Designation: A 469/A 469M – 07

# Standard Specification for Vacuum-Treated Steel Forgings for Generator Rotors[1]

This standard is issued under the fixed designation A 469/A 469M; 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 covers vacuum-treated basic electric steel forgings for generator rotors.

1.2 Supplementary requirements are provided, both in this standard and in Specification A 788/A 788M, for use when additional testing, inspection or processing is required by the purchaser.

1.3 The values stated in either inch-pound 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.

1.4 Unless the order specifies the applicable "M" specification designation, the material shall be furnished to the inch-pound units.

## 2. Referenced Documents

2.1 *ASTM Standards:* [2]

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

A 341/A 341M Test Method for Direct Current Magnetic Properties of Materials Using D-C Permeameters and the Ballistic Test Methods

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

A 418/A 418M Test Method for Ultrasonic Examination of Turbine and Generator Steel Rotor Forgings

A 773/A 773M Test Method for dc Magnetic Properties of Materials Using Ring and Permeameter Procedures with dc Electronic Hysteresigraphs

A 788/A 788M Specification for Steel Forgings, General Requirements

## 3. Ordering Information and General Requirements

3.1 In addition to the ordering information required by Specification A 788/A 788M, the purchaser shall include with the inquiry and order, a dimensioned drawing showing the mechanical test specimen locations, together with:

3.1.1 Details of any required magnetic permeability tests (6.1).

3.1.2 If the yield strength is to be determined at an offset of 0.2 % (Table 1), and number of tests (7.1.2 and 7.1.3).

3.1.3 If vertical heat treatment is required (S3).

3.1.4 If heat treatment by normalizing and tempering is required (4.2.2 and 4.2.3).

3.1.5 If post rough machining stress relief may be omitted for forgings that have been double tempered (4.2.2).

3.1.6 Details for boring including dimensions, finish, timing and additional testing if required (8.3 and S1).

3.1.7 Any applicable instructions regarding the required nondestructive examinations (8).

3.1.8 If vacuum arc remelted ingots are to be used, the purchaser may require that footnote *A* to Table 2 be applicable.

3.2 Material supplied to this specification shall conform to the requirements of Specification A 788/A 788M, which outlines additional ordering information, manufacturing requirements, testing and retesting methods and procedures, marking, certification, production analysis variations, and additional supplementary requirements.

3.3 Failure to comply with the applicable general requirements of Specification A 788/A 788M constitutes nonconformance with this specification.

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

## 4. Materials and Manufacture

4.1 The vacuum degassing requirements of Specification A 788/A 788M are mandatory.

4.1.1 Other vacuum methods of degassing may be used if the supplier can demonstrate their adequacy to the satisfaction of the purchaser, but in this case, hydrogen testing per Supplementary Requirement S4 is mandatory.

4.2 *Heat Treatment*:

[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 Tensile and Notch Toughness Requirements**

| | Grade | | | | | | |
|---|---|---|---|---|---|---|---|
| | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| Tensile strength, min, ksi | 80 | 90 | 100 | 110 | 100 | 110 | 120 |
| [MPa] | [550] | [620] | [690] | [760] | [690] | [760] | [825] |
| Yield strength,[A] min, ksi | 55 | 70 | 80 | 90 | 80 | 90 | 100 |
| [MPa] | [380] | [485] | [550] | [620] | [550] | [620] | [690] |
| Elongation in 2 in. or 50 mm, min, % | 20 | 20 | 17 | 15 | 18 | 17 | 16 |
| Reduction of area, min, % | 50 | 50 | 45 | 40 | 55 | 50 | 45 |
| $FATT_{50}$, max, F | 100 | 100 | 120 | 175 | 0 | 20 | 40 |
| [$FATT_{50}$, max, C] | [38] | [38] | [49] | [80] | [–18] | [–7] | [4] |
| Charpy absorbed energy at 70 ± 5 °F [20 ± 3 °C], min, ft·lbf[J] | 30 [40] | 30 [40] | 25 [34] | 15 [20] | 60 [80] | 50 [68] | 40 [55] |

[A] Yield strength at 0.02 % offset. Yield strength may also be specified at 0.2 % offset in which case 5000 psi (35 MPa) shall be added to these values.

