Designation: A 1 – 00 (Reapproved 2005)

Standard Specification for Carbon Steel Tee Rails [1]

This standard is issued under the fixed designation A 1; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the Department of Defense.

1. Scope

1.1 This specification covers carbon steel tee rails of nominal weights of 60 lb/yd (29.8 kg/m) and over for use in railway track, including export and industrial applications.

1.2 Supplementary requirements S1 and S2 shall apply only when specified by the purchaser in the order.

1.3 The values stated in inch-pound units are to be regarded as the standard. The values given in parentheses are for information only.

2. Referenced Documents

2.1 *ASTM Standards:* [2]

A 29/A 29M Specification for Steel Bars, Carbon and Alloy, Hot-Wrought, General Requirements for

A 700 Practices for Packaging, Marking, and Loading Methods for Steel Products for Domestic Shipment

E 10 Test Method for Brinell Hardness of Metallic Materials

E 127 Practice for Fabricating and Checking Aluminum Alloy Ultrasonic Standard Reference Blocks

E 428 Practice for Fabrication and Control of Steel Reference Blocks Used in Ultrasonic Inspection

2.2 *American Railway Engineering and Maintenance of Way Association (AREMA) Manual for Railway Engineering:* Specifications for Steel Rails, Chapter 4, Part 2[3,4]

3. Ordering Information

3.1 Orders for rails under this specification shall include the following information:

3.1.1 ASTM designation and year of issue.

3.1.2 Type of rail desired.

3.1.3 Quantity (tons or pieces as appropriate).

3.1.4 Full identification of section with dimensional drawing, if required.

3.1.5 Arrangement of drilled bolt holes, if any, with dimensional drawing, if required.

3.1.6 Quantity of right-hand and left-hand (Note 1) drilled rails, drilled both-end rails, and undrilled (blank) rails desired.

3.1.7 Supplementary requirements that shall apply (see S1 and S2).

3.1.8 Disposition of various classifications of rails (see 8.3.6 and 8.3.7).

NOTE 1—The right-hand or left-hand end of the rail is determined by facing the side of the rail on which the brand (raised characters) appears.

4. Materials and Manufacture

4.1 *Rail Types*—Rails shall be furnished as-rolled (standard and alloy), head hardened (on-line or off-line processes), or fully heat treated as agreed upon between the purchaser and the manufacturer.

4.2 *Melting Practice*—The steel shall be made by any of the following processes: basic-oxygen or electric-furnace.

4.2.1 The steel shall be cast by a continuous process, in hot-topped ingots, or by other methods agreed upon between the purchaser and the manufacturer.

4.3 *Discard*—Sufficient discard shall be taken from the bloom or ingot to ensure freedom from injurious segregation and pipe.

4.4 *Hydrogen Elimination*:

4.4.1 *Applicability*:

4.4.1.1 Rails 60 through 70 lb/yd (29.8 through 34.8 kg/m) are not subject to treatment for hydrogen elimination.

4.4.1.2 Rails over 70 through 84 lb/yd (over 34.8 through 41.7 kg/m) may be subjected to treatment for hydrogen elimination at the option of the manufacturer.

4.4.1.3 Rails over 84 lb/yd (41.7 kg/m) shall be processed by methods that prevent the formation of shatter cracks as agreed upon between the purchaser and the manufacturer.

4.4.2 Rail heats shall be tested for hydrogen content using either a sampling/analytical method or a direct measurement method of the liquid steel. The testing shall be performed either during the continuous casting process or during ingot teeming. Hydrogen content shall be recorded and available for review or reporting at the request of the purchaser. The producer shall

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] Available from American Railway Engineering and Maintenance of Way Assn., 8201 Corporate Drive, Suite 1125, Landover, MD 20785.

[4] Adapted from AREMA Specifications for Steel Rails (see 2.2).

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define the method used to determine hydrogen content, which of the following methods are used for hydrogen removal, and present evidence of applicable procedures used to control the final rail hydrogen:

4.4.2.1 Vacuum degassing.

4.4.2.2 Bloom control cooling.

4.4.2.3 Rail control cooling.

4.4.3 *Rail Control-Cooling Procedure (AREMA Specifications for Steel Rails)*—Rails shall be control-cooled in accordance with the following procedure, except when produced from vacuum degassed steel or control-cooled blooms, in which case the rails may be air-cooled, and 4.4.3.1-4.4.3.5 are not applicable.

