Designation: A 768/A 768M – 05

Standard Specification for Vacuum-Treated 12 % Chromium Alloy Steel Forgings for Turbine Rotors and Shafts [1]

This standard is issued under the fixed designation A 768/A 768M; 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.

This standard has been approved for use by agencies of the Department of Defense.

1. Scope*

1.1 This specification covers vacuum-treated 12 % chromium steel forgings for turbine rotors and shafts.

1.2 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.

1.3 *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:* [2]

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 418 Test Method of Ultrasonic Examination of Turbine and Generator Steel Rotor Forgings

A 472 Test Method for Heat Stability of Steam Turbine Shafts and Rotor Forgings

A 788 Specification for Steel Forgings, General Requirements

3. Ordering Information

3.1 In addition to the ordering information required by Specification A 788, the purchaser shall include with the inquiry and order a detailed drawing, sketch, or written description of the forging, including the mechanical test specimen location.

4. General Requirements

4.1 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.

4.2 If the requirements of this specification are in conflict with the requirements of Specification A 788, the requirements of this specification shall prevail.

5. Manufacture

5.1 The melting processes of Specification A 788 shall be applicable except that the open-hearth or basic oxygen methods of primary melting shall not be used, and the molten steel shall be vacuum degassed prior to or during pouring of the ingot.

5.1.1 If the ESR process is used, then the electrodes shall have been produced from vacuum degassed primary heat(s).

5.2 In addition to the requirements of Specification A 788, it is important to maintain the axial center of the forging in common with the axial center of the original ingot.

5.3 *Heat Treatment*:

5.3.1 The heat treatment for mechanical properties shall consist of quenching and tempering.

5.3.1.1 The preliminary heat treatment shall consist of normalizing well above the transformation temperature range. This operation may be performed before preliminary machining (see 5.4.1).

5.3.1.2 The quenching treatment shall be from above the transformation range but below the normalizing temperature described in 5.3.1.1. This treatment shall be performed after preliminary machining (see 5.4.1). Austenitizing temperatures shall be in accordance with Table 1.

5.3.1.3 The final tempering temperature shall be in accordance with Table 1.

[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.

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[2] 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.**

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TABLE 1 Heat Treating Temperature, °F [°C], Requirements

Grade	Austenitizing	1st Tempering, min	2nd Tempering
1	1725–1825 [940–995]	1125 [605]	1100 [595]
2	1900–1940 [1035–1060]	1040 [560]	1010–1040 [545–560]
3	1700–1800 [925–980]	1120 [605]	1100 [595]
4	1700–1800 [925–980]	975 [525]	950 [510]

5.3.1.4 After heat treatment and subsequent rough machining and boring (see 5.4.2 and 5.4.3), the forging shall be stress-relieved at a temperature not more than 100°F [55°C] below the final tempering temperature, but not less than 1100°F [595°C].

5.3.1.5 With the prior approval of the purchaser, the stress-relief temperature may approach, equal, or slightly exceed the final tempering temperature as a means of adjusting final strength or toughness. If the stress relief temperature is within 25°F [15°C] of the final tempering temperature, or higher, additional tension tests must be obtained (see 7.1.3).

5.3.1.6 The method of cooling during quenching and from the final tempering and stress relieving temperatures shall be reported.

5.4 *Machining*:

5.4.1 *Preliminary Rough Machining*—All exterior surfaces of the forging shall be machined prior to heat treatment for mechanical properties.

5.4.2 *Second Rough Machining*—After heat treatment for mechanical properties, all surfaces of the forging shall be rough machined prior to stress relief and the stability test.

5.4.3 *Boring*:

5.4.3.1 Forgings shall be bored to permissible bore size and tolerance when required by the purchaser's drawing.

5.4.3.2 Forgings may be bored to limits agreed to by the purchaser or indicated on the purchaser's drawing, to remove objectionable center conditions revealed by ultrasonic inspection.

5.4.3.3 Unless otherwise specified by the purchaser, the manufacturer may bore the forging at any time prior to stress relief (see Supplementary Requirement S1).

