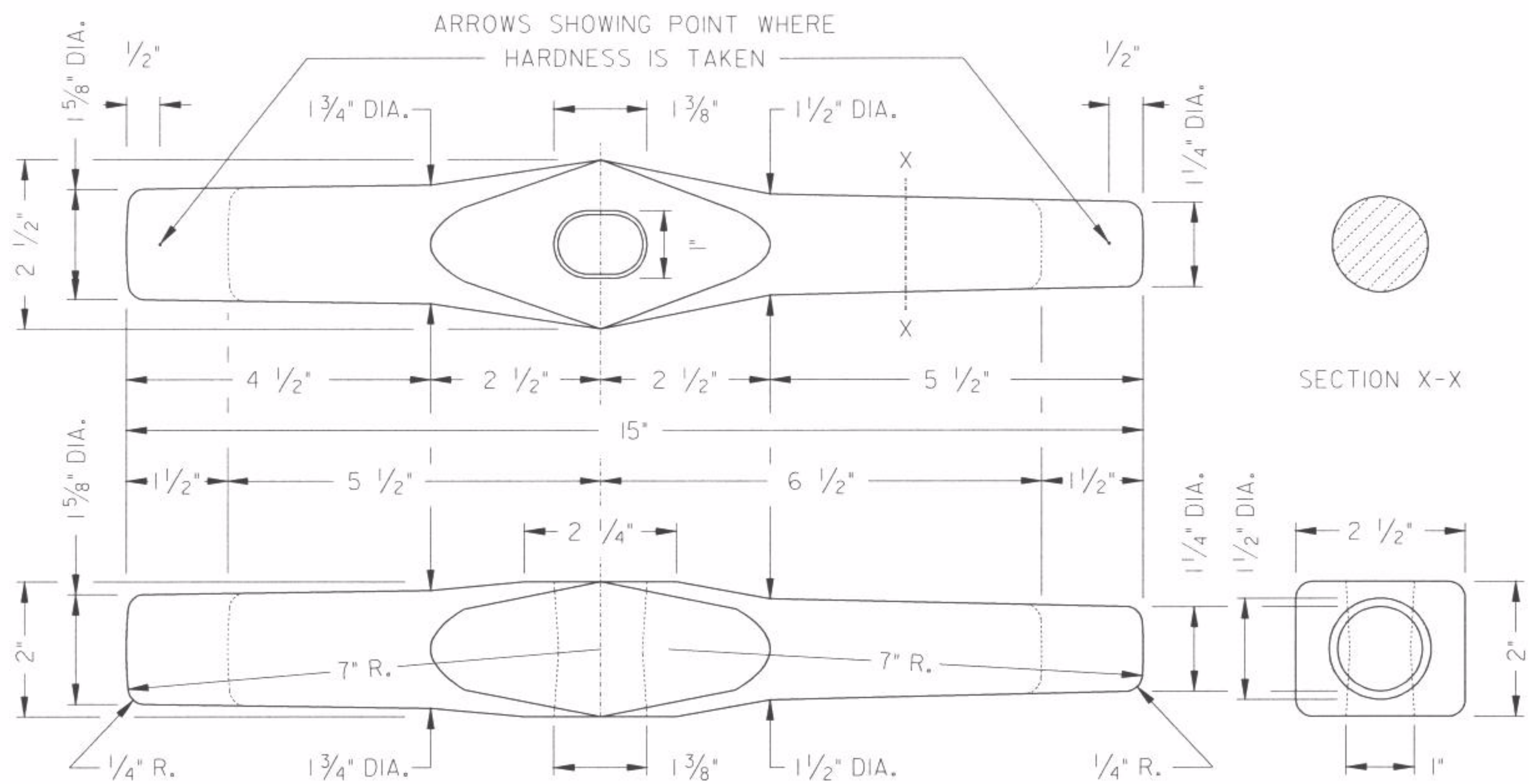
4. FURNISH IN CARBON STEEL OR AISI/SAE 4140 ALLOY STEEL.

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.

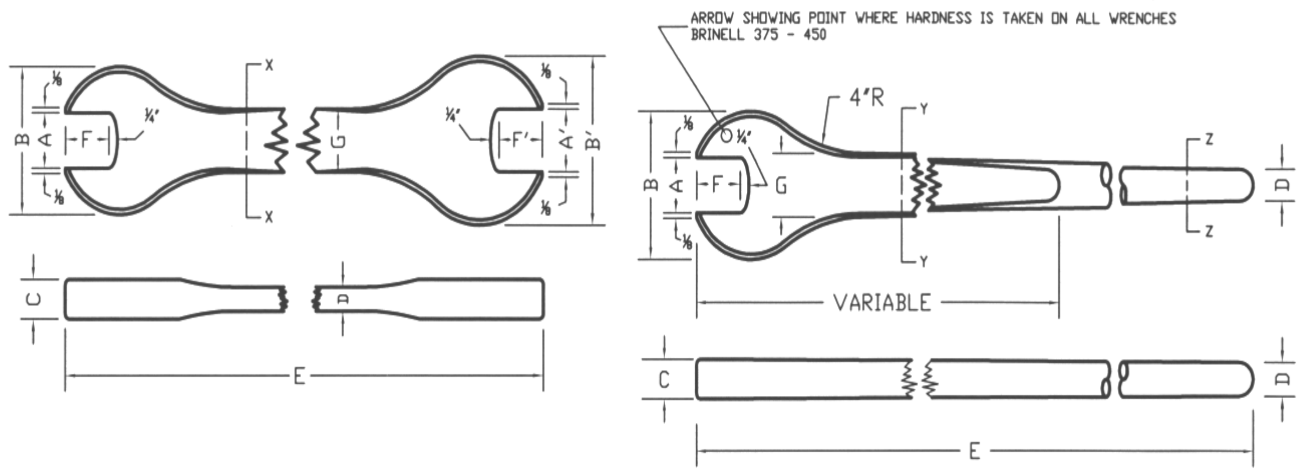
Figure 5-6-2. Plan 2-02 – AREMA Tamping Pick

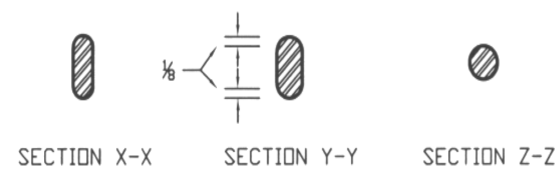


NOTE:

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 ALLOY STEEL.
4. ROCKWELL C - 51/55
5. CONTOUR GRIND HEAD PER AREMA PLANS A-00, B-83, AND D-83.
6. DASHED LINES INDICATE OUTLINE (MINIMUM) OF TOOLS AS RECLAIMED.
7. APPROXIMATE WEIGHT 10 POUNDS.

Figure 5-6-3. Plan 3-02 – AREMA Spike Maul





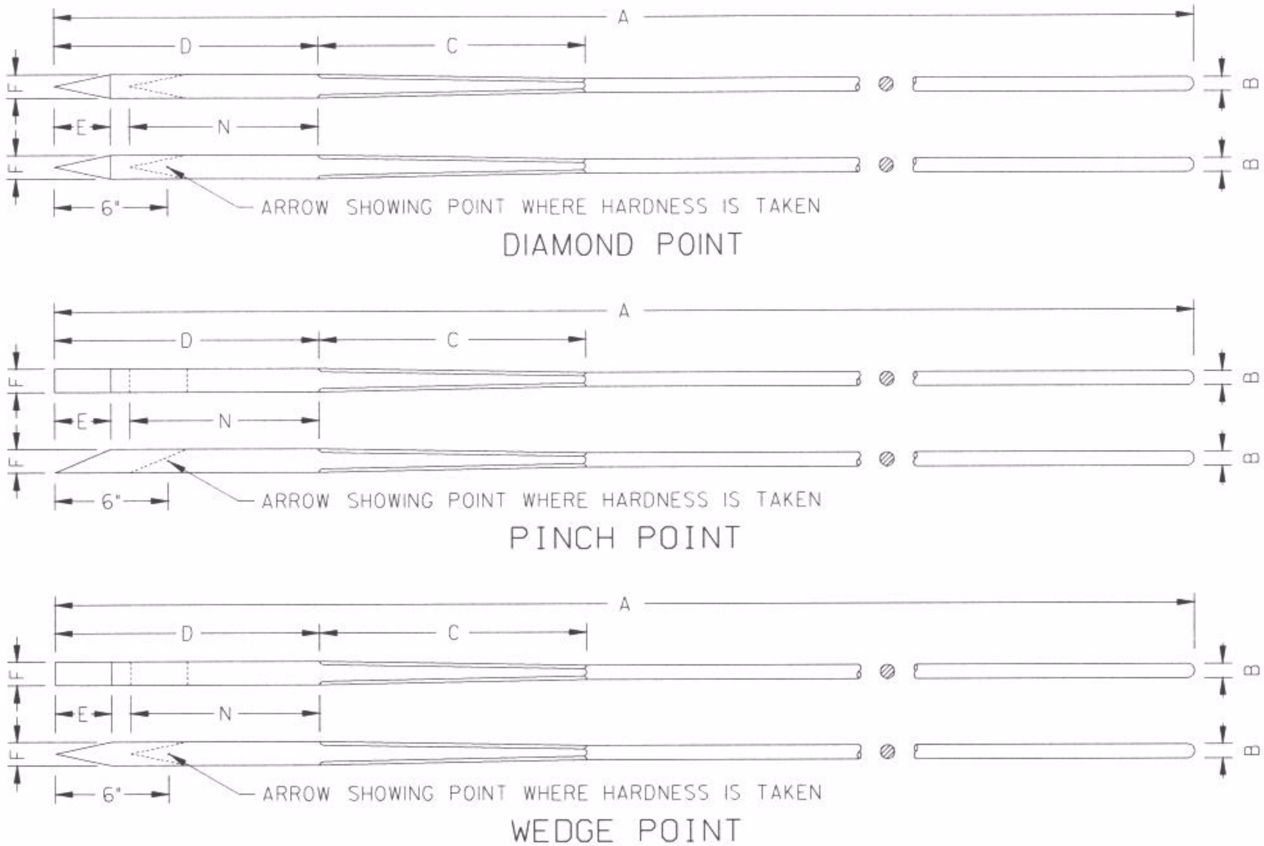
	SINGLE END - DIMENSIONS IN INCHES								
BOLT SIZES	WIDTH OF NUT	A MIN	A MAX	B	C	D	E	F	G
¾	1¼	1.257	1.330	3½	15/16	¾	30	1¼	1½
⅞	1 7/16	1.445	1.519	4	15/16	¾	36	1¼	1½
1	1⅝	1.634	1.709	4	15/16	⅞	42	1⅜	1½
1⅛	1 13/16	1.822	1.898	4⅛	15/16	⅞	48	1 9/16	1½
1¼	2	2.011	2.088	4½	1	⅞	48	1¾	1½
1⅜	2 3/16	2.199	2.277	5	1	⅞	54	1 15/16	1½

DOUBLE END - DIMENSIONS IN INCHES														
BOLT SIZES	WIDTH OF NUT	A MIN	A MAX	A' MIN	A' MAX	B	B'	C	D	E	F	F'	G
¾ & ⅞	1¼ & 1 7/16	1.257	1.330	1.445	1.519	3½	4	15/16	½	36	1¼	1¼	1½
⅞ & 1	1 7/16 & 1⅝	1.445	1.519	1.634	1.709	4	4	15/16	½	42	1¼	1⅜	1½
1 & 1⅛	1⅝ & 1 13/16	1.634	1.709	1.822	1.898	4	4⅛	15/16	9/16	48	1⅜	1 9/16	1½
1⅛ & 1¼	1 13/16 & 2	1.822	1.898	2.011	2.088	4⅛	4½	*	9/16	48	1 9/16	1¾	1½
1¼ & 1⅜	2 & 2 3/16	2.011	2.088	2.199	2.277	4½	5	1	9/16	48	1¾	1 15/16	1½
* C = 15/16 ON 1⅛ END, 1 ON 1¼ END													

NOTE

1. Width of nut shall be stamped plainly in ¾" 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 6" to ½" diam. at end when specified.
4. All wrench jaws shall be milled to dimensions shown.

Figure 5-6-4. Plan 4-07 – AREMA Track Wrenches for Recommended Track Bolt Nuts

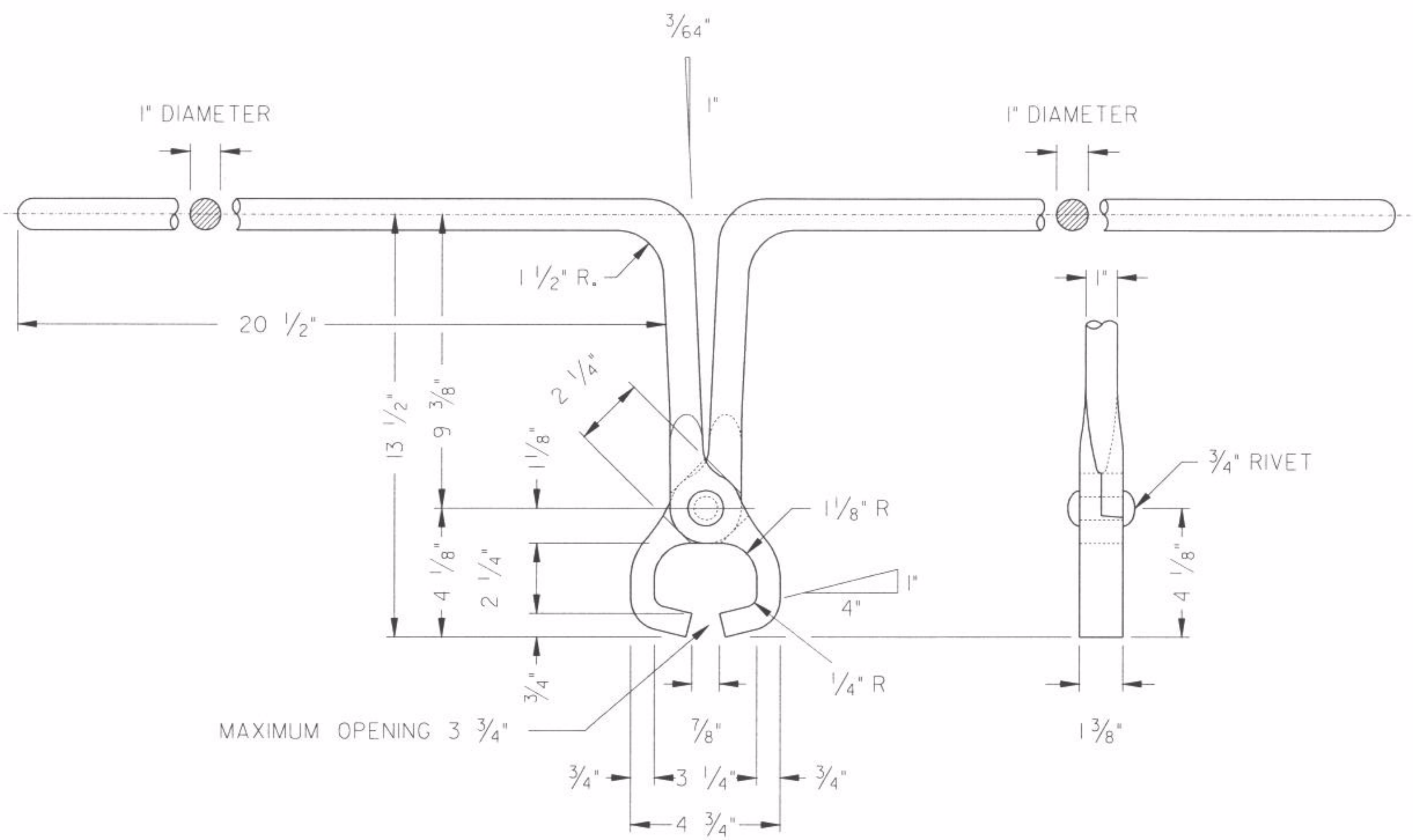


NOTE:

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"

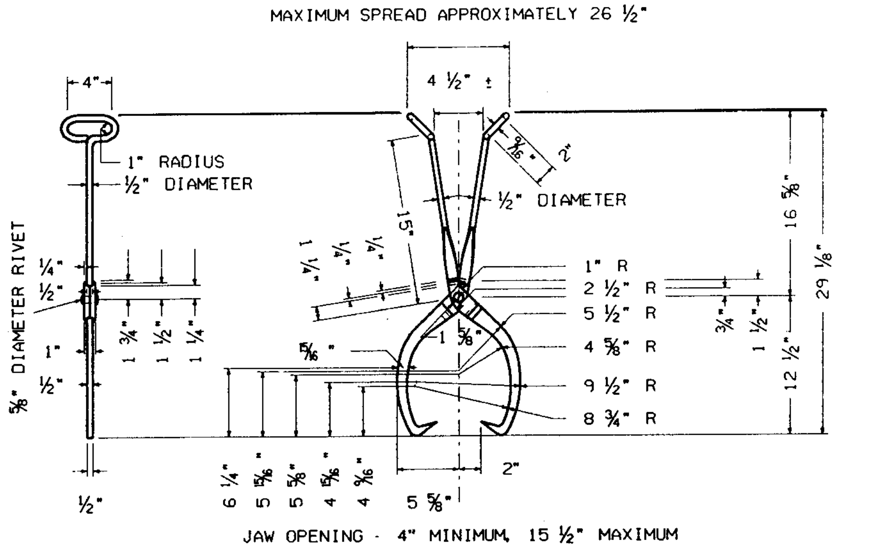
Figure 5-6-5. Plan 5-02 – AREMA Lining Bar



NOTE:

1. TOLERANCE -
   2 % ON LENGTH
   5 % 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 Tongs



NOTE
FURNISH IN CARBON OR ALLOY STEEL
NO HARDNESS TESTS REQUIRED
TOLERANCE-
2% ON LENGTH
5% ON CROSS SECTION
APPROXIMATE WEIGHT 10 POUNDS

IF SPECIFIED BY PURCHASER, FURNISH WITH,
1. HANDLES FROM ½" X 1" BARS INSTEAD OF ⁹⁄₁₆" ROUNDS
2. REPLACEABLE POINTS

STANDARD - PEAVY POINTS TO BE FINISHED BY GRINDING

ALTERNATE - REPLACEABLE POINT
⅝" SQUARE OR HEXAGON STEEL
⅜- 16 NC THREADS CLASS 2 FIT WITH LOCKNUT
CASE HARDEN 0.010 TO 0.015" FILE HARD,
OR 300 TO 350 BRINELL HARDNESS
⁷⁄₁₆" DIAMETER HOLE IN TONGS