4.4.3.1 All rails shall be cooled on the hot beds or runways until full transformation is accomplished and then charged immediately into the containers. In no case should the rail be charged at a temperature below 725°F (385°C).

4.4.3.2 The temperature of the rails before charging shall be determined with a reliable calibrated pyrometer at the top of the rail head at least 12 in. (305 mm) from the end.

4.4.3.3 The cover shall be placed on the container immediately after completion of the charge and shall remain in place for at least 10 h. After removal or raising of the lid of the container, no rail shall be removed until the top layer of rails has fallen to 300°F (149°C) or lower.

4.4.3.4 The temperature between an outside rail and the adjacent rail in the bottom tier of the container at a point not less than 12 in. (305 mm) nor more than 36 in. (915 mm) from the rail end shall be recorded. This temperature shall be the control for judging rate of cooling.

4.4.3.5 The container shall be so protected and insulated that the control temperature shall not drop below 300°F (149°C) in 7 h for rails 100 lb/yd (49.7 kg/m) in weight or heavier, from the time that the bottom tier is placed in the container, and in 5 h for rails of less than 100 lb/yd in weight. If this cooling requirement is not met, the rails shall be considered control-cooled, provided that the temperature at a location not less than 12 in. (305 mm) from the end of a rail at approximately the center of the middle tier does not drop below 300°F in less than 15 h.

5. Chemical Composition

5.1 The chemical composition of the standard, head hardened, and fully heat treated rail steel, determined as prescribed in 5.2.1, shall be within the limits shown in Table 1. The chemical composition of alloy rail will be subject to agreement between the purchaser and the manufacturer.

5.1.1 When ladle tests are not available, finished material representing the heat may be product tested. The product analysis allowance beyond the limits of the specified ladle analysis shall be within the limits for product analyses specified in Table 2.

5.2 *Heat or Cast Analysis*:

5.2.1 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 the chemical analysis requirements of Table 1 may be applied. The analysis, most representative of the heat (clear of the transition zone for continuous cast steel), shall be recorded as the official analysis, but the purchaser shall have access to all chemical analysis determinations. Additionally, any material meeting the product analysis limits shown in Table 2 may be applied after testing such material in accordance with Specification A 29/A 29M.

5.2.2 Upon request by the purchaser, samples shall be furnished to verify the analysis as determined in 5.2.1.

TABLE 1 Chemical Requirements—Heat Analysis

Element	Nominal Weight, lb/yd (kg/m)		
	60 to 84 (29.8 to 41.7), incl	85 to 114 (42.2 to 56.6), incl	115 (57.0) and over
Carbon	0.55 to 0.68	0.70 to 0.80	0.74 to 0.84
Manganese	0.60 to 0.90	0.70 to 1.00	0.80 to 1.10[A]
Phosphorus, max	0.040	0.035	0.035
Sulfur, max	0.050	0.040	0.040
Silicon	0.10 to 0.50	0.10 to 0.50	0.10 to 0.50

[A] The upper manganese limit may be extended to 1.25 % by the manufacturer to meet the Brinell hardness specification. When manganese exceeds 1.10 %, the residual alloy contents will be held to 0.25 % maximum nickel; 0.25 % maximum chromium; 0.10 % maximum molybdenum; and 0.03 % maximum vanadium.

TABLE 2 Product Analysis Allowance Beyond Limits of Specified Chemical Analysis

	Percent Under Minimum Limit	Percent Over Maximum Limit
Carbon	0.04	0.04
Manganese	0.06	0.06
Phosphorus	. . .	0.008
Sulfur	. . .	0.008
Silicon	0.02	0.02[A]

[A] Continuously cast allowances shall be 0.05 % over maximum limit for silicon.

6. Interior Condition

6.1 For both ingot steel and continuously cast steel, between macroetch testing shall be performed as agreed upon between the purchaser and the manufacturer.

