Designation: D4649 – 03 (Reapproved 2016)

Standard Guide for Selection and Use of Stretch Wrap Films[1]

This standard is issued under the fixed designation D4649; 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 guide covers recommended guidelines and test methods for the selection, specification, and use of stretch wrap films for unitizing, reinforcing, and palletizing for indoor environments. This can include storage or transport, or both, in warehouses, closed containers such as truck trailers or rail boxcars, and associated transfer terminals. This guide does not cover the performance issues associated with outdoor exposure.

1.2 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.

1.3 *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:*[2]

D882 Test Method for Tensile Properties of Thin Plastic Sheeting
D907 Terminology of Adhesives
D996 Terminology of Packaging and Distribution Environments
D1003 Test Method for Haze and Luminous Transmittance of Transparent Plastics
D1505 Test Method for Density of Plastics by the Density-Gradient Technique
D1746 Test Method for Transparency of Plastic Sheeting
D1894 Test Method for Static and Kinetic Coefficients of Friction of Plastic Film and Sheeting
D1898 Practice for Sampling of Plastics (Withdrawn 1998)[3]
D1922 Test Method for Propagation Tear Resistance of Plastic Film and Thin Sheeting by Pendulum Method
D2103 Specification for Polyethylene Film and Sheeting
D2457 Test Method for Specular Gloss of Plastic Films and Solid Plastics
D2578 Test Method for Wetting Tension of Polyethylene and Polypropylene Films
D2863 Test Method for Measuring the Minimum Oxygen Concentration to Support Candle-Like Combustion of Plastics (Oxygen Index)
D3951 Practice for Commercial Packaging
D4321 Test Method for Package Yield of Plastic Film
D4470 Test Method for Static Electrification
D5331 Test Method for Evaluation of Mechanical Handling of Unitized Loads Secured with Stretch Wrap Films
D5414 Test Method for Evaluation of Horizontal Impact Performance of Load Unitizing Stretch Wrap Films
D5415 Test Method for Evaluating Load Containment Performance of Stretch Wrap Films by Vibration Testing
D5416 Test Method for Evaluating Abrasion Resistance of Stretch Wrap Films by Vibration Testing
D5458 Test Method for Peel Cling of Stretch Wrap Film
D5459 Test Method for Machine Direction Elastic Recovery and Permanent Deformation and Stress Retention of Stretch Wrap Film
E96/E96M Test Methods for Water Vapor Transmission of Materials
E284 Terminology of Appearance

3. Terminology

3.1 *Definitions*—Terminology found in Terminology D996 shall apply.

3.2 *Definitions of Terms:*

3.2.1 *blocking*—an undesirable adhesion between touching layers of a material, such as occurs under moderate pressure during storage or use. (See Terminology D907.)

3.2.2 *clarity*—the characteristic of a transparent body whereby distinct high-contrast images or high-contrast objects (separated by some distance from the body) are observable through the body. (See Terminology E284.)

[1] This guide is under the jurisdiction of ASTM Committee D10 on Packaging and is the direct responsibility of Subcommittee D10.25 on Palletizing and Unitizing of Loads.

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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.

[3] The last approved version of this historical standard is referenced on www.astm.org.

3.2.3 *cling*—the ability of one surface of a material to adhere to itself or another surface.

3.2.4 *elastic recovery*—the extent that a material returns to its original length after being subjected to an extension.

3.2.5 *elongation*—increase in length (expressed as a percent of original length).

3.2.6 *thickness (caliper, gage)*— the perpendicular distance between opposite surface of a material.

3.3 *Definitions of Terms Specific to This Standard:*

3.3.1 *conventional braking*—a mode of stretch wrap machinery operation in which wrap material elongation is achieved by relative load motion and supply roll tension.

3.3.2 *core extension*—the length to which the core extends beyond the edge of the wrap material.

3.3.3 *cut growth resistance*—the ability of a wrap material to resist nick or cut propagation.