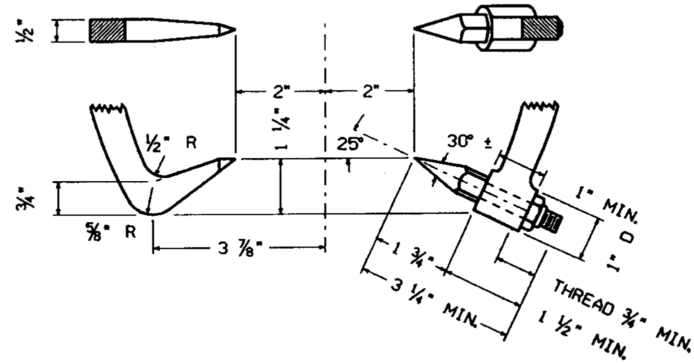


Figure 5-6-7. Plan 7-93 – AREMA Tie Tongs

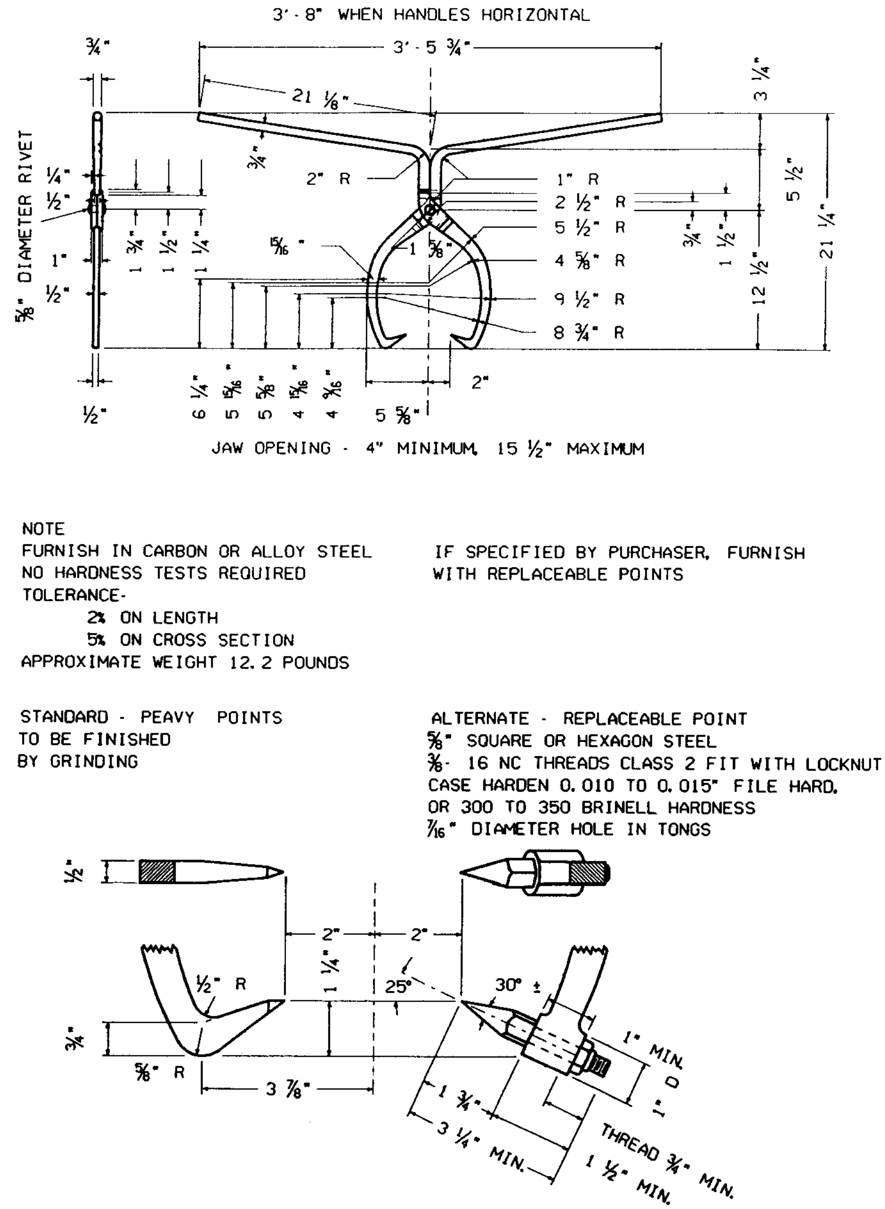


Figure 5-6-8. Plan 8-93 – AREMA Timber Tongs

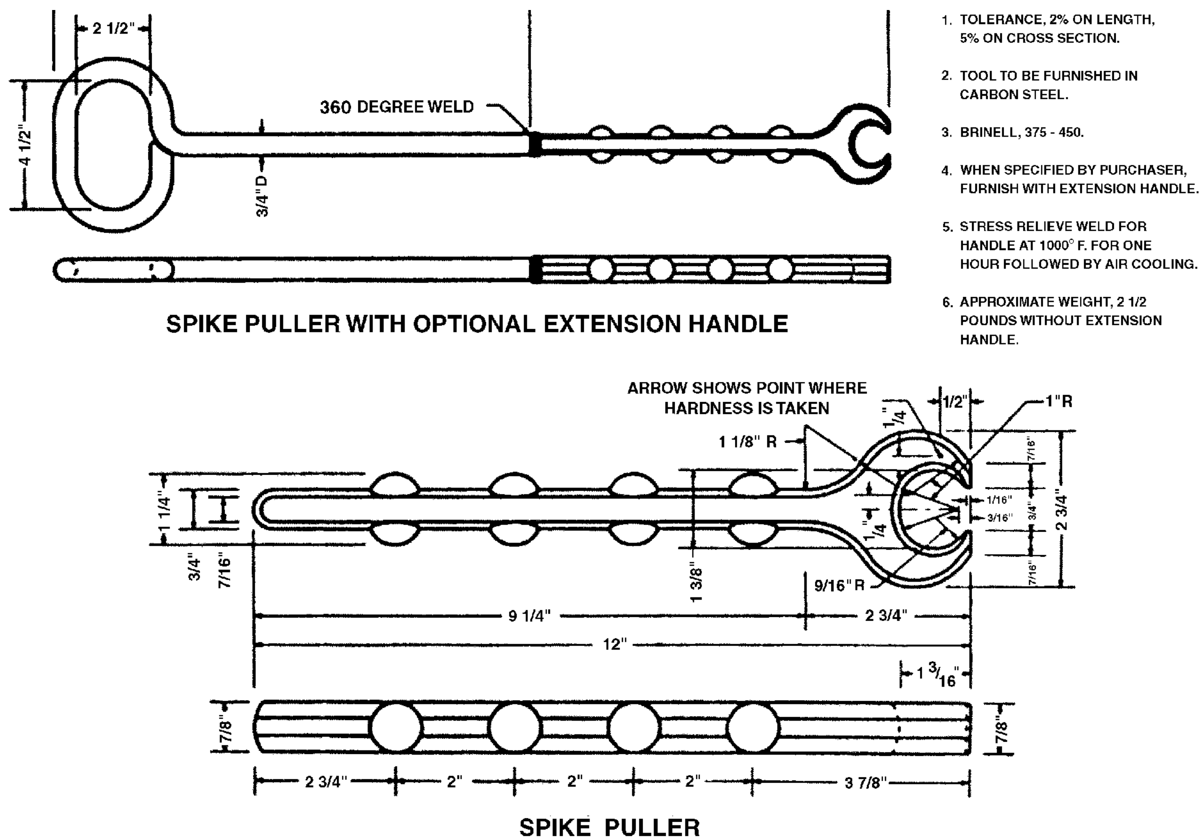


Figure 5-6-9. Plan 9-94 – AREMA Spike Puller

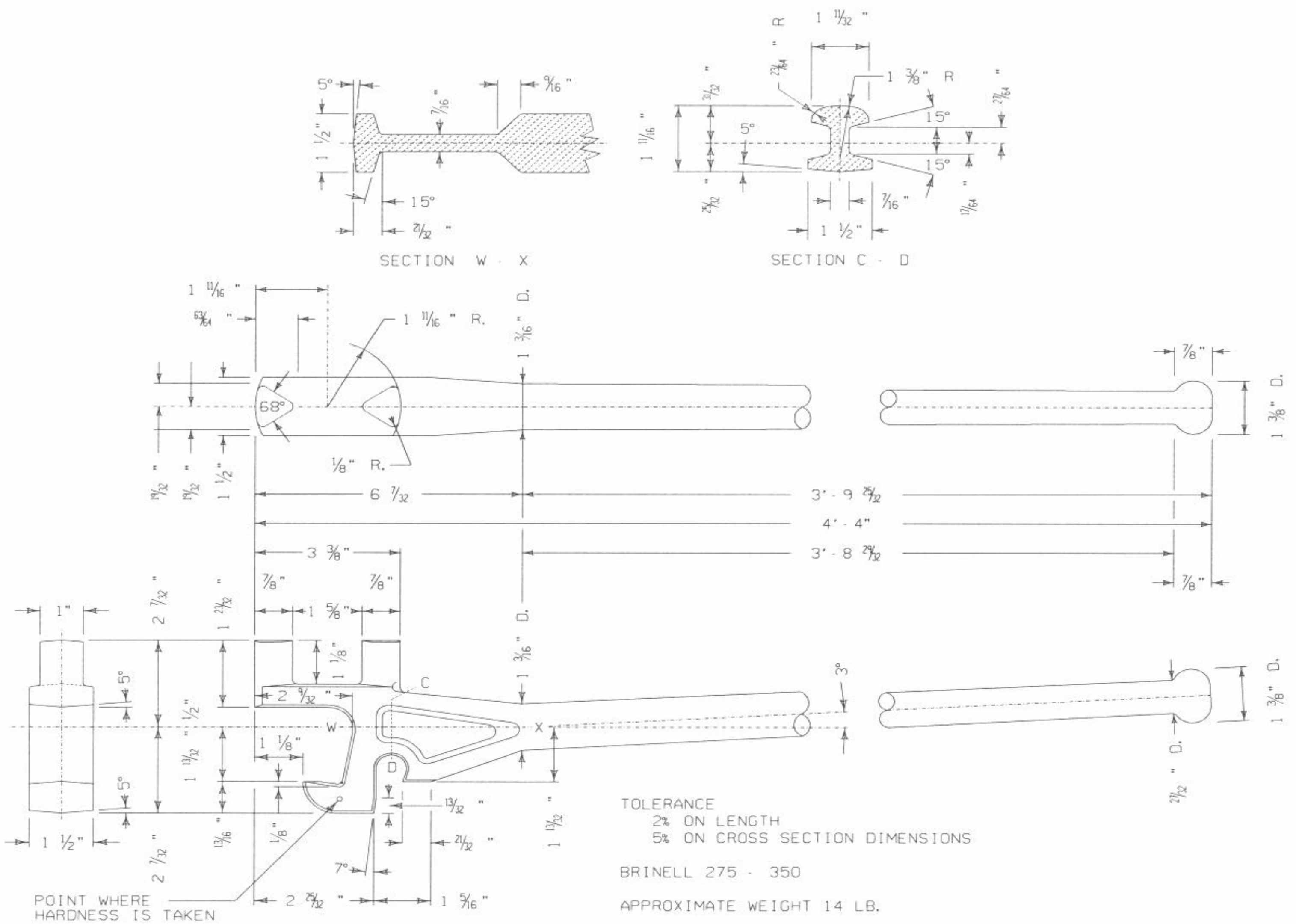


Figure 5-6-10. Plan 10-03 – AREMA Rail Fork

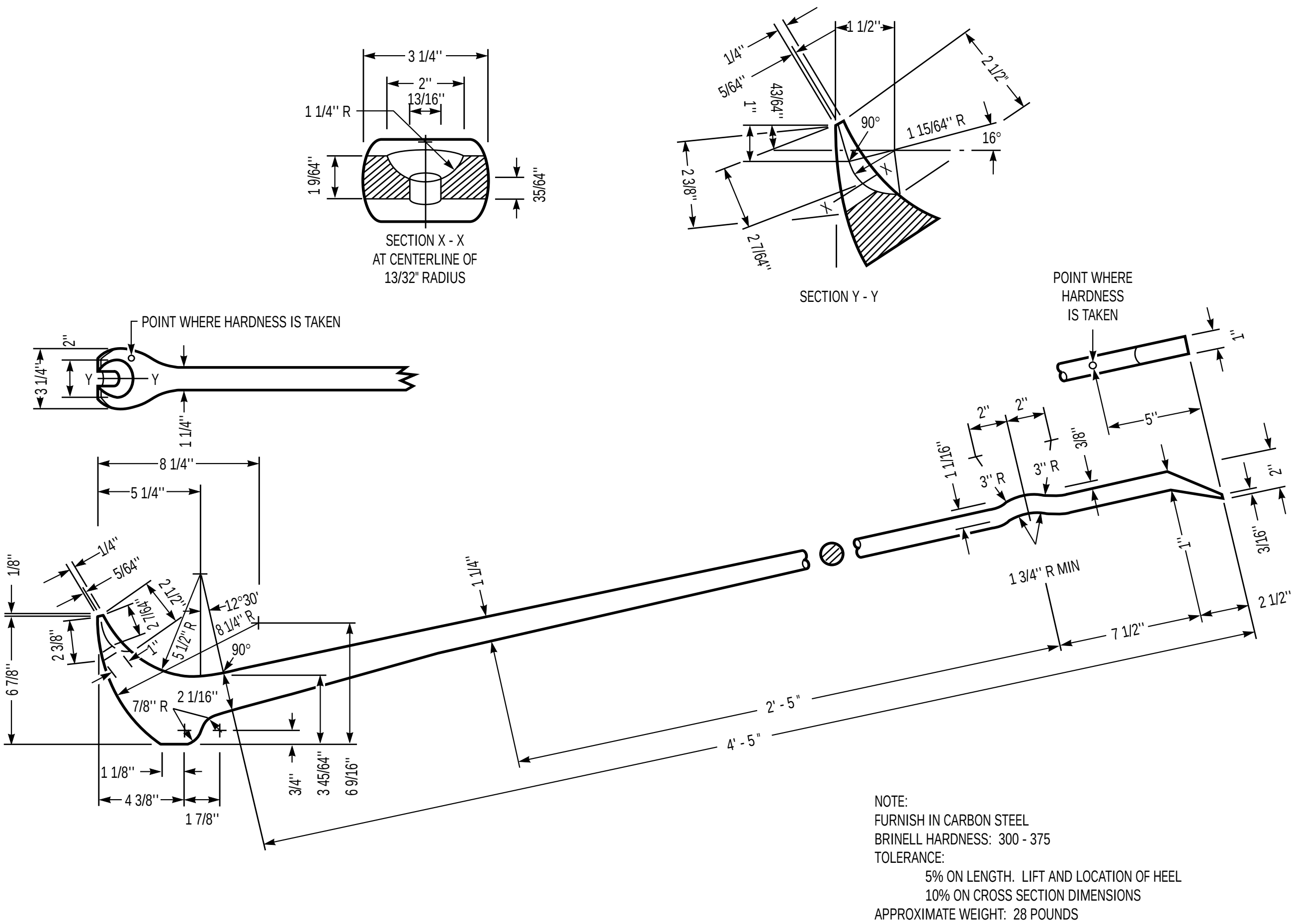


Figure 5-6-11. Plan 11-97 – AREMA Claw Bar

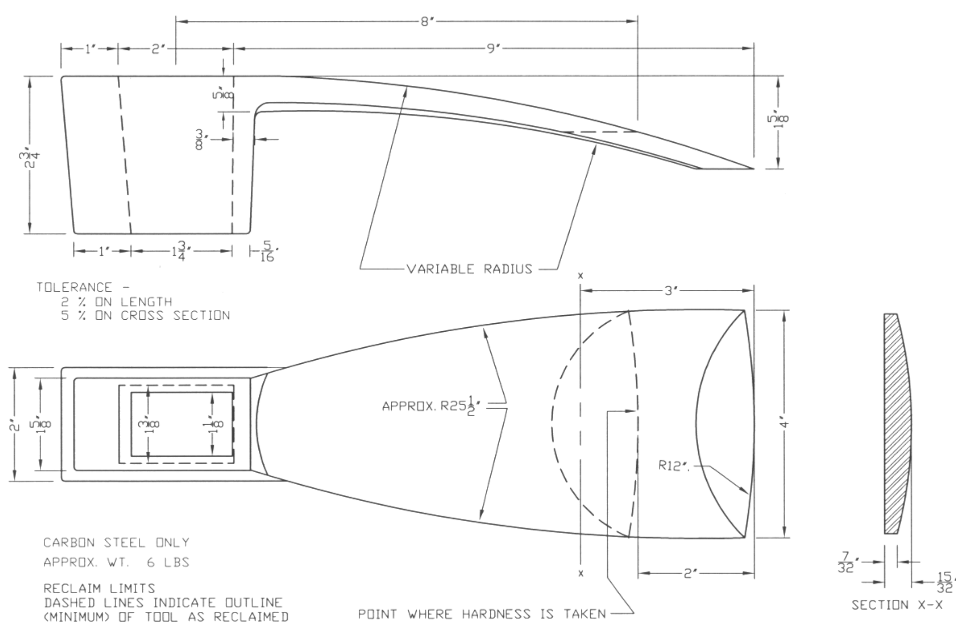


Figure 5-6-12. Plan 12-07 – AREMA Track Adz

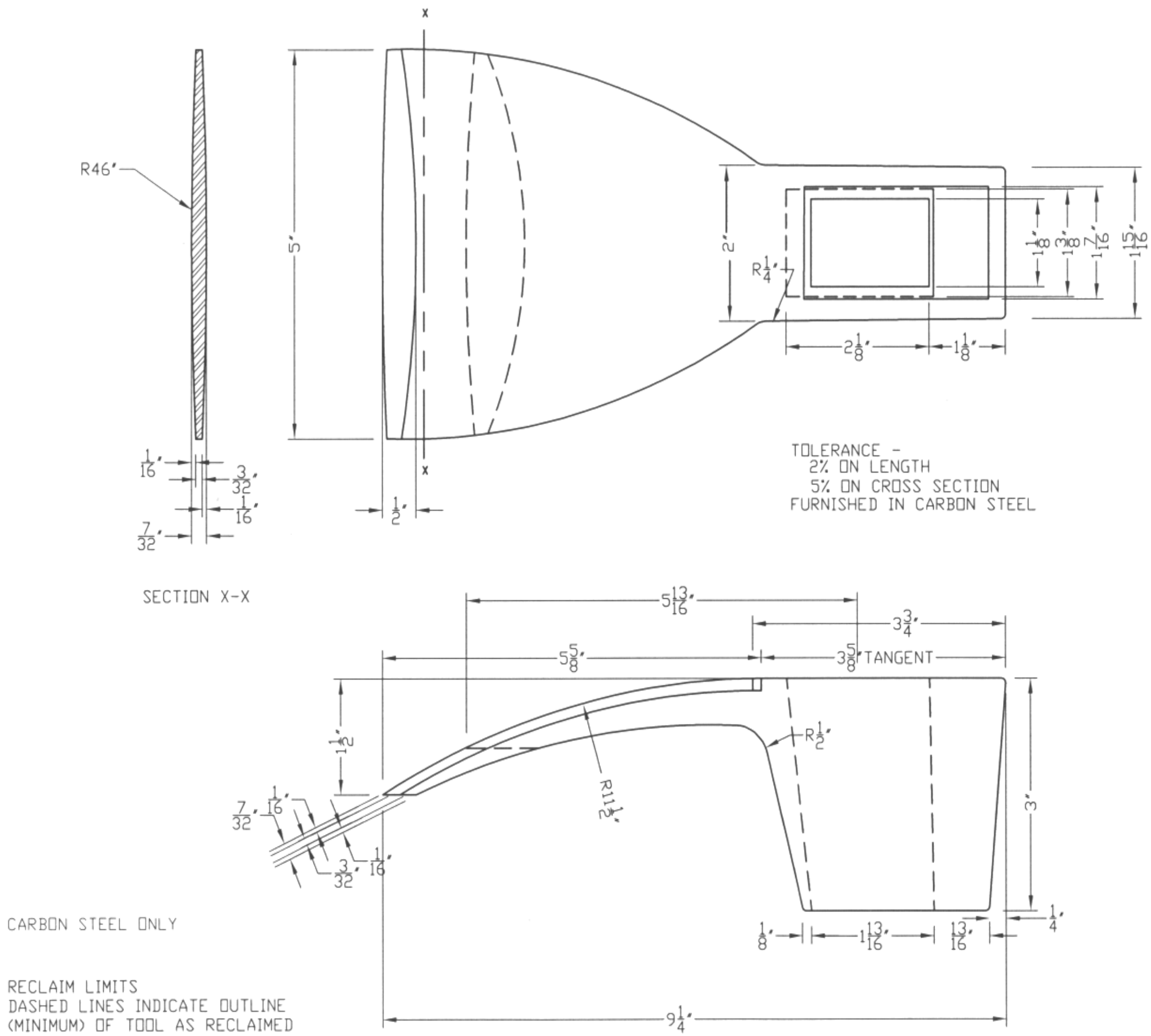
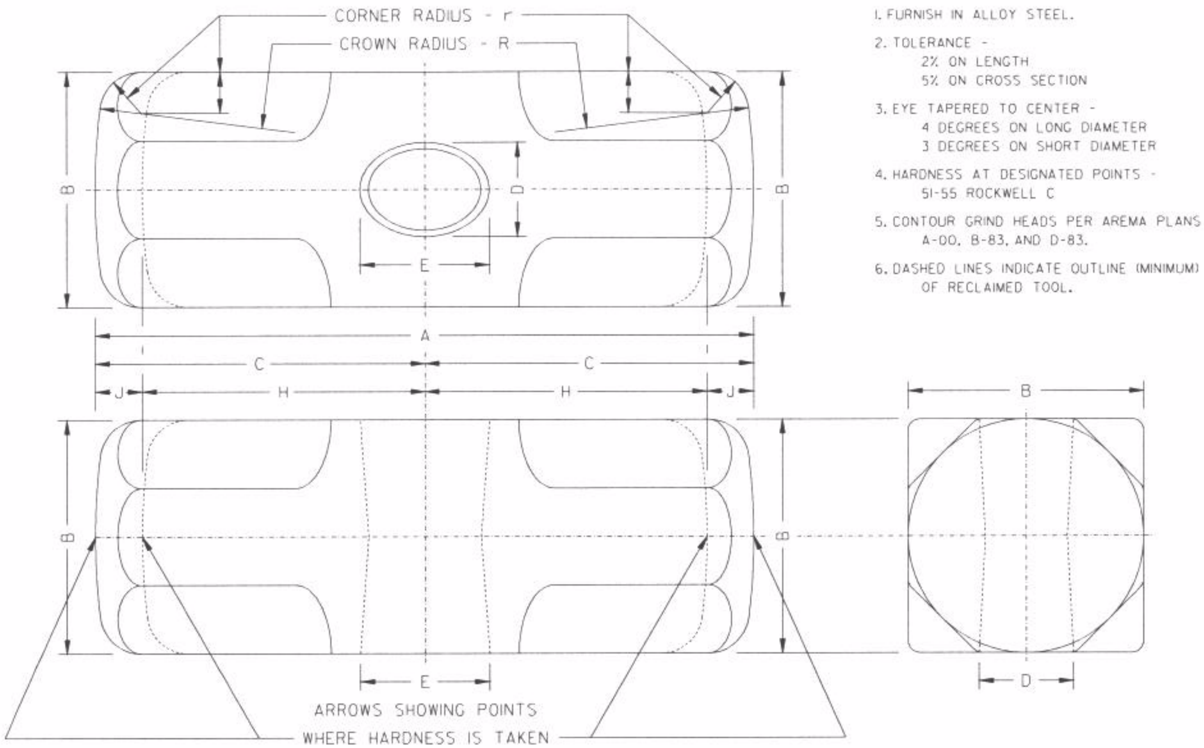
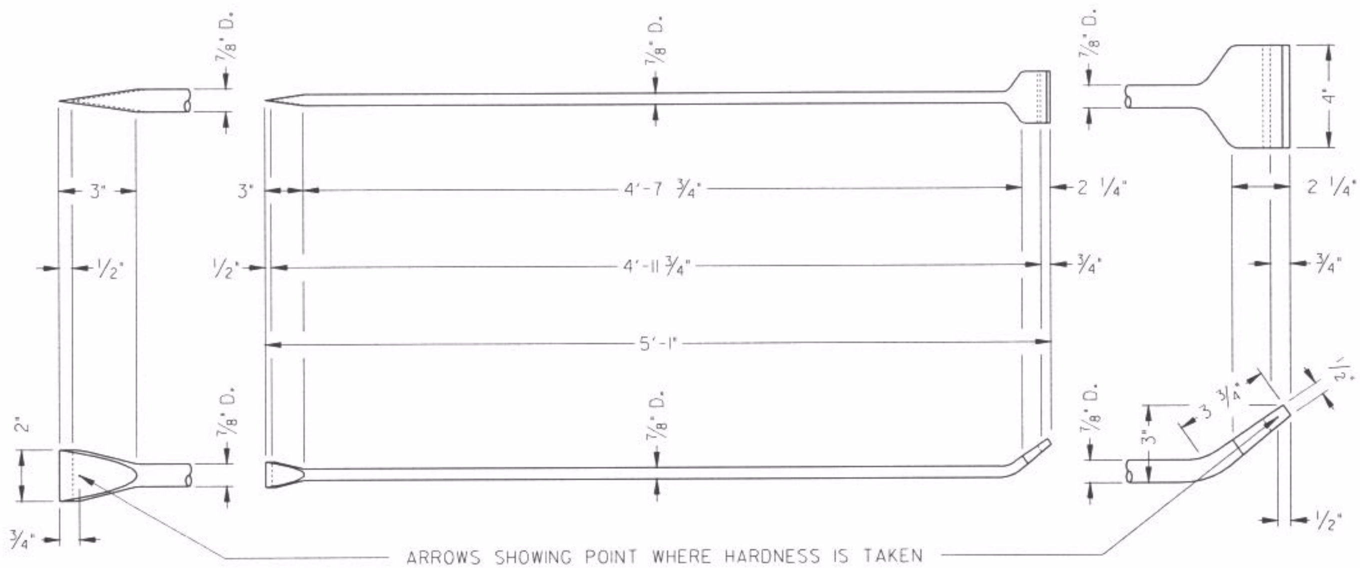


Figure 5-6-13. Plan 12A-07 – AREMA Carpenter's Adz



APPROX-IMATE 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	7/16	2 3/4	1/2
10	7	2 1/2	3 1/2	1	1 3/8	7	7/16	3	1/2
12	7 1/2	2 5/8	3 3/4	1	1 3/8	7	7/16	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

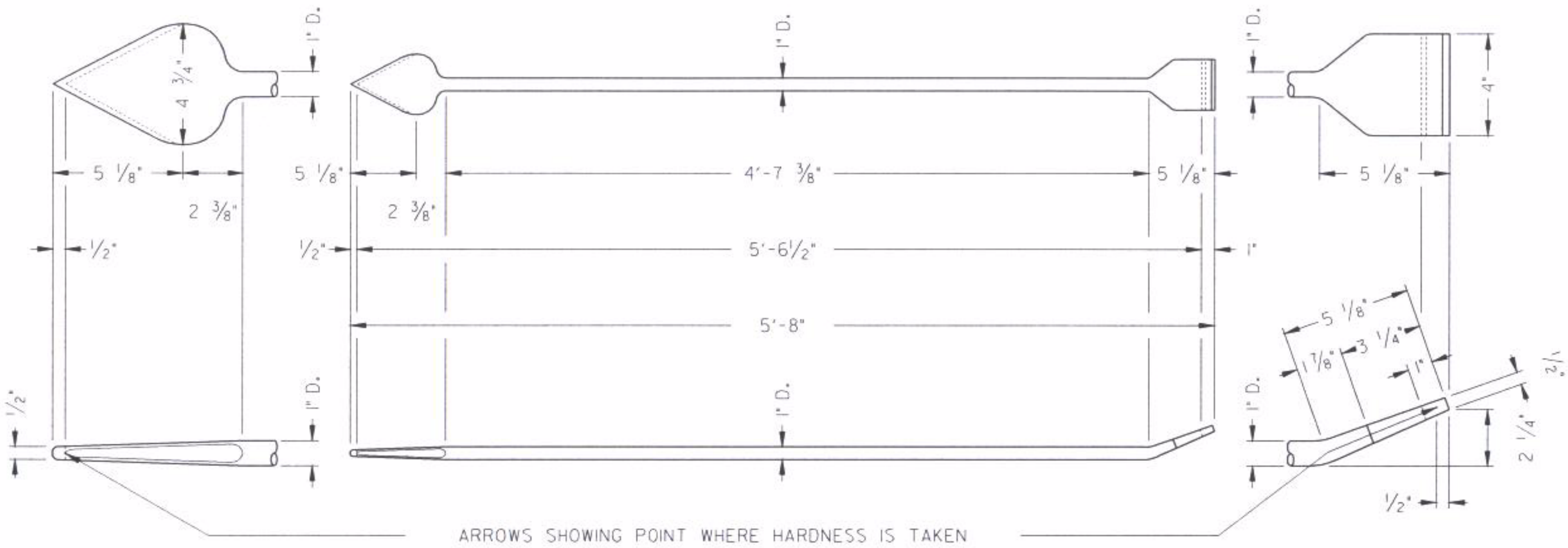
Figure 5-6-14. Plan 13-02 – AREMA Double Faced Sledge



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 13 POUNDS.