**TABLE 2 Chemical Requirements**

| Element | Composition, % | | | | |
|---|---|---|---|---|---|
| | Grade 2 | Grade 3 | Grade 4 | Grade 5 | Grades 6, 7, 8 |
| Carbon, max | 0.25 | 0.27 | 0.27 | 0.31 | 0.28 |
| Manganese, max | 0.60 | 0.60 | 0.70 | 0.70 | 0.60 |
| Phosphorus, max | 0.015 | 0.015 | 0.015 | 0.015 | 0.015 |
| Sulfur, max | 0.015 | 0.015 | 0.015 | 0.015 | 0.015 |
| Silicon, max[A] | 0.30 | 0.30 | 0.30 | 0.30 | 0.30 |
| Nickel | 2.50 min | 2.50 min | 3.00 min | 3.00 min | 3.25 to 4.00 |
| Chromium | 0.50 max | 0.50 max | 0.50 max | 0.50 max | 1.25 to 2.00 |
| Molybdenum | 0.20 to 0.50 | 0.20 to 0.50 | 0.20 to 0.60 | 0.20 to 0.70 | 0.30 to 0.60 |
| Vanadium | 0.03 min | 0.03 min | 0.03 min | 0.05 to 0.15 | 0.05 to 0.15 |
| Antimony[B] | . . . | . . . | . . . | . . . | . . . |

[A] Optional: For steel that is to be vacuum arc remelted a minimum silicon of 0.15 % may be specified.
[B] Report for information on Grades 6, 7, and 8.

4.2.1 Vertical heat treatment of the rotor forging is preferred, and Supplementary Requirement S3 should be specified by the purchase order if this is required.

4.2.2 The heat treatment for mechanical properties shall consist of quenching and tempering, but normalizing and tempering is permissible with prior purchaser approval. Also, with prior purchaser approval, the post rough machining stress relief in 4.2.3 may be omitted when double tempering is used, instead of a single temper, to complete this heat treatment cycle.

4.2.3 After heat treatment and the subsequent rough machining, the forging shall be stress relieved at a minimum temperature of 1050°F [565°C], unless otherwise specified by the purchaser.

4.3 *Machining*:

4.3.1 *Boring*—The manufacturer may bore the forging at any time prior to stress-relief anneal. (See Supplementary Requirement S1).

## 5. Chemical Composition

5.1 *Heat Analysis*—The heat analysis obtained from sampling in accordance with Specification A 788/A 788M shall comply with Table 2.

5.2 *Product Analysis*—The manufacturer shall use the product analysis provision of Specification A 788/A 788M to obtain a product analysis from a forging representing each heat or multiple heat.

## 6. Magnetic Properties

6.1 When specified in the ordering information, a permeability test shall be performed in accordance with the latest issue of Test Method A 341/A 341M or Test Method A 773/A 773M.

## 7. Mechanical Properties

7.1 *Tension Test*:

7.1.1 The steel shall conform to the requirements of Table 1.

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

7.1.3 Tests for acceptance shall be made after heat treatment of the forging for mechanical properties; however, the ultrasonic examination requirements of 8.2.3 must be considered. The purchaser may require check tests after completion of all heating cycles including stress relieving in accordance with 4.2.3.

7.1.4 Testing shall be performed in accordance with the latest issue of Test Methods and Definitions A 370.

7.1.5 The yield strength prescribed in Table 1 shall be determined by the offset method at 0.02 % as described in Test Methods and Definitions A 370.

7.2 *Impact Test*:

7.2.1 The material shall conform to the requirements for notch toughness (both fracture appearance transition temperature (FATT) and room temperature absorbed energy value) prescribed in Table 1.



