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Standard Specification for Wrought Carbon Steel Wheels[1]

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1. Scope

1.1 This specification covers one-wear, two-wear, and multiple-wear wrought carbon steel wheels for locomotives and cars, designated Class U, untreated, and Classes L, A, B, and C, heat-treated, wheels.

1.2 The service for which the various classes are intended is as follows:

1.2.1 Class B or C wheels shall be used for freight cars in interchange service.

1.2.2 Class B or C wheels are recommended for use on locomotives.

1.2.3 For passenger car service, the various classes are intended generally as follows:

1.2.3.1 *Class L*—High speed with more severe braking conditions than other classes and light wheel loads.

1.2.3.2 *Class A*—High speed with more severe braking conditions, but moderate wheel loads.

1.2.3.3 *Class B*—High speed service with severe braking conditions and heavier wheel loads.

1.2.3.4 *Class C*—(*1*) Service with light braking conditions and heavier wheel loads.

1.2.3.5 *Class C*—(*2*) Service with heavier braking conditions where off-tread brakes are employed.

1.2.4 *Class U*—Wheels may be used in service in which the wheel load and braking are low.

1.3 The use of two-wear wheels is recommended for freight car service.

1.4 The values stated in inch-pound units are to be regarded as the standard.

1.5 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*

E 59 Practice for Sampling Steel and Iron for Determination of Chemical Composition[2]

E 350 Test Methods for Chemical Analysis of Carbon Steel, Low-Alloy Steel, Silicon Electrical Steel, Ingot Iron, and Wrought Iron[2]

E 415 Test Method for Optical Emission Vacuum Spectrometric Analysis of Carbon and Low-Alloy Steel[3]

E 1019 Test Methods for Determination of Carbon, Sulfur, Nitrogen, and Oxygen in Steel and in Iron, Nickel, and Cobalt Alloys[3]

2.2 *SAE Documents:*

SAE J 442 Test Strip, Holder and Gage for Shot Peening[4]

SAE J 443 Recommended Practice for Procedures for Using Standard Shot Peening Test Strip[4]

SAE J 827 Recommended Practice for Cast Steel Shot[4]

2.3 *Military Standard:*

MIL-S-13165B Shot Peening of Metal Parts[5]

2.4 *AAR Standard:*

AAR Wheel and Axle Manual, Section G, M-107[6]

NOTE 1—The tables of tape sizes may be referred to in the AAR Wheel and Axle Manual, Section G, Part 2.

3. Ordering Information

3.1 Orders for wheels under this specification shall include the following information as appropriate:

3.1.1 Quantity (number of pieces),

3.1.2 Class (see Table 1),

3.1.3 Full identification of wheel design, including tread and flange contour, and dimensional drawing if required,

3.1.4 Rough bore size,

3.1.5 Intended service (see Section 1),

[1] This specification is under the jurisdiction of ASTM Committee A-1 on Steel, Stainless Steel, and Related Alloys and is the direct responsibility of Subcommittee A01.06 on Steel Forgings and Billets.

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[2] *Annual Book of ASTM Standards*, Vol 03.05.

[3] *Annual Book of ASTM Standards*, Vol 03.06.

[4] Available from the Society of Automotive Engineers, Inc., 400 Commonwealth Drive, Warrendale, PA 15096.

[5] Available from Standardization Documents Order Desk, Bldg. 4 Section D, 700 Robbins Ave., Philadelphia, PA 19111-5094, Attn: NPODS.

[6] Available from Association of American Railroads, 50 "F" St., Washington, DC 20001.

TABLE 1 Chemical Requirements

	Composition, %
Carbon:	
Class U	0.65–0.77
Class L, max	0.47
Class A	0.47–0.57
Class B	0.57–0.67
Class C	0.67–0.77
Manganese	0.60–0.85
Phosphorus, max	0.05
Sulfur, max	0.05
Silicon, min	0.15

3.1.6 ASTM designation and date of issue, and

3.1.7 Supplementary requirements (if any).

4. Manufacture

4.1 The steel shall be made by any of the following processes: open-hearth, electric-furnace, or basic-oxygen process.

4.2 *Discard*—Sufficient discard shall be made from each ingot to ensure freedom from piping and undue segregation.

4.3 *Temperatures*—During the manufacture, necessary care in the regulation of temperature gradients shall be exercised to obtain the physical properties to be expected from the chemical composition and mechanical work and to prevent the development of faulty structure. Immediately after the last hot fabricating operation (coning or dishing), all wheels shall be allowed to cool to a temperature below the critical range. The cooling shall be controlled to prevent injury by too rapid cooling below the critical range.