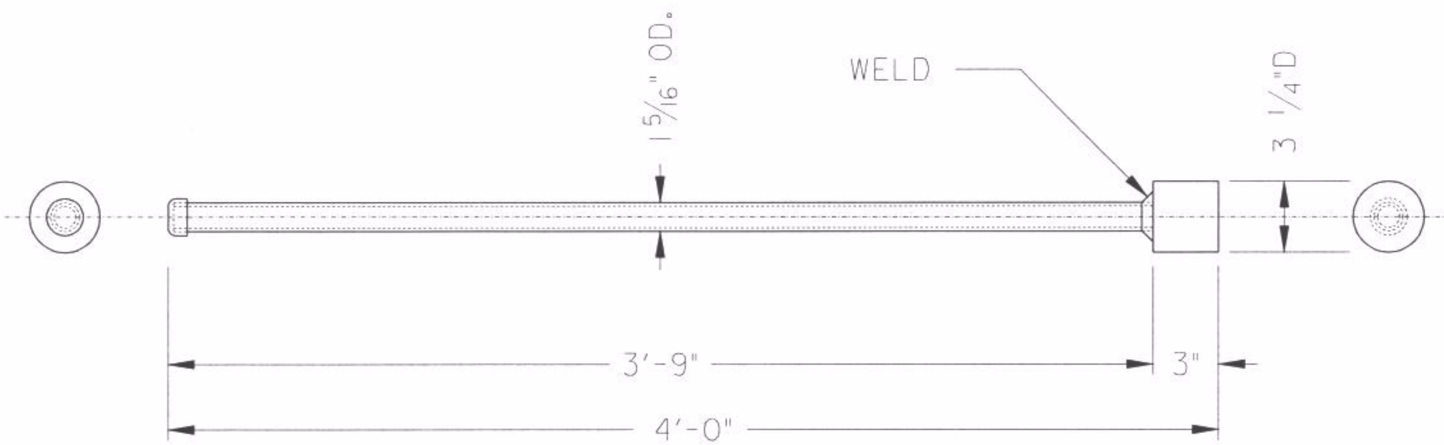
Figure 5-6-15. Plan 14-02 – AREMA Chisel End Tamping Bar



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 15 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

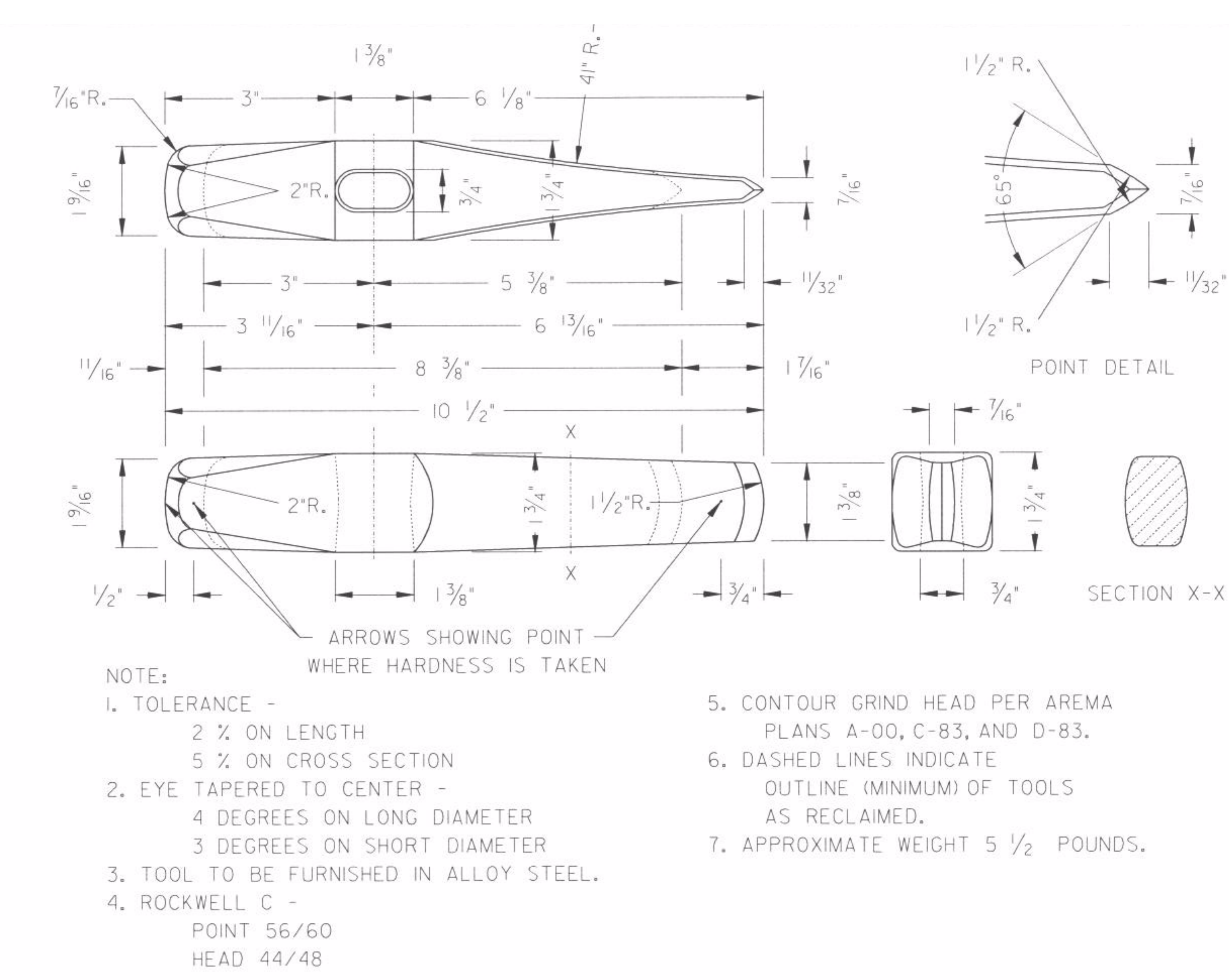
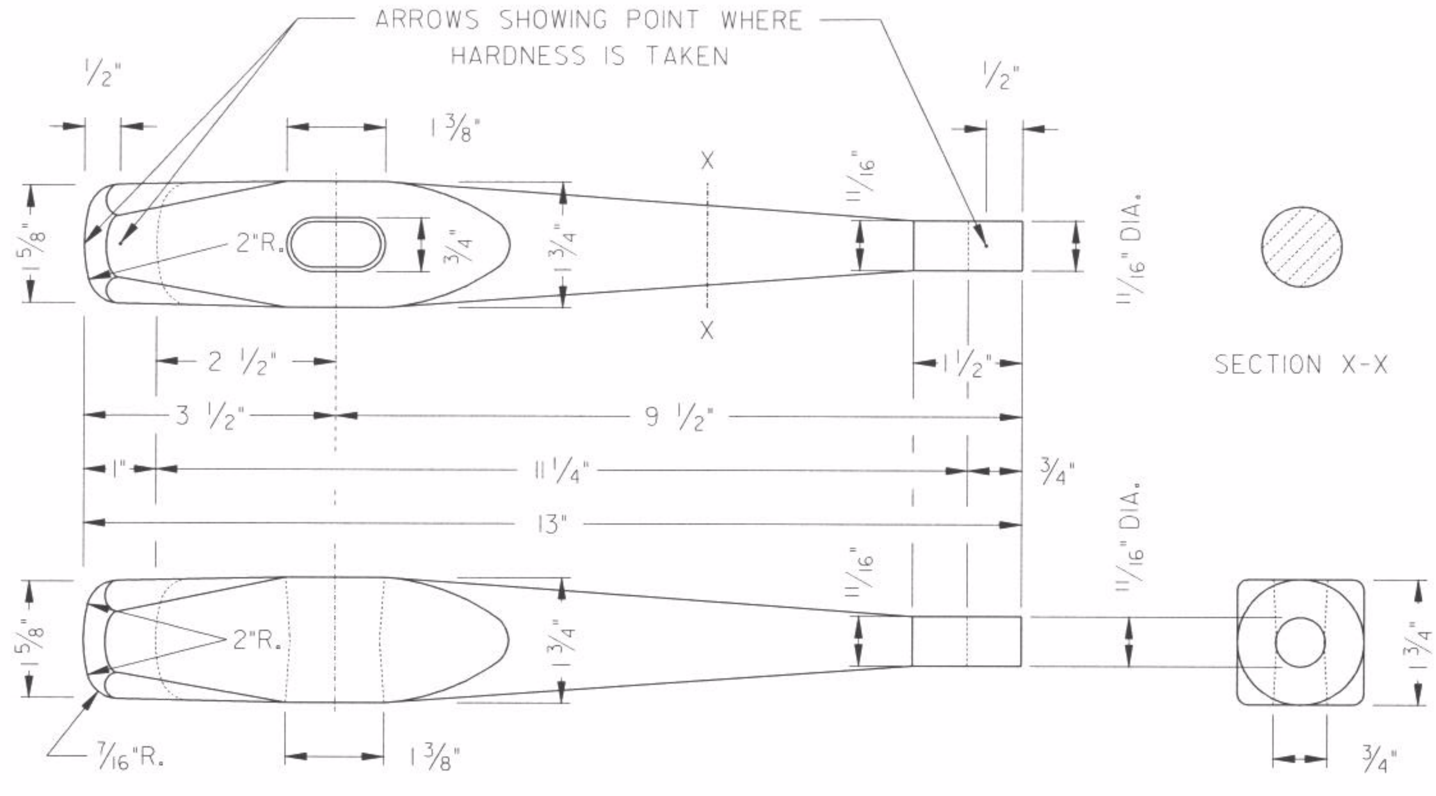


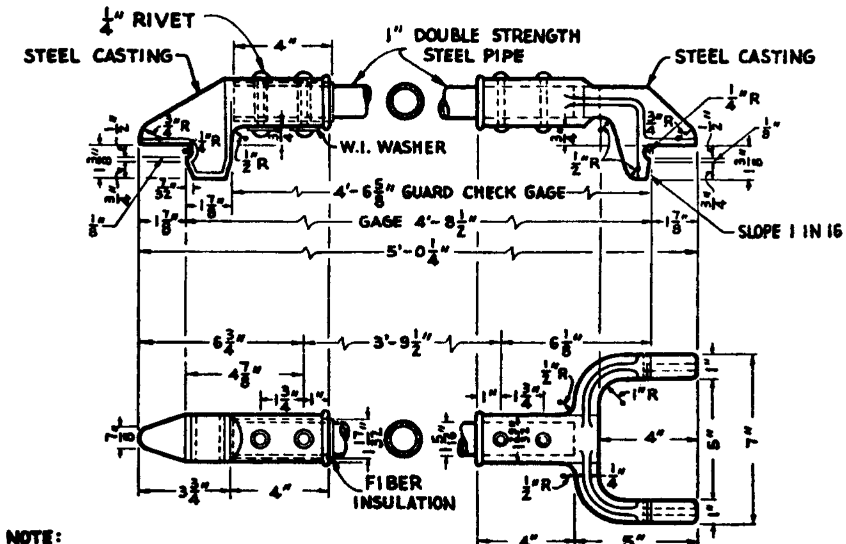
Figure 5-6-18. Plan 17-02 – AREMA Track Chisel



NOTE:

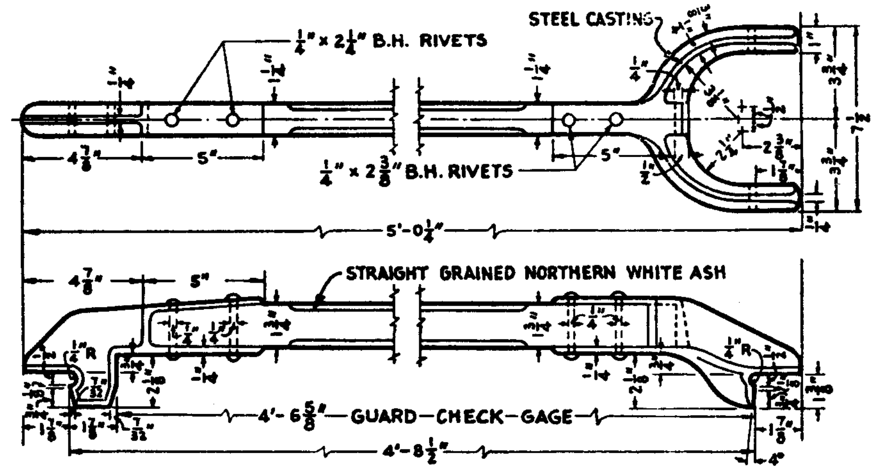
1. TOLERANCE -
   2 % ON LENGTH
   5 % ON CROSS SECTION
2. EYE TAPERED TO CENTER -
   4 DEGREES ON LONG DIAMETER
   3 DEGREES ON SHORT DIAMETER
3. TOOL TO BE FURNISHED IN ALLOY STEEL.
4. ROCKWELL C -
   POINT 52/56
   HEAD 44/48
5. CONTOUR GRIND HEAD PER AREMA PLANS A-00, C-83, AND D-83.
6. DASHED LINES INDICATE OUTLINE (MINIMUM) OF TOOLS AS RECLAIMED.
7. APPROXIMATE WEIGHT 5 1/2 POUNDS.

Figure 5-6-19. Plan 19-02 – AREMA Round Track Punch



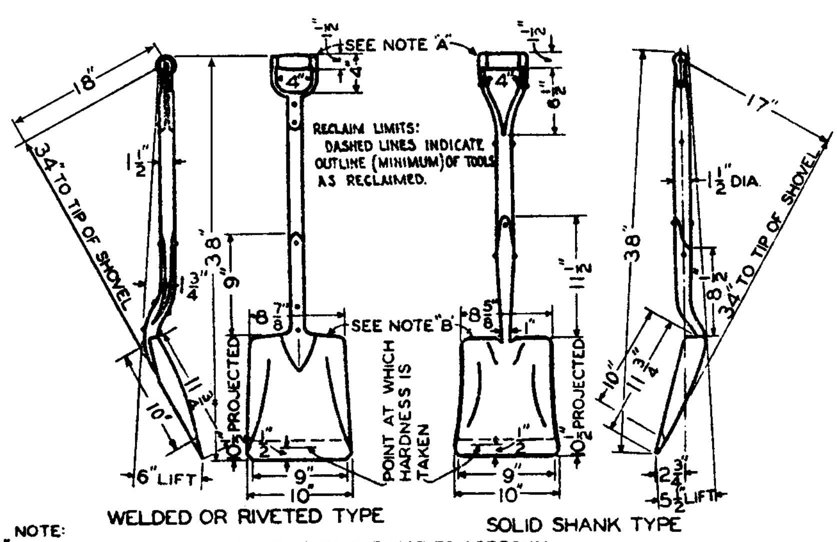
NOTE:
1. CENTER TO BE MARKED ON GAGE WHEN REQUIRED
2. NO TOLERANCE ALLOWED ON GAGE DISTANCE
3. TOLERANCE –
   2% ON LENGTH
   5% ON CROSS SECTION
4. APPROX WT 17 LB

Figure 5-6-20. Plan 20-62 – AREMA Track Gage – Pipe Center



NOTE:
1. CENTER TO BE MARKED ON GAGE WHEN REQUIRED
2. NO TOLERANCE ALLOWED IN GAGE DISTANCE
3. TOLERANCE –
2% ON LENGTH
5% ON CROSS SECTION

Figure 5-6-21. Plan 20A-62 – AREMA Track Gage – Wood Center



NOTE:
"A"- HANDLE TOPS WILL BE FURNISHED SUBJECT TO APPROVAL OF PURCHASER AS SPECIFIED IN SPLIT WOOD "D", MALLEABLE "D" OR COMBINATION STEEL WOOD "D".
"B"- FOOT TREAD ON TOP OF BLADE APPROX. 1/2" WIDE SHALL BE FURNISHED WHEN SPECIFIED.

ROCKWELL 45 - 50

Figure 5-6-22. Plan 21-62 – AREMA Track Shovel

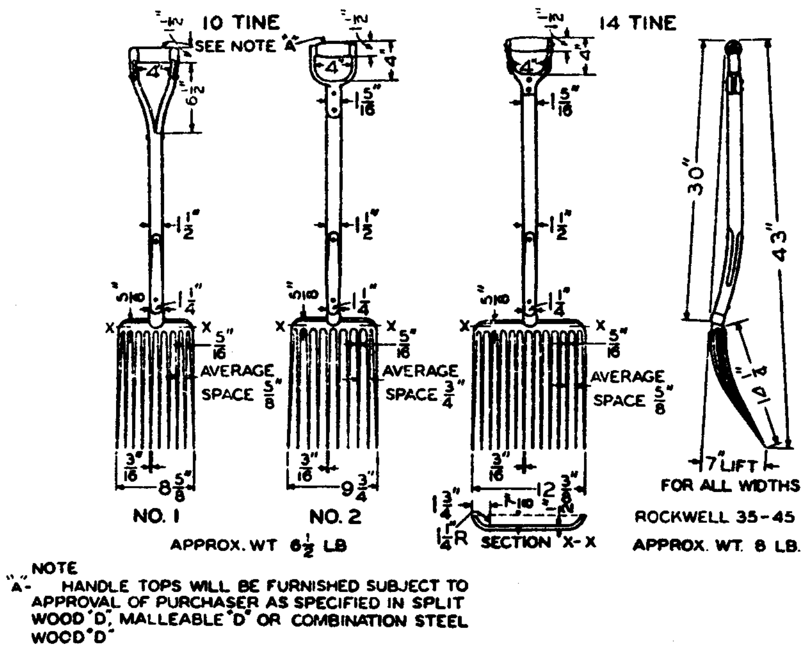


Figure 5-6-23. Plan 22-62 – AREMA Ballast Forks

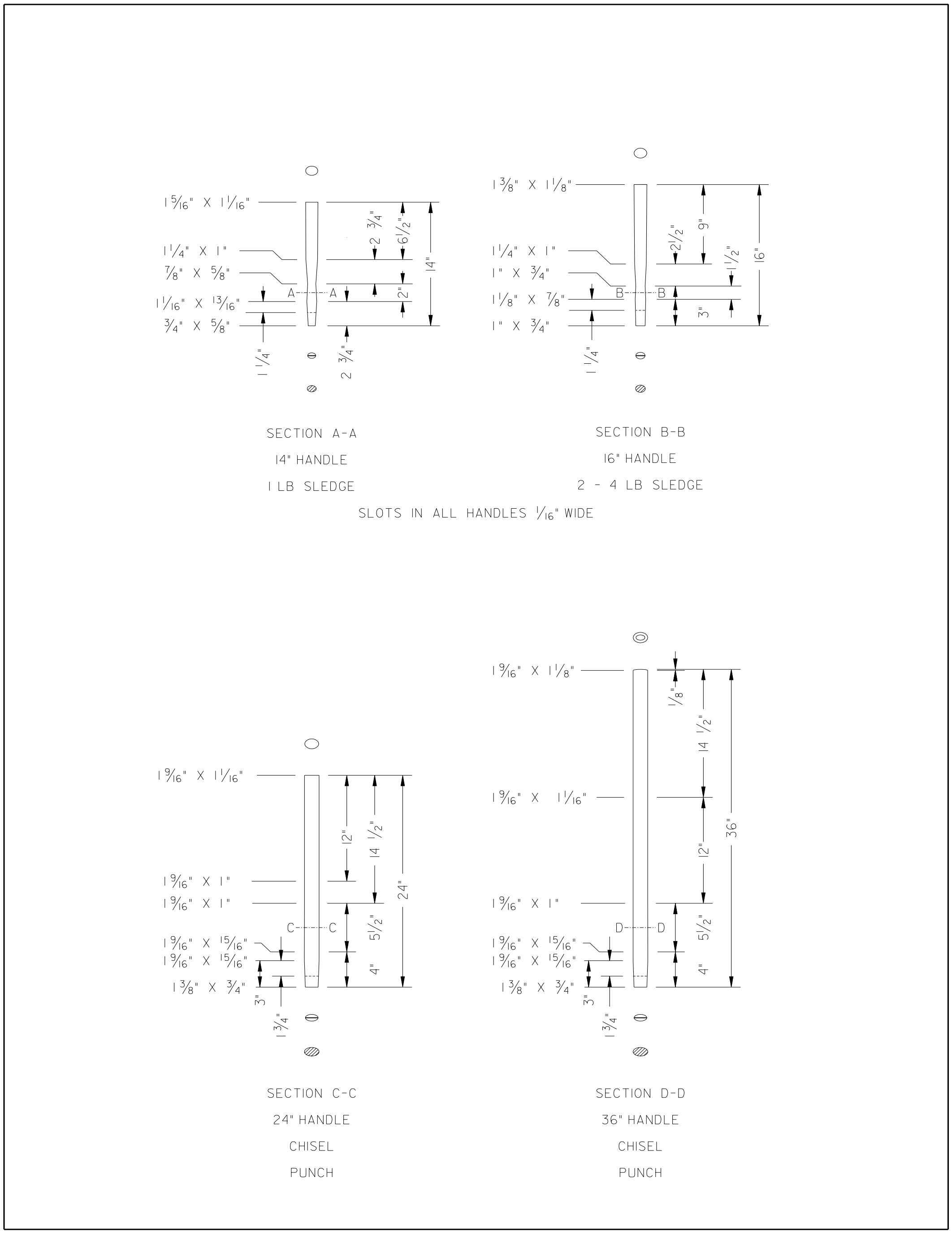


Figure 5-6-24. Plan 25-03 – AREMA Track Tool Handles

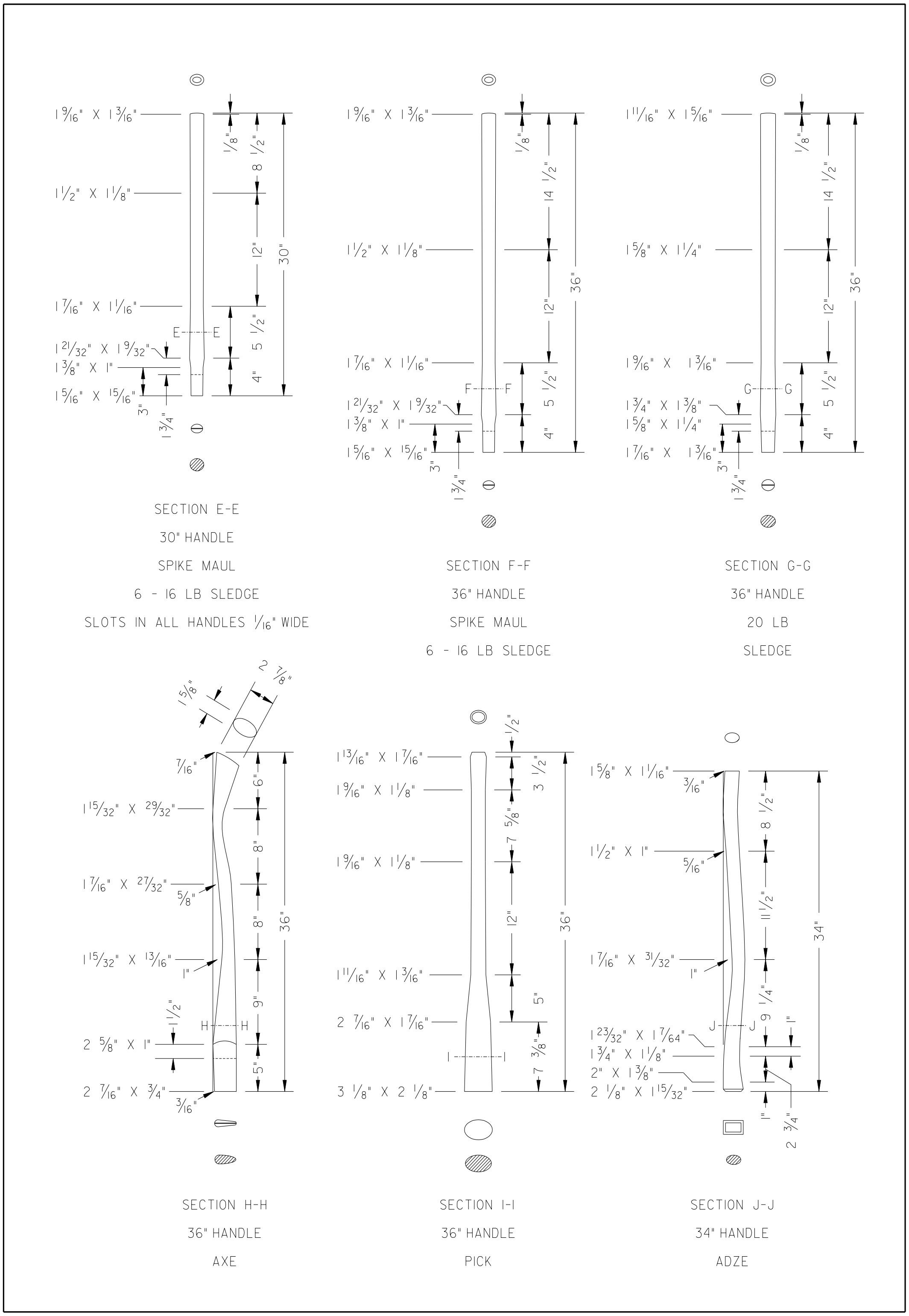


Figure 5-6-24A. Plan 25A-03 – AREMA Track Tool Handles

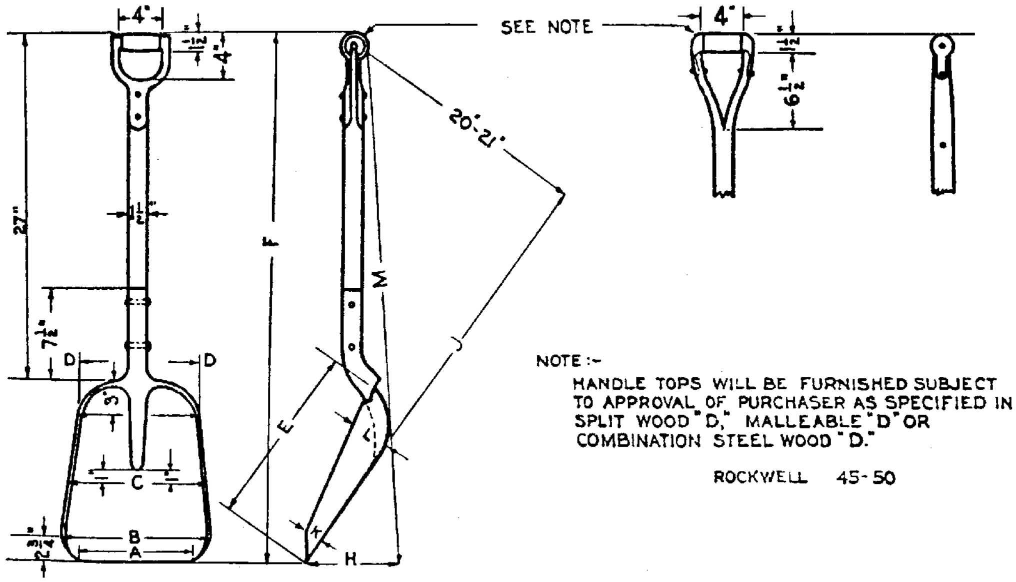


TABLE OF DIMENSIONS - SIZES Nº 2, 4 AND 6.

