Designation: A 472/A 472M – 07

# Standard Specification for Heat Stability of Steam Turbine Shafts and Rotor Forgings[1]

This standard is issued under the fixed designation A 472/A 472M; 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 the determination of heat stability of steam turbine shafts and rotor forgings to ensure stability at operating temperature. This specification is not ordinarily applicable to generator rotor forgings.

1.2 This specification is expressed in both inch-pound unit and in SI units; however, unless the purchase order or contract specifies the applicable M specification designation (SI units), the inch-pound units shall apply. The values stated in either inch-pound units or SI units are to be regarded separately as standard. Within the specification, the SI units are shown in brackets. 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 nonconformance with the standard.

1.3 Supplementary requirements of an optional nature are provided for use at the option of the purchaser. The supplementary requirements shall apply only when specified individually by the purchaser in the purchase order or contract.

1.4 *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. Ordering Information

2.1 It shall be the responsibility of the purchaser to specify all requirements necessary for testing under this specification. Requirements to be considered include, but are not limited to, the following:

2.1.1 ASTM designation and year date,

2.1.2 The minimum test temperature,

2.1.3 The portion of the forging to be subjected to the heat stability test temperature, and

2.1.4 Supplementary or other special requirements.

## 3. Procedure

3.1 The heat stability test shall be conducted by the forging supplier after final heat treatment and after the forging has been centered and machined with allowance to finish to the purchaser's drawing. Material for mechanical tests may be removed before or after the stability test at the manufacturer's option, unless check tests after the stability test are required by the purchaser.

3.2 With prior approval from the purchaser, the forgings may be stress-relieved as part of the heat stability test. When this is done, the stress-relieving temperature shall be within 50 to 100°F [30 to 55°C] below final tempering temperature. Rotate the forgings at 2 to 4 r/min and hold at stress-relieving temperature for at least 2 h/in. [2 h/25 mm] of maximum radial thickness, after which the temperature may be decreased to the specified heat stability test temperature and the test performed.

## 4. Heat Stability Test Bands

4.1 The supplier shall mark positions A, B, C, and D, spaced 90° apart circumferentially, preferably on an end of the forging. Markings shall be retained throughout all subsequent operations.

4.2 Preferably, there shall be a minimum of 5 test bands, denoted as 1, 2, 3, 4, and 5, machined on the circumference of the forging. Numbering shall start at the left side of the forging drawing. Bands 1 and 5 shall be located as close to the end of the forging as practical. Band 3 shall be located as near to midlength as practical. Bands 2 and 4 shall be located approximately equidistant between 1 and 3, and 3 and 5, respectively.

4.3 When the shipped length of the barrel portion of the forging is less than 8 ft [2.4 m], bands 2 and 4 may be omitted.

4.4 The purchaser's drawing may show the desired number and location of bands and shall indicate that portion of the forging that shall be located within the heating chamber. Bands 1 and 5 are to be located outside of the heating chamber. Preferably, the gland areas/packing seal areas are inside the heating chamber.

4.5 The test bands shall be machined with the forging running on centers except in the cases of forgings weighing over 125 000 lb [56.7 metric tons] the machining shall be performed with the forgings running on steady rests. Readings shall be taken with the forging running on centers except in the cases of forgings weighing over 125 000 lb [56.7 metric tons] where readings may be taken with the forgings running on steady rests. Between readings, the forgings may be rotated on steady rests.

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

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## 5. Surface Preparation

5.1 Remove oil, grease, dirt, and other foreign material from the surface of the forging prior to the heat stability test. A suitable coating may be applied to provide uniform emissivity.

## 6. Heating and Cooling

6.1 Place the forging in the heating chamber and rotate the forging at a speed of 2 to 4 r/min.

6.2 Place thermocouples in contact with the forging at each test band within the heating chamber. Shield the thermocouples from the heat source.

6.3 Apply heat uniformly to avoid localized overheating. Heat the forging at a rate not exceeding 200°F/h [110°C/h] to the stability test temperature specified by the purchaser. Maintain the specified testing temperature until the forging is heated uniformly. A uniform temperature condition shall be considered to exist when three consecutive hourly deflection measurements taken at the test temperature are within 0.0005 in. [0.013 mm]. To consider a uniform test temperature condition to exist, it is also necessary that the axial thermal expansion be consistent within 0.010 in. [0.25 mm] for three consecutive hourly readings at the test temperature.