5.4.4 *Machining to Purchaser's Requirements for Shipment*—The forging as shipped shall conform to the finish and dimension requirements specified on the purchaser's drawing or order.

6. Chemical Composition

6.1 The steel shall conform to the requirements for chemical composition prescribed in Table 2.

6.2 *Product Analysis*—The manufacturer shall make a product analysis from each forging. The chemical composition thus determined shall not vary from the requirements specified in Table 1 by more than the amounts prescribed in Specification A 788.

7. Mechanical Properties

7.1 *Tension Test*:

7.1.1 The steel shall conform to the tensile requirements of Table 3.

7.1.2 The number and location of tension test specimens shall be as specified on the forging drawings furnished by the purchaser.

7.1.3 Final acceptance tests shall be made after heat treatment of the forging for mechanical properties prior to stress relief, unless the stress relief temperature is within 25°F [15°C] of the tempering temperature, or higher, in which case check tests shall be made after the stress relief treatment and reported to the purchaser. The purchaser may require check tests after completion of all heating cycles, including stress relief and the heat stability tests.

7.1.4 The yield strength prescribed in Table 3 shall be determined by the offset method of Test Methods and Definitions A 370.

7.2 *Impact Test*:

7.2.1 The steel shall conform to the requirements for notch toughness (both transition temperature and room temperature impact values) prescribed in Table 3.

7.2.2 The notch toughness specimens shall be machined from radial bars taken from the main body of the forging, as shown in the forging drawing. The specimens shall be Charpy V-notch, Type A, as shown in Test Methods and Definitions A 370. The notch direction of the Charpy bars shall be tangential.

8. Nondestructive Tests

8.1 *General Requirements*:

TABLE 2 Chemical Requirements

Composition, %	Grade 1	Grade 2	Grade 3	Grade 4
Carbon	0.15 max	0.08–0.15	0.10–0.16	0.05–0.07
Manganese	1.0 max	0.50–0.90	0.25–1.00	0.70–1.00
Phosphorus	0.018 max	0.02 max	0.015 max	0.015 max
Sulfur	0.015 max	0.015 max	0.012 max	0.012 max
Silicon	0.35 max	0.30 max	0.15–0.45	0.30–0.50
Nickel	0.40–0.75	2.0–3.0	0.75 max	3.5–4.25
Chromium	11.5–13.0	11.0–13.0	11.0–13.0	11.25–12.25
Molybdenum	0.50 max	1.5–2.0	0.20 max	0.30–0.50
Vanadium	...	0.25–0.40	...	0.03 max
Columbium	...	...	0.15 min	...
Aluminum	...	...	...	0.03 max
Nitrogen	...	0.06 max	...	...

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TABLE 3 Tensile and Notch Toughness Requirements

	Grade 1		Grade 2	Grade 3		Grade 4	
	Class 1	Class 2		Class 1	Class 2	Class 1	Class 2
Tensile strength, ksi [MPa]	90–110 [620–760]	85 min [585]	150 min [1035]	90–110 [620–760]	105–125 [725–860]	110–140 [760–965]	120–150 [825–1035]
Yield strength (0.2 % offset) ksi [MPa], min	70 [485]	63 [435]	110 [760]	70 [485]	80 [550]	85 [585]	95 [655] min
Elongation, min, %	16	18	15	15	16	16	15
Reduction of area, min, %	45	45	45	45	45	45	42
$FATT_{50}$, max, °F [°C]	175 [80]	140 [60]	25 [-4]	140 [60]	175 [80]	60 [15]	80 [25]
Room temperature impact, min, ft-lb [J]	15 [20]	20 [28]	50 [70]	15 [20]	15 [20]	35 [49]	25 [35]

8.1.1 The forgings shall be free of cracks, seams, laps, shrinkage, and other injurious imperfections.

8.1.2 The purchaser may request ultrasonic, magnetic particle, dye penetrant, etch, or other accepted nondestructive inspection necessary to evaluate imperfections and to ensure compliance with this requirement.