SIZE	A	B	C	D	E	F	H	J	K	L	M
2	10½"	11¾"	11	9"	15"	40¾"	7"	35"	1⅜"	3⅜"	40¾"
4	11"	12"	11¼"	9¼"	16"	41¾"	7⅜"	36"	1⅝"	3⅝"	41¾"
6	11½"	12¼"	11½"	9½"	17"	42¾"	7⅝"	37"	1⅞"	3⅞"	42¾"

TOLERANCE + OR - ¼"

Figure 5-6-25. Plan 26-62 – AREMA Scoop

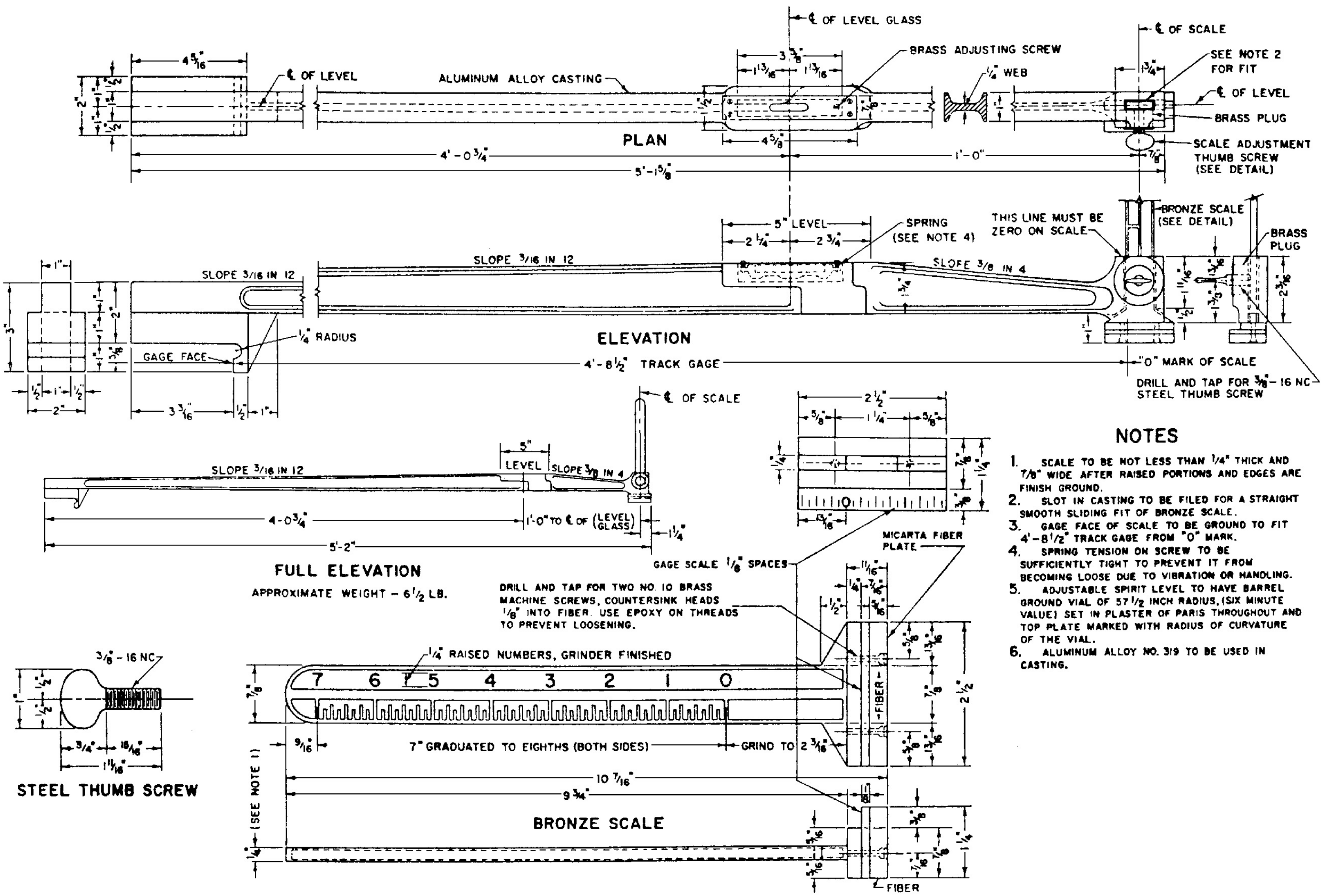


Figure 5-6-26. Plan 27-68 – AREMA Aluminum Combination Track Level and Gage (Insulated)

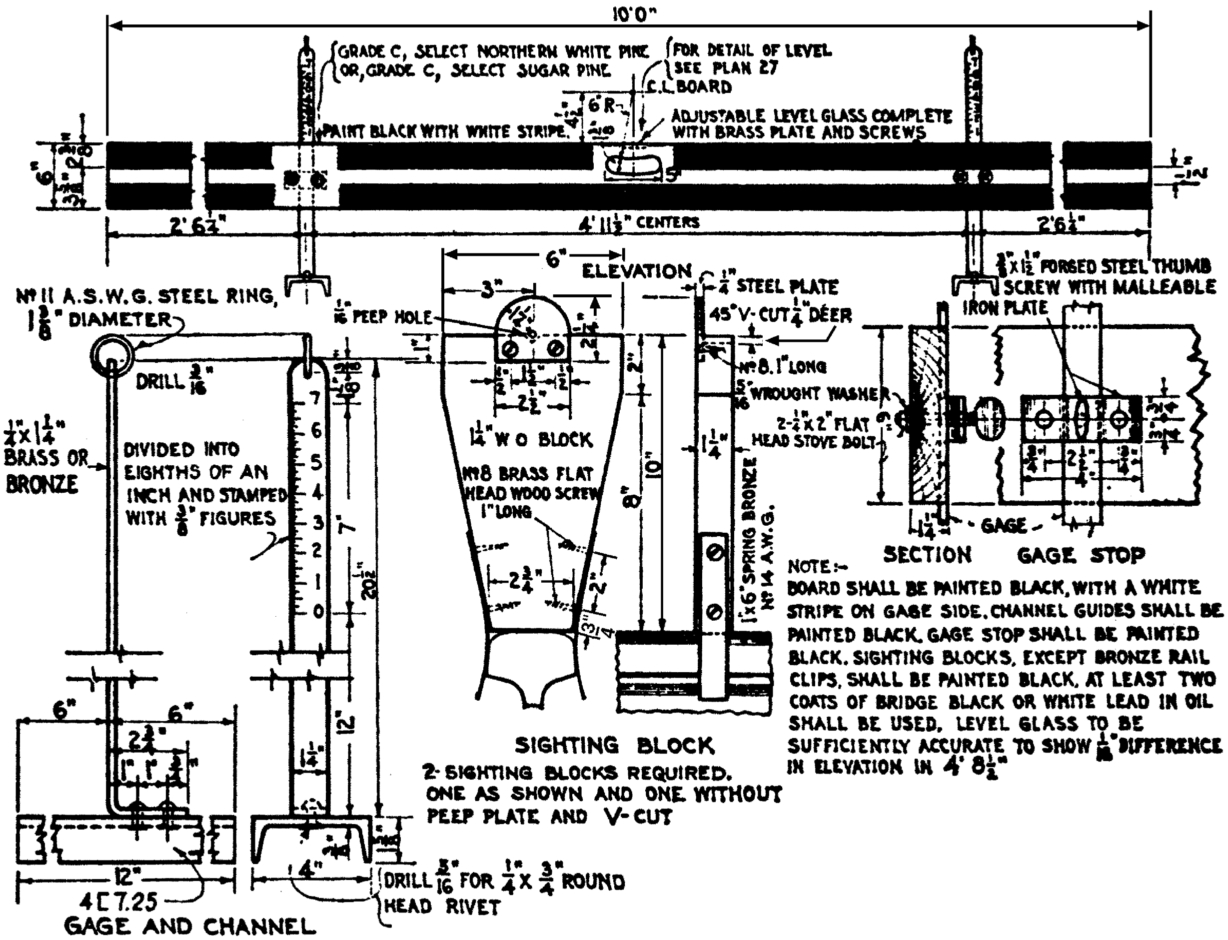
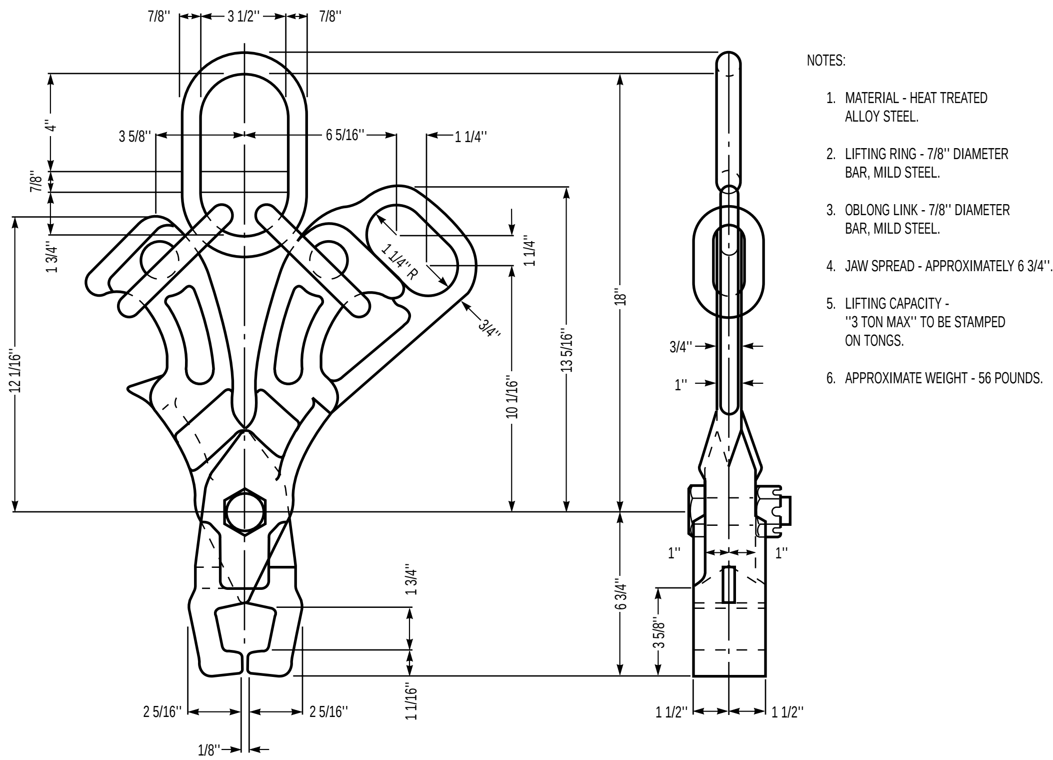
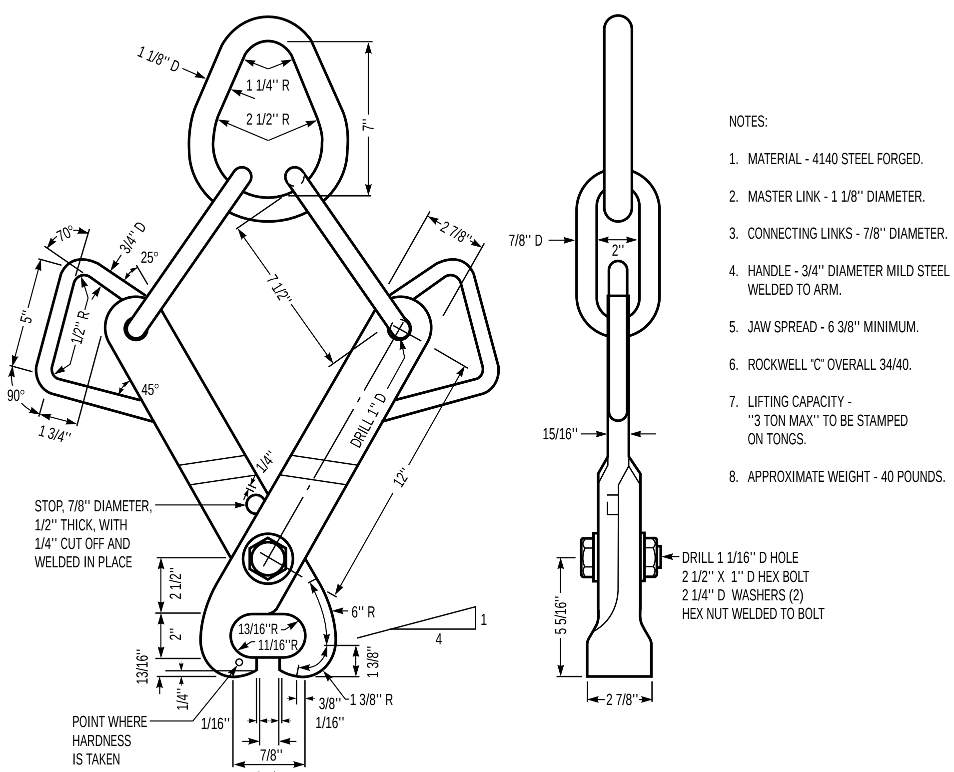


Figure 5-6-27. Plan 30-62 – AREMA Spot Board

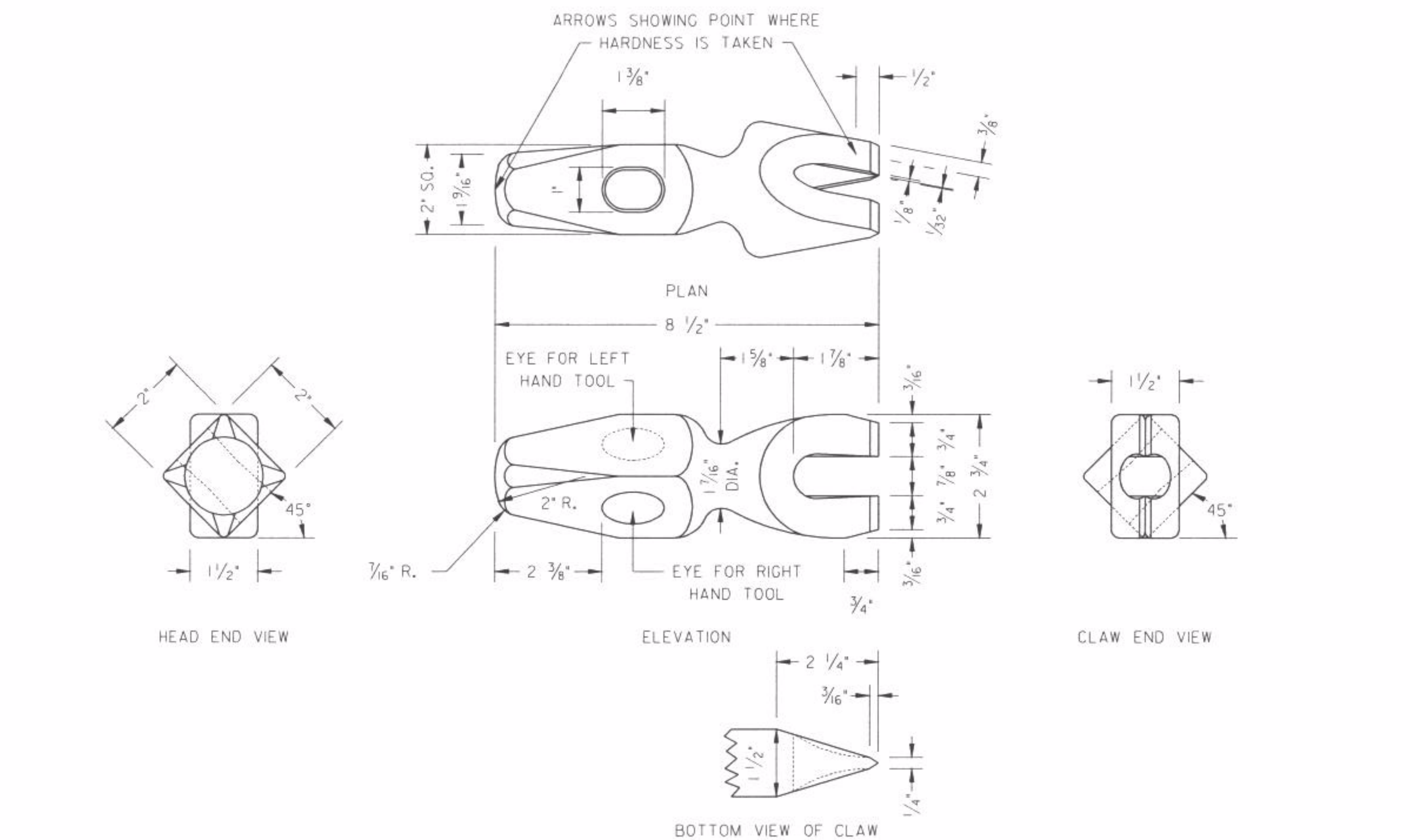


TYPE 1



TYPE 2

Figure 5-6-28. Plan 31-97 – AREMA Rail Tongs for Use with Cranes



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 ALLOY STEEL.
4. ROCKWELL C - CLAW AND HEAD 44/48
5. CONTOUR GRIND HEAD PER AREA PLANS A-03, B-83, AND D-83.
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 5-6-29. Plan 32-03 – AREMA Track Spike Lifter

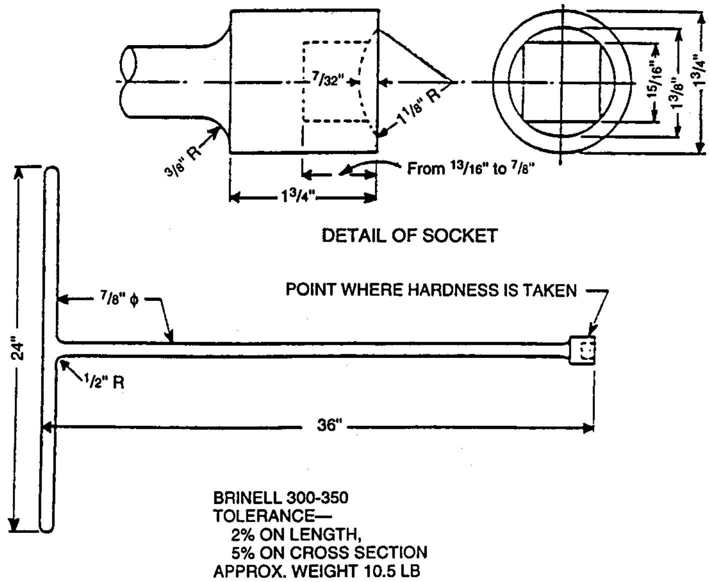
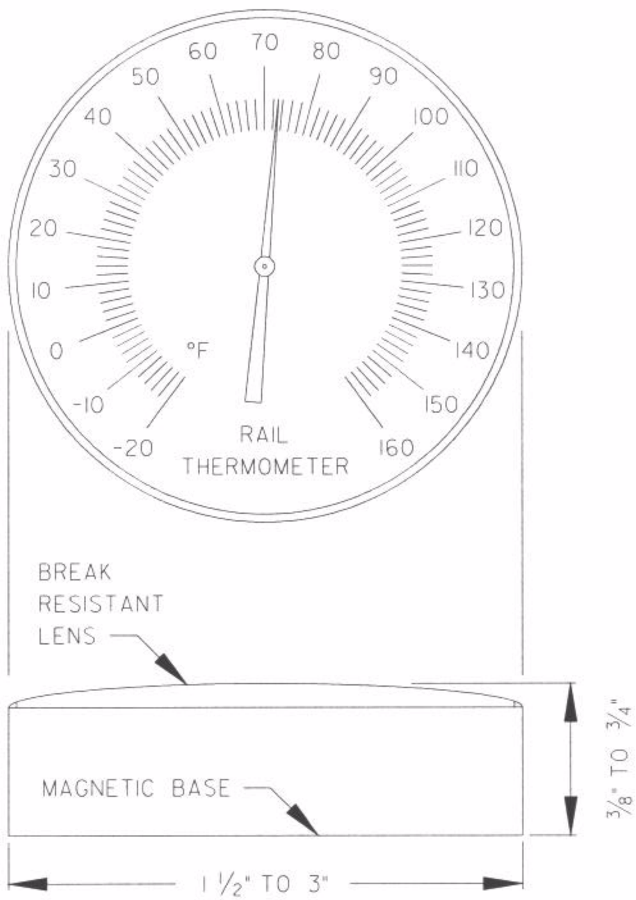


Figure 5-6-30. Plan 33-62 – AREMA Drive Spike Extractor Socket Wrench



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.

