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.

Designation: F1921/F1921M – 12 (Reapproved 2023)

Standard Test Methods for Hot Seal Strength (Hot Tack) of Thermoplastic Polymers and Blends Comprising the Sealing Surfaces of Flexible Webs[1]

This standard is issued under the fixed designation F1921/F1921M; 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 two test methods cover laboratory measurement of the strength of heatseals formed between thermoplastic surfaces of flexible webs, immediately after a seal has been made and before it cools to ambient temperature (hot tack strength).

1.2 These test methods are restricted to instrumented hot tack testing, requiring a testing machine that automatically heatseals a specimen and immediately determines strength of the hot seal at a precisely measured time after conclusion of the sealing cycle. An additional prerequisite is that the operator shall have no influence on the test after the sealing sequence has begun. These test methods do not cover non-instrumented manual procedures employing springs, levers, pulleys and weights, where test results can be influenced by operator technique.

1.3 Two variations of the instrumented hot tack test are described in these test methods, differing primarily in two respects: *(a)* rate of grip separation during testing of the sealed specimen, and *(b)* whether the testing machine generates the cooling curve of the material under test, or instead makes a measurement of the maximum force observed following a set delay time. Both test methods may be used to test all materials within the scope of these test methods and within the range and capacity of the machine employed. They are described in Section 4.

1.4 SI units are preferred and shall be used in referee decisions. Values stated herein in inch-pound units are to be regarded separately and may not be exact equivalents to SI units. Therefore, each system shall be used independently of the other. Combining values from the two systems may result in non-conformance with the standard.

1.5 *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.* The operator of the equipment is to be aware of pinch points as the seal jaws come together to make a seal, hot surfaces of the jaws, and sharp instruments used to cut specimens. It is recommended that the operator review safety precautions from the equipment supplier.

1.6 *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]

D882 Test Method for Tensile Properties of Thin Plastic Sheeting

E171 Practice for Conditioning and Testing Flexible Barrier Packaging

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

F88 Test Method for Seal Strength of Flexible Barrier Materials

F2029 Practices for Making Laboratory Heat Seals for Determination of Heat Sealability of Flexible Barrier Materials as Measured by Seal Strength

3. Terminology

3.1 *Definitions:*

3.1.1 *adhesive failure, n*—a failure mode in which the seal fails at the original interface between the surfaces being sealed.

3.1.2 *breadth, n*—temperature range over which peel force of a seal is (relatively) constant.

3.1.3 *burnthrough, n*—a state or condition of a heatseal characterized by melted holes and thermal distortion.

[1] These test methods are under the jurisdiction of ASTM Committee F02 on Primary Barrier Packaging and are the direct responsibility of subcommittee F02.20 on Physical Properties.

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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.

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3.1.3.1 *Discussion*—Burnthrough indicates that the sealing conditions (time or temperature, or both) were too high to produce an acceptable seal.

3.1.4 *cohesive failure, n*—a failure mode where either or both of the sealed webs fails by splitting approximately parallel to the seal, and the seal itself remains intact.

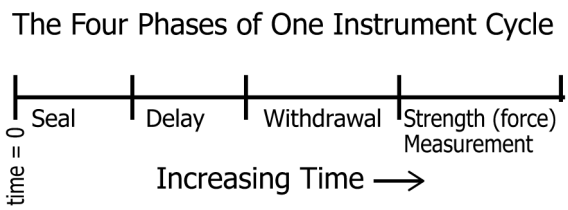
3.1.4.1 *Discussion*—Refer to Fig. 1. The term may be defined somewhat differently when applied to sealing systems involving an adhesive material as a separate component.

3.1.5 *cooling curve, n*—the graphical depiction of the increase in strength of the seal with time, as it cools during the period immediately following conclusion of the sealing cycle (for example, see Fig. 2).

3.1.5.1 *Discussion*—The cooling curve is a plot of hot seal strength versus cooling time. The portion of the cooling curve of greatest practical significance is the first 1000 ms following opening of the heatseal jaws.