5. Heat Treatment

5.1 For Classes L, A, B, and C wheels, the heat treatment shall consist of treatment of the rim only.

5.2 *Rim-Quenching Treatment*—The wheels shall be reheated uniformly to the proper temperature to refine the grain and then the rims shall be quenched. Following quenching, the wheels shall be charged into a furnace for tempering to meet the requirements of Section 12, and subsequently cooled under controlled conditions.

6. Shot Peening

6.1 *Scope*—The plate surfaces of all wheels shall be shot-peened in accordance with the following requirements:

6.2 *Requirements*:

6.2.1 *Shot*—The shot shall be SAE No. 550 or larger hardened steel as specified in SAE Recommended Practice J 827.

6.2.2 *Shot Size Control*—The peening machines shall be equipped with a separator for continuously removing broken shot. Sufficient new shot shall be added to ensure that a minimum of 85 % of No. 550 or larger shot is maintained in the machines at all times.

6.2.3 *Peening Intensity*—The peening intensity shall be sufficient to produce an average arc height of not less than 0.008 Almen C-2 on the front plate near the hub fillet and on the back plate near the rim fillet of wheels of the standard design, and at back plate hub fillet and front plate rim fillet of the reverse plate design. The area to be peened is defined as the plate area extended approximately one half of the way into the hub and rim fillet radii on the front and on the back of the wheel.

6.2.4 *Arc Height Measurement*—Measurements of arc height shall be made in accordance with SAE Standard J 442 or SAE Recommended Practice J 443.

6.2.5 *Coverage*—The minimum peening time shall be sufficient to ensure that full coverage is attained on the Almen C strip as defined in the Alternate Procedure of SAE Recommended Practices J 443, or MIL-S-13165B, Paragraph 6.11.

6.2.6 *Sequence*—Shot peening shall be performed on all wheels and after any corrective surface preparation in the plate area. Plate area is defined in 6.2.3. Peening may be performed prior to inspection.

6.2.7 *Portable Peeners*—A portable peening device may be used to re-peen small reconditioned areas (no larger than about 2 by 3 in. (50.8 by 76.2 mm)) on wheel plate surfaces excluding the critical fillet areas (front hub and back rim). The portable equipment must be capable of peening an Almen C-2 Strip to develop the required average arc height of not less than 0.008 in. (0.203 mm) with a reasonable time of peening. Peening time of wheel plates must be at least as long as the time required to develop the 0.008-in. arc height. The equipment must be tested on an Almen C Strip each 8-h shift that the portable peener is used. A record of the Almen C test results shall be maintained.

6.3 *Quality Assurance Provisions*:

6.3.1 *Wheel Surface Condition*—The peened appearance of rim and hub shall not be cause for rejection.

6.3.2 *Frequency of Test*—Arc height determinations shall be made on Almen strips attached to a test wheel at the beginning and end of each production run but not less than once in each eight operating hours.

6.3.3 *Retest*—If a test fails to meet the arc height requirements of 0.008 Almen C-2, two retests shall be made. These retests shall be averaged with the first determination. The average shall be not less than 0.008 and no more than one value of the three shall be less than 0.008.

6.3.4 *Repeening*—When test values fail to meet the provisions of 6.3.3, corrective action shall be initiated and satisfactory test values secured before proceeding with production peening. If the average Almen value of the unsatisfactory test is 0.006 or 0.007, the last half of the wheels peened prior to the unsatisfactory test, but subsequent to a satisfactory test, shall be repeened with at least ½ exposure time. If the average Almen value is less than 0.006, all the wheels peened since the last satisfactory test shall be repeened with full exposure.

7. Retreatment

7.1 Any wheel failing to meet the requirements of Section 12 may be retreated and tested in accordance with 12.1 and 12.2.

8. Mating

8.1 Wheels shall be measured and marked to the lower tape number until the next graduation is reached. Wheels shall be shipped in pairs of the same measured tape size.

9. Permissible Variations

9.1 The wheels shall conform to the permissible dimension variations specified in Table 2. When the permissible dimension variations in Table 2 allow a certain percentage of the wheels to vary by a given amount from standard dimensions for tape size, the percentage of such wheels shipped by any manufacturer shall not exceed this percentage during a calendar year. No individual purchaser may receive more than this percentage in daily shipments of such wheels except by agreement with the manufacturer.

10. Finish

10.1 Wheels shall be rough bored and shall not have black spots in the rough bore. The front hub face of wheels (1-W, 2-W, and M-W) shall be parallel to the plane of the vertical reference line and may be smooth forged or machined. The back hub face may be smooth forged or machined.

