



Standard Specification for Forgings, Carbon and Alloy Steel, for Railway Use¹

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1. Scope

1.1 This specification covers eight grades of untreated and heat-treated carbon steel forgings and six grades of heat-treated alloy steel forgings for railway use.

NOTE 1—It is recommended, when semi-finished steel is desired to process these forgings, that the latest issue of ASTM Specification A 711, for Carbon and Alloy Steel Blooms, Billets, and Slabs for Forging,² be used. This will enable the forger to select semi-finished material of such chemistry as he desires.

NOTE 2—Railway axles are covered by Specification A 21.

1.2 The grades of carbon steel forgings and the purposes for which they are frequently used are as follows, the choice depending on design and stress or service to be imposed:

1.2.1 *Grade A* is untreated and is mostly used for drop forgings and parts of minor importance, and those which are to be case hardened.

1.2.2 *Grade B* is untreated and is used for a general group of miscellaneous ordinary forgings where heat treatment is not deemed necessary.

1.2.3 *Grade C* is annealed, normalized, or normalized and tempered.

1.2.4 *Grade D* is annealed, normalized, or normalized and tempered.

1.2.5 *Grade E* is normalized and tempered.

1.2.6 *Grade F* is double normalized and tempered.

1.2.7 *Grade G* is quenched and tempered.

1.2.8 *Grade H* is normalized, quenched, and tempered.

1.2.9 *Grades E, F, G, and H* forgings are used in high-duty service on locomotives, cars, and other equipment.

1.3 The grades of alloy steel forgings are as follows:

1.3.1 *Grades I, J, and K* are normalized and tempered.

1.3.2 *Grades L, M, and N* are normalized, quenched, and tempered, and are used in heavy-duty service on locomotives, cars, and special equipment.

NOTE 3—The forgings described above were formerly designated as follows:

Current Grade	Former Designation and Grade
A	A 236, A
B	A 236, B
C	A 236, C
D	A 236, D
E	A 236, E
F	A 236, F
G	A 236, G
H	A 236, H
I	A 238, A
J	A 238, B
K	A 238, C
L	A 238, D
M	A 238, E
N	A 238, F

1.4 Supplementary Requirements (Sections S1 to S5) of an optional nature are provided. These shall apply only when specified by the purchaser.

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

2. Referenced Documents

2.1 ASTM Standards:

A 21 Specification for Carbon Steel Axles, Non-Heat-Treated and Heat-Treated, for Railway Use²

A 370 Test Methods and Definitions for Mechanical Testing of Steel Products³

A 711 Specification for Steel Forging Stock⁴

E 112 Test Methods for Determining the Average Grain Size⁵

E 381 Method of Macroetch Testing Steel Bars, Billets, Blooms, and Forgings⁵

3. Ordering Information

3.1 The purchaser shall specify in the inquiry, contract, and order the grade of steel desired, and any restrictive modifications of this specification.

3.2 Supplementary requirements are provided and shall apply only when specified in the purchase order.

4. Manufacture

4.1 *Melting Process*—The steel shall be made by one or more of the following processes: open-hearth, basic-oxygen, or electric-furnace.

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² Annual Book of ASTM Standards, Vol 01.04.

³ Annual Book of ASTM Standards, Vol 01.03.

⁴ Annual Book of ASTM Standards, Vol 01.05.

⁵ Annual Book of ASTM Standards, Vol 03.01.



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

4.3 *Forging Practice*—The forgings may be made direct from the ingot or from blooms. The total reduction from ingot or strand cast bloom to forging shall not be less than 3 to 1, unless otherwise specified.

4.4 *Cooling and Heating:*

4.4.1 After carbon steel blooms are produced, they shall be allowed to cool uniformly and shall not be subject to contact with water or drafts.

4.4.2 After alloy steel blooms are produced, they shall be cooled in closed containers, hoods, or furnaces.

4.4.3 Blooms shall be reheated for forging in a manner that will prevent internal bursts and overheating.

4.4.4 Forgings (Grades C through N) shall be slow cooled in closed containers, covered conveyors, or hoods. If forgings (Grades C through N) are heat treated directly from forging, they shall be slow cooled following the final heat treatment.