3.1.6 *cooling time, n*—time in the instrument cycle between the opening of the seal jaws and the termination of the peel force measurement.

3.1.7 *cycle, n*—the combination of instrument mechanical and electrical operations automatically performed from initiation of sealing through peeling apart a seal and measuring the hot tack strength. The cycle can be broken down into four phases: sealing, delay, withdrawal, and peel.



3.1.8 *delay time, n*—the time interval from when the heatseal jaws open after sealing two film surfaces, to the point at which withdrawal of the sample from between the jaws is initiated.

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

3.1.10 *failure mode, n*—a visual determination of the manner in which the test strip fails during grip separation.

3.1.11 *hot tack strength, n*—force per unit width of a seal needed to peel apart a hot seal measured at a specified time interval after sealing but prior to the seal cooling to ambient temperature.

3.1.11.1 *Discussion*—The desired outcome of the test is to peel apart the seal formed by the test instrument. Other types of film failure in the tensile phase of the instrument test cycle may not represent hot tack strength.

3.1.12 *hot-tack curve, n*—a plot of measured hot-tack strength versus sealing temperature at fixed dwell time and sealing pressure (for example, see Fig. 3).

3.1.12.1 *Discussion*—This is the basic curve used for comparing materials for their hot tack performance. It shows not only the maximum hot seal strength achievable by each material and the sealing temperature required, but also the breadth of the sealing temperature range at any specified level of hot tack. The portion of the curve at higher sealing temperatures may be affected by failure of the substrate rather than the seal and may not be an accurate representation of hot tack strength.

3.1.13 *seal initiation temperature, n*—sealing temperature at which a heatseal of minimum measureable strength is produced.

3.1.14 *sealing pressure, n*—force required, with transfer of heat, to fuse two surfaces together to form a seal. Pressure settings may be different than the actual applied pressure and should be verified as part of instrument calibration.

3.1.15 *sealing temperature, n*—maximum temperature reached at the interface between the two web surfaces being sealed during the dwell time of the sealing cycle.

3.1.15.1 *Discussion*—Sealing temperature will equal jaw temperature (both jaws at same temperature) if the dwell time is long enough for the interface to reach equilibrium with the jaws. At this point, seal strength will no longer rise with increasing dwell time.

3.1.16 *withdrawal time, n*—the time interval from the end of the delay phase to the beginning of the peel of the hot seal.

4. Summary of Test Method

4.1 Two sample strips are sealed by applying pressure from seal jaws under defined conditions of temperature, contact time and pressure. The strips may be either the same film or dissimilar films. Some instrument designs allow the use of a single strip of film which is cut during the sealing phase to form two strips. Either one or both of the seal jaws may be heated. The jaw faces may either be smooth or textured and may be covered with a material to promote release from the hot film.

4.2 When the jaws of the sealing unit open, the sealed strip is automatically withdrawn from between the jaws by retraction of the grips holding the unsealed ends of the strips.

4.3 As the grips move apart at a set speed and the sealed sample is peeled to eventual failure, the force required to peel open the seal is measured by the testing machine.

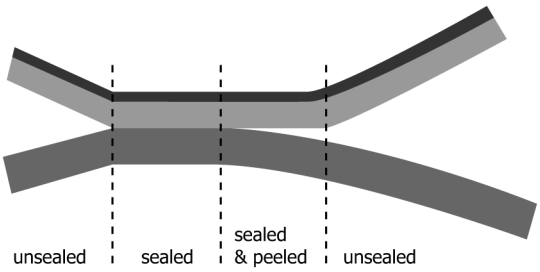
4.4 In Method A (machines of the Fixed Delay type) the machine measures and plots hot tack strength versus time after jaw opening, starting after a manufacturer-set delay and withdrawal period, which is part of the cooling curve for the material. The computer then measures the force at various user-selectable times (minimum of two), and reports the force as hot-tack strength at those cooling times.