6.2 *Macroetch Testing*—Rail soundness shall be evaluated by macroetching in a hot acid solution.

6.2.1 *Sample Location and Frequency*:

6.2.1.1 *Ingot Steel*—A test piece representing the top end of the top rail from one of the first three, middle three, and last three ingots of each heat shall be macroetched.

6.2.1.2 *Continuous Cast Steel*—A test piece shall be macroetched representing a rail from each strand from the beginning of each sequence and whenever a new ladle is begun, which is the point representative of the lowest level in the tundish (that is, the point of lowest ferrostatic pressure). One additional sample from the end of each strand of the last heat in the sequence shall also be tested. A new tundish is considered to be the beginning of a new sequence.

6.2.2 If any test specimen does not conform to the acceptable macroetch pictorial standards agreed upon between the purchaser and the manufacturer, further samples shall be taken from the same strand or ingot. For continuously cast steel, two retests shall be taken one from each side of the original sample at positions decided by the manufacturer, and the material

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between the two retest positions shall be rejected. For ingot steel, testing shall progress down the ingot. If any retest fails, testing shall continue until acceptable internal quality is exhibited. All rails represented by failed tests shall be rejected.

7. Hardness Properties

7.1 Rails shall be produced as specified by the purchaser within the limits found in Table 3 and Table 4,

7.2 The Brinell hardness test shall be performed on a rail, a piece of rail at least 6 in. (152 mm) long cut from a rail of each heat of steel or heat-treatment lot, or from a ground/milled transverse sample cut from the 6-in. piece. The test shall be made on the side or top of the rail head after decarburized material has been removed to permit an accurate determination of hardness. Alternately, the test may be made on the prepared transverse ground/milled sample ⅜ in. from the top rail surface.

7.3 The test shall otherwise be conducted in accordance with Test Method E 10.

7.4 If any test result fails to meet the specifications, two additional checks shall be made on the same piece. If both checks meet the specified hardness, the heat or heat treatment lot meets the hardness requirement. If either of the additional checks fails, two additional rails in the heat or lot shall be checked. Both of these checks must be satisfactory for the heat or lot to be accepted. If any one of these two checks fails, individual rails may be tested for acceptance.

7.5 If the results for off-line head hardened rails and fully heat treated rails fail to meet the requirements of 7.1, the rails may be retreated at the option of the manufacturer, and such rails shall be retested in accordance with 7.2 and 7.3.

8. Permissible Variations of Dimension, Weight, and Other Physical Attributes

8.1 *Section*:

8.1.1 The section of the rail shall conform to the design specified by the purchaser.

8.1.2 A variation of 0.015 in. (0.38 mm) less or 0.040 in. (1.02 mm) greater than the specified height will be permitted measured at least 1 in. (25.4 mm) from each end.

8.1.3 A variation of 0.030 in. (0.76 mm) less or 0.030 in. greater than the specified rail head width will be permitted measured at least 1 in. (25.4 mm) from each end.

8.1.4 A variation of 0.050 in. (1.27 mm) in the total width of the base will be permitted.

8.1.5 No variation will be allowed in dimensions affecting the fit of the joint bars, except that the fishing template approved by the purchaser may stand out laterally not more than 0.060 in. (1.5 mm) when measured within the 18-in. (460-mm) end locations.

8.1.6 A variation of 0.060 in. (1.5 mm) in the asymmetry of the head with respect to the base will be permitted.

TABLE 3 Hardness Requirements of Standard Carbon Rails

	Nominal Weight, lb/yd (kg/m)		
	60 to 84 (29.8 to 41.7), incl	85 to 114 (42.2 to 56.6), incl	115 (57.0) and over
Brinell Hardness, min	201	285	300

TABLE 4 Hardness Requirements of High-Strength Rails (See notes)

NOTE 1—Hardness specified in Table 4 pertain to the head area only.

NOTE 2—A fully pearlitic microstructure shall be maintained in the head.

NOTE 3—If 410 HB is exceeded, the microstructure throughout the head shall be examined at 100× or higher for confirmation of a fully pearlitic microstructure in the head.

NOTE 4—No untempered martensite shall be present within the rail.

