



Designation: A649/A649M – 09

## Standard Specification for Forged Steel Rolls Used for Corrugating Paper Machinery<sup>1</sup>

This standard is issued under the fixed designation A649/A649M; 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 ( $\epsilon$ ) indicates an editorial change since the last revision or reapproval.

### 1. Scope\*

1.1 This specification<sup>2</sup> covers two kinds of rolls used in machinery for producing corrugated paperboard. Rolls are fabricated of forged bodies and trunnions. The trunnions may be bolted or shrink assembled on one or both ends of the body. A seal weld may be made at the body/trunnion interface. Roll shells are made of carbon/manganese, or low alloy steel as hereinafter described, and are heat treated prior to assembly. Pressure rolls may be ordered surface hardened as Condition H, or without surface hardening as Condition S. Provision is made in Supplementary Requirement S1 for the optional surface hardening of corrugating rolls.

1.2 Corrugating and pressure rolls made to this specification shall not exceed 30 in. [760 mm] in inside diameter. The wall thickness of the roll body shall not be less than  $\frac{1}{12}$  of the inside diameter or 1 in. [25 mm], whichever is greater, but shall not exceed 4 in. [100 mm]. The wall thickness of the corrugating roll is measured at the bottom of the corrugations in the location of the trunnion fit. The maximum design temperature (MDT) of the roll is 600°F [315°C] and the maximum allowable working pressure (MAWP) is 250 psi [1.7 MPa]. The minimum design temperature shall be 40°F [4°C] for roll wall thicknesses up to 3 in. [75 mm]. For roll wall thicknesses over 3 in. [75 mm] to 4 in. [100 mm], the minimum design temperature shall be 120°F [50°C]. The maximum stresses on the roll bodies from the combined internal and external loading are limited to 18 750 psi [129 MPa] for the Class 2 pressure roll bodies, and 20 000 psi [138 MPa] for Class 1A, 1B, or 5 pressure or corrugating roll bodies in Grades 1 or 2. For the trunnions, the maximum stresses from the combined internal and external loading are limited to 15 000 psi [103.4 MPa] for Classes 3 or 4, or 20 000 psi [138 MPa] for Classes 1A, 1B, or 5 in Grade 2 only. The Grade 1 strength level is not permissible for trunnions.

1.3 Referring to [Table 1](#), material to Classes 1A, 1B, or 5 shall be used for the manufacture of corrugating or pressure

roll shells, and Class 2 shall be used only for pressure roll shells. Trunnions shall be made from forgings in Classes 1A, 1B, or 5 in Grade 2 strength level as restricted by Footnote B in [Table 2](#) or in forgings in either Class 3 or 4.

1.4 The values stated in either SI units or inch-pound units are to be regarded separately as standard. The values stated in each system may not be exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in non-conformance with the standard.

1.5 Unless the order specifies the applicable “M” specification designation, the material shall be furnished to the inch-pound units.

1.6 Except as specifically required in this standard, all of the provisions of Specification [A788/A788M](#) apply.

### 2. Referenced Documents

#### 2.1 ASTM Standards:<sup>3</sup>

[A275/A275M Practice for Magnetic Particle Examination of Steel Forgings](#)

[A370 Test Methods and Definitions for Mechanical Testing of Steel Products](#)

[A788/A788M Specification for Steel Forgings, General Requirements](#)

[E165 Practice for Liquid Penetrant Examination for General Industry](#)

### 3. Ordering Information

3.1 Material supplied to this specification shall conform to the requirements of Specification [A788/A788M](#), which outlines additional ordering information, manufacturing requirements, testing and retesting methods and procedures, marking, certification, product analysis variations and additional supplementary requirements.

3.2 In addition to the ordering requirements of Specification [A788/A788M](#), the purchaser shall include the maximum design temperature (MDT), if lower than 600 °F [315 °C], and the maximum allowable working pressure (MAWP), if lower than 250 psi [1.7 MPa] as allowed in 1.2 of the Scope.

<sup>1</sup> This specification is under the jurisdiction of ASTM Committee A01 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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<sup>2</sup> For ASME Boiler and Pressure Vessel Code applications see related Specification SA-649/SA-649M in Section II of that Code.

<sup>3</sup> For referenced ASTM standards, visit the ASTM website, [www.astm.org](http://www.astm.org), or contact ASTM Customer Service at [service@astm.org](mailto:service@astm.org). For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

\*A Summary of Changes section appears at the end of this standard.