3.3.4 *film force to load*—the amount of force applied by the film to a load in providing load containment.

3.3.5 *film tail*—that portion of wrap material that is applied to the load after relative load motion ceases.

3.3.6 *food wrap material*—a material designed for use in direct food contact.

3.3.7 *load containment*—the utilization and protection, or both, of product(s) for distribution and storage or both.

3.3.8 *marking wheel*—a device that makes repetitive marks indicating a known distance.

3.3.9 *measured stretch*—see *elongation*.

3.3.10 *mechanical prestretch*—a mode of stretch wrap machinery operation in which wrap material elongation is achieved through the use of a prestretch device and relative load motion.

3.3.11 *nonfood wrap material*—a material not for direct food contact.

3.3.12 *overlap*—the width of wrap material that covers a previous layer of wrap material.

3.3.13 *powered prestretch*—a mode of stretch wrap machinery operation in which wrap material elongation is achieved through use of a power assist prestretch device and relative load motion.

3.3.14 *protrusion puncture resistance*—the ability of a wrap material to withstand the force exerted by a protrusion.

3.3.15 *stretch wrap material*—a material used for overwrapping that elongates when applied under tension and, through elastic recovery conforms to the item(s) packaged.

3.3.16 *wrap cycle*—the series of operations used to wrap a load.

3.3.17 *yield (coverage)*—area per unit weight.

3.3.18 *zipper (tear)*—a self-propagating tear.

4. Significance and Use

4.1 This guide is for user evaluation, selection, specification, and application of stretch wrap materials. It may be used between the buyer and seller to arrive at purchase specifications. Specific methods are contained within the body of the guide for material evaluation, user performance, and quality assurance testing.

4.2 Care must be exercised in extrapolating test values obtained by use of the test methods outlined in this guide, to actual field performance.

5. Stretch Film Classification

5.1 Stretch wrap films may have the following types:
5.1.1 Hand applied film versus machine applied film,
5.1.2 Fabrication (blown, cast),
5.1.3 Cling Mechanism (two side, one side, no cling, migratory, non-migratory, one side slip, differentiated), and
5.1.4 Layer (monolayer, co-extruded).

5.2 Grade:
5.2.1 Colors, (clear, tints, opaque).

5.3 Class:
5.3.1 Food Contact, and
5.3.2 Non-food Contact.

6. Raw Materials and Fabrication

6.1 Typical materials covered by this guide are as follows:
6.1.1 Low-density polyethylene (LDPE),
6.1.2 Medium-density polyethylene (MDPE),
6.1.3 Linear low-density polyethylene (LLDPE),
6.1.4 Metallocene/m linear low density polyethylene (mLLDPE):
6.1.5 Ethylene vinyl acetate copolymer (EVA),
6.1.6 Poly(vinyl chloride) (PVC),
6.1.7 Polypropylene (PP),
6.1.8 Other polymeric materials or blends that meet the requirements of this guide. High density polyethylene (HDPE),
6.1.9 Ethylene methyl acrylate copolymer (EMA),
6.1.10 Very low density polyethylene (VLDPE),
6.1.11 Ethylene metallocene plastomers, and
6.1.12 Additives, modifiers and pigments.

7. Ordering Information

7.1 The inquiry and order for materials shall indicate the following where applicable:
7.1.1 Grade and class required,
7.1.2 Thickness,
7.1.3 Material length per roll,
7.1.4 Outside roll diameter,
7.1.5 Material width,
7.1.6 Core dimension (inside diameter and extension), and
7.1.7 ASTM designation, including revision date.

7.2 Where necessary, ordering information may be expanded or modified for special uses or materials, such as method of stretch and stretch percentage expected.

8. Stretch Film and Additives' Characteristics

8.1 *Physical and Mechanical Properties:*

8.1.1 The properties and test methods in Table 1 shall be used when describing the physical and mechanical characteristics of wrap materials as manufactured.

