Designation: F2961 – 15

Standard Test Method for Characterizing Gripping Performance of Gloves Using a Torque Meter[1]

This standard is issued under the fixed designation F2961; 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 is used for evaluating how gloves affect an individual wearer's ability to grip onto a hard surface object.

1.1.1 This test method establishes procedures for measuring the maximum torque that can be attained by individual's bare hand as compared to the maximum torque that is attained by the same individual wearing a glove. The torque is applied to a vertically-mounted pole attached to a torque meter.

1.2 This test method is suitable for evaluating gloves and other forms of hand protection that require the wearer to maintain a secure hold on objects.

1.3 This test method does not address all effects of wearing gloves on hand functions. Other test methods include those for evaluating the effect of wearing gloves on dexterity, tactility, and other aspects of functional performance.

1.4 It is the responsibility of the test laboratory to obtain the necessary and appropriate approval(s) required by their institution for conducting tests using human subjects.

1.5 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

1.6 *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]

D1776 Practice for Conditioning and Testing Textiles

E177 Practice for Use of the Terms Precision and Bias in ASTM Test Methods

E691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method

F1494 Terminology Relating to Protective Clothing

2.2 *NFPA Standards:*[3]

NFPA 1971 Standard on Protective Ensembles for Structural Fire Fighting and Proximity Fire Fighting

3. Terminology

3.1 For definitions of other protective clothing-related terms used in this test method, refer to Terminology F1494.

4. Summary of Test Method

4.1 The maximum torque applied to a vertically oriented cylindrical rod is measured without gloves and then later while wearing gloves. The bare hand maximum torque is compared to the gloved hand maximum torque in terms of a percentage. This percentage is useful in determining if a glove enhances or decreases an individual's ability to grip a hard object.

5. Significance and Use

5.1 This test method is intended to provide a quantitative measurement of wearing gloves on an individual's ability to grip a solid object and twist in a defined direction. The gripping performance may be different if twisted in the opposing direction or if pushing or pulling on a solid object while gripping.

5.2 This method was originally developed to help understand how materials and construction of firefighting gloves affected grip. Methods available at the time showed very little statistical difference between a wide range of gloves including many NFPA 1971 compliant firefighting gloves and also non-compliant gloves used in other applications. This method was shown to have less subject-to-subject variability and a greater range of measured grip than previous tests.[4]

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[1] This test method is under the jurisdiction of ASTM Committee F23 on Personal Protective Clothing and Equipment and is the direct responsibility of Subcommittee F23.60 on Human Factors.

Current edition approved Feb. 1, 2015. Published March 2015. Originally approved in 2014. Last previous edition approved in 2014 as F2961 – 14. DOI: 10.1520/F2961–15.

[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.

[3] Available from National Fire Protection Association (NFPA), 1 Batterymarch Park, Quincy, MA 02169-7471, http://www.nfpa.org.

[4] Ross, Barker, Watkins, and Deaton, "Methods for Measuring the Grip Performance of Structural Firefighting Gloves," *Performance of Protective Clothing and Equipment: Emerging Issues and Technologies*," ASTM STP 1544, Vol 9, A. Shepherd Ed., ASTM International, West Conshohocken, PA, 2012.

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5.3 It is possible to apply this test method to other types of gloves, other than structural firefighting protective gloves. Evaluate the relevance of this test method by examining the particular application of the gloves for end user gripping capability. In addition, understand how this test method ranks gloves in comparison with end user perceptions.

5.4 This test method does not discriminate all glove effects on wearer hand function nor does it apply to all glove types and applications. Consider additional evaluations or tests representative of the glove use applications performed to determine the overall impact of gloves on wearer hand functions.

6. Apparatus

6.1 *Testing Apparatus*—The device used to characterize the gripping performance of gloves consists of a torque meter with adjustable rod holder and a smooth acrylic cylindrical rod (Fig. 1). The rod is secured tightly in the adjustable rod holder attached to the torque meter.