4.4.5 Forgings (Grades C through N) that are heat treated directly from forging (1) shall be cooled below the transformation temperature or to approximately 1000°F (538°C) before any reheating operation, and (2) must not be permitted to cool below 500°F (260°C) without slow cooling as defined in 4.4.4.

NOTE 4—As the temperature of the forgings approaches the minimum of 500°F (260°C) a supplemental heat source may be necessary to assure an effective slow cooling cycle.

4.4.6 When properly vacuum degassed steel is used, the slow cooling requirements of 4.4.2, 4.4.4 and item (2) of 4.4.5 may be omitted, but forging blooms must then be pile cooled.

4.5 *Boring:*

4.5.1 Boring, if specified under Supplementary Requirement S5, shall be performed before normalizing or quenching in the case of normalized and tempered or quenched and tempered forgings, and before either normalizing or quenching, in the case of normalized, quenched, and tempered forgings.

4.5.2 For quenched and tempered forgings or normalized, quenched and tempered forgings it is recommended, but not mandatory, that all forgings over 7 in. (178 mm) in diameter be bored.

4.5.3 For carbon steel no solid forgings over 10 in. (254 mm) in diameter and no forgings over 8 in. (203 mm) in wall thickness shall be liquid quenched under this specification.

4.5.4 In bored forgings, the diameter of the hole shall be a matter of agreement between the manufacturer and the purchaser.

4.6 *Heat Treatment:*

4.6.1 Forgings for heat treatment shall be reheated gradually and uniformly to the proper temperature to refine the grain and shall be held at this temperature for a sufficient time to effect the desired change.

4.6.2 *Annealing*—After heating to a suitable temperature the forgings shall be allowed to cool slowly and uniformly. A furnace charge thus treated is termed an annealing charge.

4.6.3 *Normalizing*—After heating to a suitable temperature, the forgings shall be withdrawn from the furnace and allowed to cool uniformly in air. A furnace charge thus treated is termed a normalizing charge. Cooling may be accelerated by increased air circulation, which must be controlled to provide reasonably uniform cooling.

4.6.4 *Double Normalizing*—The procedure shall consist of two separate heat treatments. The second treatment shall be performed at a lower temperature than the first. A furnace charge thus treated is termed a double-normalizing charge. Cooling may be accelerated by increased air circulation, which must be controlled to provide reasonably uniform cooling.

4.6.5 *Quenching*—After heating to a suitable temperature, the forgings shall be quenched in a suitable medium under reasonably uniform conditions. A furnace charge thus treated is termed a “quenching charge.”

4.6.6 *Tempering*—Forgings shall be reheated gradually to, and held at, a suitable temperature below the critical range and shall then be allowed to cool under suitable conditions. A furnace charge thus treated is termed a “tempering charge.”

4.6.7 Heat treatment may be performed in either batch-type furnaces or continuous furnaces.

4.7 *Straightening:*

4.7.1 Straightening of forgings shall be done before machining and in such a manner as to leave the surface free of injurious scars.

4.7.2 Straightening preferably shall be performed at a temperature no lower than 950°F (510°C). Straightening performed at temperatures lower than 950°F shall be followed by stress relieving or applicable heat treatment.

5. Chemical Requirements

5.1 *Composition:*

5.1.1 Carbon steel (Grades A through H) shall conform to the requirements for chemical composition prescribed in Table 1.

5.1.2 Alloy steel (Grades I through N) shall conform to the following requirements for chemical composition:

Phosphorus 0.045 max
Sulfur 0.050 max

TABLE 1 Chemical Requirements for Carbon Steels

Elements	Composition, %				Grades G and H
	Grade A	Grade B	Grades C, D, and E	Grade F	
Carbon	0.15 max	0.15–0.25	0.40–0.55	0.45–0.59	...
Manganese	0.30–0.60	0.30–0.60	0.60–0.90	0.60–0.90	0.60–0.90
Phosphorus, max	0.045	0.045	0.045	0.045	0.045
Sulfur, max	0.050	0.050	0.050	0.050	0.050
Silicon, min	...	...	0.15	0.15	0.15