Designation: F1157 – 04 (Reapproved 2015)

Standard Practice for Classifying the Relative Performance of the Physical Properties of Security Seals[1]

This standard is issued under the fixed designation F1157; 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 practice covers methods for testing the physical properties of mechanical (passive) security seals. Where appropriate, the various tests include particular apparatus or procedural specifications required for different types of security seals. This practice does not address adhesive (tape or label style) or electronic types of security seals.

1.2 This practice will serve as a basis for comparing the response of various security seals under different simulated modes of attack. The security seal to be evaluated shall first be classified into established groupings, and then tested in the manner designated as most suitable for that class of seal, in accordance with Classification F832.

1.3 A mechanical security seal is a single use, passive device intended to detect tampering or entry into the sealed item. Removal of the security seal requires permanent and irreversible damage to the seal. The following procedures reflect the relative performance of security seals when subject to various destructive physical attacks. These tests simulate known and likely security seal implementation and attack methods.

1.4 Security seals often contain unique identification markings for authentication purposes to discourage duplication and to prevent reapplication. This practice does not address unique identifiers or vulnerabilities of security seals.

NOTE 1—See Guide F1158 for procedures on the inspection and evaluation of tampering of security seals. See also Guide F946.

1.5 It is the responsibility of users of this practice to interpret their specific security needs concerning the application of seals, and to determine the grade of seal appropriate for their particular application. ASTM assumes no responsibility for losses occurring as a result of a defeated seal, whether the defeat is apparent, or the seal is not suited for its application.

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

1.7 The following safety hazards caveat pertains only to the test procedures portion, Section 6, of this practice. *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. Referenced Documents

2.1 *ASTM Standards:*[2]

F832 Classification for Security Seals

F883 Performance Specification for Padlocks

F946 Guide for Establishing Security Seal Control and Accountability Procedures

F1158 Guide for Inspection and Evaluation of Tampering of Security Seals

3. Terminology

3.1 *Definitions:*

3.1.1 *locked seal*—condition, as intended by the manufacturer, which secures the sealed item and cannot be reversed or opened without physical destruction of the security seal.

3.1.2 *open condition*—condition which could allow entry into the sealed item and, for the purposes of this practice, a failed security seal.

3.1.3 *security seal*—passive, one-time locking device used to indicate tampering or entry, and may be designed to offer

[1] This practice is under the jurisdiction of ASTM Committee F12 on Security Systems and Equipment and is the direct responsibility of Subcommittee F12.50 on Locking Devices.

Current edition approved Jan. 1, 2015. Published January 2015. Originally approved in 1988. Last previous edition approved in 2010 as F1157 – 04 (2010). DOI: 10.1520/F1157-04R15.

[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.

limited resistance to forced entry. Security seals require inspection to determine a tampering or entry event.

4. Summary of Practice

4.1 A security seal shall be evaluated in accordance with its classification into one of five general groups and its performance in the following six tests: pull (tensile) shear, bending, impact, low temperature impact, and high temperature pull (tensile).

4.2 A security seal shall receive a grade designation based upon its measured performance in each of the required tests. This grade shall be obtained by testing five individual seals in each of the six specific tests. A minimum of 30 security seal specimens shall be required to complete testing. The grade designation shall be determined by comparing the average value of the five test results to the corresponding grade classification tables presented in this practice.

4.3 All tests shall be performed at ambient room temperature 65 ± 5°F (18.3 ± 2.8°C) unless otherwise indicated.

5. Seal Classification

5.1 *General*—For the purpose of defining the most appropriate test configuration of the security seal during tests, the security seal shall be classified as an initial step in accordance with the groups defined in Classification F832.

5.2 For the purpose of comparing the physical properties of security seals, seals are grouped in accordance with the following description of application seals:

5.2.1 *Groups:*

5.2.1.1 *Group 1*—Flexible cable and wire seals, which can be fixed or adjustable length.

5.2.1.2 *Group 2*—Strap and cinch seals.

5.2.1.3 *Group 3*—Rigid bolt and rod seals, including heavy duty metal padlock type.

5.2.1.4 *Group 4*—Twisted rod or wire seals (pigtail).