FIG. 1 Acrylic Rod Attached to a Torque Meter

6.2 Use a torque meter capable of meeting the following requirements:

6.2.1 Measuring 0 to 10.0 ± 0.5 N·m (88.5 ± 4.5 lb-in.).

6.2.2 Able to be fastened in place or heavy enough to be immobile during testing.

6.2.3 Able to measure torque in either a clockwise or counter-clockwise direction.

6.2.4 Fitting with an adjustable rod holder fixed to the upper surface of the meter.

6.2.4.1 The rod holder has four metal pins protruding upwards from the surface. Use 10 mm diameter pins that protrude 30 mm from the surface of the holder.

(1) Cover the metal pins with a rubber material that is between 2.5 and 3.0 mm thick.

6.3 Use transparent cast acrylic rod meeting the following requirements:

6.4 Measures 600 mm (24 in.) in length and has a diameter of 41.5 mm (1.625 in.).

6.4.1 Has a surface roughness value of 0.10 ± 0.05 µm (4 ± 2 µin.) and is free of visual scratches and blemishes.

6.4.2 Use an acrylic rod with four grooves cut into the bottom of the rod. Grooves should match the size of the pins with rubber covering.

6.4.2.1 Fig. 2 shows an example of a rod cut with grooves at the bottom.

7. Sampling, Test Specimens, and Test Units

7.1 Use a minimum of three glove specimens for testing each model or type of glove.

7.1.1 Use right-handed glove specimens for right-hand dominant test subjects and left-handed glove specimens for left-hand dominant test subjects.

7.1.2 Each glove specimen shall be tested by a different human subject.

7.2 Each glove specimen shall be tested in a new, as-distributed, condition.

7.2.1 Do not use glove specimens that are treated, broken-in, or conditioned in any manner other than specified in this test method prior to their evaluation unless otherwise specified.

8. Conditioning

8.1 Condition all glove specimens at a temperature of 21 ± 3°C (70 ± 5°F), and a relative humidity of 65 ± 5 %, until equilibrium is reached, as determined in accordance with Practice D1776 or for at least 24 h.

9. Procedure

9.1 Use a minimum of three test subjects with similar hand sizes.

9.1.1 Only use test subjects that obtain a bare hand average maximum torque applied value T_B greater than 4.5 N·m but less than 9.0 N·m.

9.1.2 Fit the dominant hand of each test subject with a new glove, appropriately sized, in accordance with the manufacturer's recommendations for the selection and fit of available glove sizes.