	Nominal Weight, lb/yd (kg/m)		
	60 to 84 (29.8 to 41.7), incl	85 to 114 (42.2 to 56.6), incl	115 (57.0) and over
Brinell Hardness	277 to 341	321, min	341, min

8.1.7 A variation of 0.020 in. (0.51 mm) less or 0.040 in. (1.02 mm) greater than the specified thickness of web will be permitted.

8.1.8 Verification of tolerances shall be made using appropriate gages as agreed upon between the purchaser and the manufacturer.

8.2 *Length*:

8.2.1 The standard length of rails shall be 39 ft (11.9 m) or 80 ft (24.4 m), or both, when measured at a temperature of 60°F (15°C).

8.2.2 Up to 9 % for 39 ft rail or 15 % for 80 ft rail of the entire order will be accepted in lengths shorter than the standard, varying by 1 ft (0.3 m) as follows: 79, 78, 77, 75, 70, 65, 60, 39, 38, 37, 36, 33, 30, 27, and 25 ft.

8.2.3 A variation of 7⁄16 in. (11 mm) for 39-ft (11.9-m) rails or ⅞ in. (22 mm) for 80-ft rails (24.4-m) will be permitted.

8.2.4 Length variations other than those specified in 8.2.2 and 8.2.3 may be established by agreement between the purchaser and the manufacturer.

8.3 *Drilling*:

8.3.1 Circular holes for joint bolts shall be drilled to conform to the drawings and dimensions furnished by the purchaser.

8.3.2 A variation of −0 and +1⁄16 in. (1.6 mm) in the size of the bolt holes will be permitted.

8.3.3 A variation of 1⁄32 in. (0.8 mm) in the location of the holes will be permitted.

8.3.4 Fins and burrs at the edges of bolt holes shall be eliminated. The drilling process shall be controlled to prevent mechanical or metallurgical damage to the rail.

8.3.5 When right-hand and left-hand drilling is specified, at least the minimum quantity of each indicated by the purchaser will be supplied. The excess on any one-end drilling will be applied against the order.

8.3.6 Disposition of rails classified "A" and short rails, with respect to application as right-hand drilled, left-hand drilled, and blank rails, if such categories are specified in the order, shall be established by agreement between the purchaser and the manufacturer.

8.3.7 Disposition of short rails that accrue from left-hand drilled, right-hand drilled, and undrilled (blank) rail production, and which are acceptable in accordance with 8.2.2 shall be established by agreement between the purchaser and the manufacturer.

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8.4 *Finish*:

8.4.1 Rails shall be straightened cold in a press or roller machine to remove twists, waves, and kinks, until they meet the surface and line requirements specified in 8.4.2-8.4.8, as determined by visual inspection.

8.4.2 When placed head up on a horizontal support, rails that have ends higher than the middle will be accepted, if they have a uniform surface upsweep, the maximum ordinate of which does not exceed ¾ in. (19 mm) in any 39 ft (11.9 m).

8.4.3 The uniform surface upsweep at the rail ends shall not exceed a maximum ordinate of 0.025 in. (0.64 mm) in 3 ft (0.9 m) and the 0.025-in. maximum ordinate shall not occur at a point closer than 18 in. (460 mm) from the rail end.

8.4.4 Surface downsweep and droop will not be acceptable.

8.4.5 Deviations of the lateral (horizontal) line in either direction at the rail ends shall not exceed a maximum mid-ordinate of 0.030 in. (0.07 mm) in 3 ft (0.9 m) using a straightedge and 0.023 in. (0.58 mm) maximum ordinate at a point 9 in. (229 mm) from the rail end.

8.4.6 When required, proof of compliance with 8.4.2 shall be determined by string (wire) lining, and a 3-ft (0.9-m) straightedge and taper gage shall be used to determine rail end surface and line characteristics specified in 8.4.3, 8.4.4, and 8.4.5. All ordinate determinations shall be made on the concave side, between the rail surface and the straightedge or stringline.

8.4.7 Rails shall be hot-sawed, cold-sawed, milled, abrasive wheel cut, or ground to length, with a variation in end squareness of not more than 1/32 in. (0.8 mm) allowed. Burrs shall be removed. The method of end finishing rails shall be such that the rail end shall not be metallurgically or mechanically damaged.

8.4.8 If the rail shows evidence of twist while being laid head up on the final inspection bed, it will be checked by inserting a taper or feeler gage between the base and the rail skid nearest the end. If the gap exceeds 0.090 in. (2.29 mm), the rail will be rejected. Alternatively, a twist gage may be used, and, if the rail exceeds 1.5° in 39 ft (11.9 m), the rail will be rejected. Rejected rails may be subject to straightening.

9. Rework

9.1 Rails presented for inspection that do not conform to the requirements of 8.4.1-8.4.8 may be reconditioned by the mill.

10. Classification of Rails

10.1 Rails that do not contain surface imperfections in such number or of such character as will, in the judgment of the purchaser, render them unfit for recognized uses, shall be accepted.

11. Inspection

11.1 The manufacturer shall afford the purchaser's inspector all reasonable facilities necessary to satisfy him that the material is being produced and furnished in accordance with this specification. Mill inspection by the purchaser shall not interfere unnecessarily with the manufacturer's operations. All tests and inspections shall be made at the place of manufacture, unless otherwise agreed upon.

12. Rejection and Rehearing

12.1 Material that fails to conform to the requirements of this specification may be rejected. Rejections shall be reported to the manufacturer or supplier promptly and in writing. In case of dissatisfaction with the test results, the manufacturer or supplier may make claim for a rehearing.

13. Certification

13.1 When specified in the purchase order or contract, a manufacturer's certification shall be furnished to the purchaser that the material was produced and tested in accordance with this specification and has been found to meet the requirements.

13.2 When specified in the purchase order or contract, a report of the chemical and mechanical test results shall be furnished.

13.3 A material Test Report, Certificate of Inspection, or similar document printed from or used in electronic from an electronic data interchange (EDI) transmission shall be regarded as having the same validity as a counterpart printed in the certifier's facility. The content of the EDI transmitted document must meet the requirements of the invoked ASTM standard(s) and conform to any existing EDI agreement between the purchaser and the supplier.

13.4 Notwithstanding the absence of a signature, the organization submitting either a printed document (Material Test Report, Certificate of Inspection or similar document), or an EDI transmission is responsible for the content of the report.

14. Product Marking

14.1 *Branding and Stamping*:

14.1.1 Branding shall be rolled in raised characters at least twice on the side of the web of each rail a minimum of every 16 ft (4.9 m) in accordance with the following requirements:

14.1.1.1 The data and order of arrangement of the branding shall be as shown in Table 5.

14.1.2 The heat number, rail letter, ingot number or strand and bloom, and method of hydrogen elimination (if not shown in brand) shall be hot-stamped into the web of each rail a minimum of 3 times per rail on the side opposite the brand.

14.1.2.1 The stamping data shall be as shown in Table 6.

14.1.2.2 The top rail from each open top ingot shall normally be hot-stamped "A" and succeeding ones "B,"" C," "D," "E," and so forth, consecutively; however, if the top discard is greater than normal, the rail lettering shall conform to the amount of discard, the top rail becoming "B," or other succeeding letter to suit the condition.

14.1.2.3 The top rail from each hot top ingot shall normally be hot-stamped "B" and succeeding ones "C," "D,"" E," and so

TABLE 5 Branding Data

NOTE 1—The design of letters and numerals shall be optional with the manufacturer.

Weight	Section	Method of Hydrogen Elimination (if Indicated in Brand)	Mill Brand	Year Rolled	Month Rolled
136	RE	CC	MFG	1980	111

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TABLE 6 Stamping Data

NOTE 1—The height of letters and numerals shall be ⅝ in. (16 mm).

Heat Number	Rail Letter	Ingot or Strand and Bloom Number	Method of Hydrogen Elimination (if Indicated in Stamping)
287615	ABCDEFG H/PRST	17	BC

forth, consecutively, when agreed upon between the purchaser and the manufacturer.

14.1.2.4 Ingots shall be numbered in order cast.

14.1.2.5 Only the "A," "B," and" C" rails are required to be lettered when the nominal weight per yard is less than 85 lb (42.2 kg/m).

14.1.2.6 The hot-stamping symbols pertaining to hydrogen elimination may be "CC" control cooling of rails, "BC" control cooling of blooms, or "VT" vacuum-treated.

14.1.2.7 Rail from continuous cast blooms shall be identified by a designation for heat number, strand number, and bloom number (Note 2). The rail shall be identified by an alphabetical designation beginning with "P" and succeeding ones "R," "S,"" T," and so forth, consecutively, or any other identification of the position of the rail within the cast as agreed upon between the purchaser and the manufacturer.

NOTE 2—Strand and bloom numbers may be joined at the manufacturer's option.

14.1.2.8 The ⅝-in. (16-mm) stamped characters shall have a flat face (0.040 to 0.060 in. wide) (1.02 to 1.52 mm) with bevels on each side so as not to produce metallurgical stress risers. The letters and numbers shall be on a 10° angle from vertical and shall have rounded corners. The stamping shall be between 0.020 in. (0.51 mm) and 0.060 in. (152 mm) in depth along the center of the web.

14.2 *Classification Marking*:

14.2.1 "A" rails shall be paint-marked yellow.

14.2.2 Rails less than 80 ft (24.4 m) or 39 ft (11.9 m) long shall be paint-marked green.

14.2.3 Paint markings will appear on the top of the head of one end only, at least 3 ft (0.9 m) from the end.

14.2.4 All short-length rails produced shall have the length identified on the top of the head approximately 1 ft from each end.

14.2.5 High-strength rails shall be marked by either a metal plate permanently attached to the neutral axis, hot-stamped, metallized spray-stenciled, or in the brand that gives the manufacturer, type, or method of treatment, or combination thereof. Head-hardened and fully heat-treated rails shall be paint-marked orange and alloy rail shall be paint-marked aluminum.

14.3 *Bar Coding*—The automotive Industry Action Group (AIAG) Bar Code Standard for Primary Metals for Steel Products may be considered as an auxiliary method of identification. Use of this method shall be by agreement between the purchaser and the supplier.

15. Acceptance

15.1 In order to be accepted, the rails offered shall fulfill all of the requirements of this specification.

15.2 The number of "A" rails applied on the purchaser's order will not exceed the percentage of "A" rails obtained by the manufacturer's normal ingot practice.

16. Loading

16.1 Rails shall be handled carefully to avoid damage and shall be loaded in separate cars according to classification, with the branding on all rails facing the same direction, except when the number of rails in a shipment is insufficient to permit separate loading.

17. U.S. Government Procurement

17.1 When specified in the contract or purchase order, material shall be prepared for shipment and storage in accordance with the requirements of Practices A 700.

18. Keywords

18.1 rails; railway applications; steel rails

SUPPLEMENTARY REQUIREMENTS

One or more of the following supplementary requirements shall apply only when specified by the purchaser in the inquiry, contract, or order.

S1. End Hardening

S1.1 The drilled ends may be specified to be end-hardened. When so specified, end-hardening and chamfering shall be in accordance with S1.1.1 through S1.1.7.

S1.1.1 End-hardened rails may be hot-stamped with the letters "CH" in the web of the rail ahead of the heat number.

S1.1.2 Water shall not be used as a quenching medium except in an oil-water or polymer-water emulsion process approved by the purchaser.

S1.1.3 Longitudinal and transverse sections showing the typical distribution of the hardness pattern produced by any proposed process shall, upon request of the purchaser, be submitted to the purchaser for approval before production on the contract is started.

S1.1.4 The heat-affected zone, defined as the region in which hardness is above that of the parent metal, shall cover the full width of the rail head and extend longitudinally a minimum of 1½ in. (38 mm) from the end of the rail. The effective hardness zone ½ in. (13 mm) from the end of the rail shall be at least ¼ in. (6 mm) deep.

S1.1.5 The hardness measured at a spot on the centerline of the head ¼ to ½ in. (6 to 13 mm) from the end of the rail shall show a Brinell hardness number range from 341 to 401 when the decarburized surface has been removed. A report of

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hardness determination representing the product shall be given to the purchaser or his representative.

S1.1.6 The manufacturer reserves the right to retreat any rails that fail to meet the required Brinell hardness number range.

S1.1.7 Chamfering rail ends shall be done to avoid the formation of grinding cracks.

S2. Ultrasonic Testing

S2.1 The rail may be specified to be ultrasonically tested for internal imperfections by the purchaser or manufacturer, subject to the provisions of S2.2 or S2.3.

S2.2 Full length of the rail may be tested using in-line ultrasonic testing equipment provided by the manufacturer except, if agreed between the purchaser and the manufacturer, rails may be tested in accordance with S2.3.

S2.2.1 The rail shall be free from rough surfaces, loose scale, or foreign matter that would interfere with the ultrasonic detection of defects. Testing shall be done when the rail temperature is below 150°F.

S2.2.2 The calibration test rail shall be a full-section rail of the same section as that being tested. The test rail shall be long enough to allow calibration at the same rate of speed as the production rail.

S2.2.3 The size, shape, location, and orientation of calibration references to be placed in the test rail shall be agreed upon between the purchaser and the manufacturer. At least one reference shall be put into the test rail to represent each search unit in the system.

S2.2.3.1 Recommend the following calibration references: head—3⁄32-in. (2.38-mm) flat bottom hole; web—1⁄8-in. (3.18-mm) flat bottom hole; base—1⁄16-in. (1.59-mm) deep by 1⁄4-in. (6.35-mm) long slot.

S2.2.3.2 Any indication equal to or greater than the agreed upon references when scanning the rail at the production speed shall be cause for initial rejection. A record shall be made of each suspect rail. This record shall be available to the purchaser's inspector.

S2.2.4 The calibration rail shall be run through the ultrasonic testing equipment at the start of each 8-h shift or as agreed upon between the purchaser and the manufacturer for shifts that exceed 8 h in duration, and additionally at any section change or at any indication of equipment malfunction. A record shall be maintained by the manufacturer of each time the calibration test rail is run through the test system. This record shall be available to the purchaser's inspector.

S2.2.5 In the event of a calibration failure, all rails processed since the last successful calibration shall be retested.

S2.2.6 The suspect rail may be retested using manual non-destructive testing techniques before final rejection. The testing criteria of the manual nondestructive retesting shall be in accordance with S 2.2.3. The method of inspection shall be agreed upon between the purchaser and the manufacturer.

S2.2.7 Rejected rails shall be cut back to sound metal as indicated by the ultrasonic testing subject to the length restrictions in 8.2. The cut shall be a minimum of 12 in. (304.8 mm) from any indication.

S2.3 *Manual Ultrasonic Test of Web at the Rail Ends for Weld Plant Application:*

S2.3.1 Manual end testing shall be performed using standard ultrasonic testing equipment acceptable to the purchaser and the manufacturer.

S2.3.2 The search unit shall be a standard dual-element crystal or similar transducer acceptable to the purchaser and the manufacturer.

S2.3.3 The calibration test block shall be of the following characteristics: Material 4340 AISI Steel/Nickel plated, manufactured in accordance with Practices E 127 and E 428. As an alternate, reference standards may be fabricated from a section of rail as agreed upon between the purchaser and the manufacturer.

S2.3.4 Dimensions of the calibration test block and calibration references shall be agreed upon between the purchaser and the manufacturer. (For calibration reference, the recommended thickness of the block should approximate the thickness of the rail web.)

S2.3.5 Calibration of the instrument shall be performed before the commencement of testing, every 100 rail ends thereafter, and after any test delay exceeding 30 min.

S2.3.6 When the search unit is coupled to the calibration test block, the indication height from the calibration reference shall serve as a reference level for the test. (Recommended reference levels should appear from 40 to 80 % of the maximum height on the cathode ray tube graticule.)

S2.3.7 Couplant shall be distributed over the entire web area at least 12 in. from the end of the rail and the search unit moved over the entire area in vertical or horizontal sweeps, or both.

S2.3.8 An indication equal to or exceeding the reference level shall be cause for rejection.

S2.3.9 Rejected rails may be cut back to sound metal as indicated by the ultrasonic testing, subject to the length restrictions in 8.2.

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