5.2.1.5 *Group 5*—Padlock type seals, scored seals, metal or plastic base.

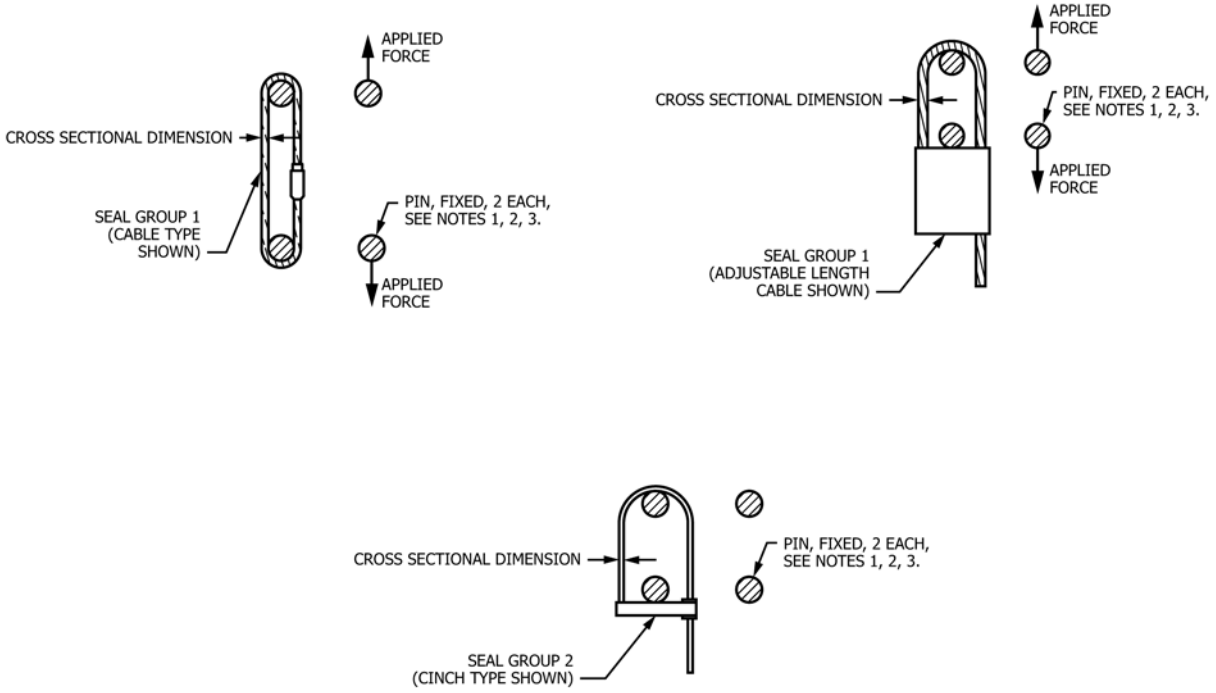
5.3 If a particular security seal does not appear to fall into any of these general classifications, the closest description shall be chosen by the user. The effectiveness of the testing procedures and relevance of the test data may be jeopardized by a faulty classification choice. These general groupings shall be assigned the arbitrary numerical listing of one through five, respectively, as shown in 5.2.1. The group number shall be documented with the test results.

5.4 The required performance levels in any test category shall not be affected by this general classification (see 5.2.1); only the manner in which the seal is physically manipulated during subsequent testing shall be affected by this portion of the evaluation. All seals shall be tested in a locked position using test fixtures appropriate for the seal group.

6. Test Procedures

6.1 *Pull (Tensile) Test:*

6.1.1 Apply a pull (tensile) load to the locked security seal in a direction opposite to the motion required to lock the seal. The travel rate of the test shall be 2 ± 1 in./min (5.08 ± 2.54 cm/min).



NOTE 1—Pin diameter 0.250 in. (6.35 mm) for smallest cross section dimension less than or equal to 0.125 in. (318 mm).
NOTE 2—Pin diameter 0.500 in. (12.7 mm) for smallest cross section dimension greater than 0.125 in. (3.18 mm).
NOTE 3—Tolerance: ±0.010 in. (0.254 mm).