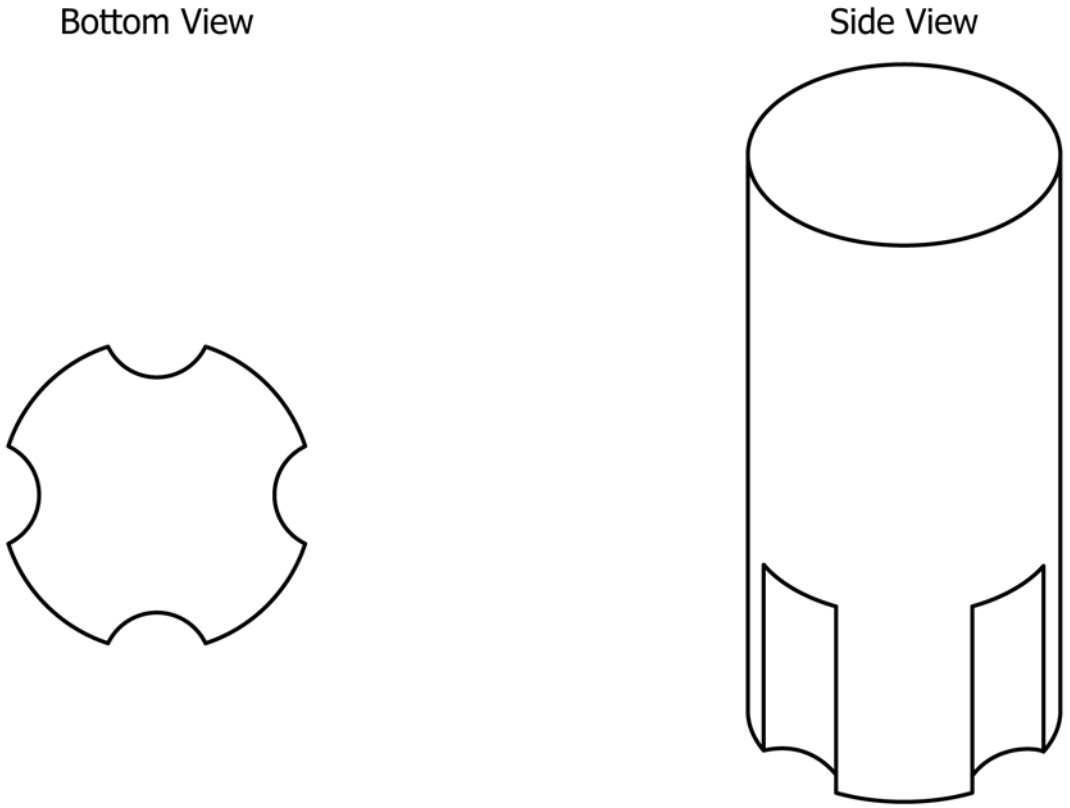

FIG. 2 Diagram of Rod Cut with Grooves at the Bottom

9.2 Conduct the test without the test subject's knowledge of the torque applied, that is, the test subject shall not be able to observe the reading from the torque meter or learn of the applied torque during any attempt to twist the rod.

9.3 No more than five different glove specimens shall be tested by the same test subject on the same day to reduce hand fatigue.

9.4 Conduct a bare hand torque measurement using a subject's dominant hand at the beginning of a testing cycle. A testing cycle consists of a bare hand measurements followed by gloved hand measurements.

9.4.1 If conducting more than one testing cycle subjects must wait 15 minutes before conducting the next cycle of testing. In addition, the glove specimens should be tested in a random order.

9.4.2 Set the torque meter to read a counter-clockwise torque for right-handed dominant test subjects. Set the torque meter to read a clockwise torque for left-hand dominant test subjects.

9.4.3 Test subjects stand such that they grab the acrylic rod with the elbow bent at a right angle and the upper arm against the side of the body.

9.4.3.1 Adjust the height of the test apparatus to provide the body and arm orientation described in 9.4.3.

9.4.3.2 The subject shall stand with feet parallel, facing the testing apparatus, and shoulder width apart.

9.4.3.3 The subject shall place the non-dominant arm at the body's side during testing.

9.4.3.4 In the correct position, the engaged arm will be parallel to the upright body from the shoulder to the elbow and perpendicular to the ventral plane of the body from the elbow to the wrist. An example can be seen in Fig. 3.

9.4.4 With the bare hand firmly in grasp of the rod, each subject will make five successive attempts to twist the rod. Each attempt counts as a repetition.

9.4.4.1 Each repetition shall last no longer than 5 s and each successive repetition shall occur within one minute of the previous repetition.

9.4.4.2 The test subject's rotation during the repetition shall be in the wrist rather than in the shoulder. An example of how the wrist looks before and after the twisting action can be seen in Figs. 4 and 5.

9.4.4.3 Record the maximum torque applied after each repetition.

9.4.4.4 Calculate the average maximum torque applied with the bare hand over the five attempts and identify it as T_B.

9.5 Use the same hand for glove specimen testing as used for the bare handed tests.

9.5.1 Test subjects don glove specimen and stand such that they grab the acrylic rod with the elbow bent at a right angle and the upper arm against the side of the body.

9.5.1.1 Adjust the height of the test apparatus to provide the body and arm orientation as described in 9.5.1.

9.5.1.2 The subject shall stand with feet parallel, facing the testing apparatus, and shoulder width apart.

FIG. 3 Example of a Correct Testing Position

9.5.1.3 The subject shall place the non-dominant arm at the body's side during testing.

9.5.1.4 In the correct position, the engaged arm will be parallel to the upright body from the shoulder to the elbow and perpendicular to the ventral plane of the body from the elbow to the wrist. An example of the correct position can be seen in Fig. 3.

9.5.2 With the gloved hand firmly in grasp of the rod, each subject will make five successive attempts to twist the rod.

9.5.2.1 Each repetition shall last no longer than 5 s and each successive repetition shall occur within one minute of the previous repetition.

9.5.2.2 The test subject's rotation during the repetition shall be in the wrist rather than in the shoulder. An example of how the wrist looks before and after the twisting action can be seen in Figs. 4 and 5.