6.4 After uniform test conditions as described in 6.3 have been reached, cool the forging, while rotating, to below 100°F [40°C]. The heating chamber may be opened during cooling, but the cover shall not be removed until the temperature of the forging is less than 500°F [260°C]. After the forging has cooled to approximately room temperature, rotate it for at least 2 h before the second cold measurements (see 7.4) are recorded.

## 7. Stability Measurements

7.1 Use an indicator located outside the heating chamber to measure to the nearest 0.0005 in. [0.013 mm]. Actuate the indicator by a rod with one end contacting the forging at test bands described in 4.2 or 4.3. Take measurements at each test band at positions A, B, C, and D. For each band, the indicator may be set to zero for the minimum deflection at one of the positions A, B, C, or D or the figures may be reduced to minima by subtraction.

7.2 *First Cold Measurements*—Take measurements on each band after rotation is started but prior to heating. If the runout exceeds 0.002 in. [0.05 mm] at any band, continue rotation for 1 h. If runout continues to exceed 0.002 in. [0.05 mm], recenter the forging or remachine the bands until the runout does not exceed 0.002 in. [0.05 mm] in any band. Refer to the last measurements as the official first cold measurements.

7.3 *Hot Measurements*—Take measurements on all bands hourly during the heating cycle until the forging has been heated to the specified temperature. When three consecutive hourly deflection measurements at the specified temperature check within 0.0005 in. [0.013 mm], cooling may commence. Refer to the last of these measurements as the official hot measurements.

7.4 *Second Cold Measurements*—After cooling in accordance with 6.4, take measurements on all bands at half-hour intervals until two consecutive deflection measurements check within 0.0005 in. [0.013 mm]. Refer to the last of these measurements as the official second cold measurements.

## 8. Interpretation of Results

8.1 The forging shall be acceptable if the movement of its center is not greater than 0.001 in. [0.025 mm] when determined by the difference between the official hot and the official cold second measurements. This movement shall be determined for each band as follows:

8.1.1 From the official hot measurements at position A subtract the official cold measurement for position A.

8.1.2 Repeat the procedure for positions B, C, and D.

8.1.3 For each of these four results, numerically total the greatest plus value and the greatest minus value without regard to sign. The maximum deflection in any band as indicated by these totals shall not exceed 0.002 in. [0.05 mm].

8.2 In case of changes in measurements in bands 1 and 5, suitable corrections may be made to results obtained from bands 2, 3, and 4. The corrected figures shall be within the requirements of 8.1.3.

8.3 If the forging does not meet the requirements of the stability test, it may be retested, stress relieved before retest or completely reheat treated before retest.

## 9. Report

9.1 The forging supplier shall report to the purchaser the official first cold measurements, the hourly measurements during heating and holding at specified temperature, the official hot measurements and the official second cold measurements, as well as the temperature of the forging when these measurements were obtained. The report shall include the calculated change in measurements as determined under 8.1.3.

## 10. Keywords

10.1 emissivity; heat stability; rotor forgings; steam turbines



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## SUPPLEMENTARY REQUIREMENTS

The following supplementary requirements shall only apply when specified individually by the purchaser in the contract or purchase order.

S1. Emissivity Coating

S1.1 Apply a surface coating that will provide a uniform thermal emissivity throughout the test. The coating shall be uniform and completely cover all surfaces within and adjacent to the ovens. Successive light coats applied by spraying are recommended.

## APPENDIX

**(Nonmandatory Information)**

### X1. RESULTS DISCUSSION

X1.1 This specification determines whether a forging will be stable at elevated temperatures and sets go/no go limits for acceptance. Instability is typically caused by one of several factors including non-uniform emissivity (see Supplementary Requirement S1) or relief of residual stresses (in both cases these rotors will normally be stable during a subsequent test), non-uniform heat treatment, and machining off the forging centerline. Rotors that do not meet the go/no go limits are considered unstable and are normally subject to further review, retested, or even re-heat treated and retested.

## SUMMARY OF CHANGES

Committee A01 has identified the location of selected changes to this standard since the last issue (A 472/A 472M – 05) that may impact the use of this standard. (Approved Sept. 1, 2007.)

(*1*) Changed standard from “test method” to “specification.”

(*2*) Added Appendix X1.

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