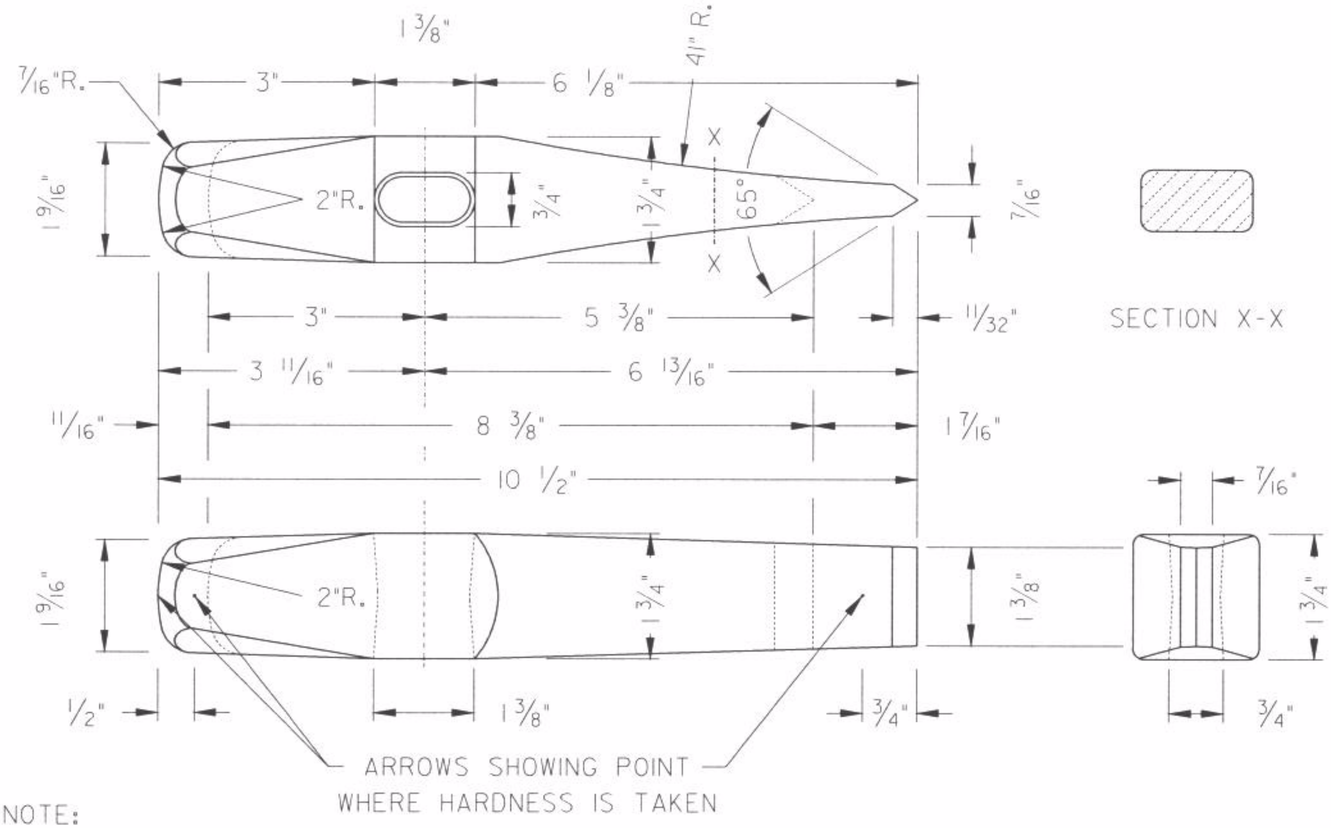
4. THERMOMETER SHALL HAVE A BI-METALLIC SENSING ELEMENT PRE-CONDITIONED AND TESTED FOR PERMANENT CALIBRATION FOR ACCURACY TO WITHIN PLUS OR MINUS OF 2 % OF FULL SCALE RANGE.

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.

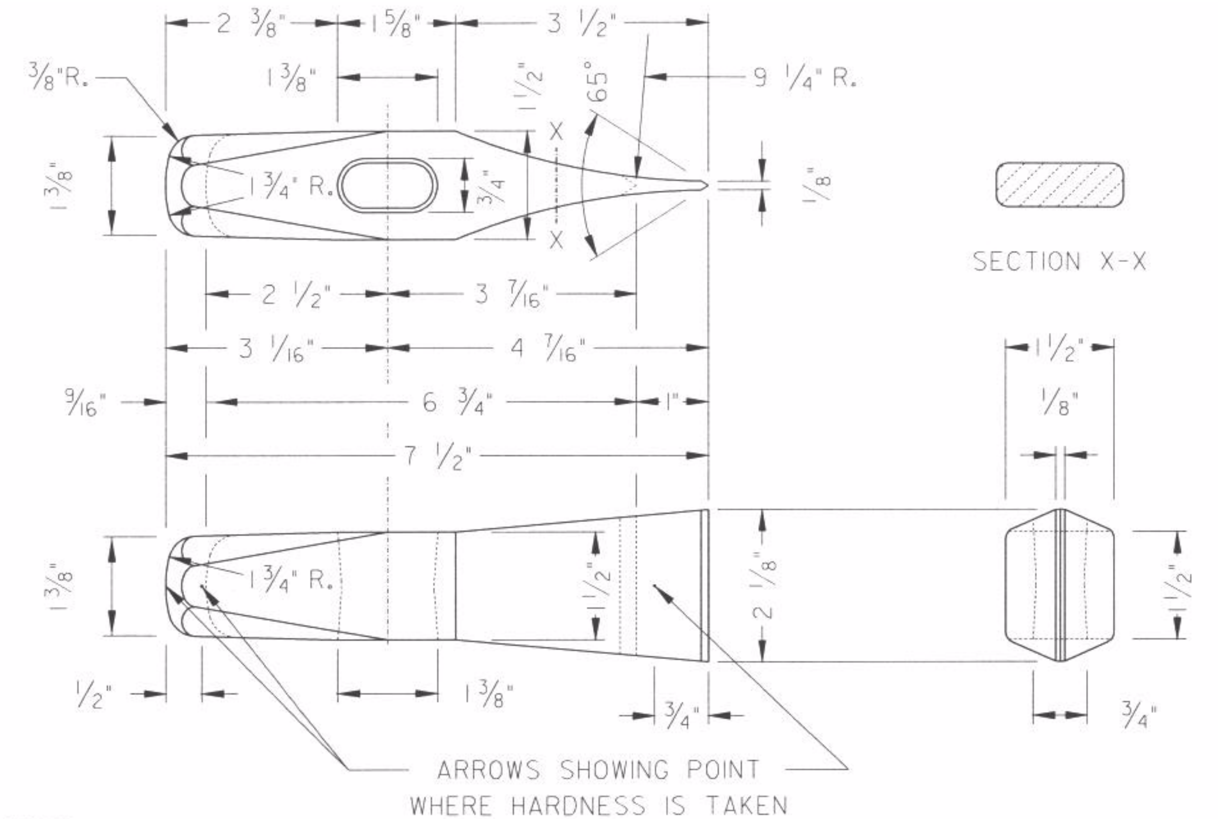
Figure 5-6-31. Plan 34-02 – AREMA Rail Thermometer



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 ALLOY STEEL.
4. ROCKWELL C -
   POINT 56/60
   HEAD 44/48
5. CONTOUR GRIND HEAD PER AREMA PLANS A-00, C-83, AND D-83.
6. DASHED LINES INDICATE OUTLINE (MINIMUM) OF TOOLS AS RECLAIMED.
7. APPROXIMATE WEIGHT 5 1/2 POUNDS.

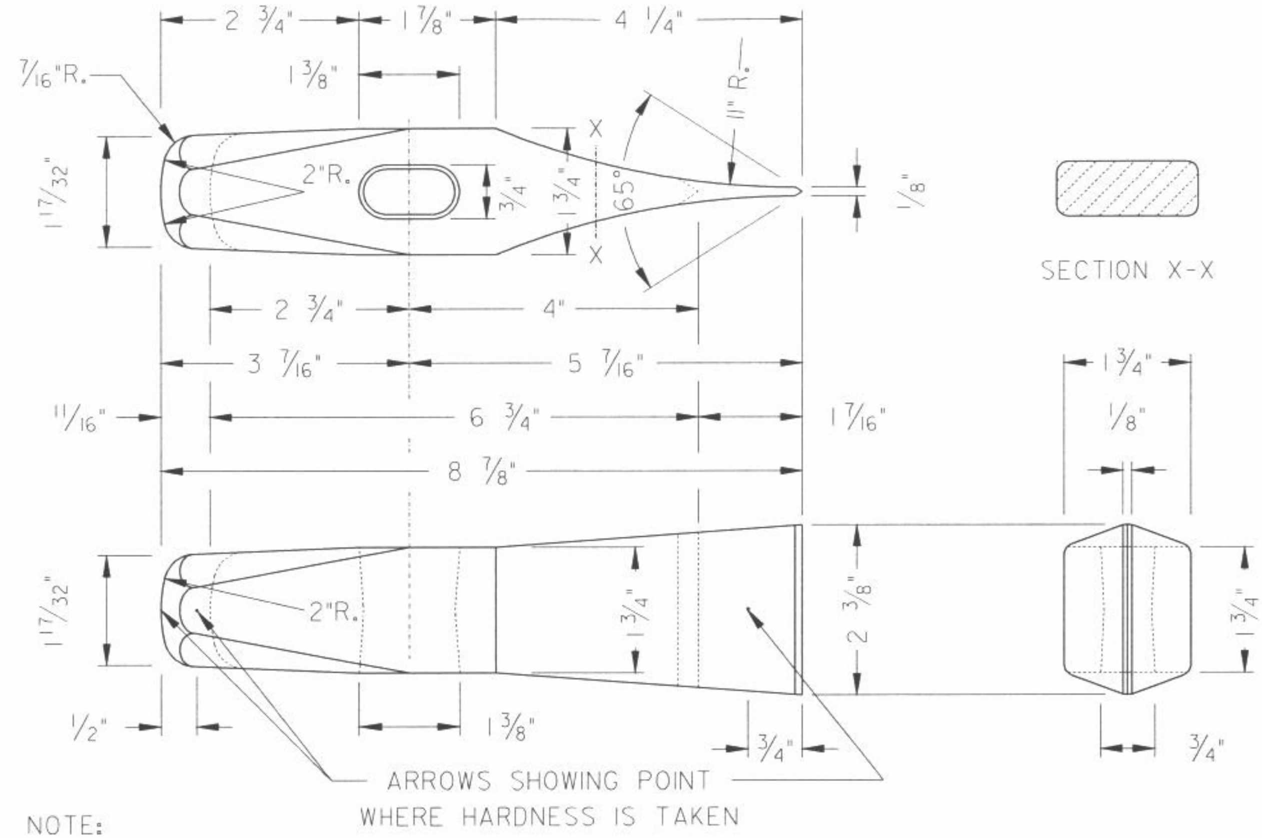
Figure 5-6-32. Plan 35-02 – AREMA Nut Cutter



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. TOOL TO BE FURNISHED IN ALLOY STEEL.
4. ROCKWELL C -
   - POINT 56/60
   - HEAD 44/48
5. CONTOUR GRIND HEAD PER AREMA PLANS A-00, C-83, AND D-83.
6. DASHED LINES INDICATE OUTLINE (MINIMUM) OF TOOLS AS RECLAIMED.
7. APPROXIMATE WEIGHT 3 POUNDS.

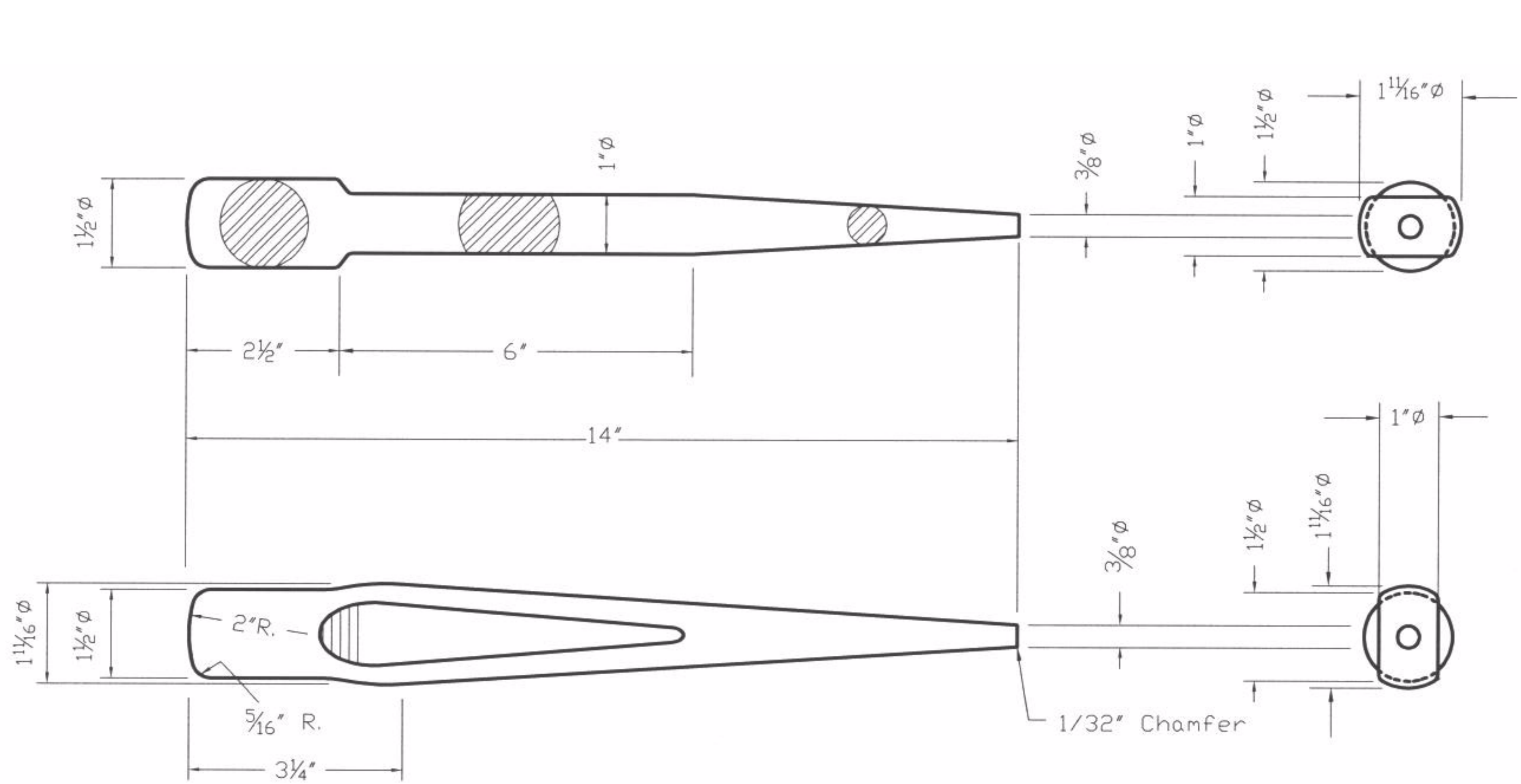
Figure 5-6-33. Plan 36-02 – AREMA 3 Pound Hot Cutter



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. TOOL TO BE FURNISHED IN ALLOY STEEL.
4. ROCKWELL C -
   POINT 56/60
   HEAD 44/48
5. CONTOUR GRIND HEAD PER AREMA PLANS A-00, C-83, AND D-83.
6. DASHED LINES INDICATE OUTLINE (MINIMUM) OF TOOLS AS RECLAIMED.
7. APPROXIMATE WEIGHT 5 POUNDS.

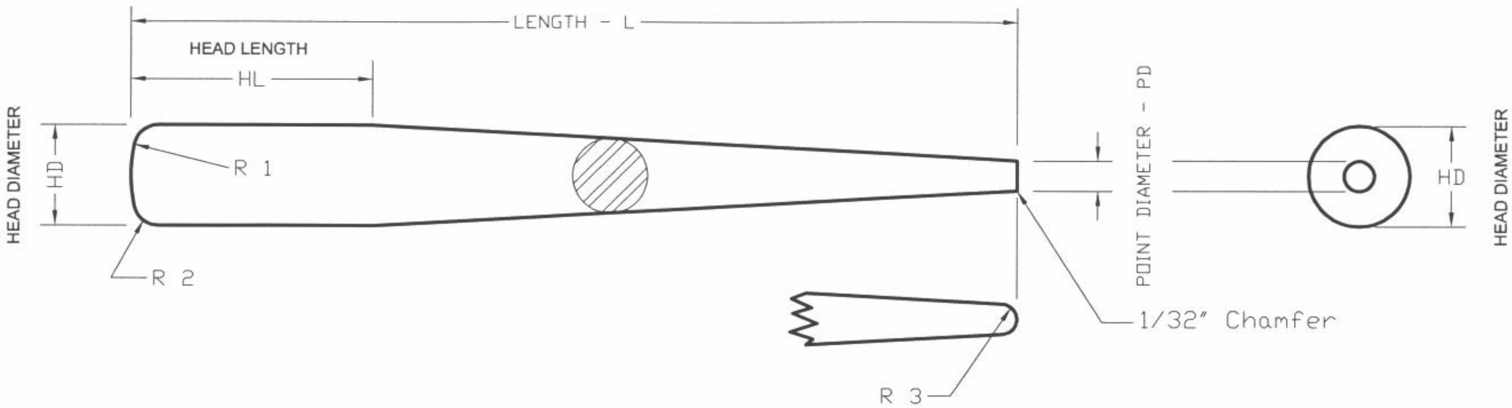
Figure 5-6-34. Plan 37-02 – AREMA 5 Pound Hot Cutter



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 5-6-35. Plan 38-06 – AREMA - Drift Pin (Short)



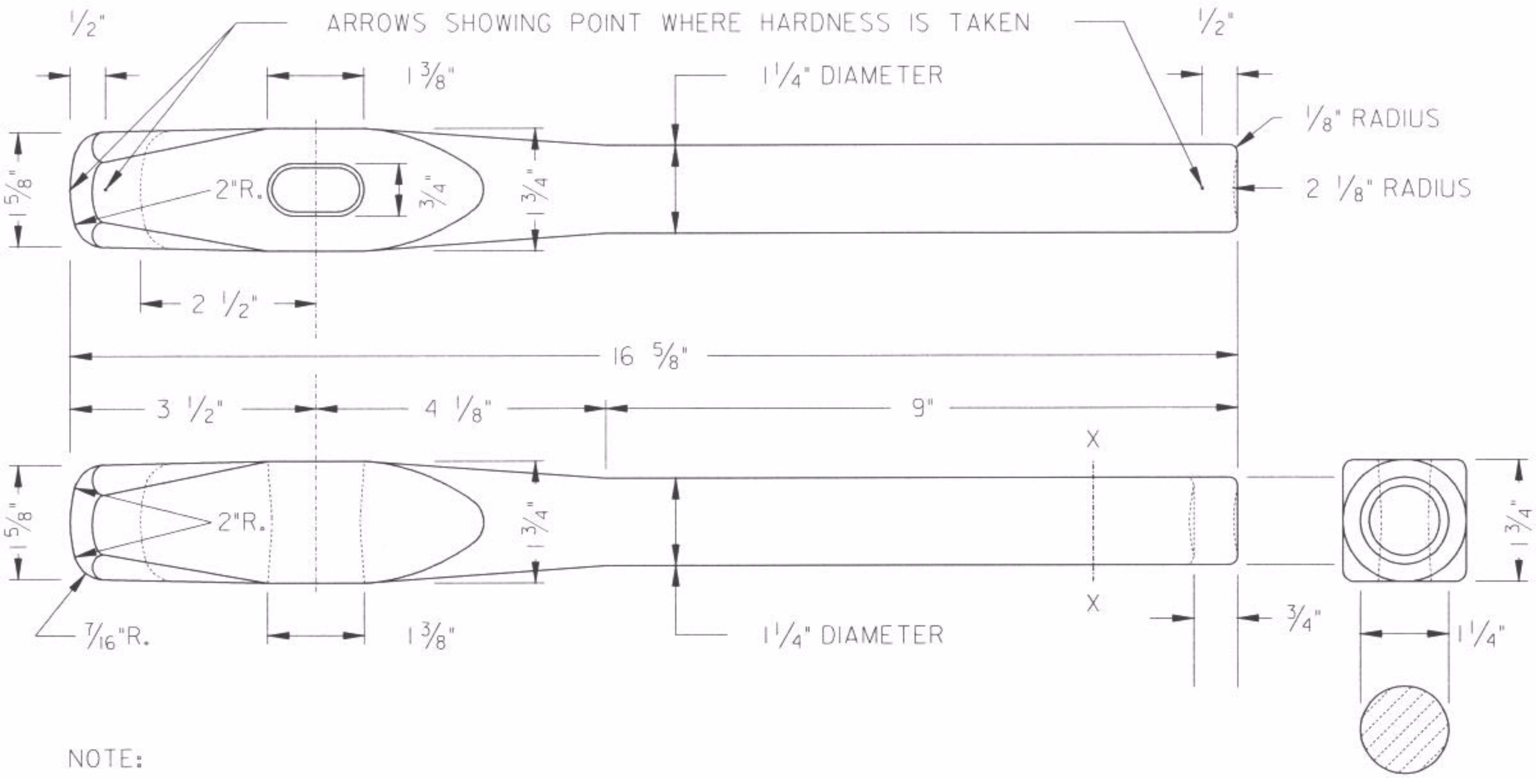
ALTERNATE POINT DETAIL TO BE FURNISHED WHEN A POINT RADIUS IS SPECIFIED IN THE TABLE OF DIMENSIONS.

NOTES:

1. TOLERANCE -
   2 % ON LENGTH
   5 % ON CROSS SECTION
2. TOOL TO BE FURNISHED IN ALLOY STEEL:
   9260 GRADE B OR
   EN30B
3. ROCKWELL C - SEE TABLE
4. CONTOUR GRIND HEAD PER AREA PLANS A - 03, C - 83, AND D - 83.

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"	1¼"	1¾"	5/16"	3/8"	NONE	32/37
19"	3"	1½"	2"	5/16"	3/8"	3/8"	32/37
26"	2"	1½"	2"	5/16"	7/8"	NONE	32/37
26"	2"	2"	2"	5/16"	7/8"	NONE	32/37

Figure 5-6-36. Plan 39-06 – AREMA - Drift Pins (Long)

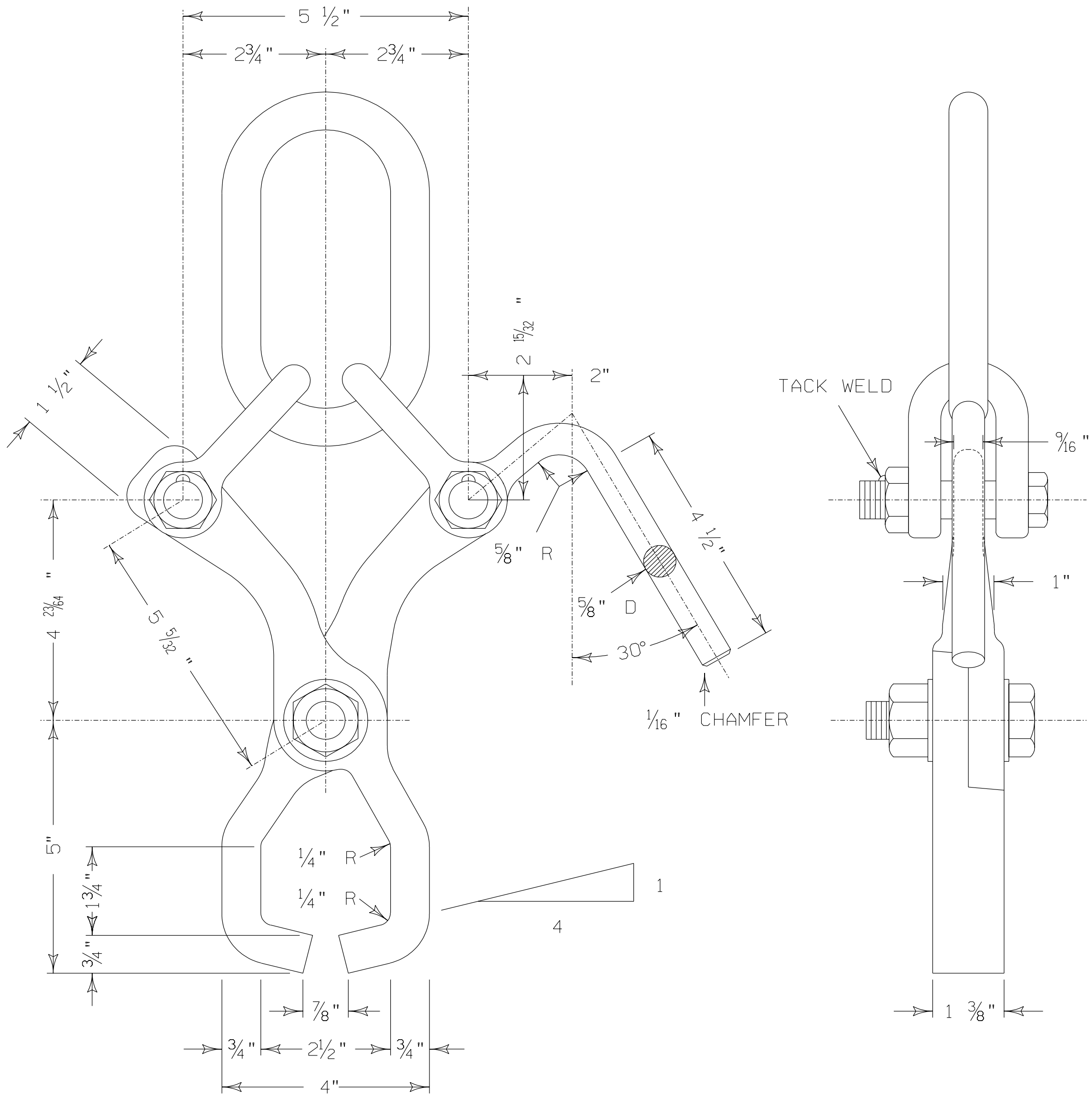


SECTION X-X

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 ALLOY STEEL.
4. ROCKWELL C -
   POINT 52/56
   HEAD 44/48
5. CONTOUR GRIND HEAD PER AREMA PLANS A-00, C-83, AND D-83.
6. DASHED LINES INDICATE OUTLINE (MINIMUM) OF TOOLS AS RECLAIMED.
7. APPROXIMATE WEIGHT 6 POUNDS.