FIG. 1 Schematic Drawings of Pull (Tensile) Test Fixture Requirements for Groups 1 and 2

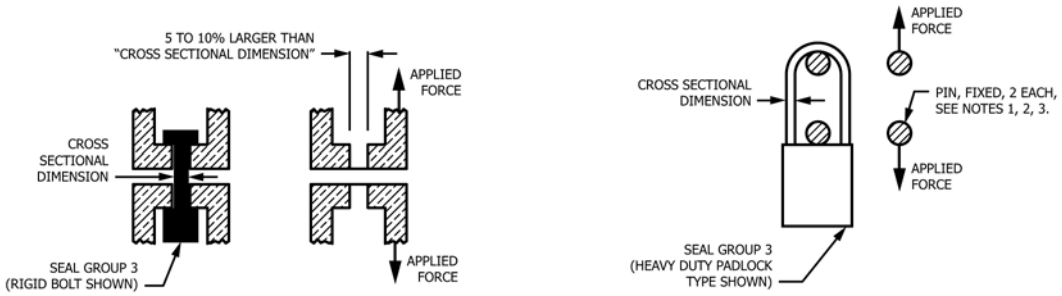


FIG. 2 Schematic Drawings of Pull (Tensile) Test Fixture Requirements for Group 3

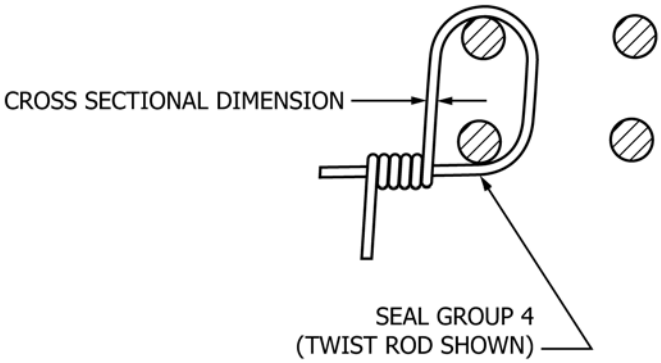


FIG. 3 Schematic Drawings of Pull (Tensile) Test Fixture Requirements for Group 4

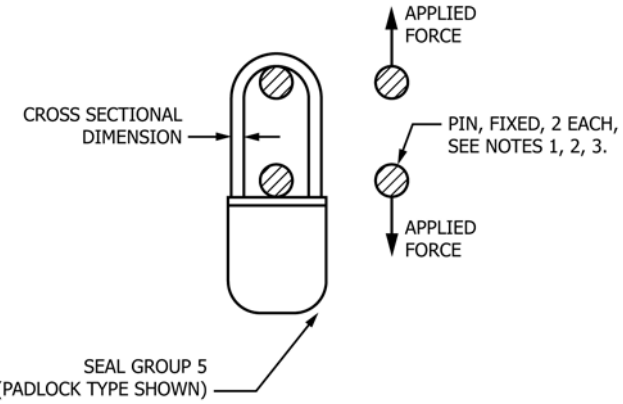


FIG. 4 Schematic Drawings of Pull (Tensile) Test Fixture Requirements for Group 5

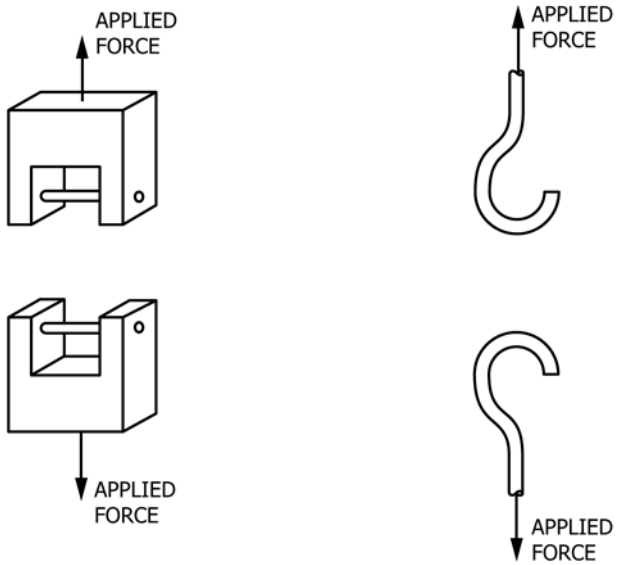


FIG. 5 Schematic Drawings of Possible Pull (Tensile) Test Fixture Configurations

6.1.2 Fixtures necessary to perform this test are determined by the group classification of the security seal. Figs. 1-4 show fixture requirements for the classification groups. Possible fixture configurations are shown in Fig. 5.

