Designation: F 1790 – 97

Standard Test Method for Measuring Cut Resistance of Materials Used in Protective Clothing[1]

This standard is issued under the fixed designation F 1790; 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 the measurement of the cut resistance of a material when mounted on a mandrel and subjected to a cutting edge under a specified load.

1.1.1 This procedure is not valid for high-porosity materials which allow cutting edge contact with the mounting surface prior to cutting, or for materials greater than 3 mm in thickness.

1.2 The values stated in SI units or in other units shall be regarded separately as standard. The values stated in each system may not be exact equivalents; therefore, each system must be used independently of the other, without combining values in any way.

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

2. Referenced Documents

2.1 *ASTM Standards:*

D 1776 Practice for Conditioning Textiles for Testing[2]

F 1494 Terminology Relating to Protective Clothing[3]

3. Terminology

3.1 *Definitions:*

3.1.1 *cut resistance*, *n—in cut testing*, the property demonstrated by a material, or combination of materials, when a sharp-edged device initiates cut through.

3.1.2 *cut through*, *n—in cut resistance tests*, the penetration of the cutting edge entirely through material after contact is made with a material.

3.1.3 *cutting edge*, *n—in cut resistance tests*, a sharp-edged device used to initiate cut through of a planar structure.

3.1.4 *protective clothing*, *n*—any material, or combination of materials, used in an item of clothing for the purpose of isolating parts of the body from a potential hazard.

3.1.4.1 *Discussion*—In this test method, the potential hazard is cutting.

3.1.5 *reference distance*, *n—in cut resistance testing*, the intercept of the reference force to the distance traversed.

3.1.5.1 *Discussion*—For this test method, the reference distance is 25 mm (1 in.).

3.1.6 *reference force*, *n—in cut resistance testing*, the load required to cause a cutting edge to traverse a specific distance resulting in a cut through.

4. Summary of Test Method

4.1 A cutting edge, with a specified load, is moved one time across a specimen mounted on a mandrel.

4.2 The distance is recorded, from initial contact to cut through, for each load.

4.2.1 A series of tests, at three different loadings must be performed to establish a range and to determine the reference forces.

4.3 The resulting load versus distance curve can be used to determine cut resistance of the specimen.

5. Significance and Use

5.1 This test method assesses the cut resistance of a material when exposed to a cutting edge under specified loads. Data obtained from this test method can be used to compare the cut resistance of different materials.

5.2 This test method only addresses that range of cutting hazards which are related to a cutting action across the surface of the material. It is not representative of any other cutting hazard to which the material may be subjected.

6. Apparatus

6.1 *Cut Protection Tester:*[4,5]

6.1.1 The cut protection tester is designed to measure the distance traveled by the cutting edge as it is maintained under a known load during the test, and then generate force distance data. Apparatus, such as shown in Fig. 1, consists of a

[1] This test method is under the jurisdiction of ASTM Committee F-23 on Protective Clothing and is the direct responsibility of Subcommittee F23.20 on Physical Properties.

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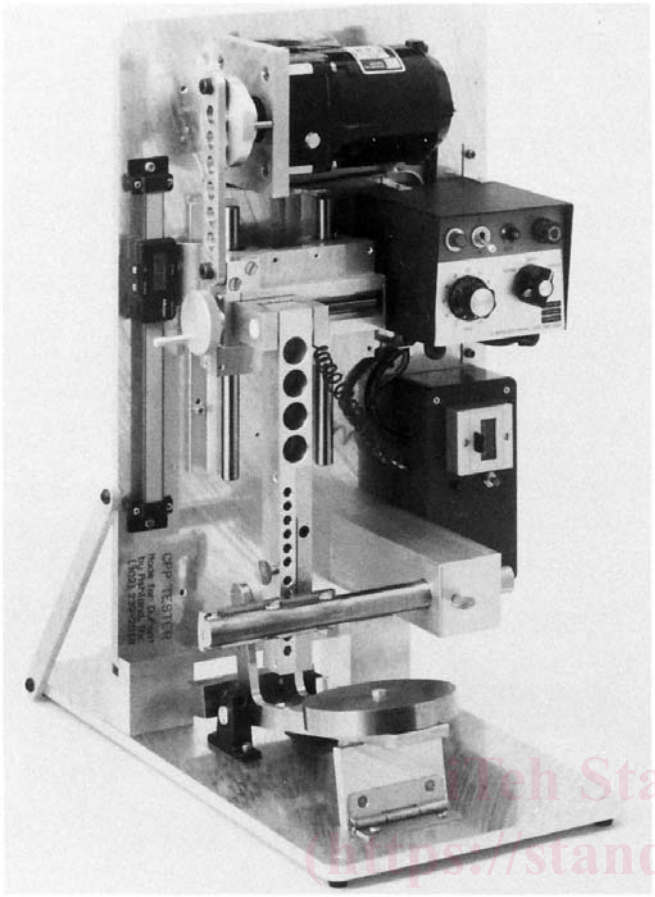
[2] *Annual Book of ASTM Standards*, Vol 07.01.