Figure 5-6-37. Plan 41-02 – AREMA Spiking Tool

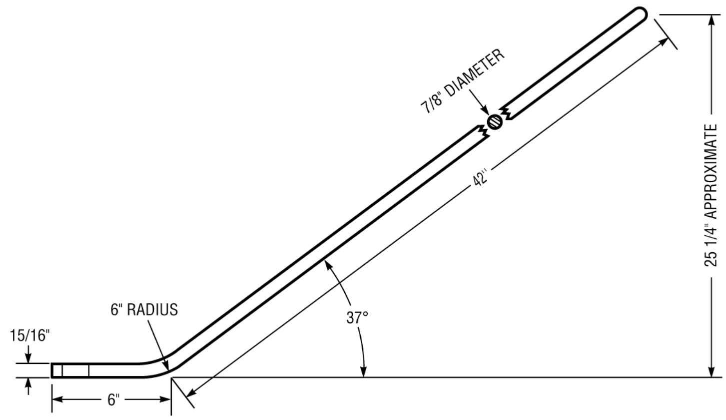


NOTES:

1. MATERIAL - FORGED C1060 STEEL.
2. WELDLESS MASTER LINK - ¾" ROUND WITH 2 ½" X 5 ½" INSIDE DIMENSIONS WITH 3 TON MINIMUM WORKING LOAD LIMIT.
3. CONNECTING LINKS - ½" MINIMUM BOLT TYPE SHACKLES WITH NUT TACK WELDED TO BOLT WITH 2 TON MINIMUM WORKING LOAD LIMIT.
4. ASSEMBLY BOLT - ¾" X 2 ¾" GRADE 5 WITH TWO FLAT WASHERS AND LOCK NUT.
5. JAW SPREAD - 6" MINIMUM
6. TOLERANCE - 2% ON LENGTH 5 % ON CROSS SECTION
7. LIFTING CAPACITY - "3 TON MAX" TO BE STAMPED ON TONGS.
8. CONNECTING LINK HOLES TO HAVE ⅛" X 45° CHAMFERS.
9. APPROXIMATE WEIGHT - 13 POUNDS.

Figure 5-6-38. 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.



SWITCH ROD THICKNESS	BOLT SIZE	WIDTH OF NUT	A	
			MINIMUM	MAXIMUM
1"	1"	1 5/8"	1.634"	1.709"
1 1/4"	1 1/8"	1 13/16"	1.822"	1.898"

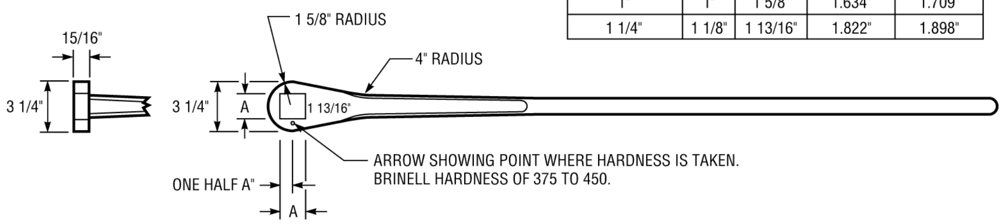
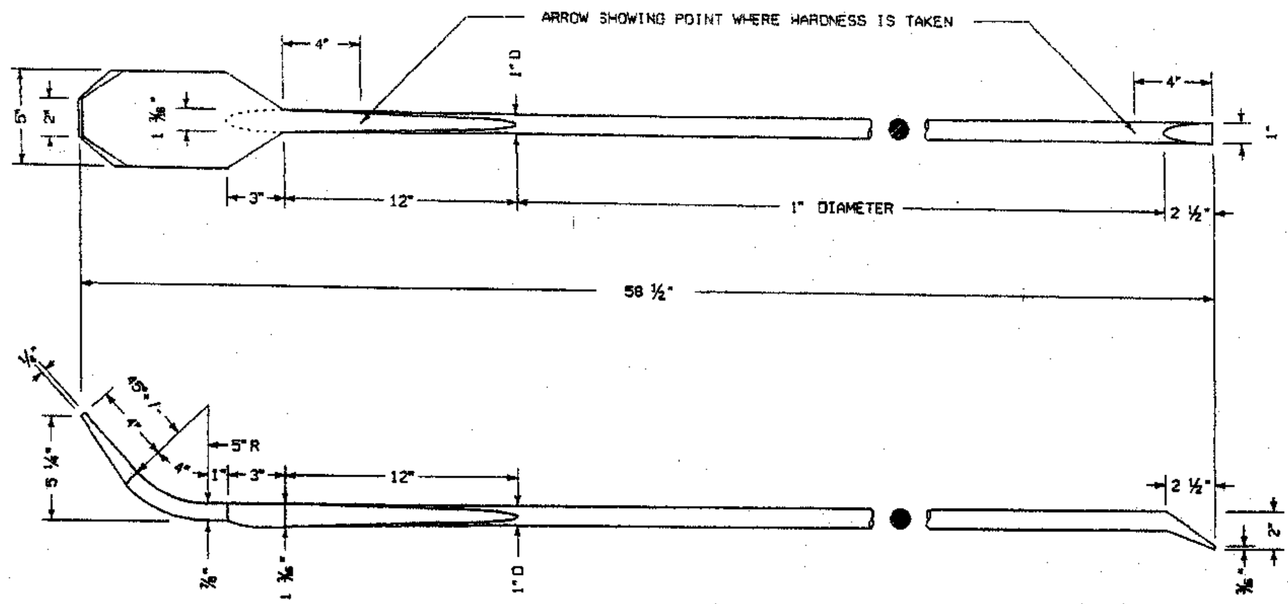


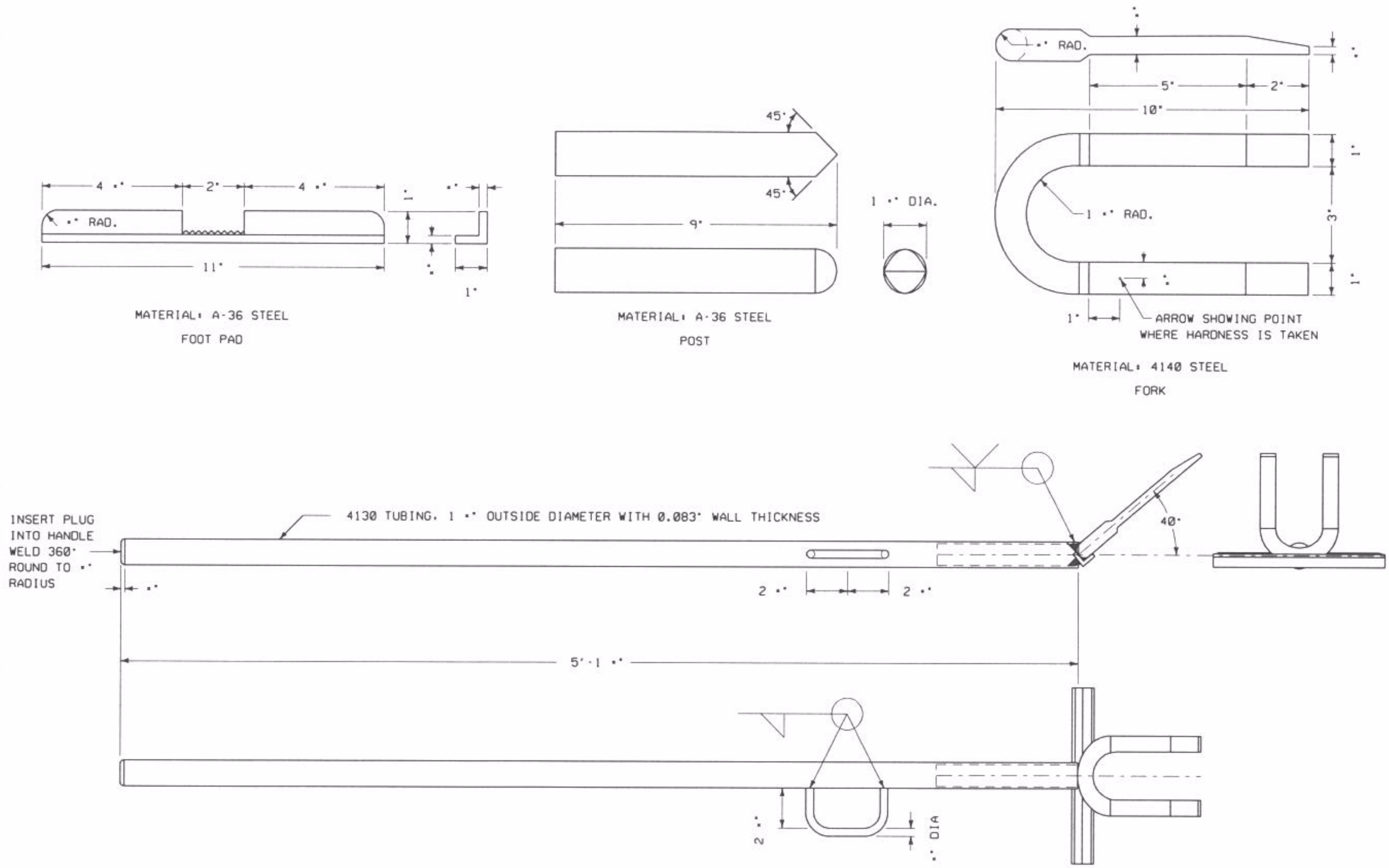
Figure 5-6-39. Plan 43-97 – AREMA Switch Clip Wrench



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

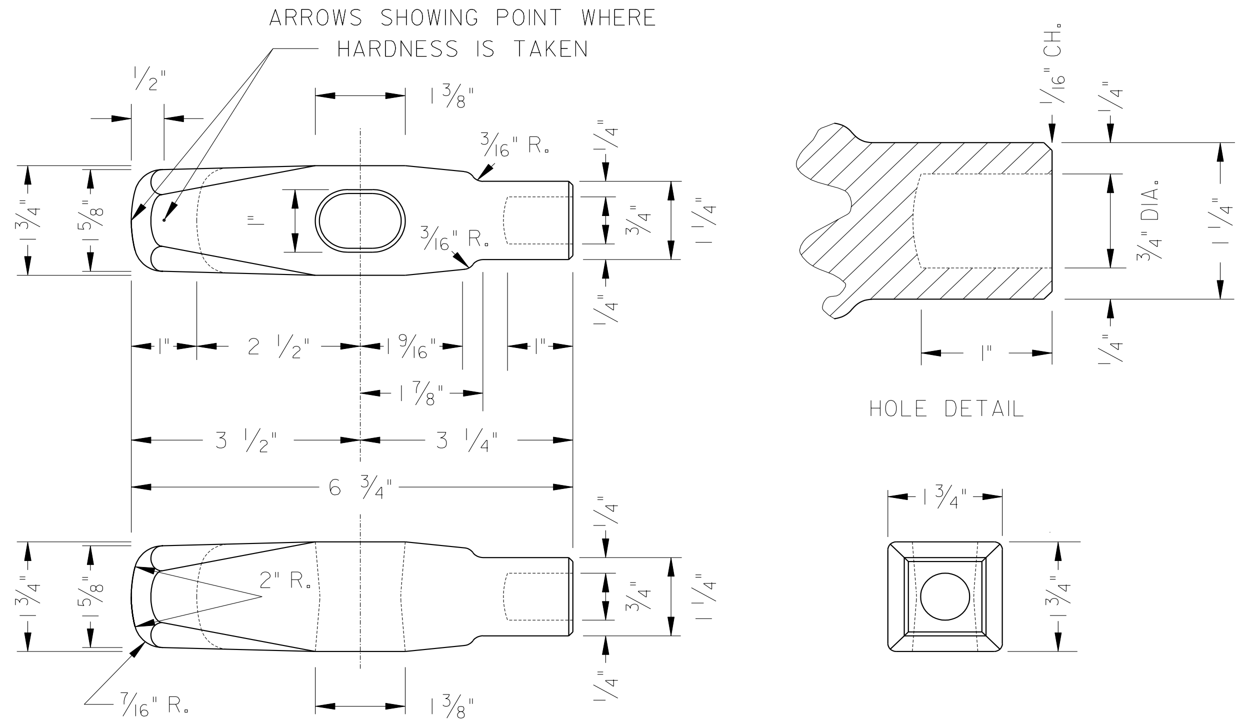
Figure 5-6-40. Plan 44-97 – AREMA Nipping Bar



NOTES:

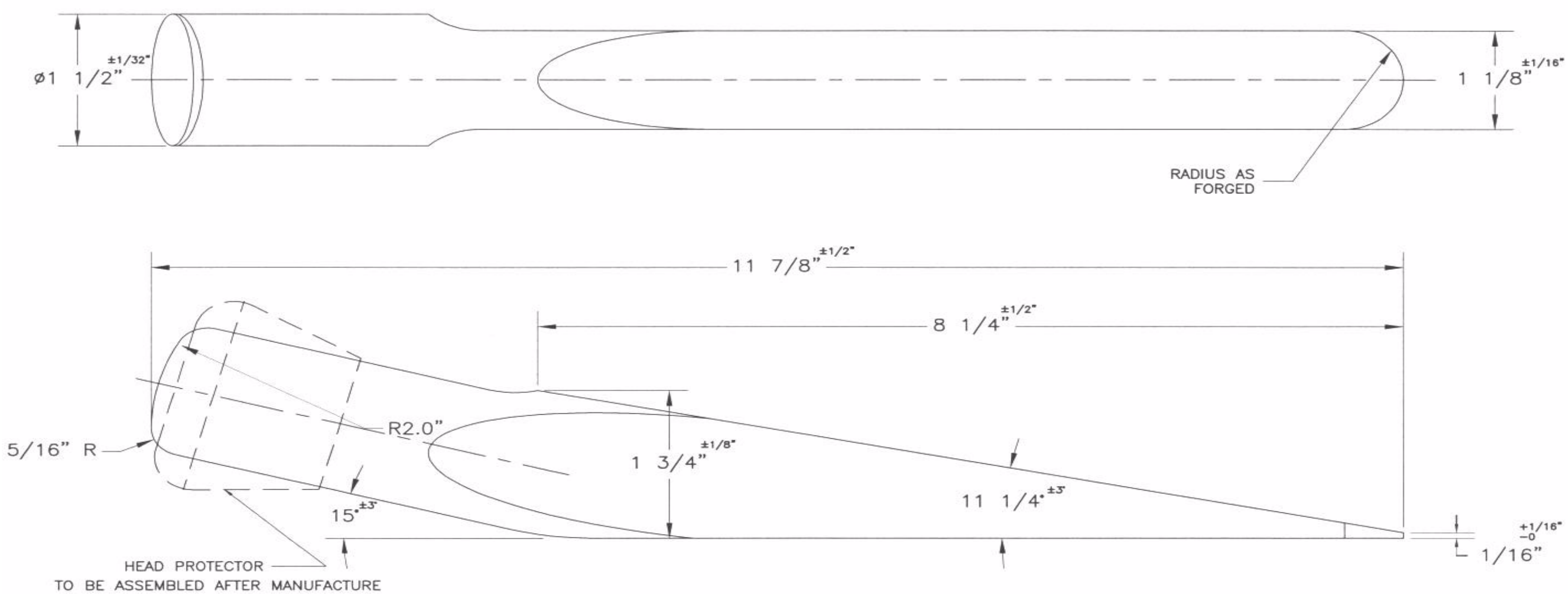
1. FURNISH IN MATERIAL SHOWN ON DRAWING.
2. TOLERANCE: 2 % ON LENGTH.
   5 % ON CROSS SECTION.
3. HARDNESS: BRINELL 330 - 400.
   NORMALIZE FORK BEFORE HARDENING.
4. FURNACE STRESS RELIEVE ALL WELDS EXCEPT HANDLE PLUG.
5. EXCLUDING HANDLE PLUG, INSPECT ALL WELDS FOR SURFACE CRACKS USING A METHOD SPECIFIED IN CHAPTER 5, PART 6, ARTICLE 6.1.2.6.
6. APPROXIMATE WEIGHT: 16 POUNDS.

Figure 5-6-41. Plan 45-98 - AREMA Nipping Fork



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 ALLOY STEEL.
4. ROCKWELL C - HEAD 44/48
5. CONTOUR GRIND HEAD PER AREMA PLANS A-03, B-83, AND D-83.
6. DASHED LINE ON HEAD INDICATES OUTLINE (MINIMUM) OF TOOLS AS RECLAIMED.
7. APPROXIMATE WEIGHT 5 POUNDS.

Figure 5-6-42. Plan 46-03 - AREMA Drift Pin Remover



NOTE:
1. TOLERANCE AS SHOWN
2. THIS DESIGN FURNISHED IN ALLOY STEEL
3. ROCKWELL "C" OVERALL 44/48
4. CONTOUR GROUND HEAD (Plan A-03)
5. APPROXIMATE WEIGHT 4-1/2 POUNDS

Figure 5-6-43. Plan 47-06 - AREMA Offset Wedge

6.5.2 HAND TOOL CONTOUR DIMENSIONS (2004)

For the hand tool contour dimensions refer to Table 5-6-16.

Table 5-6-16. Plan A-03 – AREMA Hand Tool Contour Dimensions

Type of Tool	Plan Number	Tool Size	Stock Diameter of Head (See Note 1) In inches	Radius of Crown on Face In inches	Corner Radius In inches	Dimensions Indentation In inches	Also See Plan Numbers
			D	R	r	C	
Spike Maul	3-02	–	1¼	7	¼	–	B-83 and D-83
		–	1⅝	7	¼	–	
Double Faced Sledge	13-02	1 lb	1¼	7	¼	–	B-83 and D-83
		2 lb	1⅜	7	¼	–	
		2½ lb	1½	7	¼	–	
		3 lb	1⅝	7	¼	–	
		4 lb	1¾	7	⅜	–	
		6 lb	2 1/8	7	⅜	–	
		8 lb	2¼	7	7/16	–	
		10 lb	2½	7	7/16	–	
		12 lb	2⅝	7	7/16	–	
		16 lb	2 7/8	7	½	–	
		20 lb	3 1/8	7	½	–	
Track Chisel	17-02	–	1 9/16	2	7/16	7/32	C-83 and D-83
Round Track Punch	19-02	–	1⅝	2	7/16	7/32	C-83 and D-83
Track Spike Lifter	32-03	–	1 9/16	2	7/16	7/32	C-83 and D-83
Nut Cutter	35-02	–	1 9/16	2	7/16	7/32	C-83 and D-83
Hot Cutter	36-02	3 lb	1⅜	1¾	⅜	3/16	C-83 and D-83
Hot Cutter	37-02	5 lb	1 17/32	2	7/16	7/32	C-83 and D-83
Drift Pin - Short	38-06	14"	1½	2	5/16	5/16	C-83 and D-83
Drift Pin - Long	39-06	18"	1¼	1¾	5/16	5/16	C-83 and D-83
		19"	1½	2	5/16	5/16	
		26"	1½	2	5/16	5/16	
		26"	2	2	5/16	5/16	
Square Flatter	40-83	–	1 5/16	1¾	⅜	3/16	C-83 and D-83
Spiking Tool	41-02	–	1⅝	2	7/16	7/32	C-83 and D-83

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 5-6-44 when establishing the tool contact face contour according to the following steps:

a. Draw tool head centerline C/L.

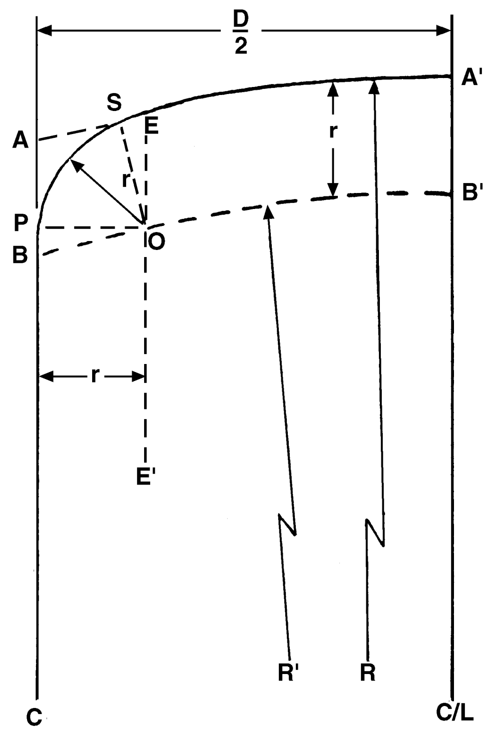
b. Draw line AC, representing the side of the tool head. Except in tapered tools, this line is parallel to C/L at a distance of D/2. D is the stock diameter of the tool or with hexagons and octagons the distance across the flats.

c. Draw arc AA' with a radius of R.

d. Draw line EE' parallel to line AC at a distance (r) equal to the corner radius to be used.

e. 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.

f. 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.



D = Stock Diameter or with hexagons and octagons the distance across the flats

R = Crown Radius

r = Corner Radius

R' = Crown Radius–Corner Radius

Figure 5-6-44. Plan B-83 – AREMA Contour of Hand Tool Striking Faces

6.5.4 METHOD FOR ESTABLISHING THE CORNER CONTOUR OF HAND TOOL STRUCK FACES (¾ INCH STOCK AND OVER) (1984)

Refer to Figure 5-6-45 when establishing the tool contact face contour according to the following steps:

a. Draw tool head centerline C/L.

b. 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.

c. Draw line aa' perpendicular to C/L.

d. Draw line ab' at a 45 degree angle from line aa.