6.1.2.1 Fixtures shall be designed such that applied stresses are within the elastic limit of the fixture material.

6.1.2.2 Fixtures shall be designed to eliminate any artificial influences upon the tested strength characteristics of the test specimen.

6.1.3 Record the tensile value required to cause an open condition for each of the five test specimens. Assign the grade designation in accordance with 4.2 and Table 1.

6.2 *Shear Test:*

6.2.1 Apply a shear force to the security seal specimen to measure its resistance to a severing action. The shear plane shall occur at the security seal's weakest section. The shear rate shall be 0.5 ± 0.2 in./min (1.27 ± 0.508 cm/min).

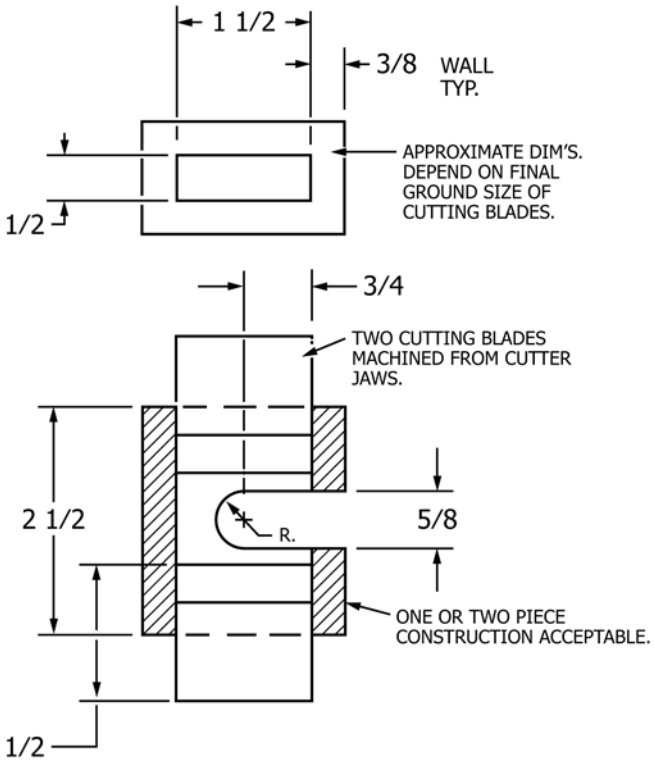
6.2.2 Fixtures necessary to perform this test are determined by the specimen's cross-sectional dimensions, material, and construction.

6.2.2.1 Fixtures shall be designed such that applied stresses are within the elastic limit of the fixture material.

6.2.2.2 Fixtures shall be designed to eliminate any artificial influences upon the tested strength characteristics of the test specimen.

(1) Conduct shear tests with the shackle cutting fixture and blades defined in Performance Specification F883 (see Fig. 6).

(2) Conduct shear test with precise shear fixture defined in Fig. 7 if the fixture defined in 6.2.2.2*(1)* cannot sever the security seal. The precision cutting fixture is designed for smaller cross sections and flexible materials. (**Warning—**Do not exceed a shear force greater than 2000 lbf (8896 N). If a specimen does not sever during the application of 2001 lbf (8900 N), halt test and unload test equipment. Record shear force of 2000 lbf (8896 N). Do not test specimen to failure. Sudden and violent rupture of the test specimen can endanger personnel, equipment, and property.)



NOTE 1—All dimensions are in inches (1 in. = 25.4 mm).

NOTE 2—See Performance Specification F883 for definition of cutter jaws.

FIG. 6 Fixture for Use in Shear Test for Security Seals (Patterned After Padlock Shackle Cutting Fixture in Performance Specification F883)

6.2.3 Record the shear force required to cause an open condition for each of the five test specimens. Assign the grade designation in accordance with 4.2 and Table 2.