4.5 In Method B (machines of the Variable Delay type) the computer plots maximum hot tack strength versus time after completion of a user-selected delay time. The maximum force encountered during grip travel is determined from that plot and reported as hot-tack strength for the delay time employed in that test.

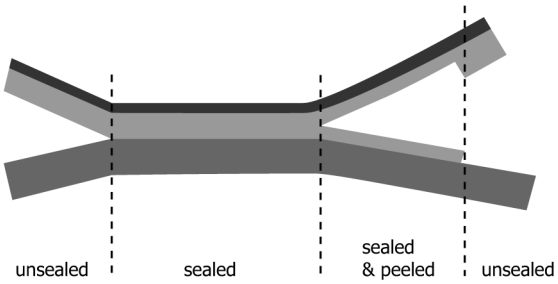
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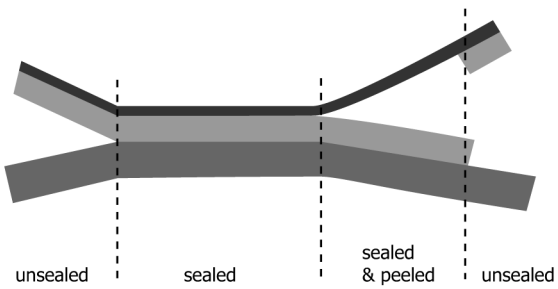
SEAL SEPARATION MODES



ADHESIVE PEEL



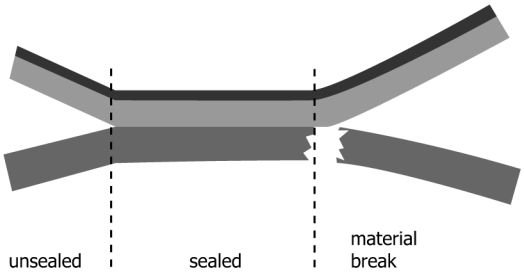
COHESIVE PEEL



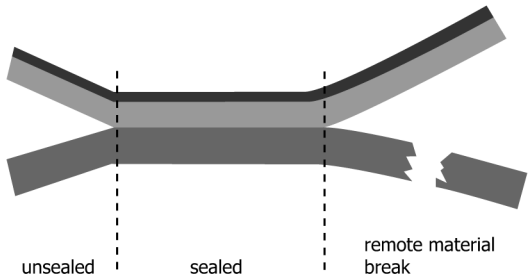
DELAMINATION

INTERFERENCES

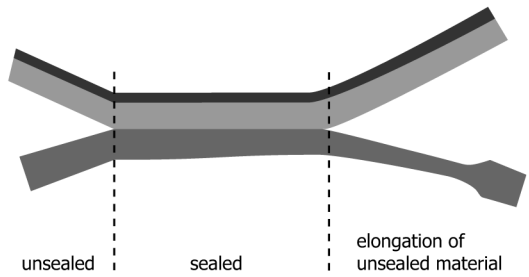
Though the diagrams show only one web being affected, it is possible for either or both webs to partially or fully exhibit interferences. Delamination, when not a designed seal separation mode, is an interference.



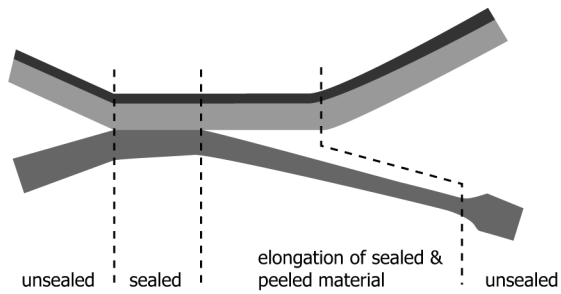
MATERIAL BREAK



MATERIAL BREAK (REMOTE)



MATERIAL ELONGATION



PEEL WITH ELONGATION

NOTE 1—Schematic representation of seal failure modes for seals between two webs. No diagram is included for systems including an adhesive as a third component.

FIG. 1 Test Strip Failure Modes

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