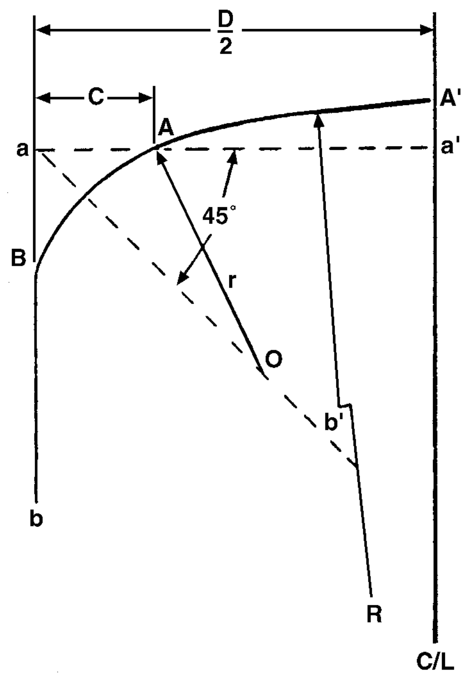
e. On line aa', locate point A, which is the distance C (Corner indentation shown in Table 5-6-16) from point a.

f. From point A, locate point O on line ab by scribing an arc of radius r (the corner radius).

g. From point O scribe the corner arc BA with radius (r).

h. 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.

i. 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 5-6-45. Plan C-83 – AREMA Contour of Hand Tool Struck Faces

6.5.5 CONTOUR BLENDING OF CORNERS (1984)

Refer to Figure 5-6-46 for the contour blending of corners.

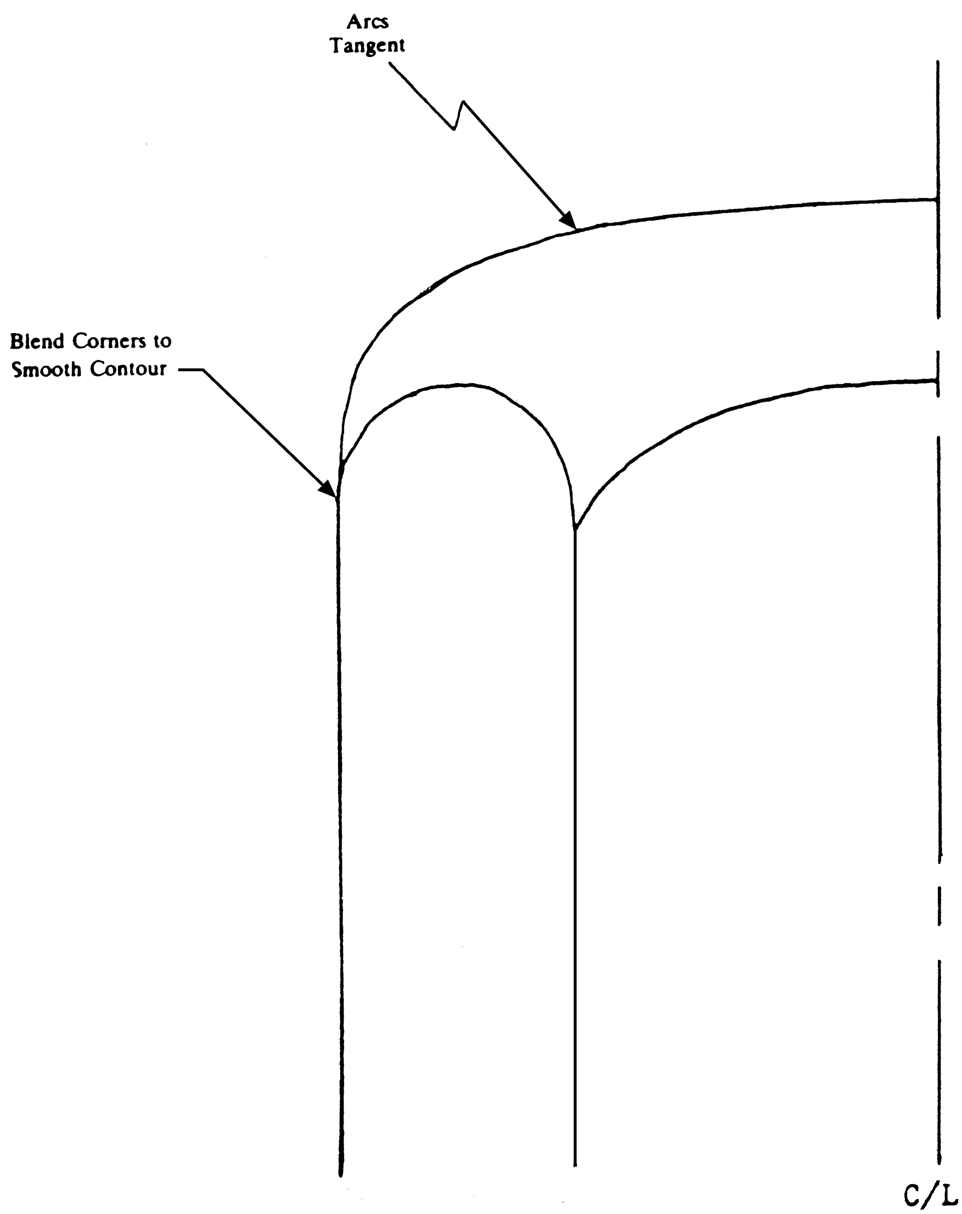


Figure 5-6-46. Plan D-83 – AREMA Contour Blending of Corners

SECTION 6.6 RECOMMENDED PRACTICES FOR USING, REDRESSING, SHARPENING AND REPLACING HANDLES IN TRACK TOOLS[1] (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 5-6-14 and Table 5-6-15 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.

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[1] References, Vol. 94, (1994), p. 83.

- Striking surfaces: Rockwell C hardness 51 to 55.
- Cutting surfaces: Rockwell C hardness 56 to 60.
- Punch ends: Rockwell C hardness 52 to 56.
- Drift pins: Rockwell C hardness 44 to 48 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) 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). 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 ¾ 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

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American Railway Engineering and Maintenance-of-Way Association

Part 7

Rail Anchors[1]

— 1990 —

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

SECTION 7.1 SPECIFICATIONS FOR RAIL ANCHORS[1] (1990)

7.1.1 SCOPE (1990)

These specifications define the 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 specification, remanufactured anchors are defined as used drive-on or spring-type anchors which have been reformed to restore performance to the requirements described herein, except where specifically noted.)

7.1.2 FUNCTION (1990)

Rail anchors transmit static and dynamic longitudinal forces in the rail to the cross tie. A sufficient number of anchors are required to hold the rail in a fixed position.

7.1.3 DESIGN (1990)

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 by the following slip test.

7.1.4 BEARING AREA (1990)

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.

7.1.5 SLIP TEST (1990)

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. 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 AREMA dimensional specification without any variation in the width and thickness of the base.

   NOTE: Some purchasers require that the load be applied to the end of the rail in increments varying from 500 to 1,000 pounds and held for 5 to 10 seconds to enhance uniformity of testing.

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

[1] Revised 1990.

dial gage. 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 5,000 pounds where it shall be held for three minutes before measuring slippage, which shall not exceed a total of 1⁄16 inch; the 5,000-pound load shall be held for an additional three minutes during which time there shall be no further slippage.

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, *or as required by the purchaser*, during production to insure that the rail anchors meet the above criteria.

7.1.6 FRACTURE TEST (1990)

a. New 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 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.

7.1.7 RETESTS AND REJECTION (1990)

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 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, all of the anchors from the lot from which the samples were taken 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.

7.1.8 DIMENSIONS (1990)

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 reject all nonconforming anchors. 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 specification. The remanufacturer shall not be held responsible for the dimensional configuration or tolerances as related to original anchor design.

7.1.9 WORKMANSHIP (1990)

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.

7.1.10 IDENTIFICATION (1990)

Each new rail anchor shall be hot-stamped to show the rail section and year of manufacture. 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.

7.1.11 BAGGING (1990)

Unless otherwise specified all new or remanufactured anchors shall be bagged fifty (50) acceptable anchors per bag for shipment or storage. All anchors within each bag shall be for the same rail size and shall be of the same type of anchor. All correctly filled anchor bags shall have the open end of the bag closed completely and securely bound in such a manner as to insure that the bound end will not reopen during handling and shipping.

7.1.12 TAGGING (1990)

Each bag shall have securely affixed to the outside an inspector's tag which shows the date of manufacture or remanufacture, type of anchor and the intended rail sizes covering the anchors contained in that bag.

7.1.13 SHIPPING TAG (1990)

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

7.1.14 INSPECTION (1990)

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 facilities to satisfy him that the materials 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.

7.1.15 ACCEPTANCE (1990)

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

SECTION 7.2 RECOMMENDED PRACTICES FOR RAIL ANCHOR APPLICATION AND MAINTENANCE (1990)

7.2.1 GENERAL (1990)

a. Anchor shall be applied to the rail sections for which they are designed.

b. Rails having reduced base width and/or flange thickness account wear, corrosion, or rolling variations may require custom manufactured anchors for satisfactory performance. The purchaser or the anchor manufacturer's representative shall provide appropriate measurements of rail base to aid in optimizing rail anchor design.

c. Anchors applied at any one tie shall be of the same type.

d. Where the minimum recommended quantity of anchors is not sufficient to restrain the rail, additional anchors as determined by the Engineer/Maintenance shall be applied.

e. The base of the rail shall be reasonably clean and cribs open to accept the anchor and provide maximum rail restraint.

f. 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 and spiked. Anchors should be applied from the gage side of the rail when possible.

g. When rail or ties are renewed or respaced, anchors shall be properly repositioned.

h. 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.

i. Care shall be taken when applying rail anchors to ensure that they are properly seated. The manufacturer's instructions or recommendations must be followed.

j. 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.

k. 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 weld to prevent nicks or gouges within the heat-affected zone of welds.

l. Rails shall be fully anchored immediately after laying. When necessary trains must be operated at slow speed until track is anchored at proper temperatures.

m. 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 crossings to prevent rail movement.

n. Damaged, defective, or ineffective anchors shall be replaced.

o. 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.

Part 8

Highway/Railway Grade Crossings[1]

— 2007 —

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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 though 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 (2006)

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 (2006)

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. (Reference 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 crossties 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/railway grade crossings, in accordance with the provisions of the MUTCD is an integral part of the design of new or reconstructed crossings. Active crossing devices shall comply with the applicable portions of the AREMA *Communications and Signals Manual of Recommended Practices*. Care must be taken to coordinate the design and operation of any highway traffic control devices at the highway/railway intersection with other traffic control devices or systems at nearby roadway/roadway intersections so as to avoid queuing vehicles on or afoul of the highway/railway crossing, or to allow any such traffic to clear the crossing in the event of a train movement. (See also Sections 8.6 and 8.7 of this Chapter.) 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/railway grade crossing should provide for non-mountable raised center medians at least 8’-6” in width and extending at least 50 feet (200 feet preferred) on either side of the crossing to allow for the placement of additional crossing traffic control devices in the median. All public highway/railway crossings should be additionally equipped with advance warning signs, and all paved approaches to public highway/railway at-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. (Reference 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 (2006)

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/railway 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 the roadway authority‘s respective requirements for roadway traffic detours or other work zone traffic control, 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 (2006)

8.3.1 ROADWAY APPROACH REHABILITATION AND MAINTENANCE (2006)

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/railway 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.

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 (2007)

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 crossties.

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 ¼” 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 (2006)

A minimum of at least 12 inches of clean ballast conforming to AREMA specifications, 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 the bottom of tie and the sub-ballast or subgrade.

8.4.6 TIES (2006)

New treated (nominal 7”x 9”) hardwood, concrete 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, 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.

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 HIGHWAYS PARALLEL WITH RAILWAYS[1] (1962)

8.6.1 GENERAL (1993)

a. Many instances have occurred in the past where highways have been built parallel with and close to existing lines of railroad, followed later by the construction of spur or connecting tracks crossing the highways at grade to serve industrial plants subsequently established beyond the highways. In other instances, in residential areas, after streets or highways have been built parallel with and close to existing railroad tracks, it has been found necessary to construct streets through an area and across the main running tracks of the railroad at grade in order to serve the area more adequately. Many such cases have not only increased the number of grade crossings, but have greatly increased the accident potential.

b. To minimize hazards and inconveniences to all who might be affected the following principles are recommended for the guidance of railroads, industries, public authorities, and developers of property, in cooperative planning for the future. Adherence to these principles will insure the locating of highways

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[1] References, Vol. 53, 1952, pp. 669, 984; Vol. 54, 1953, pp. 487, 1306; Vol. 55, 1954, pp. 389, 965; Vol. 63, 1962, pp. 184, 732. Reapproved with revisions 1962.

with due regard to expected traffic conditions and with proper attention to safety, and will have the effect of holding to the minimum the construction of public highways close to and parallel with railroad tracks. Reference to highways in these recommendations includes streets, avenues, boulevards, rural roads, through or arterial highways, limited access highways, freeways and parkways.

8.6.2 INDUSTRIAL OR MANUFACTURING AREA IN OR NEAR CITIES (1993)

a. It is desirable that public highways paralleling railroad main tracks be located far enough away from railroad rights-of-way to make possible the industrial development of suitable areas without having service tracks cross public thoroughfares. The minimum distance between railroad tracks and parallel public roads in industrial areas in or near cities should be 500 feet, with 800 feet preferable in the case of small and medium plants, and 2,000 feet where large plants are to be accommodated.

b. The number of public highways crossing railroad main tracks, whether over, under, or at the grade of such tracks within a given industrial area should be kept to the minimum. To minimize the interference with track connections serving industrial plants, it is desirable that any such crossings of highways and main tracks be located not closer than ½ mile apart, measured along the tracks.

c. Where highways generally parallel with main tracks intersect highways that cross the main tracks, there should be sufficient distance between the tracks and the highway intersection to permit appropriate roadway connections that will enable highway traffic in all directions to move expeditiously with safety.

8.6.3 URBAN RESIDENTIAL OR RETAIL COMMERCIAL AREAS (1993)

a. It is desirable that streets paralleling railroad main tracks in urban residential or retail commercial areas be located at least 200 feet from the normal right-of-way of the railroad.

b. It is desirable that highway crossings of main tracks, whether over, under or at grade of these tracks, be located not closer than ½ mile apart, measured along the tracks.

c. Where a community has been built up alongside a main line of a railroad, and there are numerous streets crossing main tracks, with other streets generally parallel with and close to the tracks, the parallel streets in some instances can be effectively used to serve as outlets for the intermediate intersecting streets, thus enabling the abandonment of some of the intermediate grade crossings.

d. Where a community is to be developed alongside a main line of a railroad, the number of highway crossings of main tracks should be kept to the minimum. This can be accomplished by planning the street layout of the area so that a limited number of streets will cross the tracks, while others will end at the parallel street nearest the railroad right-of-way.

e. When property adjacent to a railroad is in a transition stage, such as from retail commercial to either light or heavy industrial, planning for changes of highways in the area should include possible future rail service requirements that would be brought about by the changed conditions and the subsequent industrial development. Care should be taken to avoid locating such public highways immediately adjacent to railroad right-of-way or station grounds.

8.6.4 RURAL AREAS (1993)

a. Where public highways are planned to be constructed generally parallel with railroad main tracks in other than urban residential or retail commercial areas, it is desirable that they be located at least 1,000 feet from the railroad main tracks.

b. When it is proposed to locate or reconstruct a highway generally parallel with a railroad in a rural area, the possibility of locating manufacturing or industrial plants along the line of railroad should not be overlooked.

c. Even though there may appear to be no immediate plan for the establishment of either light or heavy manufacturing plants in the area in question, and topographic features do not preclude such development, before planning construction of a new highway parallel with the railroad, consideration should be given to the factors that would influence the selection of a site or sites for the location of such manufacturing or industrial plants. Sufficient space should ordinarily be reserved to permit such location of plants adjacent to the railroad without interference from a new highway. Therefore, if it is proposed to construct a new highway generally parallel with a railroad in a rural area, it is desirable to locate the highway at least 1,000 feet from the railroad main tracks.

8.6.5 PHYSICALLY RESTRICTED AREAS (1993)

a. Where highways must be located adjacent to railways because of physical restrictions, they shall be so designed and constructed as not to interfere with the railway roadbed section. Provision shall also be made for a subgrade cross section of the track or tracks adequate to include space for such items as the following:

(1) Signals, signs and appurtenances.

(2) Crossing protective devices.

(3) Pole lines and catenary structures.

(4) Underground facilities.

(5) Drainage.

(6) Utilization of off-track equipment.

(7) Track equipment set-offs.

b. Where the possibility of intrusion occurs, the highway authorities shall install barriers to prevent highway vehicles from getting on the railway right-of-way and obstructing trains or otherwise endangering railway facilities and operations.

c. In the design of the highway consideration should be given to the disposal of snow so that it will not be deposited in such a location as to interfere with proper operation of railway facilities.

8.6.6 CROSSING PROTECTION (1993)

a. At locations where streets generally parallel with railroad main tracks, intersect cross streets near grade crossings of such main tracks, suitable highway traffic control protection should be provided to protect the traffic moving from the parallel streets, intending to cross the main tracks, in the event of a train movement. Likewise, adequate protection should be provided to take care of traffic crossing the main tracks to enter the parallel streets.

b. Provision shall be made for proper drainage so as not to endanger railway facilities, and consideration should be given to contemplated changes in railway grade and alignment.

SECTION 8.7 PROBLEMS RELATED TO LOCATION AND CONSTRUCTION OF LIMITED ACCESS HIGHWAYS IN VICINITY OF OR CROSSING RAILWAYS[1] (1962) R(2006)

8.7.1 GENERAL (1962)

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. Problems related to the location of limited access highways in vicinity of railways are as follows:

   (1) Loss of access if the limited access highway replaces an existing public way.

   (2) Inability of railway to serve lands lying beyond the highway that may be suitable for industrial development.

   (3) Access to intervening lands by an industry desiring to locate between the railway and a limited access highway.

e. Other problems relating to the location and construction of limited access highways are common to the location and construction of any highway. These problems are outlined in, Section 8.6, Location of Highways Parallel with Railways (1962).

SECTION 8.8 LICENSE OR EASEMENT APPLICATIONS (HIGHWAY – STREET – ROADWAYS)[2] (1962)

8.8.1 PURPOSE (1962)

This outline is for the guidance of highway personnel and others in making application for license or easement for highway, street, or roadway on railway property. Before a license or easement is granted, consideration must be given by several departments of the railway. By following this guide, field and office work, by both the applicant and railway, can be held to the minimum and the granting of licenses and easements greatly expedited.

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[1] References Vol. 58, 1957, pp. 443, 1141; Vol. 63, 1962, pp. 184, 732. Reapproved without change 1962.

[2] 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.

8.8.2 PROCEDURE (1962)

8.8.2.1 Preliminary Review

When it becomes apparent that a license or easement on railway property is being considered, the locating engineer for the highway, street or roadway shall immediately contact the chief engineer of the railway for an on-the-ground review.

8.8.2.2 Plans

The applicant shall furnish the following drawings:

a. Plan view or situation map showing:

   (1) Railway property lines and improvements, such as tracks, buildings, and pole lines that are likely to be involved. Railways have maps of all their property and generally will make them available to responsible organizations and individuals.

   (2) Boundaries of the property to be used by license or easement, with both ends tied in with bearings to the center line of a main track. The tie-in points are to be located by measuring along the center line of the main track to the nearest permanent railway structure. The license or easement shall also be located in relation to local land survey ties where practicable.

   (3) Distance along the center line of main track from tie-in points to the nearest railway mile post or survey station.

   (4) Proposed highway, street, or roadway, together with secondary structures to be installed on the license or easement, incidental to the highway, street, or roadway.

   (5) Existing and proposed drainage and structures.

   (6) Edge of slopes.

   (7) Location of any construction or temporary license or easement.

b. Profiles of center line of proposed highway, street, or roadway, showing original ground line and proposed grade. Relative base-of-rail or top-of-rail elevation of the main track at tie-in points of the easement or license shall be shown.

c. Details of present and proposed drainage shall be furnished when runoff characteristics or storage are affected.

d. Cross sections of present ground line, showing proposed roadbed. The sections shall be carried to the center line of a main track when the proposed roadbed is adjacent to the track roadbed. Where a crossing of railway tracks is involved, full details as to grade of road, tracks, pavement section and crown, superelevation, construction details, and procedure shall be furnished on a large-scale detail drawing.

e. A plat showing the property to be used by license or easement shall be furnished on 8″×10″ or 8½″×13″ (where practicable) vellum or other material suitable for making reproductions.

8.8.2.3 Submission

a. The plans shall be submitted to the chief engineer of the railway, together with a formal letter signed by the applicant or a person duly authorized to negotiate such license or easement. The letter shall request the license or easement, explain the need for the license or easement, as well as state amount of compensation offered.

b. The letter of submission shall include the name of the engineer in charge of the work to be contacted for a review of the proposal on the ground.

c. A copy of the application (letter and plans) shall be sent to the railway superintendent in charge of the territory where the license or easement is desired. If the railway superintendent is not known, the application shall be sent in duplicate to the chief engineer.

8.8.3 GENERAL (1962)

The location of highways, streets or other roadways should be made in accordance with Section 8.6, Location of Highways Parallel with Railways (1962); Article 8.6.2, Article 8.6.3 and Article 8.6.4, where practicable. When the location cannot be made in accordance with Article 8.6.2, Article 8.6.3 and Article 8.6.4, then Article 8.6.5 of the same document shall govern.

American Railway Engineering and Maintenance-of-Way Association

Part 9

Design Qualification Specifications for Elastic Fasteners on Timber Cross Ties[1]

— 1994 —

FOREWORD

This specification is intended to provide necessary guidance to qualify the design of an Elastic Rail Fastener system for use in a mainline railway track with wood cross ties. These are minimum requirements; products qualifying under this specification may not perform acceptably where vehicle loading exceeds conventional 100 ton (rated) loads or where curvature or grade are more severe than that in general practice.

Individual components within a qualifying system are not necessarily qualified when used in a different system of components. Modifications to a qualifying system, either in components, geometry, materials or manufacturing procedures are grounds for requiring re-qualification under this specification.

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[1] References, Vol. 94 (1994), p. 86.

LIST OF FIGURES

LIST OF TABLES

SECTION 9.1 DEFINITIONS (1994)

9.1.1 TERMS (1994)

The following terms are for general use in this part. Specialized terms appear in individual articles. Refer to the Glossary located at the end of the chapter for definitions.

Cross Tie

Elastic Clip

Elastic Rail Fastener

Engineer

Hold Down Device

Lateral Load

Longitudinal Load

Rail Clip

Rail Fastener (This specification only addresses wood tie supports.)

- Resilient Rail Fastener
- Elastic Fastener

Rail Seat

Rigid Clip

Track Modulus

Vertical Load

SECTION 9.2 GENERAL REQUIREMENTS (1994)

9.2.1 SUBMITTALS (1994)

Fastener systems for qualification testing under this specification shall be submitted with the following documentation prior to initiation of qualifying testing:

a. Drawings of the assembly and each component including mating plates, spikes, screws, etc., by others;

b. Bills of material listing part/component identification;

c. General description of materials used in each component identified in the assembly drawings;

d. Manufacturing tolerance, including mating tolerances among system components and the rail;

e. Identification of special conditions such as at rail joints and other special applications where the submitted design may not apply.

9.2.2 MINIMUM ACCEPTANCE (1994)

All fasteners tested, with the exception of those special conditions identified in Paragraph 9.2.1e, shall provide minimum functional performance stated by all articles of this specification through the full range of tolerances of all mating components including rail and ties as shown on the submitted drawings.

9.2.3 QUALIFICATION TEST FACILITY (1994)

Sampling, testing and reporting shall be conducted by a laboratory, institution or agency approved by the Engineer.

9.2.4 FASTENER PROFILE (1994)

In principle, the fastener system should have a profile which clears the silhouette of all operating and maintenance equipment intended for use on the track.

SECTION 9.3 LABORATORY QUALIFYING TESTS (1994)

9.3.1 TEST CONFIGURATION (1994)

a. The test configurations shall be as specified by each test sequence.

b. The standard tie for qualification testing under this specification is a new dried wood tie of the Southern Yellow Pine species, AREMA Grade 5 in cross section, and no less than 42.5 inches length. The centerline of the test rail shall be placed no less than 18.25 inches and no more than 21.25 inches from the end of the tie.