8.2 *Ultrasonic Inspection*:

8.2.1 An ultrasonic inspection shall be made on the machined forging at the manufacturer's plant. This inspection shall be made in accordance with Test Method A 418 to demonstrate freedom from detrimental internal defects.

8.2.2 The ultrasonic inspection shall be made from all available surfaces prior to removal of test specimens that would interfere with complete testing of the forging.

8.2.3 Forgings with recordable ultrasonic indications shall be referred to the purchaser for evaluation based on the nature, frequency, and location of indications, both stationary and traveling. If the ultrasonic indications are considered objectionable, it shall be determined by conventional or mutually acceptable inspection procedures whether the forging will be rejected.

8.3 *Internal Inspection*:

8.3.1 Boring, when specified for internal periscopic inspection, shall be in accordance with the drawings furnished by the purchaser. The drawings shall specify the nominal dimensions of the bore hole.

8.3.2 If objectionable conditions are encountered during the internal inspection of the bore hole, the manufacturer shall notify the purchaser of the location and nature of the condition. Further action shall be taken only after mutual agreement between the manufacturer and purchaser.

9. Stability Test

9.1 Each forging shall be subjected to a heat stability test at the manufacturer's plant in accordance with the latest issue of Test Method A 472 to determine the stability or freedom from tendency to distort during high temperature operating conditions.

9.2 The stability test shall be conducted after the forging has been stress relieved in accordance with 5.3.1.4.

NOTE 1—If agreed to by the purchaser, the stress relief may be performed as part of the stability test.

9.3 *Stability Test Requirements*:

9.3.1 The purchaser's drawings shall indicate the minimum portion of the forging to be included within the heating chamber during the stability test.

9.3.2 The purchaser's drawings or order shall indicate the minimum stability test temperature.

10. Retreatment

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

10.2 If bore core properties are specified under Supplementary Requirement S1 and retemper is necessary after boring, the remaining portions of the bore core shall be replaced in the bore during retemper.

10.3 If complete retreatment, including normalizing or quenching, is necessary after boring, the feasibility of retreating portions of the bore core in the bore of the forging shall be discussed between manufacturer and purchaser and a procedure agreed upon before treatment.

11. Certification and Reports

11.1 In addition to the certification requirements of Specification A 788, the following shall be reported:

11.1.1 Product analysis results.

12. Package Marking, Packaging, and Loading

12.1 In addition to the marking requirements in Specification A 788, test specimens shall be identified with numbers corresponding to the forging identification numbers and numbers corresponding to test location and type if specified on the purchaser's drawings or order.

12.2 In addition, the axial bores of bored forgings shall be protected and suitably plugged to prevent damage or corrosion during shipment or storage.

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SUPPLEMENTARY REQUIREMENTS

The following supplementary requirement shall apply only when specified by the purchaser in the inquiry, contract, and order. Details of this supplementary requirement shall be agreed upon between the manufacturer and the purchaser.

S1. Bore Core Properties

S1.1 The purchaser may require the removal of the longitudinal bore core from the forging after heat treatment for mechanical properties and subsequent approval of the usual surface mechanical property tests.

S1.1.1 The diameter of the longitudinal bore core shall be subject to agreement between the manufacturer and the purchaser.

S1.1.2 The purchaser may require mechanical tests on tension of impact specimens from locations in the longitudinal bore core as specified on the forging drawings furnished by the purchaser.

S1.1.3 The acceptable level of mechanical properties obtained from specimens from the longitudinal bore core shall be as agreed upon between the manufacturer and the purchaser.

S2. Magnetic Particle Examination

S2.1 A magnetic particle examination of the complete exterior and bore surfaces of the machined forging shall be made at the forging manufacturer's plant. The examination shall be performed in accordance with the latest issue of Test Method A 275/A 275M.

S2.2 Forgings with either cracks or linear indications of any length are subject to rejection unless they can be removed to the purchaser's satisfaction.

SUMMARY OF CHANGES

Committee A01 has identified the location of several changes made to this standard since the last issue (A 768 –95 (2001)) that may impact its use.

(1) Converted the standard to dual unit format.
(2) Deleted several sections that are already covered in the general requirements specification, A 788.

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