Designation: A 649/A 649M – 04

Standard Specification for Forged Steel Rolls Used for Corrugating Paper Machinery[1]

This standard is issued under the fixed designation A 649/A 649M; 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.

1. Scope*

1.1 This specification[2] 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 are surface hardened. 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 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 inch-pound units or SI [metric] units are to be regarded separately as standards. Within the text and tables, the SI units are shown in brackets. The values stated in each system are not exact equivalents; therefore, each system must be used independent of the other. Combining values from the two systems may result in nonconformance with the specification.

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 A 788 apply.

2. Referenced Documents

2.1 *ASTM Standards:* [3]

A 275/A 275M Test Method for Magnetic Particle Examination of Steel Forgings

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

A 788 Specification for Steel Forgings, General Requirements

E 165 Practice for Liquid Penetrant Examination

3. Ordering Information

3.1 Material supplied to this specification shall conform to the requirements of Specification A 788, 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 A 788, 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.

[1] 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.

Current edition approved Sept. 1, 2004. Published October 2004. Originally approved in 1971. Last previous edition approved in 2003 as A 649/A 649M–99 (2003).

[2] For ASME Boiler and Pressure Vessel Code applications see related Specification SA-649/SA-649M in Section II of that Code.

[3] 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.

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

Copyright © ASTM International, 100 Barr Harbor Drive, PO Box C700, West Conshohocken, PA 19428-2959, United States.

Copyright ASTM International
Reproduced by IHS under license with ASTM
No reproduction or networking permitted without license from IHS
Not for Resale
Reproduction authorized per License Agreement with Kathe Hooper (ASTMIHS Account); Mon Jan 24 15:23:01 EST 2005

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[A]	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

[A] When vacuum carbon deoxidation (VCD) is used the silicon content shall be 0.10 % maximum.

TABLE 2 Tensile Requirements

Class	Grade	Yield Strength, min[A]		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[B]	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

[A] 0.2 % offset.
[B] For trunnion application, a maximum tensile strength of 125 ksi [860 MPa] applies for Grade 2 of Classes 1A, 1B, or 5.

3.3 If the requirements of this specification are in conflict with the requirements of Specification A 788, 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.

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*—The working face of pressure rolls shall be surface hardened either before or after fitting the trunnions, at the manufacturer's option.

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 ⅜ 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°F [t – 28°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 A 370. Tension test specimens shall be the standard round ½-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 *Trunnions*—Test material shall be provided from each heat of steel in each heat-treatment furnace charge. One longitudinal tension specimen shall be taken from each test piece and the axis of the specimen shall be located at any point midway between the center and surface of the solid forging.

6.2 *Hardness*:

6.2.1 Roll body forgings shall have a Brinell hardness from 352 HB to 415 HB (Grade 1) or 207 HB to 285 HB (Grade 2). No less than three hardness determinations shall be made on

Copyright ASTM International
Reproduced by IHS under license with ASTM
No reproduction or networking permitted without license from IHS
by ASTM Int'l (all rights reserved);
Reproduction authorized per License Agreement with Kathe Hooper (ASTMIHS Account); Mon Jan 24 15:23:01 EST 2005
Not for Resale

each roll. The hardness readings are to be taken on the outside of the roll bodies using care to prepare locations for tests that are free of decarburization but not so deep as to affect the usefulness of the material.

6.2.2 The surface hardened pressure roll body forgings shall have a hardness of 58 HRC to 65 HRC or equivalent. No less than three hardness determinations shall be made on each roll. The hardness depth shall not exceed ¼ [6 mm].

7. Retreatment

7.1 If the results of the mechanical tests of any forging do not conform to the specified requirements, the manufacturer may retreat the forging one or more times, but not more than three additional times without approval of the purchaser.

8. Magnetic Particle Examination

8.1 The entire surface of the roll, including the seal weld area, shall be examined by either a wet continuous method in accordance with Test Method A 275/A 275M or by a liquid penetrant method in accordance with Practice E 165 after machining or grinding. The use of prods in the magnetic particle method is not permitted.

8.2 Only indications with major dimensions greater than ⅛ in [3.2 mm] are considered relevant.

8.3 *Acceptance Standards*—The following relevant indications are unacceptable:

8.3.1 Any linear indications greater than 3⁄16 in. [4.8 mm] long.

8.3.2 Rounded indications greater than 3⁄16 in. [4.8 mm].

8.3.3 Four or more indications in a line separated by 1⁄16 in. [1.6 mm] or less edge to edge.

8.3.4 Ten or more indications in any 6 in.^{2} [38.71 cm^2] of surface.

9. Hydrostatic Testing

9.1 The machined roll assembly shall be hydrostatic tested at 1½ times the maximum allowable working pressure (MAWP). The MAWP pressure shall be furnished by the purchaser.

9.2 The recommended minimum hydrostatic test temperature is 70°F [21°C].

10. Marking, Packaging, and Loading

10.1 In addition to the marking requirements of Specification A 788, the MDT and the MAWP shall be included together with any required application code marking.

10.2 Packaging and loading shall be done so that the forging is not damaged during shipment to the purchaser.

11. Keywords

11.1 internal pressure; machinery—corrugating; roll assembly—forged; rolls—corrugating; rolls—pressure; steel forgings—alloy; steel forgings—carbon; steel rolls; surface-hardened; trunnions—bolted; trunnions—shrink-fitted

SUPPLEMENTARY REQUIREMENTS

The following supplementary requirements shall apply only when specified by the purchaser on the order and agreed to by the manufacturer:

S1. Surface-Hardened Corrugating Rolls

S1.1 After all surfaces have been machined, the outer surface of the corrugating rolls may be surface-hardened to a surface hardness of Rockwell 53 HRC to 65 HRC. The depth of hardness shall not exceed ⅜ in. [9.5 mm]. A minimum of three hardness determinations shall be made on the surface. Additional hardness tests shall be made to establish the depth of hardness. The hardened surface shall be magnetic particle tested (see Section 8).

S2. Notch Toughness

S2.1 For applications where minimum notch toughness limits are required, impact testing shall be specified for both roll bodies and trunnions. The following requirements shall be specified:

S2.1.1 Type of impact specimen and test standard (for example, ASTM Test Methods and Definitions A 370 specimen Type A or B).

S2.1.2 Minimum value for absorbed energy or lateral expansion.

S2.1.3 Test temperature.

S2.1.4 Frequency of testing.

S2.2 Trunnion and pressure rolls may be liquid quenched and tempered instead of the heat treatments specified in 4.2 when impact testing is required.

Copyright ASTM International
Reproduced by IHS under license with ASTM
No reproduction or networking permitted without license from IHS
Copyright by ASTM Int'l (all rights reserved);
Reproduction authorized per License Agreement with Kathe Hooper (ASTMIHS Account); Mon Jan 24 15:23:01 EST 2005
Not for Resale

SUMMARY OF CHANGES

Committee A01 has identified the location of the following changes since A 649/A 649M-99 (2003) that may impact the use of this standard.

(1) Scope revised to reference maximum design temperature, ordering (3), hydrostatic test (9), and marking requirements (10) revised.

ASTM International takes no position respecting the validity of any patent rights asserted in connection with any item mentioned in this standard. Users of this standard are expressly advised that determination of the validity of any such patent rights, and the risk of infringement of such rights, are entirely their own responsibility.

This standard is subject to revision at any time by the responsible technical committee and must be reviewed every five years and if not revised, either reapproved or withdrawn. Your comments are invited either for revision of this standard or for additional standards and should be addressed to ASTM International Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee, which you may attend. If you feel that your comments have not received a fair hearing you should make your views known to the ASTM Committee on Standards, at the address shown below.

This standard is copyrighted by ASTM International, 100 Barr Harbor Drive, PO Box C700, West Conshohocken, PA 19428-2959, United States. Individual reprints (single or multiple copies) of this standard may be obtained by contacting ASTM at the above address or at 610-832-9585 (phone), 610-832-9555 (fax), or service@astm.org (e-mail); or through the ASTM website (www.astm.org).

Copyright ASTM International
Reproduced by IHS under license with ASTM
No reproduction or networking permitted without license from IHS
Copyright by ASTM Int'l (all rights reserved);
Reproduction authorized per License Agreement with Kathe Hooper (ASTMIHS Account); Mon Jan 24 15:23:01 EST 2005
Not for Resale