



Designation: A469/A469M – 07 (Reapproved 2022)

Standard Specification for Vacuum-Treated Steel Forgings for Generator Rotors¹

This standard is issued under the fixed designation A469/A469M; 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 [A788/A788M](#), for use when additional testing, inspection or processing is required by the purchaser.

1.3 The values stated in either inch-pound units or SI (metric) units are to be regarded separately as standard. Within the text and tables, the SI units are shown in brackets. The values stated in each system are not necessarily exact equivalents; therefore, to ensure conformance with the standard, each system shall be used independently of the other, and values from the two systems shall not be combined.

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

1.5 *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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.6 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*²

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

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.

[A341/A341M Test Method for Direct Current Magnetic Properties of Soft Magnetic Materials Using D-C Permeameters and the Point by Point \(Ballistic\) Test Methods](#)
[A370 Test Methods and Definitions for Mechanical Testing of Steel Products](#)
[A418/A418M Practice for Ultrasonic Examination of Turbine and Generator Steel Rotor Forgings](#)
[A773/A773M Test Method for Direct Current Magnetic Properties of Low Coercivity Magnetic Materials Using Hysteresigraphs](#)
[A788/A788M Specification for Steel Forgings, General Requirements](#)

3. Ordering Information and General Requirements

3.1 In addition to the ordering information required by Specification [A788/A788M](#), 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 (Supplementary Requirement 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 Supplementary Requirement 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 [A788/A788M](#), 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 [A788/A788M](#) constitutes nonconformance with this specification.

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 °F ± 5 °F [20 °C ± 3 °C], min, ft-lbf [J] | 30 | 30 | 25 | 15 | 60 | 50 | 40 | |
| | [40] | [40] | [34] | [20] | [80] | [68] | [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.

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

4. Materials and Manufacture

4.1 The vacuum degassing requirements of Specification **A788/A788M** 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 in accordance with Supplementary Requirement S4 is mandatory.

4.2 Heat Treatment:

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 **A788/A788M** shall comply with **Table 2**.

5.2 *Product Analysis*—The manufacturer shall use the product analysis provision of Specification **A788/A788M** 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 **A341/A341M** or Test Method **A773/A773M**.

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.