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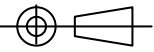
This standard sets forth a standard test method for stress relaxation testing threaded and non-threaded fasteners.

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THE INITIAL RELEASE OF THIS DOCUMENT SUPERSEDES MIL-STD-1312-17.
DESIGNATION FOR THIS TEST METHOD REMAINS MIL-STD-1312-17.

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1. SCOPE

1.1 Applicability. This test method outlines the procedure for stress relaxation testing threaded and non-threaded fasteners. The following methods designed to produce comparable results are specified:

- a. Stress relaxation machine method, and
- b. Stress relaxation cylinder method

2. REFERENCED DOCUMENTS

The following document(s) forms a part of this specification to the extent specified herein. The issues of the documents which are indicated as DOD adopted shall be the issue in the current DoDISS and the supplement thereto, if applicable.

ASTM International

- ASTM E4 Load Verification of Testing Machines
- ASTM E83 Verification and Classification of Extensometers
- ASTM E220 Calibration of thermocouples by comparison techniques

Copies can be obtained from ASTM International, 100 Barr Harbor Drive, PO Box C700, West Conshohocken, PA 19428-2959. www.astm.org

NCSL International

- NCSL Z540.3 Requirements for the Calibration of Measuring and Test Equipment

Copies can be obtained from NCSL International, 2995 Wilderness Place, Suite 107, Boulder, CO 80301. www.ncsli.org

3. DEFINITIONS

Not applicable.

4. GENERAL REQUIREMENTS

4.1 Test apparatus

4.1.1 Testing machines. The testing machines used shall be capable of maintaining the initial length of the loaded fastener within .0002 inches. This shall be accomplished by means of an Extensometer which activates an unloading or loading mechanism whenever the initial stressed length changes by .0002 inches.

4.1.1.1 Heating equipment and temperature control. The heating equipment and temperature control shall be capable of maintaining the indicated temperature of the fastener over its entire length within ± 5 °F (2.8 °C) up to a test temperature of 2,300 °F (1,260 °C).

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4.1.1.2 Thermocouples

- a. All thermocouples must be fabricated from calibrated thermocouple wire. The accuracy of this calibration shall be in accordance with ASTM E220:
 1. ± 2 °F (1.1 °C) from 0 °F (-17.8 °C) to 530 °F (276 °C).
 2. ± 4 °F from 530 °F (276 °C) to 2,300 °F (1,260 °C).
- b. Ceramic insulators or like materials shall be used from the thermocouple junction to at least 12 inches outside the furnace. The leads outside the furnace shall be covered with an insulating material.
- c. The thermocouple shall be assembled so that the hot junction is held securely against the test fastener (see Figure 1) and the thermocouple performance is not degraded by location.
- d. A minimum of two thermocouples shall be attached to each test fastener. Where practical, one thermocouple shall be attached to each end, and one in the middle of the test fastener (see Figure 1).
- e. Where radiation can affect the temperature reading, the thermocouple shall be protected by shielding.

4.1.1.3 Temperature recording. The temperature recording device shall be capable of maintaining a record of the temperature of the test fastener for the full duration of the test.

4.1.1.4 Load measuring. The load measuring device shall be capable of measuring the load applied to the test member with an accuracy of ± 2 percent for the full range of the machine capacity. The calibration of the machine system shall conform to the requirements of NCSL Z540.3. Its accuracy shall be verified every 6 months by a method complying with ASTM E4, using a calibration device calibrated by the National Bureau of Standards not more than 2 years before its use. Alternatively, the load measuring device may be calibrated in a universal testing machine whose calibration has been verified in accordance with ASTM E4.

4.1.1.5 Alignment. The fixture and machines shall be capable of axial alignment. The alignment shall be checked with an alignment gage capable of measuring the elastic strain on four equally spaced places (located 90 degrees apart, on a common axis) on the alignment gage surface. The axiality of alignment of machines and fixtures shall be such that an elastic strain difference of not more than 15 percent of the average strain shall be obtained on opposite sides of the alignment gage at the test load.

4.1.1.6 Loading rate. The axial load shall be applied to the test fastener at the rate of 100,000 pounds/minute ± 10 percent per square inch of nominal shank area.

4.1.1.7 Load recording. The load recording device shall be capable of maintaining a continuous record of the residual load on the test fastener with an accuracy of ± 2 percent for the full duration of the test. This instrumentation shall plot load versus time.

4.1.1.8 Specimen holding fixtures

4.1.1.8.1 Fixture requirements. The stress relaxation test fixtures shall be capable of producing uniaxial loading. The hole shall be perpendicular to the bearing surface within .001 inches. The fixtures must be fabricated from materials capable of withstanding the test loads and temperatures without permanent deformation.

4.1.1.8.2 Fixture dimensions. The stress relaxation fixtures shall conform to those shown in Figure 2. When the fastener grip length is less than $2 \times \text{ØD}$, the fixtures in Figure 3 shall be used.

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5. DETAIL REQUIREMENTS

5.1 Machine method test procedures

5.1.1 Load determination. When the initial test load at test temperature is not provided in the product specification, or test authorization, it shall be determined from the following information, and utilized by the method described in 5.1.1.1.