[3] *Annual Book of ASTM Standards*, Vol 11.03.

[4] Cut test equipment is available from: Red Clay, Inc., 2388 Brackenville Rd., Hockessin, DE 19707.

[5] This is the sole source of supply of this apparatus known to the committee at this time. If you are aware of alternative suppliers, please provide this information to ASTM Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee,[1] which you may attend.



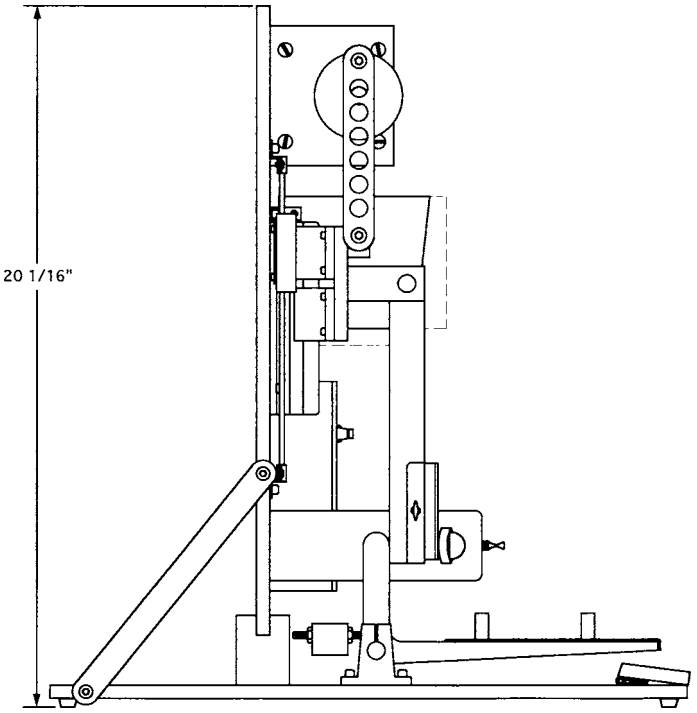
NOTE 1—Legend:
A—motor-driven balanced arm
B—cutting edge
C—mandrel
D—motor/drive wheel
E—weights

FIG. 1 Schematic of CPP Test Equipment

motor-driven balanced arm (A) holding the cutting edge (B) in contact with the specimen mounted on a mandrel (C). As the arm is driven downward, the blade moves across the specimen until the force, generated by the weights (E) mounted on the lever arm assembly, causes the specimen to sustain a cut through.

6.1.1.1 The apparatus is powered by a 1/50-hp AC motor.[5,6] The motor speed is adjusted by a power controller.[5,7] The cut through is electronically recorded as the cutting edge makes contact with the sample holder. The distance traveled is recorded on a distance meter capable of recording to 0.1 mm (0.004 in.).

6.1.2 Weights (E) are mounted on the lever arm assembly. The apparatus must be capable of handling loads ranging from 10 g (0.35 oz) to 15 kg (33 lb).



NOTE 1—Legend:
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FIG. 2 Schematic of CPP Test Equipment (Side View)

6.2 *Mandrel*—The top surface of the mandrel is a rounded form which has an arc of 32 mm (1.25 in.) in a circle having a radius of 38 mm (1.5 in.). The surface of the mandrel should either be made of electroconductive material or be covered with an electroconductive material. Double-faced tape is used to secure the specimens to the electroconductive surface.

6.3 *Blade*[5,8]—Blades shall be made of stainless steel with a hardness greater than 45 HRC. Blades shall be 1.0 ± 0.5 mm thick and ground to a bevel width of 2.5 ± 0.2 mm along a straight edge. This is an included angle of approximately 22° at the cutting edge. Blades shall have a cutting edge length greater than 65 mm and blades shall be more than 18 mm wide.

6.4 *Calibration Material*[5,9]—Calibration material is a 1.6-mm (0.0625-in.) Neoprene having a hardness of 50 ± 5 Shore A and a thickness of 1.57 mm (0.062 in.) ± 10 %.

6.5 *Data Analysis*—Data analysis can be accomplished by a computer, capable of analyzing the data collected using exponential regression analysis.

