Designation: F 269 – 60 (Reapproved 2002)

Standard Test Method for Sag of Tungsten Wire [1]

This standard is issued under the fixed designation F 269; 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 test method covers a determination of the sag properties of tungsten wire 0.030 in. (0.76 mm) and over in diameter.

1.2 The values stated in inch-pound units are to be regarded as the standard. The values given in parentheses are for information only.

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 consult and establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Apparatus

2.1 *Bell Jar Envelope*—A suitable envelope surrounding the test apparatus. The envelope may consist of a glass bell jar, preferably of a heat resistant glass (**Warning** —A protective medium shall be provided over an exposed glass to prevent injury by flying glass in the event of an explosion), or may be constructed of metal, in which case a transparent window shall be provided in order that the behavior of the specimen under test may be observed. The envelope may be rigidly supported in a fixed position or may by suspended in such a manner that it can be raised or lowered into position over the test apparatus. A means shall be provided for maintaining within the envelope an atmosphere and steady supply flow of hydrogen. A flow meter shall be incorporated in the hydrogen line so that measurement and control of the gas flow may be maintained. The hydrogen line shall discharge at the upper levels of the envelope and shall be baffled by a suitable diffusing device so that no direct stream of the gas will play upon the test specimens.

2.2 *Specimen Support*—A suitably designed support and clamping device for holding the specimen within the envelope during testing. This support, which may be rigidly fixed or capable of being raised into or lowered from the envelope, shall be made from a suitable metallic conductor so that electrical current from the power supply may be used to heat the test specimen. An insulated clamping fixture shall be provided at the top of the support so that the hairpin test specimen will be firmly held. This clamping device shall be capable of rotating 90° on its axis in order that the test specimen may be heated both in a vertical-position with its apex down and in a horizontal position. A means shall be provided for accomplishing this rotation without requiring the removal of the test specimen from the clamping fixture.

2.3 *Weights*—A set of weights comprising loads of 3, 4, 6, 7, 9, 10, and 13 lb (1.4, 1.8, 2.7, 3.2, 4.1, 4.5, and 5.9 kg). A hook shall be provided for attaching the required weight to the apex of the test specimen. This hook should be made from tungsten wire and should be capable of supporting the heaviest weight at the elevated temperature of testing, without fear of breaking.

NOTE 1—A tungsten wire with a diameter of 0.080 in. is recommended for use as a hook.

2.4 *Cathetometer* or any other suitable instrument for measurement of the vertical displacement of the test specimen that results from the sag test. This instrument shall have a suitable scale so that movement of the specimen of as little as 0.5 mm may be read.

2.5 *Power Supply*—A supply of electric current sufficient to heat the test specimen to the required test temperatures. A meter shall be provided in this supply to permit measurement of the current to an accuracy of ±2 %.

3. Materials

3.1 Hydrogen used for the test atmosphere shall have a purity meeting the following requirements:

3.1.1 *Moisture* (water), not more than 2.5 g/1000 ft^3 (2.5 g/28 m^3) as indicated by a dew point of − 65°C or below.

3.1.2 *Oxygen*, not more than 10 ppm.

3.1.3 *Hydrocarbons* (*plus CO and* CO_2), not more than 20 ppm.

3.1.4 *Nitrogen*, not more than ½ %.

4. Test Specimen

4.1 *Surface*—The specimen of tungsten wire to be tested for sag shall have a clean, bright surface and shall be at least 15 in. in length.

4.2 *Forming*—With the aid of external heat, the test specimen shall be bent into a hairpin-shape until the distance

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between the ends is 1 in. The hairpin is formed by bending the wire around a pin whose diameter is approximately twice that of the test specimen.

NOTE 2—Note more than 20 % of the hairpin length (measured from the apex) shall be heated above a black heat when the hairpin is formed. Also, the legs of the formed hairpin shall lie in the same plane.

4.3 *Test Length*—The formed test specimen shall be of sufficient length so that when clamped in the fixture, the exposed lengths measured from the top of the apex will be as follows:

Wire Diameter of Test Specimen, in. (mm)	Exposed Length, *L*, in. (mm)
0.0300 to 0.0349 (0.762 to 0.886)	4⅛ (104)
0.0350 to 0.0449 (0.889 to 1.140)	4½ (114)
0.0450 to 0.0549 (1.143 to 1.394)	5⅛ (130)
0.0550 to 0.0649 (1.397 to 1.648)	5⅝ (143)
0.0650 to 0.0749 (1.651 to 1.902)	6 (152)
0.0750 to 0.0849 (1.905 to 2.156)	6¼ (160)
0.0850 to 0.1000 (2.159 to 2.540)	6½ (165)

5. Procedure

5.1 Mount the test specimen vertically downward in the test apparatus. Move the apparatus, with the specimen in place, into the bell jar envelope. Introduce sufficient hydrogen into the bell jar at a positive flow to form a safe protective atmosphere for the test specimen. Attach the appropriate weight to the test specimen as indicated in the following table:

Wire Diameter of Test Specimen, in. (mm)	Weight, lb (kg)
0.0300 to 0.0349 (0.762 to 0.886)	3 (1.4)
0.0350 to 0.0449 (0.889 to 1.140)	4 (1.8)
0.0450 to 0.0549 (1.143 to 1.394)	6 (2.7)
0.0550 to 0.0649 (1.397 to 1.648)	7 (3.2)
0.0650 to 0.0749 (1.651 to 1.902)	9 (4.1)
0.0750 to 0.0849 (1.905 to 2.156)	10 (4.5)
0.0850 to 0.1000 (2.159 to 2.540)	13 (5.9)

5.2 After the bell jar envelope is completely flushed with hydrogen, raise the temperature of the test specimen at a constant rate of 2600 K true temperature in 1 min and hold at that temperature for 5 min, after which lower the current to zero in 1 min at a constant rate.

NOTE 3—Variables that influence temperature determination by electrical current are as follows:

(1) Nature of wire surface,
(2) Hydrogen flow through bell jar envelope,
(3) Purity and moisture content of hydrogen,
(4) Contact of test specimen in it supports, and
(5) Measurement of the diameter of the test specimen.

Variables that influence temperature determination by optical methods are as follows:

(1) Variations in wall thickness of glass,
(2) Films on glass,
(3) Defects in glass,
(4) Inaccuracies inherent in optical pyrometer, and
(5) Nature of wire surface.

5.3 When the test apparatus has cooled, remove the weight and move the test specimen through an angle of 90° so that the plane formed by the legs of the specimen is horizontal. Measure the vertical distance of the apex in millimeters and record as the zero point or initial reading.

5.4 Raise the temperature of the test specimen at a constant rate of 2600 K in 1 min and hold at that temperature for 5 min before removing the power.

5.5 When the apparatus and specimen have cooled, measure the sag before removing the specimen from the apparatus. Measure the vertical distance of the apex of the specimen in millimeters and record as the final reading. The sag is defined as the difference between the initial and final readings after being held at 2600 K for 5 min.

6. Report

6.1 Report the following information:
6.1.1 Name of the manufacturer of the wire,
6.1.2 Manufacturer's wire type,
6.1.3 Metal lot number,
6.1.4 Ingot number,
6.1.5 Wire size, and
6.1.6 Sag results in millimeters on each ingot.

7. Keywords

7.1 creep testing; hydrogen atmosphere; sag properties; tungsten wire