TABLE 1 Physical and Mechanical Properties of Materials

Property	Common Unit	SI Unit	ASTM Test Method
Breaking factor	1 lbf/in.	kN/m	D882
Clarity	%	%	D1746
Cling (peel)	gm	N	D5458
Coefficient of friction at approximately 72 and 100°F (22 and 38°C)	...	...	D1894
Density	lb/in.^{3}	g/cm^3	D1505
Elastic recovery	%	%	D5459
Elongation at break	%	%	D882
Flammability	% 0	% 0	D2863
Force at elongation (50, 100, 150, 200 %)	lbf/in.	kN/m	D882
Gloss	...	...	D2457
Haze	%	%	D1003
Protrusion puncture	in./lb	M/kg	[A]
Static electrification	V	V	D4470
Stress retention	%	%	D5459
Tear resistance (Elmendorf)	gm	N	D1922
Ultimate tensile strength	lb/in.^{2}	Pa	D882
Water vapor transmission rate	g/24 h-100 in.^{2}	g/h-m^2	E96/E96M, Procedure E
Wetting tension	dyne/cm	dyne/cm	D2578
Yield (coverage)	in.^{2}/lb	m^2/Kg	D4321

[A] New Standard Test Method for Protrusion Puncture Resistance of Stretch-Wrap Materials is under development.

8.1.2 The practices listed in Table 2 can be an aid when describing performance characteristics of wrap materials, as used for unitizing, reinforcing, and palletizing.

8.1.3 Some of the test methods described in Table 1 may be applied to multiple wraps or stretched specimens, or both, to aid in assessing their performance characteristics.

8.1.4 Other tests that may be of value for evaluating actual performance are given in Annex A1.

8.2 *Other Properties*—Food contact stretch films must conform to FDA or other governmental regulations, or both, as applicable.

8.3 *Recyclability/Disposability* —Stretch film should be recycled whenever possible. Disposability shall be in accordance with local, state, and federal regulations.

8.4 *Static Discharge*— Some plastic packaging wrap materials may build up static electrical charge. Care should be exercised in using these materials especially where potential flammable air vapor or air dust mixtures can exist.

9. Dimensions, Mass, and Permissible Variations

9.1 The material dimensions and their permissible variations shall conform to the following, unless otherwise specified by the user:

TABLE 2 Test Methods Related to Performance

Procedure	ASTM Test Method
Test Method for Evaluating Abrasion Resistance of Stretch Wrap Material	D5416
Test Method for Evaluating Load Containment Performance of Stretch Wrap Material by Vibration Testing	D5415
Test Method for Evaluation of Horizontal Impact Performance of Stretch Wrap Materials	D5414
Test Method for Evaluation of Mechanical Handling of Unitized Loads Secured with Stretch Wrap Materials	D5331

9.1.1 Thickness (caliper, gage) is expressed in fractions of an inch or mils. For example, the nominal thickness of 80-gage wrap material is 80/100 000, 0.00080 in., or 0.8 mils,

9.1.1.1 As determined by Specification D2103, and

9.1.1.2 The actual wrap material thickness shall not vary more than ±25 % of the nominal gage thickness in any one point across the width nor 20 % from the nominal thickness for the average of five consecutive points across the web, measured in a minimum of 1-in. or 25-mm increments.

9.1.2 *Roll Weight or Yield*—See Table 3.

9.1.2.1 Gross weight of hand wrap films generally under 12 lb.

9.1.3 The film roll width tolerance for wrap materials is ±¼ in. (6 mm) unless otherwise agreed upon between the buyer and the seller.

9.1.3.1 Standard widths are 10 to 80 in. (254 to 2032 mm) plus 10 to 20 in. (254 to 508 mm) on hand wrap applications. Nonstandard widths are also available.