10.2 Wheels shall be machined and finished smooth without excessive tool chatter.

10.3 Wheels shall be given a thorough surface examination and gaging at the place of manufacture before being offered for inspection. They shall have a workmanlike finish and must be free of conditions likely to develop in or cause removal from service.

10.4 Wheels shall not be covered with any substance to such an extent as to hide defects.

10.5 "As forged'' surfaces shall be free of abrupt changes in section or grooves and in a clean condition free of scale prior to final inspection. Where corrective machining or grinding has been employed, such surfaces shall not exceed a roughness of 500 µin. (12.7 µm) prior to final shot peening, and a uniform transition from the machined or ground surface into the plane of the "as forged'' surface must be provided.

11. Chemical Requirements

11.1 *Heat or Cast Analysis*:

11.1.1 The steel shall conform to the requirements for chemical composition shown in Table 1.

11.1.2 An analysis of each heat or cast of steel shall be made by the manufacturer to determine the percentages of the elements specified in Table 1. This analysis shall be made from a test sample taken preferably during the pouring of the heat. The chemical composition thus determined, together with such

TABLE 2 Permissible Variations in Wheel Dimensions

Wheel Dimensions	Narrow Flange Type		Wide Flange Type	
	in.	mm	in.	mm
Flange:				
Height of flange	+1/16 −0	+1.6 −0	+1/16 −0	+1.6 −0
Thickness of flange	+1/16 −0	+1.6 −0	+1/32 −3/32	+0.8 −2.4
Radius of throat	±1/16	±1.6	±1/16	±1.6
Rim:				
Tape sizes, less than 44 in. (1.18 m)	+14 −0[A]	+14 −0[A]	+14 −0[A] 5 % −5[B]	+14 −0[A] 5 % −5[B]
Inside diameter (back face of rim)				
(x) maximum governed by rim thickness and tape size	(x) − 3/8	(x) −9.5	(x) −3/8	(x) −9.5
Inside diameter (front face of rim)				
Maximum variation from back face diameter	+0 −1/4 [C]	+0 −6.4 [C]	±1/4 [D]	±6.4 [D]
Thickness of rim (measured with AAR steel wheel gage, or equivalent)				
Corner at inside diameter of back rim face, radius, max (sharp corner preferable)	1/8	3.2	1/8	3.2
Rotundity, opening in ring gage, max	1/32	0.8	1/32	0.8
Width of rim	±1/8	±3.2	±1/8	±3.2
Plane of back face, distance from straightedge:				
Over entire rim face, max	. . .	. . .	1/16	1.6
Over rim face more than 1¼ in. (31.8 mm) from inside edge, max	1/32	0.8	. . .	. . .
Plate:				
Thickness of plate (may vary)	−0	−0	−0	−0
Hub:				
Diameter of hub	+1 −0	+25.4 −0	+1 −0	+25.4 −0
Wall thickness maximum variations:				
Outer surface machined	1/8	3.2	. . .	. . .
Not machined	3/8	9.5	3/8	9.5
Length of hub	±1/8	±3.2	±1/4	±6.4
Depression of hub:				
Back rim face to front hub face	+0 −1/8	+0 −3.2	+0 −1/4	+0 −6.4
Projection of hub (back rim face to back hub face)	±1/8	±3.2	±1/4	±6.4
Bore:				
Diameter of bore:				
Rough bore (finished bore not specified)	+1/16 −1/8	+1.6 −3.2	+1/16 −1/8	+1.6 −3.2
Rough bore (¼ in. (6.4 mm) less than finished bore)	+1/16 −1/8	+1.6 −3.2	+1/16 −1/8	+1.6 −3.2
Eccentricity of bore—between rough bore and tread, max	1/16[E]	1.6[E]	1/16[E]	1.6[E]

[A] Tape sizes are not in inches or millimetres. The tables of tape sizes may be referred to in the Wheel and Axle Manual of the Association of American Railroads, latest edition.

[B] No shipment shall exceed this percentage except by agreement with the manufacturer.

[C] Not less than specified and in any one wheel shall not vary more than 1/8 in. (3.2 mm).

[D] Ninety-five percent shall not be less than specified. Five percent may be 1/8 in. (3.2 mm) less than specified. One hundred percent shall not vary more than 1/8 in. (3.2 mm) on any two radii in any one wheel.

[E] 5 % of wheels delivered may be over 1/16 in. (1.6 WM) total dial indicator reading (TDIR), and these must not exceed 3/32 in. (2.4 mm) TDIR.

identifying records as may be desired, shall be reported to the purchaser or his representative and shall conform to the requirements specified in Table 1.

