Designation: C1147 – 14 (Reapproved 2022)

Standard Practice for Determining the Short Term Tensile Weld Strength of Chemical-Resistant Thermoplastics[1]

This standard is issued under the fixed designation C1147; 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 the preparation and evaluation of joints between two pieces of weldable grades of thermoplastic materials, backed and unbacked, (such as those shown in Table 1) up to 2 in. (50 mm) in thickness.

1.2 Since there are numerous new technologies and techniques constantly being developed for plastic welding, there are no profiles and procedures that can be considered as standard for all plastics at various thicknesses. This practice is not intended to define profiles and procedures; however, it is intended to establish methods to evaluate minimum short term weld factors to be achieved by the welder for the respective plastics.

1.3 Weld procedures used for test pieces shall reflect procedures to be used in actual fabrication.

1.4 Welding methods to be used include machine welding, extrusion welding, and hot gas welding.

1.5 This practice can be utilized by relevant certification bodies to assess welder proficiency and qualification.

1.6 The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.

1.7 *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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

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

1.8 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D883 Terminology Relating to Plastics

D4285 Test Method for Indicating Oil or Water in Compressed Air

D5947 Test Methods for Physical Dimensions of Solid Plastics Specimens

E4 Practices for Force Calibration and Verification of Testing Machines

3. Terminology

3.1 *Definitions*—For definitions of terms used in this practice, see Terminology D883.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *butt welding (machine)*—the fusing together of two pieces of plastic which are aligned in the same plane, with the same mating thickness, by application of heat and pressure, also called hot-plate welding.

3.2.2 *chemical-resistant*—the ability of a material to resist degradation by reaction with, dissolution by, or reduction of physical continuity from contact with a chemical agent or agents, thereby retaining its capacity to perform as a structural or aesthetic entity.

3.2.3 *extrusion welding*—a process in which heated plastic is forced through a shaping orifice (or die) and applied with pressure to suitably prepared, locally preheated plastic pieces of the same resin base, to join them.

3.2.4 *hot-gas welding*—a technique for joining thermoplastics (usually sheets) in which the materials are first softened by a jet of hot gas from a welding gun. A rod of the same plastic is used to fill the heated gap and join the sheets at the same time pressure is applied by either the rod or the tip of the gun. Sometimes referred to as string bead welding.

[1] This practice is under the jurisdiction of ASTM Committee D20 on Plastics and is the direct responsibility of Subcommittee D20.19 on Film, Sheeting, and Molded Products.

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[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.

TABLE 1 Typical Guide for Hot Gas Welding Temperatures

NOTE 1—For other welding techniques, consult material and equipment supplier for recommendations.

	°F (°C)[A]	Recommended Gas Type[B]
HDPE	500–600 (260–316)	Nitrogen or Air
PP	550–600 (288–316)	Nitrogen or Air
PVC	500–550 (260–288)	Air
CPVC	550–660 (288–349)	Air
PVDF	650–680 (343–360)	Nitrogen or Air
ECTFE	665–695 (352–368)	Nitrogen
ETFE	675–710 (357–377)	Air
FEP	650–725 (343–385)	Air
PFA	675–750 (357–399)	Air
MFA	536–554 (280–290)	Air

[A]Measured ¼ in. (6 mm) inside weld tip, directly in gas stream.
[B]Inert gas may be used in place of air.

3.2.5 *hot-plate welding*—synonymous with butt welding (machine).

3.2.6 *short term weld factor*—a dimensionless number that provides a relative measure of the tensile strength of a welded thermoplastic test specimen to the tensile strength of the manufactured sheet.

4. Summary of Practice

4.1 The sheets are prepared and welded. Tensile test specimens containing a section of the weld are prepared and tested. Specimens of unwelded sheet are tested and compared to the welded specimens. The short term weld factor determined is compared to the standard (see Table 2), or to the factor agreed upon between the supplier and the user.

5. Significance and Use

5.1 The mechanical performance of welded thermoplastic structures is largely dependent on the quality of the welding operation. It is necessary for fabricators to determine that the proper welding procedures are being followed and that welders maintain their proficiency. Results from this practice are indicative of skill in proper welding procedures for different thermoplastic materials and the use of appropriate welding equipment. If the welded test specimens have short term weld factors that meet or exceed the minimums as set forth in this practice, it can be concluded that, with the same degree of skill and diligence by the welder, acceptable welds can be obtained in fabricated structures.

TABLE 2 Minimum Short Term Weld Factors

Thermoplastic	Hot Gas	Extrusion	Hot Plate
HDPE	0.8	0.8	0.9
PP	0.8	0.8	0.9
PVC	0.8	[A]	0.9
CPVC	0.6	[A]	0.8
PVDF	0.8	0.8	0.9
ECTFE	0.9	0.9	0.9
ETFE	0.9	0.9	0.9
FEP	0.9	0.9	0.9
TFE (PFA Filler)	0.9	0.9	[A]
PFA	0.9	0.9	0.9

[A] Not applicable.

6. Apparatus

6.1 The apparatus for welding shall consist of the following:

6.1.1 *Welding Device,* suitable for joining thermoplastics.

6.1.2 *Air Supply,* when needed, conforming to Test Method D4285.

6.1.3 *Temperature Measuring Device,* capable of measuring the welding temperature to within ±1 % for the specific plastic as set forth in Table 1.

6.1.4 *Clamps,* suitable for holding the specimen while welding.

6.1.5 *Saw,* suitable for cutting thermoplastic sheet.

6.1.6 *Sander, Router, Joiner, or Saw,* suitable for beveling edges of sheet.

6.2 The apparatus for testing tension specimens shall consist of the following:

6.2.1 *Tensile Machine*—A testing machine capable of pulling the specimens at a rate of 2 ± 0.1 in./min (50 ± 2.5 mm/min) of crosshead movement (speed of movement when the machine is running without a load).

6.2.1.1 The rate of movement between heads of the testing machine shall remain essentially constant under changing loads (see Note 2).

NOTE 2—It is difficult to meet this requirement when loads are measured with a spring type or pendulum type weighing device.

6.2.1.2 The testing machine shall measure the load to within 1 %. The testing range shall be so selected that the maximum load on the specimen falls between 15 and 85 % of the full scale capacity.

6.2.1.3 The use of autographic equipment to record the load versus head movement is recommended.

6.2.1.4 Verification of the testing machine shall be made in accordance with the recommendations of Practices E4.

6.2.2 *Micrometer or Vernier Caliper,* suitable for measuring width and thickness of the test specimen to the nearest 0.001 in. (0.025 mm).

7. Test Specimens

7.1 *Test Pieces For Hot Gas and Extrusion Welding*—Start with a 10 by 42 in. (250 by 1050 mm) piece of plastic sheet of the type and thickness to be tested. Cut the sheet as shown in Fig. 1 to yield five pieces, four measuring 5 by 18 in. (125 by 450 mm) and one measuring 6 by 10 in. (150 by 250 mm). Two 5 by 18 in. (125 by 450 mm) pieces will be used for horizontal welding and two 5 by 18 in. (125 by 450 mm) pieces for vertical welding.

7.1.1 The 6 by 10 in. (150 by 250 mm) sample shall be cut into control specimens as described in Section 7.2.2. Label each piece as to type of plastic, method of welding, orientation of welding and welder identification.

7.1.2 *Edge Preparation*—Bevel one 18 in. (450 mm) edge of each 5 by 18 in. (125 by 450 mm) piece in preparation for welding. Beveling shall be done using suitable apparatus such as routers, sanders, joiners, or saws, that accurately reflect methods utilized in the field. Typical bevel profiles for the various sheet thicknesses are illustrated in Fig. 2 and Fig. 3. These profiles are optional and do not have to be used by the fabricator to meet the weld test standard, however, experience

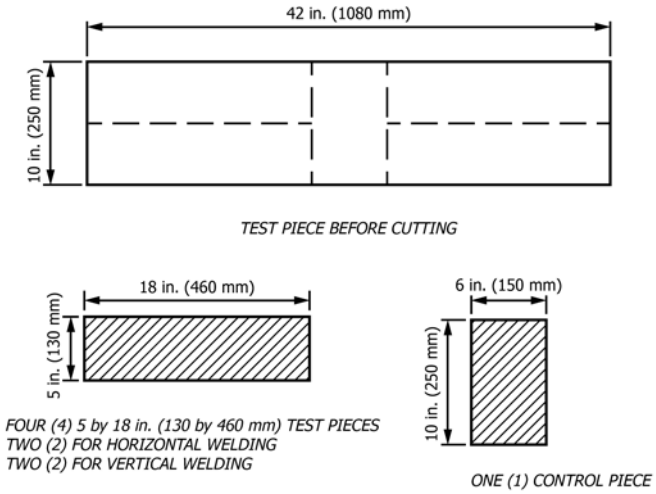

FIG. 1 Test Pieces

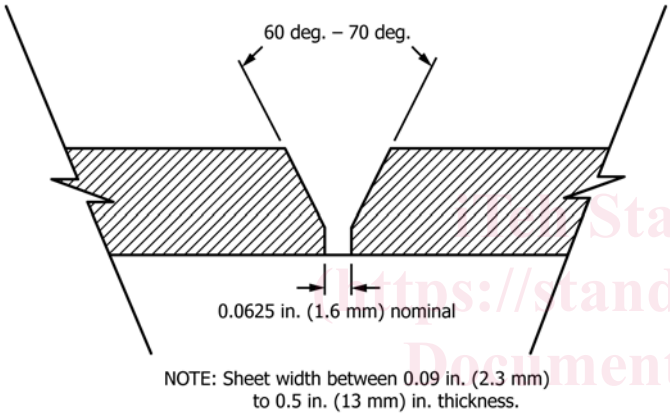

FIG. 2 Typical Bevel Profile (Sheet >0.090 to 0.5 in. (2.3 mm to 13 mm) in Thickness)

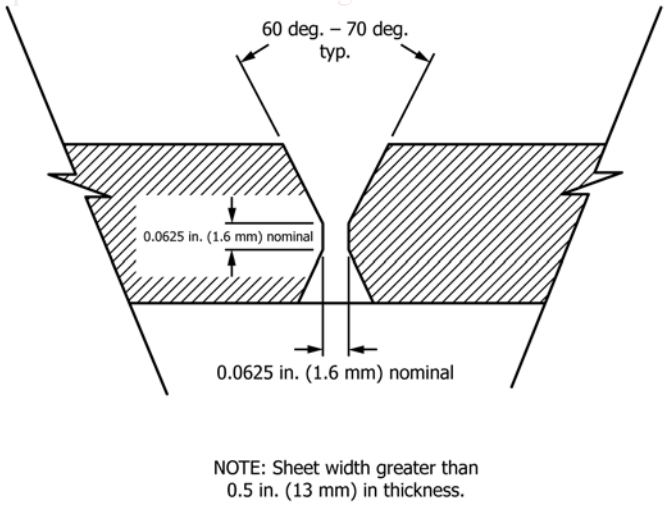

FIG. 3 Typical Bevel Profile (Sheet >0.5 in. (13 mm) Thick)

has shown that the use of beveled edges is advantageous to weld quality in sheet greater than 60 mils (1.5 mm) in thickness in hot gas and extrusion welding processes. Do not use solvents or other chemicals for cleaning the beveled surfaces that in any way will adversely affect the properties of the plastic. The cleaning operation should not in any way alter the profile or bevel of the edge. Details of bevels and test procedures used should accompany test specimens and the report of test results.

7.1.3 *Welding Procedure*—Securely clamp the test sheets to be welded to a suitable fixture and adjust welding device temperature as specified in Table 1. Weld two specimens, one vertically to simulate tank walls, and one horizontally to simulate tank floors. If a machine such as a hot plate welder or other equipment that is in a fixed position is being used, the two test specimens, cut and configured as in 7.1, are welded in the machine's normal welding plane. The two samples shall not be welded in the same cycle of the machine. Welding procedures must be identified and adequately described as part of the report. The completed weld may be projecting above or be flush with adjacent surfaces.

7.2 *Preparation of Test Specimens:*

7.2.1 *Weld Test Specimens*—Cut and discard a 1 in. (25 mm) strip off each end of an 18 by 10 in. (460 by 250 mm) welded specimen resulting in a piece 16 by 10 in. (400 by 250 mm). Cut remaining piece across the weld into 1 ± 0.01 in. (25 ± 0.25 mm wide) by 10 in. (250 mm) long strips. The width of the test specimens can be varied depending on the capacity of the tensile machine and the type and thickness of plastic being tested. Set aside at least 10 of these specimens from the vertically welded sample and the same number from the horizontal for weld test evaluation and condition a minimum of 16 h at 73 ± 4°F (23 ± 2°C).

7.2.2 *Control Specimens*—Cut 5 pieces off the 6 by 10 in. (150 by 250 mm) control specimen to the same dimensions as welded test specimens. Condition at least 5 specimens for evaluation for 16 h at 73 ± 4°F (23 ± 2°C).

8. Test Procedure

8.1 *Tensile Strengths:*

8.1.1 *Control Specimens*—Measure width and thickness of the test pieces in accordance with D5947 to the nearest 0.001 in. (0.025 mm) at the one-third intervals of that length not held by the grips. Record the respective measurements, calculate the respective cross-sectional areas, and calculate the average cross-sectional area of test pieces.

8.1.1.1 Conduct the tensile test using a suitable test machine pulling at a cross-head speed of 2 ± 0.1 in. (50 ± 2.54 mm)/min.

8.1.2 *Welded Specimens*—Measure width and thickness of the test pieces in accordance with D5947 to the nearest 0.001 in. (0.025 mm) at the one-third intervals of that length not held by the grips. Do not measure thickness within ¼ in. (6 mm) of the weld bead area. Record the respective measurements, calculate the respective cross-sectional areas and calculate the average cross-sectional area of test pieces.

8.1.2.1 Conduct the tensile test using a suitable test machine at a cross-head speed of 2 ± 0.1 in. (50 ± 2.54 mm)/min.

9. Calculation

9.1 Calculate the tensile strengths of each specimen as follows:

$$S = P/A \quad (1)$$