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7.2.2 Charpy V-notch specimens from surface radial test locations shall be oriented with the root of the notch perpendicular to a radial axis of the forging and parallel to the longitudinal axis of the forging. The notch shall be located as far below the heat treated surface of the forging as possible without exceeding the dimensions specified for the test material. The actual distance from the outside diameter of the forging to the specimen notch shall be reported.

## 8. Nondestructive Test Requirements

8.1 *General Requirements*—The forgings shall be free of cracks, seams, laps, shrinkage, and other injurious imperfections.

8.2 *Ultrasonic Inspection*:

8.2.1 An ultrasonic inspection shall be made at the forging manufacturer's plant on the machined forgings. In making the ultrasonic inspection, reference shall be made to the latest issue of Test Method A 418/A 418M.

8.2.2 Forgings having recordable ultrasonic indications shall be referred to the purchaser and evaluated on the basis of nature, frequency, and locations of indications both traveling and stationary. If the ultrasonic indications are considered objectionable, it shall be determined by conventional or mutually acceptable inspection procedures whether the forging will be rejected.

8.2.3 Forgings shall be ultrasonically examined prior to removal of the mid-body radial tension coupons.

8.3 *Internal Inspection*—Boring, when specified for borescope inspection, shall be as shown on the drawings furnished by the purchaser. The drawings shall specify the nominal dimensions and surface finish of the hole. Magnetic particle examination of the bore surface shall be performed in accordance with the latest issue of Test Method A 275/A 275M. The manufacturer shall report the results of the examination to the purchaser and any further action shall be taken only after mutual agreement.

## 9. Retreatment

9.1 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 approval of the purchaser, and retests shall be made in accordance with 7.1.2.

9.2 If boring, specified under Supplementary Requirements S1, was completed, the remaining portions of the bore core shall be replaced in the bore during retreatment.

## 10. Certification and Reports

10.1 In addition to the requirements of Specification A 788/A 788M, the product analysis results shall be reported.

## 11. Packaging and Package Marking

11.1 In addition to the marking requirements of Specification A 788/A 788M, axial bores, if any, shall be protected and suitably plugged for shipment or storage.

## 12. Keywords

12.1 generator rotor forgings; steel forgings; vacuum-treated steel; vertical heat treatment; yield strength at 0.02 % offset

## SUPPLEMENTARY REQUIREMENTS

The following supplementary requirements shall apply only when specified by the purchaser on the order.

## S1. Bore Core Tests

S1.1 The purchaser may require physical tests from the bar cored from the longitudinal bore of the forging. These core tests will be for information only.

S1.2 Specimens for bore core tests shall be cored from the forging after heat treatment for mechanical properties.

## S2. Method of Forging

S2.1 The purchaser may specify that hot working be performed on a press.

## S3. Vertical Heat Treatment

S3.1 Heat treatment for mechanical properties shall be performed with the forging in the vertical position.

## S4. Hydrogen Determination

S4.1 A hydrogen determination shall be made. The acceptable hydrogen limit as well as the stage in processing when sampling, the sample preparation procedure and the method of analysis shall be as agreed upon by manufacturer and purchaser.

## S5. Magnetic Particle Examination

S5.1 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.

S5.2 The purchaser shall establish the minimum length of linear indications to be considered relevant.

S5.3 Forgings with either cracks or relevant linear indications are subject to rejection unless they can be removed to the purchaser's satisfaction.

## S6. Silicon Content

S6.1 The maximum silicon content shall be 0.10 %.



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## SUMMARY OF CHANGES

Committee A01 has identified the location of selected changes to this standard since the last issue (A 469/A 469M – 06) that may impact the use of this standard. (Approved March 1, 2007.)

(*1*) Added Supplementary Requirement S6.

Committee A01 has identified the location of selected changes to this standard since the last issue (A 469/A 469M – 04) that may impact the use of this standard. (Approved March 1, 2006.)

(*1*) Added Subsection 3.1.8.

(*2*) Deleted minimum silicon requirement in Table 2.

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