9.3.2 SAMPLING (1994)

A minimum of 10 complete assemblies shall be selected by the responsible testing agency from a lot of individual components which are representative of production-run components. A minimum of two full assemblies shall then be chosen as test assemblies. All selected test assemblies shall be subjected to the full battery of testing under this specification.

9.3.3 TEST SEQUENCE (1994)

The test procedures are provided in the following subarticles. The test sequence for each system is found in Table 5-9-1.

Table 5-9-1. Test Sequence

Sequence	Test Description	Article Reference
1.	Uplift Test	9.3.4
2.	Longitudinal Restraint Test	9.3.5
3.	Repeated Load Test	9.3.6
4.	Uplift Test (repeat #1)	9.3.4
5.	Longitudinal Restraint Test (repeat #2)	9.3.5
6.	Rotational Restraint	9.3.7

9.3.4 UPLIFT TEST (1994)

a. The uplift test shall be the test configuration shown in Figure 5-9-1.

b. With the tie rigidly fixed to the load frame, a load shall be applied to the rail through the vertical rail centerline, perpendicular to the rail seat, in the direction away from the tie. Simultaneously, the vertical deflection of the rail relative to the load frame and separately, the tie plate relative to the load frame, and the vertical position of the hold-down devices relative to the tie, shall be measured. Prior to qualification runs, the system will be "bedded in" using 1,000 cycles vertical load from –3,000 to +3,000 pounds. Torque adjustment or re-driving components after bedding-in is not permitted. All measurements shall be zeroed after bedding-in which shall then be the initial condition.

c. All measurements shall be taken to a load of 8,000 pounds, with data permanently recorded every 500 pounds. The load shall then be released with all measurements being recorded as in the load application cycle.

d. The fastener system shall be rejected if, during any one test run:

(1) The rail separates more than 0.050 inch from the tie;

(2) The tie plate is displaced more than 0.030 inch from the "seated-in" position after unloading;

(3) The rail base vertical deflection after unloading is greater than 0.010 inch;

(4) The hold-down devices uplift more than 0.030 inch from initial conditions any time during the load cycle.

e. The fastener system and its components shall be inspected under full load conditions and after unloading for separation or damage relevant to the particular design under test.

f. Load versus deflection curves shall be plotted for every run as test documentation.

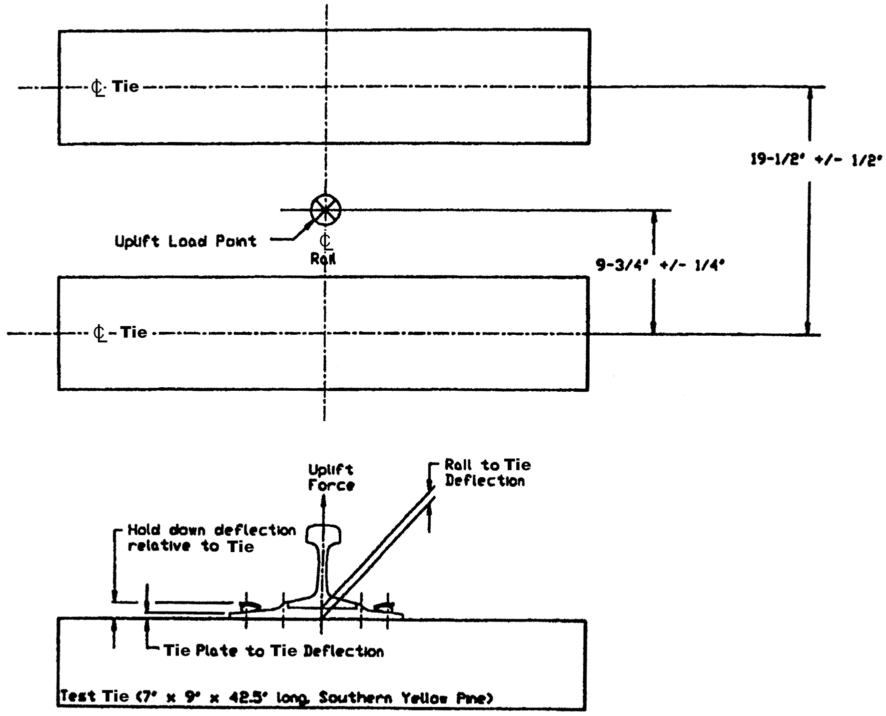


Figure 5-9-1. Uplift Test Configuration

9.3.5 LONGITUDINAL RAIL RESTRAINT (1994)

The longitudinal rail restraint test includes testing under static and dynamic load conditions. The longitudinal rail restraint test shall be the test configuration in Figure 5-9-2 for both load conditions.

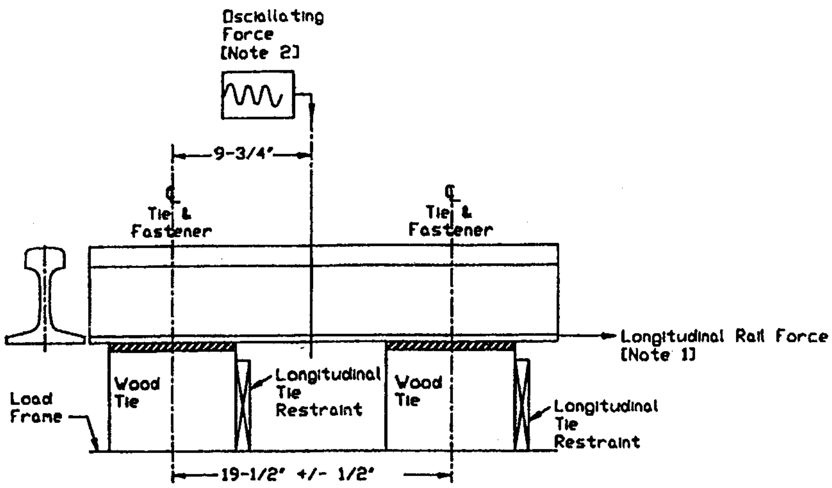
9.3.5.1 Static Longitudinal Load Test

a. With the standard tie rigidly fixed to the load frame in the vertical plane and along the longitudinal rail axis, pre-apply 1,000 pounds, longitudinal load to a point within 3/8 inch of the rail base, while measuring the longitudinal deflection of the rail relative to the tie (or load frame) and, separately, the tie plate relative to the load frame.

b. The applied longitudinal load and resulting longitudinal deflections of the rail relative to the tie plate shall be measured at every 500 pound increment of longitudinal load. The load shall continue to be applied until the rail slips longitudinally 1/2 inch through the fastener. After the rail longitudinal slip occurs with a 1/2 inch longitudinal measured deflection, the load shall be released and the rail longitudinal deflection shall be recorded. If the post-load longitudinal deflection differs from that at the final full load, the testing agency shall report the reasons for the difference in post-loading deflection readings such as tie rotation, visible deflection of tie plate relative to tie, etc.

c. The fastener system shall be rejected if, during any one test run, the rail slips continuously in the longitudinal direction more than 1/2 inch at less than 4,800 pounds.

d. Longitudinal load versus longitudinal deflection shall be plotted for every run as test documentation.



NOTES:

1. Longitudinal Rail Force shall be applied within 3/8" of the bottom of the rail base and at the centerline of the rail cross section.
2. An oscillating vertical load of 1000 pounds (peak to peak) shall be applied at a rate of 15 cycles per second (+/– 2 cycles per second).
3. Longitudinal tie restraint shall be rigidly fixed to load frame.

Figure 5-9-2. Longitudinal Rail Restraint Test Configuration

9.3.5.2 Dynamic Longitudinal Load Test

a. With the standard tie rigidly fixed to the load frame in the vertical plane and along the longitudinal rail axis, pre-app1y 1,000 pounds longitudinal load to a point within ⅜ inch of the rail base, while measuring the longitudinal deflection of the rail relative to the tie (or load frame) and, separately, the tie plate relative to the load frame. During the longitudinal load application, a vertical vibration of 1,000 pounds (peak to peak) at a frequency of 15 Hz (±2 Hz) shall be applied through the rail at the mid-point between ties.

b. The applied longitudinal load and resulting longitudinal deflections of the rail relative to the tie plate shall be measured every 500 pounds of longitudinal load. The load shall continue to be applied until the rail slips longitudinally ½ inch through the fastener. After the rail longitudinal slip occurs with a ½ inch longitudinal measured deflection, the load shall be released and the rail longitudinal deflection shall be recorded. If the post-load longitudinal deflection differs from that at the final full load, the testing agency shall report the reasons for the post-loading difference in deflection readings such as tie rotation, visible deflection of tie plate, etc.

c. The fastener system shall be rejected if, during any one test run, the rail slips continuously in the longitudinal direction more than ½ inch at less than 4,000 pounds.

d. Longitudinal load versus longitudinal deflection shall be plotted for every run as test documentation.

9.3.6 REPEATED LOAD TEST (1994)

a. The repeated load test shall be the test configuration shown in Figure 5-9-3.

b. With the ties rigidly fixed to the load frame, vertical and lateral loads shall be applied for 3 million cycles in the sequence shown in Table 5-9-2.

Minimum test documentation shall include all measured data (loads and deflections) from each periodic measurement sequence.

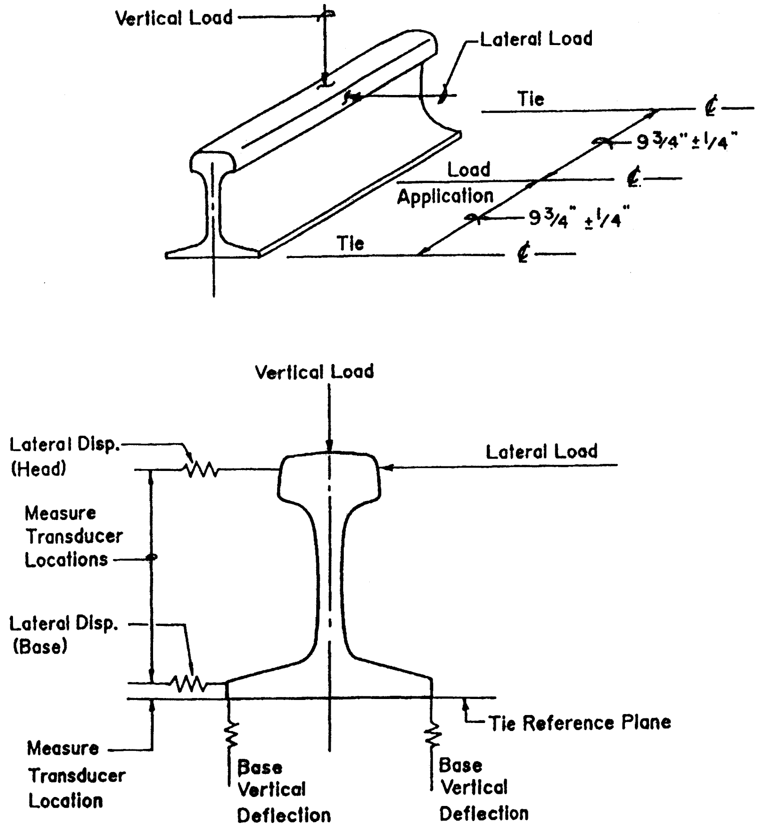


Figure 5-9-3. Repeated Load Test Configuration

Table 5-9-2. Repeated Load Cycle
(See Note 1)

Step	Vertical Load (lb)	Lateral Load (lb)
1	0	0
2	–3,000	0
3	42,000	0
4	42,000	21,000
5	21,000	13,000
6	0	3,000
7	0	–3,000

Note 1: Steps 1 through 7 represent one load cycle; this sequence shall be repeated for the number of load cycles specified.
Each step in the load sequence shall have the same time duration.
Positive vertical loads are downward through the rail head, fastener and tie, illustrated in Figure 5-9-3.
Positive lateral loads are applied at the gage side of the rail towards the field side.
Rail base deflection measurements shall be placed within 1/4 inch of the rail base edge.

c. The measurements shall include but not be limited to:

(1) Vertical load.

(2) Lateral load.

(3) Lateral rail head deflection.

(4) Lateral rail base deflection.

(5) Vertical deflection at each edge of the rail base relative to the tie.

d. Measurements shall be conducted during the first ten cycles of loading (with all instrumentation adjusted to zero values before first load). Measurements shall then be conducted during ten load cycles after every 300,000 load cycles (±50,000 cycles).

e. The testing agency shall record any tightening of bolt or screw components during the repeated load test. This documentation shall include a description of the tightening or adjustment made and the number of load cycles at which the adjustment was done.

f. The fastener system shall be rejected if:

(1) Any component fails.

(2) Vertical or lateral permanent deflection exceeds 1⁄16 inch (relative to the load frame) more than the system tolerance, such as rail-to-plate lateral shoulder clearance.

(3) The maximum lateral deflection of the rail head is 1⁄8 inch at any time during the test.

(4) A Purchaser considers the amount or frequency of system adjustments to be excessive.

g. Minimum test documentation shall include all measured date (loads and deflections) from each periodic measurement sequence.

9.3.7 ROTATIONAL RESTRAINT (1994)

a. Using the final test configuration (the second longitudinal resistance test), the rail shall be loaded laterally (i.e. parallel to the tie) at the rail head while measuring the rail base lateral deflection and the vertical deflection at both rail base edges.

b. No vertical load shall be applied during this sequence.

c. After a lateral load of 1,000 pounds is applied to take up all lateral tolerance, the deflection measurements shall be set to zero. The three deflections shall be measured at lateral load increments of 1,000 pounds to a maximum of 4,000 pounds or a deflection greater than 0.100 inch, whichever occurs first. This test sequence shall be completed in not less than one minute.

d. The lateral load shall then be returned to zero, followed by final deflection measurements.

e. The fastener system shall be rejected if any component fails (breaks, permanently deforms to an unserviceable condition) within the 4,000 pound load limit, or a deflection greater than 0.100 inch occurs at a lateral load less than 4,000 pounds.

AREMA
American Railway Engineering and Maintenance-of-Way Association

Part 10

Miscellaneous

— 2005 —

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SECTION 10.1 SPECIFICATIONS FOR STEEL DRIVE SPIKES[1] (1963)

10.1.1 SCOPE (1994)

a. These specifications cover steel drive spikes.

b. A supplementary requirement, Article 10.1.14, of an optional nature is provided. It shall apply only when specified by the purchaser.

10.1.2 PROCESS (1994)

The steel shall be made by one or more of the following processes: open-hearth, electric-furnace, acid-bessemer, basic-oxygen.

10.1.3 MANUFACTURE (1994)

The heads of the spikes shall be formed and the threads rolled hot or cold.

10.1.4 CHEMICAL COMPOSITION (1994)

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

Carbon, min, percent	0.18
Copper, when specified under supplementary requirement Article 10.1.14, min, percent	0.20

[1] References, Vol. 62, 1961. pp. 648, 946; Vol. 63, 1962, pp. 490, 755; Vol. 64, 1963, pp. 430, 683. Rewritten 1963.

10.1.5 TENSILE PROPERTIES (1994)

The full-size finished spikes shall conform to the following minimum requirements as to tensile properties:

Tensile strength, psi.	60,000
Yield point, psi	0.5 tensile strength
Elongation in 2 inches min, percent . . .	18

10.1.6 BENDING PROPERTIES (1994)

The body of a full-size finished spike shall stand being bent cold through 90 degrees around a pin the diameter of which is not greater than three times the diameter of the spike without cracking the outside of the bent portion.

10.1.7 NUMBER OF TESTS (1994)

a. One tension test and one bend test shall be made from each lot of 100 kegs or fraction thereof.

b. If any test specimen develops flaws, it may be discarded and another specimen substituted.

10.1.8 RETESTS (1963)

If the percentage of elongation of any tension test specimen is less than specified in Article 10.1.5 and any part of the fracture is more than 3⁄4 inch from the center of the gage length, as indicated by scribe scratches marked on the specimen before testing, a retest shall be allowed.

10.1.9 PERMISSIBLE VARIATIONS IN DIMENSIONS (1963)

a. The purchaser shall specify in the inquiry and order, the plan to which the spikes are to be manufactured. The following plans cover designs of steel drive spikes:

   - Plan 1M – AREMA cone-neck drive spike.
   - Plan 2M – AREMA washer-head timber drive spike.
   - Plan 3M – AREMA timber drive spike.

b. The finished spikes shall conform to the dimensions and permissible variations in dimensions specified in the plan. The design and depth of the threads shall be as indicated on the plan.

10.1.10 FINISH (1963)

The head shall be concentric with and firmly joined to the body of the spike. The material shall be free from injurious defects and shall have a workmanlike finish.

10.1.11 MARKING (1963)

A letter or brand indicating the manufacturer shall be located on the top of washer part of the spike head as shown on plans.

10.1.12 INSPECTION (1963)

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.

10.1.13 REJECTION (1963)

a. Material that does not 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.

10.1.14 SUPPLEMENTARY REQUIREMENT (1963)

The following supplementary requirement shall apply only when specified by the purchaser in the inquiry order and contract.

- Copper may be specified as shown in Article 10.1.4.

SECTION 10.2 PLANS FOR DRIVE SPIKES[1] (1963)

10.2.1 GENERAL (1963)

For drive spike plans refer to Figure 5-10-1 through Figure 5-10-3.

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.

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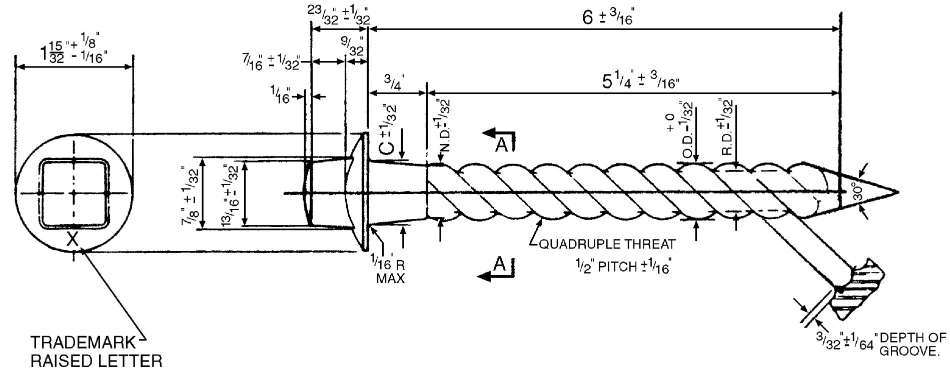
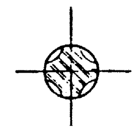
[1] References, Vol. 62, 1961, pp. 649, 946; Vol. 63, 1962, pp. 490, 755; Vol. 64, 1963, pp. 431, 683. Reapproved without change 1962.



DESCRIPTION	* ND NOMINAL DIAMETER	
	11/16"	3/4"
O.D. OF THREAD	23/32" MAX.	25/32" MAX.
R.D. - ROOT DIAMETER	17/32"	19/32"
C - TOP OF CONE NECK	25/32"	27/32"

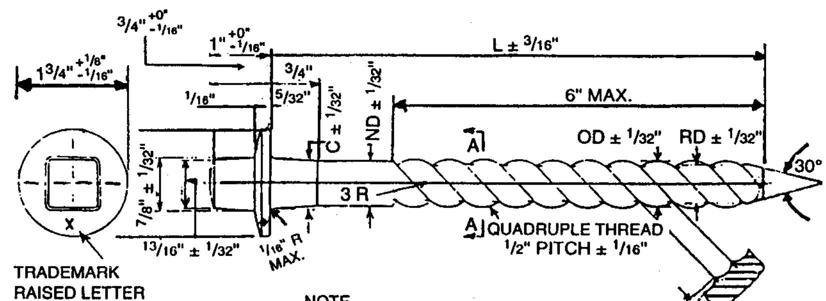
NOTES
OTHER LENGTHS PROCURABLE
*ORDER BY NOMINAL DIAMETER.
DESIGNED TO FIT 11/16" AND 3/4" SQUARE AND ROUND HOLES.



SECTION A - A

SPIKES TO CONFORM TO CURRENT A.R.E.A. SPEC. FOR DRIVE SPIKES.

Figure 5-10-1. Plan 1M-63 – AREMA Cone-neck Drive Spike (1963)



NOTE
*ORDER BY NOMINAL DIAMETER AND LENGTHS UNDER HEAD.

DESCRIPTION	*ND—NOMINAL DIAMETER		
	5/8"	11/16"	3/4"
OD OF THREAD	23/32"	25/32"	27/32"
RD-ROOT DIAMETER	17/32"	19/32"	21/32"
C-TOP OF CONE NECK	11/16"	25/32"	13/16"

SECTION A-A

SPIKES TO CONFORM TO CURRENT A.R.E.A. SPEC. FOR DRIVE SPIKES.

Figure 5-10-2. Plan 2M-63 – AREMA Washer-head Timber Drive Spike (1994)

10.3.3 GENERAL SAFETY (2005)

a. 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.

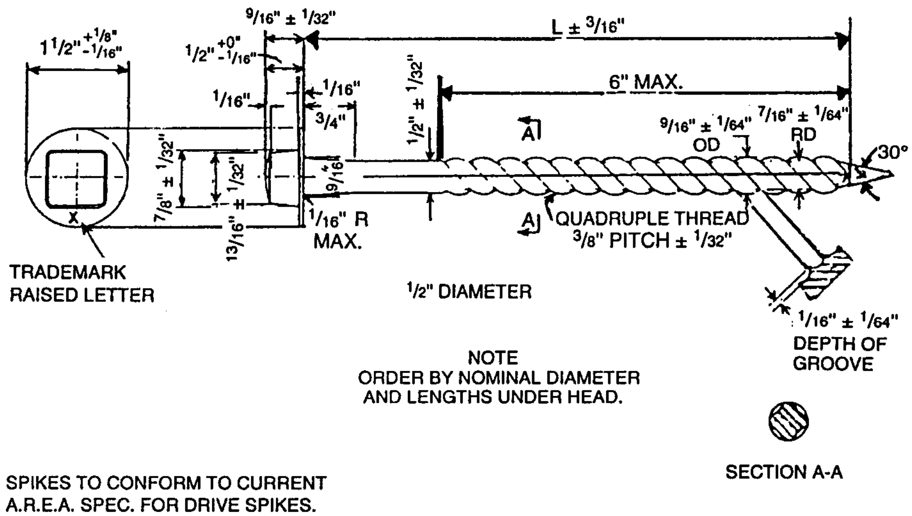


Figure 5-10-3. Plan 3M-63 – AREMA Timber Drive Spike (1994)

b. 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.

c. 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.

d. 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 5-10-1.

Table 5-10-1. Band Type Guard Positioning

Overall Thickness of Abrasive Wheel in Inches	Maximum Exposure of Wheel Beyond Edge of Guard in Inches
1	½
2	¾
3	1
4	1½

10.3.9 GRINDING EQUIPMENT (2005)

a. For surface grinding on rail ends, engine burns and thermite welds, grinders equipped with mechanical vertical feed control are recommended.

b. 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.

c. 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)

a. 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.

b. 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.

c. 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

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

Area Width

Overall dimension of the plate parallel to the rail it supports. Tie plates are generally from seven to eight inches wide.

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.)

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 Tie

A transverse component of a track system whose functions are the control of track gage and the transmission of rail loads to ballast.

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

Engineer

The purchaser, or the purchaser's designated employee or representative authorized to act on the purchaser's behalf.

Field Side

End of tie plate designed to be located on the opposite side of the rail from the centerline of track.

Gage Side

End of tie plate designed to be located closest to the centerline of track.

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

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.

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.

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.

Out-of-face Tamping
Lifting and tamping the entire track to restore it to a uniform surface and cross level. Lifts should be made and tamped in increments of 2 inches maximum.

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.

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.

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.

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.

Skin Lift
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.

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.

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

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."

Vertical Load

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.

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References

The following is a list of references used in Chapter 5, Track and placed here in alphabetical order for your convenience.

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4. *Manual on Uniform Traffic Control Devices, 2003 Edition*, Federal Highway Administration (FHWA), Washington, D.C.

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8. *Railroad-Highway Grade Crossing Handbook*, 2^{nd} Edition (1986), Federal Highway Administration (FHWA), Washington, D.C.: Publication No. FHWA-TS-86-215.

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