6.3 *Bending Test:*

6.3.1 Apply a moment to the security seal specimen to measure its resistance to a bending or twisting action. For the purpose of the bending test, security seals are categorized as flexible (Groups 1 and 2), rigid (Groups 3 and 4), padlocks with metallic hasps (Group 5), and padlocks with non-metallic hasps (Group 5).

6.3.2 Flexible security seals include cable and wire seals (Group 1), and strap and cinch seals (Group 2) and shall be subjected to bending. Fig. 8 shows necessary fixture requirements.

6.3.2.1 Fixtures shall be designed such that applied stresses are within the elastic limit of the fixture material.

6.3.2.2 Fixtures shall be designed to eliminate any artificial influences upon the tested strength characteristics of the test specimen.

6.3.2.3 The pre-test orientation shall be considered 0°. Bend the security seal from 0° to 90°. Reverse the motion and bend the security seal from 90° to -90°, an arc of 180°. Repeat this 180° arc until the security seal exhibits an open condition.

6.3.2.4 Record the bending cycles required to cause an open condition for each of the five test specimens. A bending cycle is defined as one complete arc of 180°. Assign the grade designation in accordance with 4.2 and Table 3.

6.3.3 Rigid security seals include rigid bolt, rod and heavy duty metal padlock security seals (Group 3), and twisted rod or wire seals (Group 4), and shall be subjected to bending. Fig. 9 shows necessary fixture requirements.

6.3.3.1 Fixtures shall be designed such that applied stresses are within the elastic limit of the fixture material.

6.3.3.2 Fixtures shall be designed to eliminate any artificial influences upon the tested strength characteristics of the test specimen.

6.3.3.3 The pre-test orientation shall be considered 0°. Bend the security seal and measure the moment necessary to bend from 0° to 90°. Reverse the applied bending and measure the moment necessary to cause a bend from 90° to 0°. Repeat this range of motion, until the security seal exhibits an open condition. For calculation purposes, the moment arm is defined as the perpendicular distance between line of action of the applied force and the point of bend.

6.3.3.4 Record the maximum bending moment required to cause an open condition for each of the five test specimens. Assign the grade designation in accordance with 4.2 and Table 4.

6.3.4 Metallic hasp padlock security seals (Group 5) shall be subjected to a twisting or torsional moment. Fig. 10 shows necessary fixture requirements.

6.3.4.1 Fixtures shall be designed such that applied stresses are within the elastic limit of the fixture material.

6.3.4.2 Fixtures shall be designed to eliminate any artificial influences upon the tested strength characteristics of the test specimen.

6.3.4.3 Apply a moment to the security seal body until the seal exhibits an open condition.

6.3.4.4 Record the maximum moment required to cause an open condition for each of the five test specimens. Assign the grade designation in accordance with 4.2 and Table 4.

6.3.5 Non-metallic hasp padlock security seals (Group 5) shall be subjected to a twisting or torsional moment. Fig. 11 shows necessary fixture requirements.

6.3.5.1 Fixtures shall be designed such that applied stresses are within the elastic limit of the fixture material.

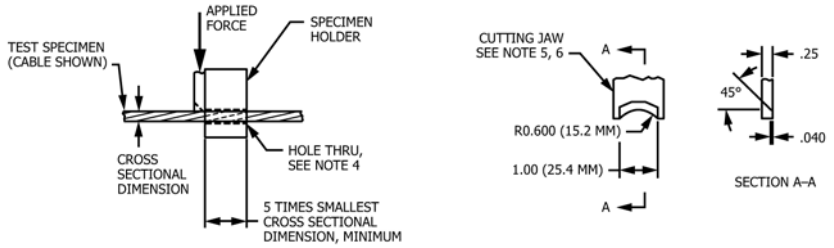
6.3.5.2 Fixtures shall be designed to eliminate any artificial influences upon the tested strength characteristics of the test specimen.

6.3.5.3 The pre-test orientation with the torsion bar contacting both shackle legs shall be considered 0°. Rotate the torsion bar from 0° to 90° so the bar is in constant contact with the shackle legs. Reverse the motion and rotate the bar from 90° to 0°. Repeat this arc of 90° until the security seal exhibits an open condition.

6.3.5.4 Record the bending cycles required to cause an open condition for each of the five test specimens. A bending cycle is defined as a rotation from 0° to 90° to 0°. Assign the grade designation in accordance with 4.2 and Table 3.

6.4 *Impact Test:*

6.4.1 Apply a sequence of energy (impact) loads to each security seal specimen to determine its resistance to impact.



NOTE 1—Hole through specimen holder shall not exceed 10 % of the cross section dimension(s) of specimen.
NOTE 2—Hardness of cutting jaw 60 to 62 Rockwell "C" scale.
NOTE 3—Cutting jaw shall remain parallel ±0.005 in. (0.127 mm) to specimen holder.
NOTE 4—Tolerance ±0.005 in. (0.127 mm) ; ±0.01 in. (0.254 mm); ±0.5°.

FIG. 7 Precision Shear Fixture for Use in Shear Test

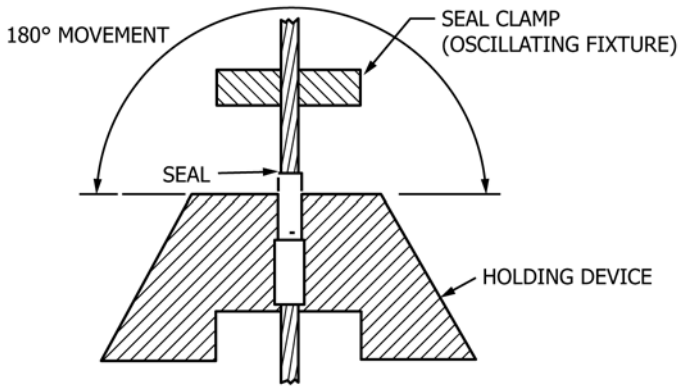


FIG. 8 Schematic Drawing of Bending Test Fixture as Applied to Groups 1 and 2

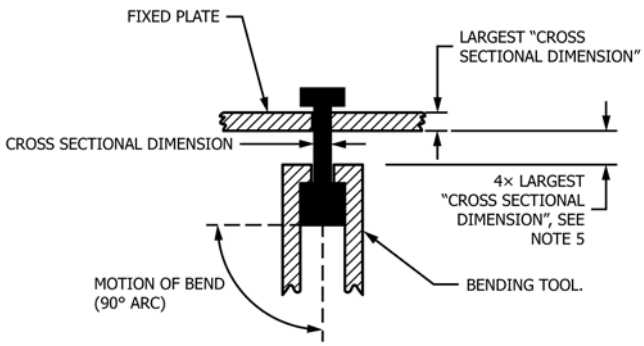


FIG. 9 Schematic Drawing of Bending Test Fixture as Applied to Groups 3 and 4

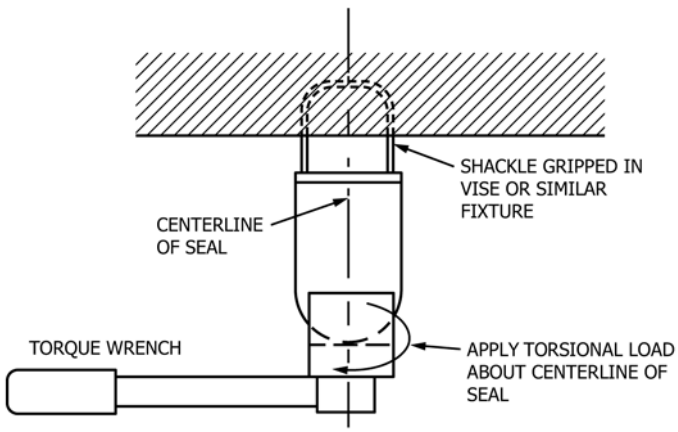


FIG. 10 Schematic Drawing of Bending Test as Applied to Metallic Padlock Class 5 Security Seals

Apply an impact load to the locked security seal in a direction opposite to the motion required to lock the seal.

6.4.2 Fixtures necessary to perform this test shall be similar in configuration to those specified in the pull (tensile) test described in 6.1.2.