7. Hazards

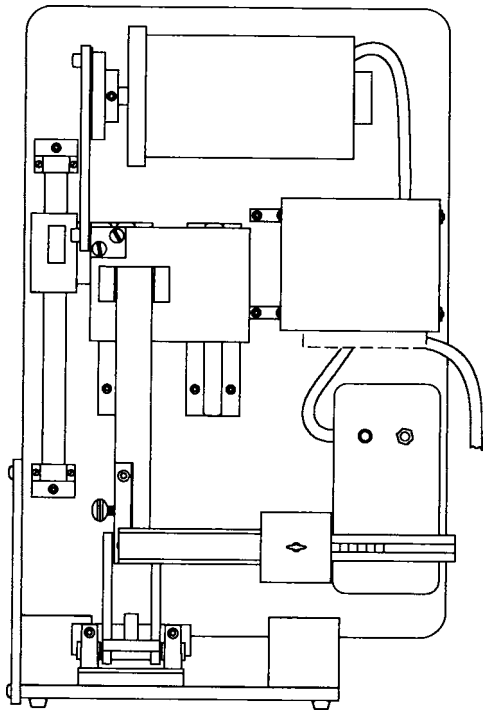
7.1 This test equipment can pose a potential hazard to the technician if proper safety precautions are not followed. This

[6] TYPE NSH-11D4 motor supplied by Bodine Electric Co., 2800 W. Bradley Place, Chicago, IL 60618 has proven satisfactory for this test method.

[7] TYPE BSH200 speed controller supplied by Bodine Electric Co., 2800 W. Bradley Place, Chicago, IL 60618 has proven satisfactory for this test method.

[8] Blade 88-0121 TYPE: GRU-GRU, supplied by American Safety Razor Co., Razor Blade Lane, Vernona, VA 24482, has proven satisfactory for this test method. Its specifications include a cutting edge length greater than 69 mm, width of greater than 18 mm, and a thickness of 0.85 to 0.93 mm.

[9] Neoprene, Style NS-5550, or equivalent supplied by Fairprene, 85 Mill Plain Road, Fairfield, CT 06430 has proven satisfactory for this test method.



NOTE 1—Legend:
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FIG. 3 Schematic of CPP Test Equipment (Front View)

instrument is to be used only by authorized personnel that have had hands-on training.

7.2 Remove weights when installing or removing a blade.

7.3 Store used blades in a sealed container.

7.4 Remove blades at the end of each test or when not in use.

7.5 NEVER MOUNT TEST SAMPLE WITH A BLADE IN CUT POSITION.

7.6 Turn off machine before making instrument adjustments to avoid the chance of a low-voltage shock.

7.7 Keep hands and fingers away from moving parts when machine is operating.

8. Sampling

8.1 *Lot Sample*—As a lot sample for acceptance testing, take at random the number of shipping units directed in an applicable material specification.

8.2 *Laboratory Sample*—As a laboratory sample for acceptance testing, take at random from each shipping unit in the lot sample, the number of packages or pieces directed in an applicable material specification or other agreement between the purchaser and the supplier.

8.3 *Test Specimens*:

8.3.1 Cut three 50 by 100-mm (2 by 4-in.) specimens at random from each laboratory sampling unit. Cut all woven and knit structures on the bias to make a 0.785 rad (45°) between the warp and filling (wale and course) directions of the fabric and the blade.

8.3.2 On each specimen, make five determinations at three different loads for a total of 15 determinations for each laboratory sampling unit.

9. Calibration

9.1 *Calibration of Blade Supply*—Calibrate the cutting edge supply by using a load of 4 N (0.88 lbf) on the calibration material at the beginning and end of each sample being tested, or when changing to a blade supply from a different manufacturing lot number. The length of the calibration cut through must be between 18 and 38 mm (0.70 and 1.5 in.). The cut through lengths at the beginning and end of each sample test should not differ in length by more than 10 mm (0.40 in.).

9.1.1 When the length of cut through is outside these distances, check for the following:

9.1.2 The cutting edges being used are new.

9.1.3 The Neoprene material is the same as that specified in Section 6.

9.1.4 The calibration procedure for the lever arm indicates that the force at point of contact is 4 N (0.88 lbf).

9.2 *Calibration of Lever Arm Balance*—With no weights on the lever arm, and a used blade mounted in the blade holder, adjust the position of the counterweight until the edge of the blade touches the curved surface of the mandrel without exerting any visible force on the mandrel.

9.2.1 This neutral position may be verified with gentle taps on the stand next to the machine.

9.2.2 Any disturbance should cause the counterweight to fall away from the mandrel as the lever arm pivots.

9.3 *Calibration of Lever Arm Load*:

9.3.1 To calibrate force, an alternate mandrel fitted with an electronic load cell is required.

9.3.2 Place a known weight of less than 1 kg on the lever arm and record the force indicated by the load cell. Repeat this procedure using different weights between 50 and 1000 g.

9.3.2.1 The load cell is delicate. Do not exceed its rating. Stressing a load cell more than 1.5 times its maximum rating will result in damage.

9.3.3 Perform a linear regression analysis using the actual (known) weight values on the *x*-axis and the force indicated by the load cell on the *y*-axis, Eq 1.

$$y = ax + b \quad (1)$$

where:
y = force,
x = known weight,
a = slope (correction factor), and
b = intercept of slope.

9.3.3.1 The coefficient of x is the correction factor to be applied to the actual weights to determine the load on the blade.

9.3.4 Calibration of the lever arm load should be performed at least once a month and whenever the machine is moved.

10. Conditioning

10.1 Condition test specimens as indicated in Practice D 1776D 1776.