



Standard Test Method for Shear Strength of Plastics by Punch Tool¹

This standard is issued under the fixed designation D 732; 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.

This standard has been approved for use by agencies of the Department of Defense.

1. Scope *

1.1 This test method covers the punch-type of shear test and is intended for use in determining the shear strength of test specimens of organic plastics in the form of sheets and molded disks in thicknesses from 0.127 to 12.7 mm (0.050 to 0.500 in.).

1.2 The values stated in SI 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 establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

NOTE 1—There is no known ISO equivalent to this standard.

2. Referenced Documents

2.1 ASTM Standards:

D 618 Practice for Conditioning Plastics and Electrical Insulating Materials for Testing²

D 4000 Classification System for Specifying Plastic Materials³

D 4066 Specification for Nylon Injection and Extrusion Materials³

E 4 Practices for Load Verification of Testing Machines⁴

E 691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method⁵

3. Terminology

3.1 Definition:

3.1.1 *shear strength*—the maximum load required to shear the specimen in such a manner that the moving portion has completely cleared the stationary portion. It is expressed in megapascals (or pounds-force per square inch) based on the

area of the sheared edge or edges.

4. Significance and Use

4.1 Shear strength obtained by a tool of the punch type is one of the recognized methods of comparing materials or obtaining data for engineering design. However, it must be recognized that for end-use application there may be many factors not taken into account in this test method, such as stress-concentrating geometries and rates of shear, which can profoundly affect shear strength. Moreover, the fact that the shear strength is calculated by dividing the load by the area of the sheared edge (circumference \times thickness) should not be interpreted as indicating that the shear strength value so obtained is solely a material property, independent of thickness.

4.2 For many materials, there may be a specification that requires the use of this test method, but with some procedural modifications that take precedence when adhering to the specification. Therefore, it is advisable to refer to that material specification before using this test method. Table 1 of Classification System D 4000 lists the ASTM materials standards that currently exist.

5. Apparatus

5.1 *Testing Machine*—Any suitable testing machine of the constant-rate-of-crosshead movement type. The testing machine shall be equipped with the necessary drive mechanism for imparting to the crosshead a uniform, controlled velocity with respect to the base. The testing machine shall also be equipped with a load-indicating mechanism capable of showing the total compressive load carried by the test specimen. This mechanism shall be essentially free from inertia-lag at the specified rate of testing and shall indicate the load with an accuracy of $\pm 1\%$ of the indicated value or better. The accuracy of the testing machine shall be verified in accordance with Practices E 4.

5.2 *Shear Tool*—A shear tool of the punch type which is so constructed that the specimen is rigidly clamped both to the stationary block and movable block so that it cannot be deflected during the test. A suitable form of shear tool is shown in Fig. 1.

5.3 *Micrometers*—Suitable micrometers for measuring the

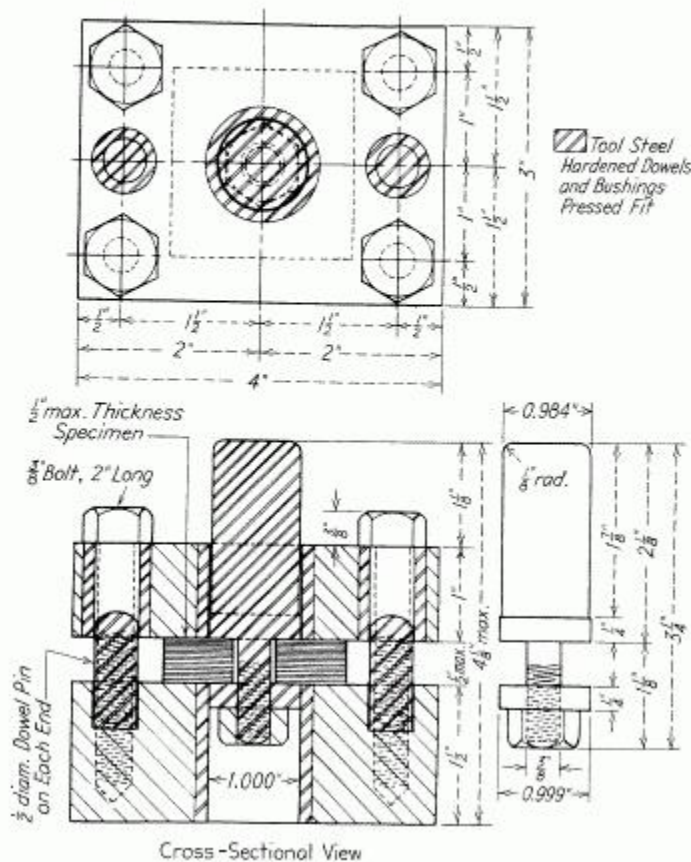
¹ This test method is under the jurisdiction of ASTM Committee D-20 on Plastics and is the direct responsibility of Subcommittee D 20.10 on Mechanical Properties. Current edition approved March 10, 1999. Published June 1999. Originally published as D 732 – 43 T. Last previous edition D 732 – 93.