6.4.2.1 Fixtures shall be designed such that applied stresses are within the elastic limit of the fixture material.

6.4.2.2 Fixtures shall be designed to eliminate any artificial influences upon the tested strength characteristics of the test specimen.

6.4.2.3 Determine the maximum impact load, when repeated five successive times, that each security seal specimen can sustain without exhibiting an open condition. Impact loads shall range from 10 ft-lbf (13.56 J) to 50 ft-lbf (67.79 J), in increments of 10 ft-lbf (13.56 J).

6.4.2.4 Record the maximum impact load, when repeated five successive times, that each of five specimens can sustain without exhibiting an open condition. The average impact load value from the five specimens shall determine its grade designation in accordance with Table 5.

6.5 *Extreme Temperature Tests:*

6.5.1 Apply a pull (tensile) test at an elevated temperature and an impact test at a low temperature to simulate performance at extreme temperatures.

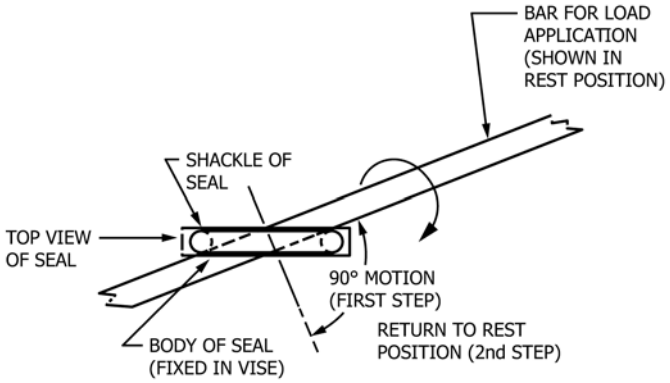


FIG. 11 Schematic Drawing of Bending Test as Applied to Non-metallic Padlock Group 5 Security Seals

TABLE 1 Pull (Tensile) Test Requirements for Grade Classification of Security Seals at Room (65°F (18.3°C)) and Elevated Temperature (180°F (82.2°C))

Load to Failure, (lbf (N))	Seal Grade Level Awarded
>5000 (>22241)	F
>3000 to 5000 (>13345 to 22241)	E
>1000 to 3000 (>4448 to 13345)	D
>200 to 1000 (>890 to 4448)	C
>50 to 200 (>222 to 890)	B
1 to 50 (4.45 to 222)	A

TABLE 2 Shear Test Requirements for Grade Classification of Security Seals

Compressive Load to Cut, lbf (N)	Seal Grade Level Awarded
>2000 (>8896)	F
>1000 to 2000 (>4448 to 8896)	E
>750 to 1000 (>3336 to 4448)	D
>500 to 750 (>2224 to 3336)	C
>200 to 500 (>890 to 2224)	B
1 to 200 (4.45 to 890)	A

TABLE 3 Bending Test Requirements for Grade Classification of Flexible Security Seals Groups 1,2, and 5 (Non-Metallic Padlock)

Cycles to Failure for Bending of Flexible Seals	Seal Grade Level Awarded
2001 or more	F
1001 to 2000	E
501 to 1000	D
251 to 500	C
101 to 250	B
1 to 100	A

TABLE 4 Bending Test Requirements for Grade Classification of Rigid Security Seals Groups 3, 4, and 5 (Metallic Padlock)

Maximum Bending Moment, lbf-ft (Nm), for Bending of Rigid Seals	Seal Grade Level Awarded
>70 (>94.91)	F
>50 to 70 (>67.79 to 94.91)	E
>35 to 50 (>47.45 to 67.79)	D
>20 to 35 (>27.12 to 47.45)	C
>10 to 20 (>13.56 to 27.12)	B
10 or less (13.56 or less)	A

TABLE 5 Impact Test Requirements for Grade Classification of Security Seals at Room Temperature (65°F (18.3°C)) and Reduced Temperature (-10°F (-23.3°C))

Impact Loading Sustained, ft-lbf (J)	Seal Grade Level Awarded
>50 (>67.79)	F
>40 to 50 (>54.23 to 67.79)	E
>30 to 40 (>40.67 to 54.23)	D
>20 to 30 (>27.12 to 40.67)	C
>10 to 20 (>13.56 to 27.12)	B
10 or less (13.56 or less)	A

6.5.2 Follow procedures specified in 6.1, except perform test with specimen at an elevated temperature of 180 ± 5°F (82.2 ± 2.8°C). The thermal conditioning chamber shall be maintained at its steady state target temperature for at least two hours to reach equilibrium. The specimen shall be soaked for at least four hours after the chamber attains equilibrium.