9.5.2.3 Record the maximum torque applied after each attempt.

9.5.2.4 Calculate the average maximum torque applied with the gloved hand over the five attempts and identified as T_G.

10. Calculation

10.1 Compare the average maximum torque with a gloved hand with the bare-handed average maximum torque for each test subject. Calculate the percentage of bare-handed control value as follows:

$$\%\ BHCV = \frac{T_G}{T_B} \times 100 \tag{1}$$

where:

$\%BHCV$ = percentage of bare-handed control value,
T_G = average maximum torque applied with gloved hand, and
T_B = average maximum torque applied with bare hand.

10.1.1 Values higher than 100 %BHCV indicate that gloves tested enhances the wearer's ability to grip a solid object while values lower than 100 % decreases the wearer's ability to grip a solid object.

10.2 Average the three subject's %BHCV to obtain the overall %BHCV.

FIG. 4 Example of Wrist Before Twisting

11. Report

11.1 Record and report the glove size used for testing.

11.2 Record and report the %BHCV for each test subject.

11.3 Record and report the average %BHCV for all test subjects.

11.4 Explain any departures from the specified apparatus or procedure.

12. Precision and Bias

12.1 The precision of this test method is based on an intralaboratory study of ASTM WK33658, New Standard Test Method for Characterizing Gripping Performance of Gloves Using a Torque Meter, conducted in 2013. A single laboratory participated in this study, testing three types of gloves. Every "test result" represents an individual determination. The laboratory reported four replicate test results for each glove type. Except for the use of only one laboratory, Practice E691 was followed for the design and analysis of the data; the details are given in ASTM Research Report No. F23-1010.[5]

12.1.1 *Repeatability (r)*—The difference between repetitive results obtained by the same operator in a given laboratory applying the same test method with the same apparatus under constant operating conditions on identical test material within short intervals of time would in the long run, in the normal and correct operation of the test method, exceed the following values only in one case in 20.

12.1.1.1 Repeatability can be interpreted as maximum difference between two results, obtained under repeatability conditions that are accepted as plausible due to random causes under normal and correct operation of the test method.

12.1.1.2 Repeatability limits are listed in Table 1 below.

[5] Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:F23-1010. Contact ASTM Customer Service at service@astm.org.

FIG. 5 Example of Wrist After Twisting

TABLE 1 Bare Hand Control Value (%)

	Average[A] $\bar{x}$	Repeatability Standard Deviation s_r	Repeatability Limit r
Thin Cotton Glove	54.4812	2.5061	7.0171
Firefighting Glove	96.2172	4.9395	13.8305
Nitrile Glove	96.6886	2.2629	6.3361

[A]The average of the laboratories' calculated averages.

12.1.2 *Reproducibility (R)*—The difference between two single and independent results obtained by different operators applying the same test method in different laboratories using different apparatus on identical test material would, in the long run, in the normal and correct operation of the test method, exceed the following values only in one case in 20.

12.1.2.1 Reproducibility can be interpreted as maximum difference between two results, obtained under reproducibility conditions that are accepted as plausible due to random causes under normal and correct operation of the test method.

12.1.2.2 Reproducibility limits cannot be calculated from a single laboratory's results.

12.1.3 The above terms (repeatability and reproducibility limit) are used as specified in Practice E177.

12.1.4 Any judgment in accordance with 12.1.1 would normally have an approximate 95 % probability of being correct; however, the precision statistics obtained in this ILS must not be treated as exact mathematical quantities which are applicable to all circumstances and uses. The limited number of laboratories reporting replicate results essentially guarantees that there will be times when differences greater than predicted by the ILS results will arise, sometimes with considerably greater or smaller frequency than the 95 % probability limit

would imply. Consider the repeatability limit as a general guide, and the associated probability of 95 % as only a rough indicator of what can be expected.

12.2 *Bias*—At the time of the study, there was no accepted reference material suitable for determining the bias for this test method; therefore, no statement on bias is being made.

12.3 The precision statement was determined through statistical examination of twelve results, from a single laboratory, on the three different types of gloves.

13. Keywords

13.1 firefighting gloves; grip; protective gloves; torque; whole glove function

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