² Annual Book of ASTM Standards, Vol 08.01.

³ Annual Book of ASTM Standards, Vol 08.02.

⁴ Annual Book of ASTM Standards, Vol 03.01.

⁵ Annual Book of ASTM Standards, Vol 14.02.



NOTE 1—In case of difficulty in obtaining hardened dowels and bushings, the entire shear tool may be made from a fairly good grade of steel, eliminating all of the bushings shown. The actual working surfaces will wear faster than when hardened tool steel is used. When they show signs of appreciable wear, the shear tool can then be bored out to take either hardened or unhardened bushings, depending upon which are available.

Table of Metric Equivalents

in.	1/8	1/4	3/8	1/2	0.984	0.999	1	1 1/8	1 1/2	1 3/4	2	2 1/4	3	3 1/4	4	4 1/4
mm	3.2	6.4	9.5	12.7	24.9	25.1	25.4	28	38	47	51	54	76	82	102	105

FIG. 1 Punch-Type Shear Tool for Testing Specimens 0.127 to 12.7 mm (0.050 to 0.500 in.) in Thickness

thickness of the test specimen to an incremental discrimination of at least 0.025 mm (0.001 in.).

6. Test Specimen

6.1 The specimen shall consist of a 50-mm (2-in.) square or a 50-mm (2-in.) diameter disk cut from sheet material or molded into this form. The thickness of the specimen may be from 0.127 to 12.7 mm (0.050 to 0.500 in.). The upper and lower surfaces shall be parallel to each other and reasonably flat. A hole approximately 11 mm (7/16 in.) in diameter shall be drilled through the specimen at its center.

7. Conditioning

7.1 *Conditioning*—Condition the test specimens at 23 ± 2°C (73.4 ± 3.6°F) and 50 ± 5 % relative humidity for not less than 40 h prior to test in accordance with Procedure A of Practice D 618, for those tests where conditioning is required. In cases of disagreement, the tolerances shall be ±1°C (±1.8°F) and ±2 % relative humidity.

7.1.1 Note that for some hygroscopic materials, such as nylons, the material specifications (for example, Specification

D 4066) call for testing “dry as-molded specimens.” Such requirements take precedence over the above routine preconditioning to 50 % relative humidity and require sealing the specimens in water vapor-impermeable containers as soon as molded and not removing them until ready for testing.

7.2 *Test Conditions*—Conduct tests in the standard laboratory atmosphere of 23 ± 2°C (73.4 ± 3.6°F) and 50 ± 5 % relative humidity, unless otherwise specified in the test method. In cases of disagreement, the tolerances shall be ±1°C (±1.8°F) and ±2 % relative humidity.

8. Procedure

8.1 Use five specimens.

8.2 Measure the thickness of the test specimen with a suitable micrometer to the nearest 0.025 mm (0.001 in.) at several points 12.7 mm (0.500 in.) from its center.

8.3 Place the specimen over the 9.5 mm (3/8 in.) hole in the punch and fasten tightly to it by means of the washer and nut. Then assemble the tool jig and tighten the bolts.

8.4 Maintain the crosshead speed of the machine during the test at 1.25 mm (0.05 in.)/min, measured when the machine is

running idle. The tolerances should be 1.3 ± 0.3 mm (0.050 ± 0.010 in./min).

8.5 Push down the punch far enough so that the shoulder clears the specimen proper. The specimen will then be adjacent to the necked-down portion of the punch, and it should be possible to remove the specimen readily from the tool.

NOTE 2—For thick specimens of some materials the punched-out piece tends to stick in the die. If the test is continued only to the point where maximum load has been developed and starts to fall off rapidly, the specimen may be readily removed from both punch and die.

9. Calculation

9.1 Calculate shear strength in megapascals (or pounds-force per square inch), determined by dividing the load required to shear the specimen by the area of the sheared edge, which shall be taken as the product of the thickness of the specimen by the circumference of the punch.

10. Report

10.1 Report the following information:

10.1.1 Complete identification of the material tested, including type, source, manufacturer's code number, form, principal dimensions, previous history, etc.,

10.1.2 Method of test, type of test specimen, and dimensions,

10.1.3 Atmospheric conditions in the test room,

10.1.4 Conditioning procedure used,

10.1.5 Diameter of punch,

10.1.6 Load in newtons (or pounds-force) required to shear each specimen, and the average value, and

10.1.7 Shear strength in megapascals (or pounds-force per square inch) for each specimen, the average value, and the standard deviation.

11. Precision and Bias⁶

11.1 Table 1 is based on a round-robin test conducted in

⁶ Supporting data are available from ASTM Headquarters. Request RR: D20-1120.

1983, in accordance with Practice E 691, involving six materials tested by eleven laboratories. Each "test result" was the average of five individual determinations. Each laboratory obtained one test result for each material.

NOTE 3—**Caution:** The following explanations of r and R (11.2-11.2.3) are intended only to present a meaningful way of considering the approximate precision of these test methods. The data given in Table 1 should not be applied rigorously to the acceptance or rejection of materials, as those data are specific to the round robin and may not be representative of other lots, conditions, materials, or laboratories. Users of this test method should apply the principles outlined in Practice E 691 to generate data specific to their laboratory and materials, or between specific laboratories. The principles of 11.2-11.2.3 would then be valid for such data.

11.2 *Concept of r and R in Table 1*—If S_r and S_R have been calculated from a large enough body of data, and for test results that were averages from testing five specimens for each test result, then:

11.2.1 *Repeatability*—Two test results obtained within one laboratory shall be judged not equivalent if they differ by more than the r value for that material. The r value is the interval representing the critical difference between two test results for the same material, obtained by the same operator using the same equipment on the same day in the same laboratory.

11.2.2 *Reproducibility*—Two test results obtained by different laboratories shall be judged not equivalent if they differ by more than the R value for that material. The R value is the interval representing the critical difference between two test results for the same material, obtained by different operators using different equipment in different laboratories.

11.2.3 The judgments in 11.2.1 and 11.2.2 will have an approximately 95 % (0.95) probability of being correct.

11.3 *Bias*—No statement may be made about the bias of this test method, as there is no standard reference material or reference test method that is applicable.

12. Keywords

12.1 punch tool; shear strength

TABLE 1 Shear Strength

Material ^A	Values Expressed in Units of Pound-Force per Square Inch					
	Average Thickness, in.	Mean	S_r ^B	S_R ^C	r ^D	R ^E
RIM	0.134	2 900	32	155	92	439
HDPE	0.071	3 410	27	135	76	382
Polyester	0.128	8 580	57	278	163	788
SMC	0.210	14 700	304	569	862	1 610
Polyester ^F	0.0104	10 200	384	1 950	1 080	5 530
PCTFE ^F	0.0076	7 900	528	2 730	1 490	7 740

^A The complete designations for the materials in Table 1 are: reaction injection molding (RIM), high-density polyethylene (HDPE), sheet molding compound (SMC), and polychlorotrifluoroethylene (PCTFE).

^B S_r is the within-laboratory standard deviation for the indicated material. It is obtained by pooling the within-laboratory standard deviations of the test results from all of the participating laboratories: $S_r = \sqrt{[(S_{r1})^2 + (S_{r2})^2 \dots + (S_{rn})^2] / n}$.

^C S_R is the between-laboratory reproducibility, expressed as standard deviation: $S_R = \{S_r^2 + S_L^2\}^{1/2}$ where S_L is the standard deviation of laboratory means.

^D r is the within-laboratory critical interval between two test results = $2.8 \times S_r$.

^E R is the between-laboratory critical interval between two test results = $2.8 \times S_R$.

^F Values for 0.010 in. thick polyester specimens and 0.007 in. thick PCTFE specimens are included in Table 1 to show that the repeatability and reproducibility of shear strength values were greatly inferior to corresponding data obtained on specimens of 1.780 mm (0.070 in.) minimum thickness. Therefore, the scope of this test method was revised to limit test specimen thickness to the range from 1.27 to 12.7 mm (0.050 to 0.500 in.).

SUMMARY OF CHANGES

This section identifies the location of selected changes to this test method. For the convenience of the user, Committee D-20 has highlighted those changes that may impact the use of this test method. This section may also include descriptions of the changes or reasons for the changes, or both.

D 732 - 99: precision and bias statement placed in appropriate format, and
(1) Changes to scope, ISO equivalency statement added, keywords added.

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