6.5.3 Follow procedures specified in 6.4, except perform test with specimen at a reduced temperature of -10 ± 5°F (-23.3 ± 2.8°C). The thermal conditioning chamber shall be maintained at its steady state target temperature for at least two hours to reach equilibrium. The specimen shall be soaked for at least eight hours after the chamber attains equilibrium.

7. Report

7.1 Report the following information concerning the performance of a given security seal tested in accordance with this practice:

7.1.1 The classification number best describing that particular seal,

7.1.2 The grade level awarded for the pull test,

7.1.3 The grade level awarded for the shear test and specify shear fixture,

7.1.4 Reporting of whether the seal in question was tested under the flexible or rigid bending test guidelines,

7.1.5 The grade level awarded for the bending test,

7.1.6 The grade level awarded for the impact test,

7.1.7 The grade level awarded for the pull test at 180 ± 5°F (82.2 ± 2.8°C), and

7.1.8 The grade level awarded for the impact test at -10 ± 5°F (-23.3 ± 2.8°C).

TABLE 6 Comprehensive Grade Classification Table[A,B]

	A	B	C	D	E	F
Pull Test, lbf (N)	1 to 50 (4.45 to 222)	>50 to 200 (>222 to 890)	>200 to 1000 (>890 to 4448)	>1000 to 3000 (>4448 to 13345)	>3000 to 5000 (>13345 to 22241)	>5000 (>22241)
Shear Test, lbf (N)	1 to 200 (4.45 to 890)	>200 to 500 (>890 to 2224)	>500 to 750 (>2224 to 3336)	>750 to 1000 (>3336 to 4448)	>1000 to 2000 (>4448 to 8896)	>2000 (>8896)
Bending Test (Rigid Seals), lbf-ft (Nm)	0 to 10 (0 to 13.56)	>10 to 20 (>13.56 to 27.12)	>20 to 35 (>27.12 to 47.45)	>35 to 50 (>47.45 to 67.79)	>50 to 70 (>67.79 to 94.91)	>70 (>94.91)
Bending Fatigue Test (Flexible Seals), cycles	1 to 100	101 to 250	251 to 500	501 to 1000	1001 to 2000	2001 or more
Impact Test, ft-lbf (J)	0 to 10 (0 to 13.56)	>10 to 20 (>13.56 to 27.12)	>20 to 30 (>27.12 to 40.67)	>30 to 40 (>40.67 to 54.23)	>40 to 50 (>54.23 to 67.79)	>50 (>67.79)
Elevated Temperature (180 ± 5°F (82.2 ± 2.8°C)) Pull Test, lbf (N)	1 to 50 (4.45 to 222)	>50 to 200 (>222 to 890)	>200 to 1000 (>890 to 4448)	>1000 to 3000 (>4448 to 13345)	>3000 to 5000 (>13345 to 22241)	>5000 (>22241)
Reduced Temperature -10 ± 5°F (-23.3 ± 2.8°C) Impact Test, ft-lbf (J)	0 to 10 (0 to 13.56)	>10 to 20 (>13.56 to 27.12)	>20 to 30 (>27.12 to 40.67)	>30 to 40 (>40.67 to 54.23)	>40 to 50 (>54.23 to 67.79)	>50 (>67.79)
Report						

[A] Completed test results will show classification code prior to six letters designating test results of each test performed, for example, 3-E-E-D-C-D-B.
[B] A minimum of five seals to be tested in each category, a total of 30 seals required to complete tests for classification rating of a specific seal.

7.1.9 The final classification of the seal will include all of the above: the classification number first, followed by six letters (see Table 6).

8. Keywords

8.1 locking device; modes of attack; security seal; single use locking device