11.2 *Chemical Analysis*—Chemical analysis of each heat of steel shall be made by one of the following test methods. All analyses should note which test method is used for the carbon or chemical determinations, or both.

11.2.1 *Test Method I*—Apply one of the procedures given below in 11.2.1.1 through 11.2.1.3 to determine total carbon:

11.2.1.1 Total carbon by the combustion gravimetric method, Test Method E 350;

11.2.1.2 Total carbon by the combustion thermal conductivity method, Test Methods E 1019; or

11.2.1.3 Total carbon by combustion, followed by quantitative infrared analysis, Test Methods E 1019, or report the standardization method used.

11.2.2 *Test Method II*—Use Test Method E 415.

11.3 *Product Analysis*—An analysis may be made by the purchaser from a wheel block or from a finished wheel selected from each heat by the purchaser's representative. The chemical composition thus determined shall conform to the requirements specified in Table 1, with a permissible carbon variation of −0.02 or +0.03 percentage points. Samples from wheel blocks shall be drilled from the end of the block midway between the center and outside. When a finished wheel is used, the sample shall be obtained from the rim face or the hub in a manner that will not impair the usefulness of the wheel. No drilling of the finished wheel plate shall be permitted. Each sample from any one block or wheel shall be thoroughly mixed together and shall be clean, and free of scale, oil, and other foreign substances. Total carbon shall be determined in accordance with 11.2.1 above.

11.4 *Sampling Method*—When wheel blocks or when whole wheels are not available for chemical analysis, the laboratory conducting the chemical analysis shall follow a standard sampling method. This standard method of sampling shall be Practice E 59, used in conjunction with Test Methods E 350, E 415, or E 1019 for chemical analysis (see 11.2).

12. Mechanical Requirements

12.1 The Brinell hardness of the rim, when measured in accordance with the requirements of 12.2, shall show the values as listed in Table 3.

12.2 *Method of Measurement*—Measurement shall be made on the front face of the rim with the edge of the impression not less than 3⁄16 in. (4.8 mm) from the radius joining face and tread. Before making the impression, any decarburized metal shall be removed from the front face of the rim at the point chosen for measurement. The surface of the wheel rim shall be properly prepared to permit accurate determination of hardness.

TABLE 3 Rim Hardness Values

Class	Minimum Hardness, HB	Maximum Hardness, HB
L	197	277
A	255	321
B	277	341
C	321	363

12.3 *Number of Tests*:

12.3.1 Where continuous heat-treating furnaces are used, Brinell hardness measurements shall be made on 10 % of the wheels from each heat. Where batch-type heat-treating furnaces are used, Brinell hardness measurements shall be made on 10 % of the wheels from each heat-treatment lot, provided that at least one wheel is selected for test from each heat represented in the heat treatment lot. For either process, when there are less than 20 wheels from a heat, a minimum of two wheels shall be checked for hardness except when there is only one wheel from a heat, in which case a Brinell hardness measurement shall be made on the one wheel.

12.3.2 If all the wheels tested meet the requirements of Section 12, all of the wheels represented shall be accepted.

12.3.3 If any wheel tested fails to meet the requirements of Section 12, it shall be checked by making two additional hardness measurements, one on each side of the point first measured and each approximately 1 in. (25.4 mm) from that point. If both of these check measurements meet the requirements of Section 12, the wheel shall be considered to have met the requirements of Section 12.

12.3.4 When continuous heat-treating furnaces are used, should any of the wheels tested fail on check test to meet the requirements of Section 12, the manufacturer may test for individual hardness measurements all of the wheels of that heat in the lot submitted for inspection and those meeting the requirements of Section 12 shall be accepted. Where batch heat-treating furnaces are used, should any of the wheels tested fail on check test to meet the requirements of Section 12, the manufacturer may test all of the wheels in the heat-treatment lot for individual hardness measurement and those meeting the requirements of Section 12 shall be accepted.

13. Inspection

13.1 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 inspection shall be made at the place of manufacture, unless otherwise agreed.

13.2 The purchaser may make tests to govern the acceptance or rejection of the wheels in his own laboratory or elsewhere. Such tests shall be made at the expense of the purchaser.

13.3 The gages and tapes shall conform to and be used as required by the standards of the Mechanical Division, Association of American Railroads.

NOTE 2—The tables of tape sizes may be referred to in the Wheel and Axle Manual of the Association of American Railroads, effective Oct. 1, 1978.

13.4 *Ultrasonic Examination*—For detecting internal discontinuities in the rims of all steel wheels, ultrasonic inspection shall be made by following the procedures and by using equipment that complies with the following requirements:

13.4.1 *Equipment*: