Designation: F2029 – 08

Standard Practices for Making Heatseals for Determination of Heatsealability of Flexible Webs as Measured by Seal Strength[1]

This standard is issued under the fixed designation F2029; 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 These practices cover laboratory preparation of heatseals and the treatment and evaluation of heatseal strength data for the purpose of determining heatsealability of flexible barrier materials. It does not cover the required validation procedure for the materials and production equipment.

1.2 Testing strength or other properties of the heatseals formed by these practices is not included in this standard. Refer to Test Method F88 for testing heatseal strength.

1.3 The practices of this standard are restricted to sealing with a machine employing hot-bar jaw(s). Impulse, high-frequency, and ultrasonic heating methods are not included.

1.4 These practices apply primarily to webs intended to be used on commercial machines employing reciprocating sealing jaws, such as most form-fill-seal packaging machines, platen heatsealers, and so forth. Conditions of dwell time and sealing pressure on machines of this type typically are different from those on rotary machines.

1.5 The procedure of this practice with respect to choice of heatsealing conditions apply to ultimate seal strength or hot tack measurement.

1.6 Seals may be made between webs of the same or dissimilar materials. The individual webs may be homogeneous in structure or multilayered (coextruded, coated, laminated, and so forth).

1.7 Strength of the heatseal as measured by Test Method F88 is the criterion for judging heatsealability employed in these practices.

1.8 Determination of heatsealability as judged by seal continuity, typically measured by air-leak, dye penetration, visual examination, microorganism penetration, or other techniques, are not covered by these practices.

1.9 The values stated in SI units are to be regarded as standard. The values given in parentheses are for information only.

1.10 *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]

F88 Test Method for Seal Strength of Flexible Barrier Materials

F1921 Test Methods for Hot Seal Strength (Hot Tack) of Thermoplastic Polymers and Blends Comprising the Sealing Surfaces of Flexible Webs

D4332 Practice for Conditioning Containers, Packages, or Packaging Components for Testing

3. Terminology

3.1 *Definitions:*

3.1.1 *dwell time, n*—the time interval when the sealing jaws are in contact with, and exerting pressure on, the material being sealed.

3.1.2 *heatseal curve, n*—a plot of measured seal strength versus sealing temperature when dwell and pressure are fixed.

3.1.2.1 *Discussion*—This is the basic curve for comparing sealability of materials. It plots the force required to extend a sealed test strip to failure, as a function of sealing temperature when dwell and pressure are fixed. The portion of the curve at higher sealing temperatures may be affected by failure of the substrate and may not be an accurate representation of seal strength.

3.1.3 *heatseal strength, n*—force required to peel the seal apart, per unit width of seal.

3.1.3.1 *Discussion*—In many tests of seal strength, it is not the seal that fails, it is the substrate or a layer. In those tests, the

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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.

true heatseal strength may be somewhat higher than the measured force that caused the specimen to fail. Some materials are intentionally designed to fail in a layer not at the seal interface in order to gain other attributes such as transfer appearance. In this case, this failure is the desired outcome. Homogeneous materials with fusion seals, for example, commonly break along a line immediately adjacent to the seal, while the seal itself remains intact.

3.1.4 *heatsealability, n*—the property of thermoplastic polymers and blends, when comprising a surface of a flexible web, that defines how well the material bonds to itself or a dissimilar material when sealed by the application of pressure, heat, and dwell (time).

3.1.4.1 *Discussion*—How well the material bonds is expressed quantitatively as seal strength as a function of the sealing conditions of temperature, time, and pressure. Since strength of a heatseal can be measured either while the seal is still hot (hot tack) or after cooling and stabilizing (ultimate strength), a complete evaluation of heatsealability of a material may include both tests.

3.1.5 *hot tack, n*—strength of a hot seal measured at a specified time interval after completion of the sealing cycle but prior to the temperature of the seal reaching ambient. Refer to Test Methods F1921.

3.1.6 *seal initiation temperature, n*—the sealing temperature at which a heatseal of significant strength (typically 0.5 N/cm; 125 g/25 mm; 0.3 lb/in.) is produced.

3.1.7 *sealing interface, n*—the interface of the two web surfaces being sealed.

3.1.8 *sealing pressure, n*—the force per unit area of seal applied to the material by the sealing jaws during the sealing process.

3.1.8.1 *Discussion*—During the dwell time, the sealing pressure pulse rises from zero usually to a plateau level and then drops to zero. Frequently, there is an initial spike. Very short dwell times may not have a plateau. Two parameters can be used to characterize the pressure variable. One is a calculated average pressure, that excludes the initial rise, as well as, the terminal fall of pressure, and the other is the maximum value reached either during any initial impact spike or later.

NOTE 1—A common error is to report air pressure in the cylinder applying the force as the sealing pressure.

3.1.9 *sealing temperature, n*—the setpoint in degrees of each temperature controlled sealing jaw. The actual surface temperature of the sealing jaws making contact with the materials. The Set Point Temperature is the controller setting which will produce the desired surface temperature. Often, the setpoint temperature will be numerically higher that the surface temperature.

3.1.10 *ultimate seal strength, n*—the final value of strength that is reached after the heatseal has both cooled to ambient temperature and achieved stability in strength.

3.1.10.1 *Discussion*—Some materials, when cooling from a melt, continue to change in strength over extended periods of time after reaching ambient temperature.

4. Significance and Use

4.1 This practice allows determination of the heatsealability of a surface or sealant layer. While it is necessary to have a heatseal surface layer that has adequate seal strength for the application, other material properties, such as the specific construction and total thickness, both chosen to satisfy requirements other than heatsealability, will impact the sealing properties of the material. This practice allows the impact of changes in material properties on heatsealability to be measured.

5. Apparatus

5.1 *Laboratory Heatsealer:*

5.1.1 *Sealing Jaws*—Heat controlled jaw or jaws with appropriate sealing surfaces to provide a flat seal. If only one heated jaw is used, the unheated jaw should be covered with a gasket material such as a silicone rubber of known durometer.

5.1.1.1 *Jaw Temperature Control*—Each jaw should have independent temperature control and the precision of the controlling unit should be known and calibrated. The temperature should be verified periodically using a calibrated pyrometer adequate for the range of use.

5.1.1.2 *Heated Jaw Coatings or Coverings*—Anti-stick or compressible jaw coatings or coverings, such as TFE-fluorocarbon, TFE-fluorocarbon/glass cloth, or oriented PET film are often used to prevent the test specimen from adhering to the sealing jaws. Thick or heat flow-resistance materials will impact the rate of heat transfer from jaws to sealing surface. It is important to inspect the quality of these materials periodically to prevent loss of properties causing unwanted temperature fluctuations in the sealing process.

(1) Unheated Jaw Coating or Coverings—Silicone or other heat resistant rubbers of known durometer may be used. The rubber may be covered TFE-fluorocarbon, TFE-fluorocarbon/glass cloth, or oriented PET film. It is important to inspect the quality of these materials periodically to prevent loss of properties causing unwanted temperature fluctuations in the sealing process.

5.1.1.3 *Jaw Sealing Surfaces,* must be capable of being aligned for parallelism.

(1) The uniformity of pressure across the sealing jaws can be checked using pressure indicating materials or devices by actuating the sealing jaws while at ambient temperature.

(2) Temperature applied to sealing jaws may affect the alignment and parallelism of the jaw sealing surfaces as a result of thermal expansion.

5.1.2 *Dwell Time*—Variable control and readout of dwell time, with minimum range of 100 to 10 000 milliseconds.

5.1.2.1 Time of jaw closure should be measured directly (as by force sensor output, micro switch, optically, and so forth).

5.1.2.2 Precision of dwell time control should be ±10 ms or better.

5.1.3 *Pressure,* variable control, with readout of sealing pressure.

5.1.3.1 The sealing pressure for machines that have only an air pressure gauge on the air supply line and whose cylinder size is known can be calculated using the formula below:

$$P_{seal} = \left(\frac{A_{line}}{A_{jaw}}\right) P_{line} - P_w \quad (1)$$

where:

P_{seal} = pressure of the sealing jaw,
P_{line} = pressure of the incoming air line,
A_{jaw} = area of the sealing jaw,
A_{line} = cross-sectional area of the incoming air line, and
P_w = pressure loss due to mechanical work which is frequently difficult to calculate with any precision.

5.1.3.2 When materials are being sealed under pressure the silicone rubber on the unheated jaw will compress. When thin materials being sealed are less than the full length of the sealing jaw, the compression can be significant enough to change the contact to the full area of the jaw. As a result, the pressure is then distributed across the entire surface and this area is what should be used in the pressure calculation. When sealing thick materials, only the area of the seal should be used to calculate the sealing pressure since contact is limited to the surface of the thicker materials.

5.1.3.3 Machines that have only an air pressure gage indicating the air supply pressure, should have a table relating sealing and supply pressure.

6. Test Specimen

6.1 The number of test specimens shall be chosen to permit an adequate determination of representative performance based on a statistical rationale. When heatseal strength will be measured at a series of sealing temperatures, an adequate or agreed upon number of replicates shall be used to determine the mean value for each material at each temperature. When the measurements will not be part of a series where an identifiable trend is expected, a separate determination of the number of replicates should be made.

6.2 Mark the transverse direction and the seal side of each piece. Superimpose the two pieces to be sealed, with the transverse directions parallel and the seal surfaces facing each other. Seal each specimen with the jaws parallel to either the machine or transverse direction noting the orientation of the sample. Perform the heatseal process at the same location relative to the sealing jaws. A strip for seal-strength testing will subsequently be cut perpendicular to the seal at its center, and the seal will be peeled by pulling the strip.

NOTE 2—The seal must be located on the specimen so the legs of the strip on each side of the seal will be long enough to span the distance between the grips of the testing machine.

6.3 Alternatively to sealing a wide spectrum and then cutting a strip for strength testing, strips of the width for strength testing may be cut in the machine direction and sealed, either to strips of similar material or to dissimilar strips. The sealed strip may then be tested for strength without further preparation. Comparisons should be made only among specimens sealed by the same procedure.

6.4 Common strip widths are 25 mm (1.00 in.) and 15 mm (0.59 in.).

7. Procedure

7.1 *Calibration and Alignment*—Prior to starting testing, ensure that the heatsealer is in proper calibration and that the jaws have been aligned for parallelism.

7.2 *Sealing Conditions,* for heatsealability testing, either ultimate seal strength or hot tack, shall be within the ranges specified below for all makes and types of heatsealers.

7.2.1 *Dwell Time*—The dwell time must be long enough for the sealing interface to come to the known temperature of the jaws. This depends on the thickness and construction of the web, as well as on jaw configuration factors. Typical minimum dwell times (without anti-stick jaw covering):

Films: 1 mil (25μ) and under: dwell time, 500 ms (0.5 s)
Films: 1 to 2.5 mil (64μ): dwell time, 1000 ms (1 s)

7.2.1.1 The minimum required dwell time can be determined from a few trial sealing cycles. Refer to A2.1. This procedure usually will be necessary for thicker films, structures containing paper or foil, or when anti-stick jaw coverings are used.

7.2.2 *Sealing Pressure*—Set pressure in the range of 138 to 413 kPa (20 to 60 psi). See Appendix X1 for discussion of effect of pressure on heatseal strength.

7.2.3 *Web Sealability:*

7.2.3.1 *Temperature*—Choice of temperature setting of each jaw (including unheated) is dependent on application of the data. In the absence of reasons to the contrary, it is recommended both jaws be set to the same temperature.

7.2.3.2 *Dwell Time*—Set the dwell time to the desired period.

(1) If the dwell time is set sufficiently long that the heat flow through the webs is at steady-state, the seal strength of the material can be measured independently of dwell time, as long as the dwell time is above the equilibrium dwell time.

7.2.3.3 *Sealing Pressure*—Set pressure in the range of 138 to 413 kPa (20 to 60 psi), or at other level depending on specific application. See Appendix X1 for discussion of effect of pressure on heatseal strength.

7.2.3.4 *Jaw Configuration*—The coatings or coverings applied to the sealing jaws should be nearest practical as the commercial application being simulated. In absence of specific information on this point, flat steel jaws covered with TFE-fluorocarbon/glass cloth are recommended.

7.2.4 *Sticking of Specimen to Jaws*—Specimens having a heatsealing surface where the melting range is significantly lower than its opposite surface, usually can be sealed directly with bare metal jaws over most of the desired sealing temperature range. For example, sealing a PET/LDPE to a nylon/LDPE film.

7.2.4.1 If the specimen is homogeneous throughout, or with multilayered materials where the external construction is the same ABA, enclose it in a folded piece of 10 to 15μ (approx 0.5 mil) polyester film during the sealing cycle to avoid sticking to the jaws. Alternatively, cover the jaws with 75μ (3 mil) TFE-fluorocarbon/glass cloth, or tape. The choice of coverings or coatings should be made according to 7.2.3.4.

7.3 *Heatseal Curve*—To generate the curve, temperature is typically varied in 5 to 10° intervals, although to locate maxima or other features, smaller steps may be desirable locally. The first temperature point typically is at about the seal initiation temperature. Commonly, testing is continued at increasing temperature levels until the web suffers excessive stretch, distortion, shrinkage, or burnthrough.

7.3.1 Make the number of test specimens chosen to permit an adequate determination of representative performance based on a statistical rationale.

7.3.2 Dwell time can also be used as the independent variable by fixing the temperature and sealing pressure at which the test is performed.

7.4 *Conditioning*—If conditioning before testing is appropriate, normal, and desirable, then condition the test specimens at 23 ± 2°C (73.4 ± 3.6°F) and 50 ± 5 % relative humidity for not less than 24 h prior to test. See Practice D4332 for guidance on conditioning practices.

7.5 *Strength Testing*—The seal shall be tested when its strength no longer changes with time. See Test Method F88.

7.6 *Single-Point Measurements (Quality Control Testing)*—Refer to Annex A1 for guidelines for selecting temperature.

8. Report

8.1 The report shall contain the following information concerning specimens tested:

8.1.1 *General Information:*

8.1.1.1 Date of sealing,

8.1.1.2 Operator,

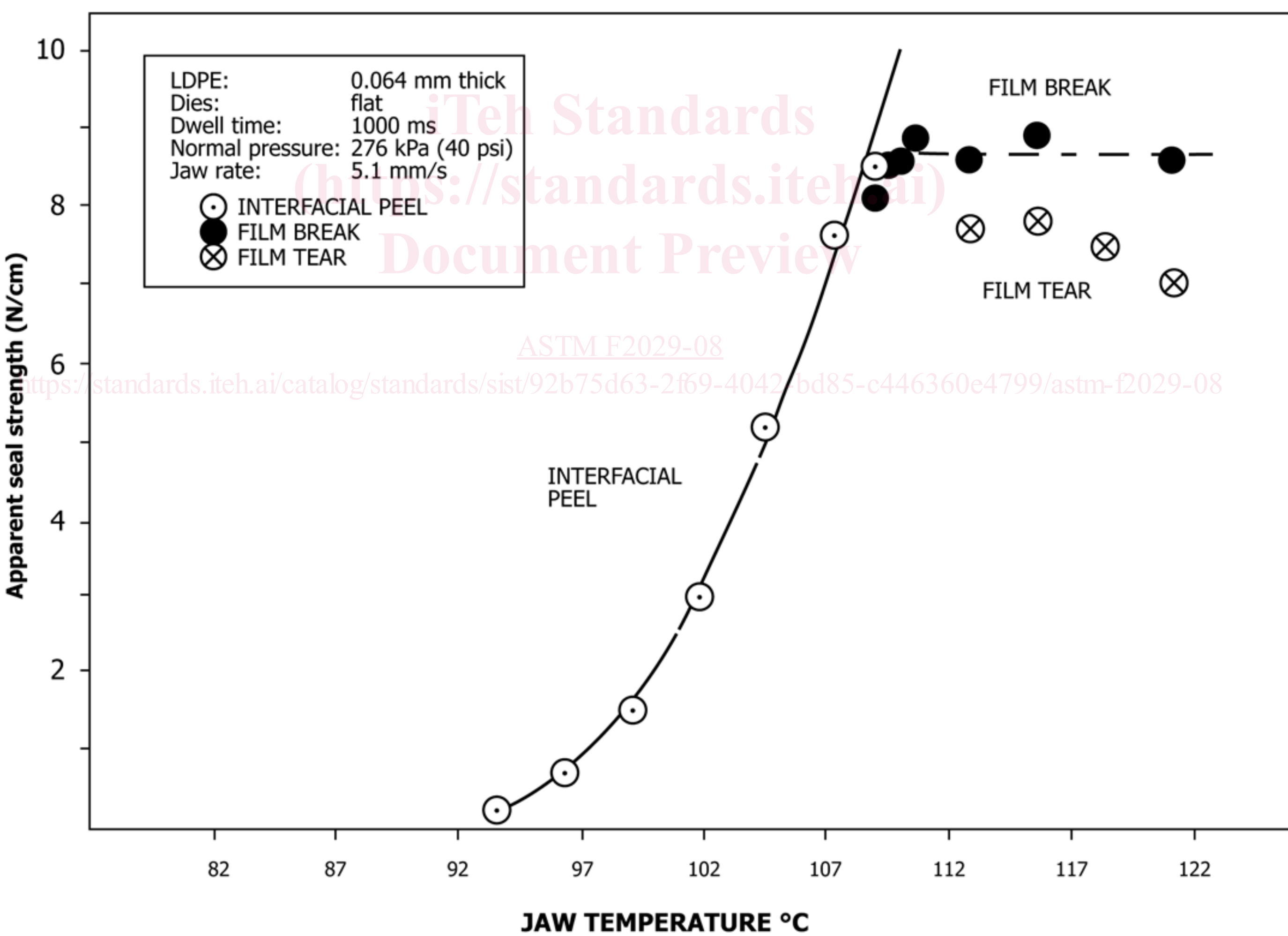
8.1.1.3 Heatsealer; type and model,

8.1.1.4 Number of heated jaws and type of coating or covering on each, and

8.1.1.5 Where applicable, ambient temperature and humidity.

8.1.2 Complete identification of materials sealed, as appropriate.

8.1.3 Thickness and width of specimens and web construction, if known.



NOTE 1—Fig. 1 is a heatseal curve of low density polyethylene. It shows the typical initial increase in seal strength as temperature is raised past seal initiation, indicated by a peeling failure mode. As sealing temperature is increased to the melting range of the polymer, the seal no longer peels apart; instead, the web material fails by a tensile failure. The curve levels off, and the values of failure force are usually less repeatable than during seal failure. In this area of the curve, seal strength may be in excess of the observed strength values.

FIG. 1 Failure Modes of Seals made with LDPE Film