- a. A room temperature torque versus induced load curve similar to that shown in Figure 4 shall be generated for threaded fasteners. For non-threaded fasteners, the initial room temperature induced load shall be determined by an appropriate method.
- b. A room temperature load versus elongation curve similar to that shown in Figure 5 shall be generated for both threaded and non-threaded fasteners.
- c. A load versus elongation curve shall be generated at the test temperature, or calculated from the modulus of elasticity of the test fastener material at the test temperature. These curves shall be plotted as shown in Figure 5.

5.1.1.1 Method. The method for determining the initial test load is as follows:

5.1.1.1.1 Threaded fasteners

- a. Determine the room temperature induced load (Load "A" in Figure 4) relative to the recommended tightening torque for the threaded fasteners. This load must be lower than the proportional limit "C" in Figure 4. The proportional limit is where the torque induced load curve deviates from a straight line.
- b. If the recommended torque is not available, determine the load equal to 60 percent of the fastener minimum ultimate tensile strength. Develop a torque versus induced load curve (Figure 4) to determine the proportional limit "C." The initial test load must be lower than the proportional limit "C" in Figure 4.
- c. Determine the elongation "X" (Figure 5) relative to the torque induced load "A" (Figure 4).
- d. Determine the test temperature load "B" relative to the elongation "X" in Figure 5. The load "B" in Figure 5 is the recommended initial test load for relaxation tests conducted using the stress relaxation machine.

5.1.1.1.2 Non-threaded fasteners

- a. If the recommended load is not available, non-threaded fasteners shall be installed using their prescribed installation tools, and the resultant fastener load measured.
- b. A room temperature load versus elongation curve similar to that shown in Figure 5 shall be generated.
- c. Determine the elongation "X" in Figure (5) relative to the fastener load determined in (a) above.
- d. Determine the test temperature load "B" relative to the elongation "X" in Figure 5. The load "B" in Figure 5 is the initial test load for relaxation tests conducted using the stress relaxation machine.

5.1.2 Relaxation machine set-up. Assemble the test member into the test fixture such that fixture faces do not touch each other. Attach Extensometers and thermocouples to test member, in accordance with 5.1.2.1. Assemble the loaded fixture in the furnace, and seal furnace ends. After the test temperature has been reached, maintain temperature for 30 minutes before applying initial load. Apply initial load and adjust Extensometers so that a .0002 inch (.0051 mm) increase in test member length will activate the unloading mechanism. The unloading should decrease the stress just enough to restore the test member to its original length, before the creep occurred. The test temperature and specimen length shall be maintained and load versus time recording shall be continued for the specified time. The temperature shall be monitored at sufficient intervals to assure conformance.

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- 5.1.2.1 Measured length of specimen. The length measured by the Extensometers in the testing machine shall be as follows:
- The overall length of the bolt or pin, where the properties of only the bolt or pin are to be determined (Figure 6).
 - The length between bearing faces when the properties of the fastener system are to be determined (Figure 7).
- 5.1.2.2 Relaxation determination. The relaxation results may be reported as the final stress versus the initial stress for a given time and temperature if so specified in specification or test authorization. Unless so specified, the results shall be plotted as shown in Figure 8 where the residual stress (or load) is plotted against log time. When plotted as stress, it is recommended that the stress calculations be made using the pitch diameter or threaded members and the shank diameter after installation of non-threaded members. The area used shall be stated in the report.
- 5.2 Cylinder method test procedures. The cylinder method is only applicable to threaded fasteners.
- 5.2.1 Heating apparatus and temperature control. The heating apparatus and temperature control shall be capable of maintaining the indicated temperature of the heating zone of the furnace within ± 3 °F (1.7 °C) through 1,200 °F (649 °C) and ± 5 °F (2.8 °C) over 1,200 °F (649 °C).
- 5.2.2 Test cylinders. The cylinders shall be made from material having the same coefficient of thermal expansion and the same thermal treatment as the material in the test fasteners. The internal diameter of the cylinders should be .003 inches (.08 mm) to .008 inches (.20 mm) larger than the nominal test fastener diameter. The bearing surfaces shall be square to the I.D. within .003 inch FIM. The outside diameter of the cylinder shall be at least three times the basic major diameter of the test fastener.
- 5.2.2.1 Cylinder load determination. Follow the method for determining the initial test load for threaded fasteners described in 5.1.1 and 5.1.1.1.1a, b, c and d. The elongation "X" and the load "B" in Figure 5 are the elevated temperature elongation and initial loads for relaxation tests conducted using the cylinder method.
- 5.2.3 Elongation formula. Elongation by calculation shall not be used unless it is known that the torque induced load at that elongation is lower than the proportional limit "C," in Figure 4.
- 5.2.3.1 The following formula may be used to determine the test elongation for threaded fasteners when the initial load at the test temperatures have been properly determined:

$$\Delta L = \frac{S}{E} \left(L.C. + \frac{3}{4} H + G \frac{P.D. - D}{D} \right)$$

Where:

- ΔL = Desired elongation (inches)
 S = Desired stress at basic pitch diameter area of bolt thread in KSI
 E = Modulus of elasticity of bolt material at room temperature
 $L.C.$ = Cylinder length (inches)
 H = Maximum height of nut (inches)
 $P.D.$ = Basic pitch diameter of bolt thread (inches)
 D = Nominal diameter of bolt shank (inches)
 G = Nominal grip length of bolt (inches)

The room temperature and elevated temperature elongation shall be calculated and plotted similar to the load versus elongation curve in Figure 5.

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