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STANDARD SPECIFICATIONS

FOR

QUENCHED-AND-TEMPERED CARBON-STEEL AXLES, SHAFTS, AND OTHER FORGINGS FOR LOCOMOTIVES AND CARS[1]

A.S.T.M. Designation: A 19 – 36

These specifications are issued under the fixed designation A 19; the final number indicates the year of original adoption as standard or, in the case of revision, the year of last revision.

ADOPTED, 1911; REVISED, 1912, 1914, 1916, 1918, 1921, 1927, 1936.

Scope.

1. When used for forgings for locomotives, these specifications cover quenched-and-tempered carbon-steel driving axles, engine and trailing-truck axles, main and side rods, straps, crank pins and piston rods.

MANUFACTURE

Process.

2. The steel shall be made by either or both the following processes: open-hearth or electric-furnace.

Discard.

3. A sufficient discard shall be made from each ingot to secure freedom from injurious piping and undue segregation.

Prolongation for Tests.

4. Unless otherwise specified, for test purposes at least 20 per cent of the forgings shall be provided with prolongations or, at the manufacturer's option, a forging may be selected.

Boring.

5. (*a*) Unless otherwise specified by the purchaser, all axles, shafts and similar forgings having a minimum diameter over 7 in. shall be bored. The boring shall be done before quenching.

(*b*) In the case of boring, the diameter of the hole, unless otherwise specified, shall be at least 20 per cent of the minimum outside diameter of the forging, exclusive of collars and flanges.

Heat Treatment.

6. The procedure to be followed in quenching and tempering shall consist in allowing the objects, immediately after forging, to cool to a temperature below the critical range, under suitable conditions to prevent injury by too rapid cooling. They shall then be uniformly reheated to the proper temperature to refine the grain

[1] Under the standardization procedure of the Society, these specifications are under the jurisdiction of the A.S.T.M. Committee A-1 on Steel.

(a group thus reheated being known as a "quenching charge"), and quenched in some medium under substantially uniform conditions for each quenching charge. Finally, they shall be uniformly reheated to the proper temperature for tempering or "drawing back" (a group thus reheated being known as a "tempering charge"), and allowed to cool uniformly.

CHEMICAL PROPERTIES AND TESTS

Chemical Composition.

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

Carbon	First Class by Size	0.25 – 0.60 per cent
	Second " " "	0.35 – 0.60 "
	Third " " "	0.35 – 0.65 "
	Fourth " " "	0.35 – 0.70 "
Manganese		0.40 – 0.70 "
Phosphorus		not over 0.05 "
Sulfur		" " 0.05 "

Ladle Analyses.

8. An analysis of each melt of steel shall be made by the manufacturer to determine the percentages of the elements specified in Section 7. This analysis shall be made from a test ingot taken during the pouring of the melt. The chemical composition thus determined shall be reported to the purchaser or his representative, and shall conform to the requirements specified in Section 7.

Check Analyses.

9. (*a*) An analysis may be made by the purchaser from a forging representing each melt. The chemical composition thus determined shall conform to the requirements specified in Section 7. Drillings for analysis may be taken from the forging or from a full-size prolongation of the same, at any point midway between the center and surface of solid forgings, and at any point midway between the inner and outer surfaces of the wall of bored forgings; or turnings may be taken from a test specimen.

(*b*) In addition to the complete analysis specified in Paragraph (*a*), a phosphorus determination may be made by the purchaser from each broken tension test specimen. The phosphorus content thus determined shall conform to the requirement specified in Section 7.

PHYSICAL PROPERTIES AND TESTS

Tension Tests.

10. (*a*) The forgings shall conform to the minimum requirements as to tensile properties specified in Table I.

(*b*) The classification by size of the forging shall be determined by the specified diameter or thickness which governs the size of the prolongation from which the test specimen is taken.

(*c*) The elastic limit called for by these specifications shall be determined by an extensometer reading to 0.0002 in. The extensometer shall be attached to the specimen at the gage marks and not to the shoulders of the specimen nor to any part of the testing machine. When the specimen is in place and the extensometer attached, the testing machine shall be operated so as to increase the load on the specimen at a uniform rate. The observer shall watch the elongation of the specimen as shown by the extensometer and shall note, for this determination, the load at which the rate of elongation shows a sudden increase. The extensometer shall then be removed from the specimen, and the test continued to determine the tensile strength.

TABLE I.—TENSILE REQUIREMENTS FOR FORGINGS HAVING A MAXIMUM OUTSIDE DIAMETER OR THICKNESS OF NOT OVER 10 IN. WHEN SOLID, OR NOT OVER 20 IN. WHEN BORED.

Size	Tensile Strength, lb. per sq. in.	Elastic Limit, lb. per sq. in.	Elongation in 2 in., per cent		Reduction of Area, per cent	
			Inverse Ratio	Not under	Inverse Ratio	Not under
Up to 4 in. in outside diameter or thickness, 2-in. max. wall	90 000	55 000	$\frac{2\,100\,000}{\text{Tens. str.}}$	20.5	$\frac{4\,000\,000}{\text{Tens. str.}}$	39
Over 4 to 7 in. in outside diameter or thickness, 3½-in. max. wall	85 000	50 000	$\frac{2\,000\,000}{\text{Tens. str.}}$	20.5	$\frac{3\,800\,000}{\text{Tens. str.}}$	39
Over 7 to 10 in. in outside diameter or thickness, 5-in. max. wall	85 000	50 000	$\frac{1\,900\,000}{\text{Tens. str.}}$	19.5	$\frac{3\,600\,000}{\text{Tens. str.}}$	37
Outside diameter or thickness not over 20 in., 5 to 8-in. wall	82 500	48 000	$\frac{1\,800\,000}{\text{Tens. str.}}$	19	$\frac{3\,400\,000}{\text{Tens. str.}}$	36

(*d*) Tests of forgings shall be made only after final treatment.

Bend Tests.

11. If specified by the purchaser, bend tests shall be made as follows:

(*a*) For the first and second classes by size, the test specimen shall stand being bent cold through 180 deg. around a pin 1 in. in diameter, without cracking on the outside of the bent portion.

(*b*) For the third and fourth classes by size, the test specimen shall stand being bent cold through 180 deg. around a pin 1½ in. in diameter, without cracking on the outside of the bent portion.

Proof Tests.

12. Unless otherwise specified by the purchaser, all forgings shall be subjected to an impact proof test. The details of this test shall be agreed upon by the manufacturer and the purchaser.[1]

Test Specimens.

13. (*a*) Tension and bend test specimens shall be taken from a full-size prolongation of any forging. For forgings with large ends or collars the prolongation may be of the same cross-section as that

[1] For information relative to proof tests of finished forgings, see Appendix, p. 200.