**TABLE 1 Chemical Requirements**

	Composition, %					
	Class 1A	Class 1B	Class 2	Class 3	Class 4	Class 5
Carbon	0.45–0.60	0.40–0.60	0.55 max	0.35 max	0.35 max	0.50–0.60
Manganese	0.55–1.05	0.60–0.95	0.50–0.90	0.40–0.70	0.60–1.05	0.90–1.50
Phosphorus	0.025 max	0.025 max	0.025 max	0.025 max	0.025 max	0.025 max
Sulfur	0.025 max	0.025 max	0.025 max	0.025 max	0.025 max	0.025 max
Silicon <sup>A</sup>	0.15–0.35	0.15–0.35	0.15–0.35 max	0.15–0.35	0.15–0.35 max	0.15–0.35
Nickel	...	1.55–2.00	...	...	...	0.60 max
Chromium	0.80–1.15	0.65–0.95	...	0.80–1.15	...	0.30 max
Molybdenum	0.15–0.50	0.20–0.45	...	0.15–0.25	...	0.15 max

<sup>A</sup> When vacuum carbon deoxidation (VCD) is used the silicon content shall be 0.10 % maximum.

**TABLE 2 Tensile Requirements**

Class	Grade	Yield Strength, min <sup>A</sup>		Tensile Strength, min		Elongation in 2 in. or 50 mm, %, min	Reduction of Area, %, min
		ksi	[MPa]	ksi	[MPa]		
1A, 1B or 5	1	130	[890]	150	[1030]	12.0	30
1A, 1B or 5	2 <sup>B</sup>	65	[450]	100	[690]	14.0	30
2	...	37.5	[260]	75	[515]	20.0	50.0
3 or 4	...	30	[205]	60	[415]	22.0	55

<sup>A</sup> 0.2 % offset.

<sup>B</sup> For trunnion application, a maximum tensile strength of 125 ksi [860 MPa] applies for Grade 2 of Classes 1A, 1B, or 5.

3.3 When ordering pressure rolls the purchaser shall stipulate the required condition, either surface hardened (Condition H) or as heat treated (Condition S). In the event that the condition is not specified the default condition is H.

3.4 If the requirements of this specification are in conflict with the requirements of Specification **A788/A788M**, then the requirements of this specification shall prevail.

## 4. Materials and Manufacture

### 4.1 Forging Process:

4.1.1 Roll body forgings may be made as solid forgings and subsequently bored.

4.1.2 Trunnions or gudgeons which are to be subsequently assembled to form the roll shall be made as a solid forging or where practical upset from segments cut from billets or bars.

### 4.2 Heat Treatment:

4.2.1 Heat Treatment for Mechanical Properties (Requirements do not apply to surface treatment):

4.2.1.1 Machining—The forged roll body shall have all surfaces rough machined, including boring, prior to heat treatment for mechanical properties and be tested in accordance with 6.1.2.1. The manufacturer may opt to bore after heat treatment for mechanical properties instead provided the forging is tested in accordance with 6.1.2.2.

4.2.1.2 Roll bodies shall be normalized, liquid quenched, and tempered to produce the required mechanical properties, except that for Class 2 forgings, and when Grade 2 strength requirements are specified, a normalize and temper heat treatment may be applied.

4.2.1.3 The trunnions shall be normalized and tempered or annealed to produce the required mechanical properties.

4.2.2 Surface Hardening of Pressure Roll Forgings—For Condition H the working face of pressure rolls shall be surface hardened either before or after fitting the trunnions, at the manufacturer's option. Surface hardening by weld overlays is not permitted for Condition H or (subsequently) for Condition S.

4.3 Assembly and Weld—Except for integrally forged or bolted-on trunnions, the assembly shall be made by shrink fitting trunnions into the prepared body ends. If used, welding of the trunnion to the roll body is restricted to a  $\frac{3}{8}$  in. [9.5 mm] max. seal weld, made with low hydrogen materials. A minimum preheat of 400°F [205°C] and a minimum post weld heat treatment of 850°F [455°C] for 8 h shall be used. The maximum post weld heat treatment shall be not higher than  $t - 50^\circ\text{F}$  [ $t - 28^\circ\text{C}$ ] where  $t$  is the final tempering temperature. All welds shall be machined or ground for the final magnetic particle or liquid penetrant examination.

## 5. Chemical Composition

5.1 The steel shall conform to the requirements for chemical composition prescribed in **Table 1**.

## 6. Mechanical Properties

### 6.1 Tensile Requirements:

6.1.1 The material shall conform to the requirements for tensile properties prescribed in **Table 2** when tested in accordance with Test Methods and Definitions **A370**. Tension test specimens shall be the standard round  $\frac{1}{2}$ -in. [12.5 mm] diameter, 2-in. [50 mm] gage length. The yield strength prescribed in **Table 2** shall be determined by the 0.2 % offset method.

6.1.1.1 Tests for acceptance shall be made after the heat treatment of the forgings, for mechanical properties in accordance with 4.2.1.

### 6.1.2 Number, Location, and Orientation of Test Specimens:

6.1.2.1 Roll Body Forgings—A full-size prolongation shall be provided on a roll body forging representing each heat of steel in each heat-treatment furnace charge. One longitudinal tension test specimen shall be taken from the prolongation and the axis of the specimen shall be located midway between the inner and outer surfaces of the wall body.

6.1.2.2 If bored after heat treatment per 4.2.1.1, the central long axis of the longitudinal test specimen shall be located at