9.1.3.2 Roll width, measured by a steel tape having an accuracy of ±⅛ in. (3 mm).

9.1.4 The roll diameter tolerance is ±5 % of nominal outside diameter.

9.1.5 The length per roll of film wrap materials shall be within + 4 – 0 % of the length as marked, or as otherwise agreed between the buyer and the seller, as measured by a tapeless measure.

10. Workmanship, Finish, and Appearance

10.1 Wrap materials shall be generally free from defects that may affect the serviceability such as wrinkles, fold-over creases, soft spongy areas, and gels.

10.1.1 No splices are allowed.

11. Sampling

11.1 Sampling shall be in accordance with Practice D1898.

12. Test Methods

12.1 The test methods in Annex A1 are not ASTM standards, however these procedures are a necessary part of this guide.

13. Preparation for Delivery

13.1 Lot or serial number must appear on the individual roll, pallet or case.

13.2 Shipping container or individual rolls, or both, shall be labeled in accordance with Practice D3951 with the following additional markings:

13.2.1 Product name,

13.2.2 Thickness,

13.2.3 Material width in inches or millimetres,

13.2.4 Material length per roll in feet or meters,

13.2.5 Material weight per roll in pounds or kilograms, and

TABLE 3 Average Weight/Yield Tolerances for Stretch Wrap Material

Number of Rolls	Tolerance, %
Any one roll	±7
Lots over 25	±5

13.2.6 Manufacturer's or seller's name.

13.3 Where necessary, labeling information may be expanded or modified for special uses or materials.

14. General Uses

14.1 Tensioned stretch film may be used to secure a handling base (skids, platforms, pallets, slip sheets, etc.) to a unit load to expedite handling (tertiary package).

14.2 Stretch film may be used to secure cushioning, edge protection, or other package components to an individual item (office furniture, windows, etc.) (primary/secondary package).

14.3 Stretch film may be used as a primary protective wrap for individual products (rolled products, metal coils, etc.) (primary package).

14.4 Stretch film may be used to bundle multiple products and provide surface protection (metal extrusions, wood molding) (primary package).

14.5 Stretch film may be applied to rolled forage crops to facilitate the decomposition into silage (primary package)

15. Film Force Applied to the Load

15.1 *Concept of Load Containment*—Proper load containment allows the film to securely hold a load in place, so the load safely arrives intact at a customer's location. Stretch film is properly applied when: film is elongated; applied under tension; and the elastic recovery conforms to the load. Load containment can be increased with additional wraps of stretch film, heavier gauge film, or increased post-stretch.

15.2 *Film Load Containment Properties*—Films can differ in stretch retention and elastic recovery characteristics.

15.3 Film force to load is usually measured by determining the force required to pull the film a certain distance away from the load.

15.4 Film elongation is achieved with pre-stretch and post-stretch. In a typical application, the majority of film elongation is achieved in a pre-stretch mode of operation.

15.4.1 Pre-stretch is a mode of operation in which stretch film elongation is achieved between a pre-stretch device, typically between two rollers rotating at different speeds.

15.4.2 Post-stretch is a mode of stretch film machinery operation in which film elongation is achieved after leaving the pre-stretch device and before reaching the load. Generally this is achieved by an adjustment to the film force to load machine setting.

15.5 *Wrapping Techniques:*

15.5.1 Each application may require different load containment properties based on the product and methods of distribution. These properties can be obtained with different film properties and machine settings.

15.6 *Film Force Measurement Procedures:*

15.6.1 *Pull-Plate Method*—A fish type scale is attached to a non-yielding round plate and the film is pulled away from the load. At a measured distance the pounds (kilograms) of force applied to the plate by the film is recorded.

15.6.2 *Wrap-Scale-In Method*—A strain gauge such as a bathroom type scale is attached to the load and the stretch film is applied to the load. The strain gauge is used to record the pounds (kilograms) of force applied to the gauge by the film and is recorded.

15.6.3 *Effects of Time and Temperature on the Film Forces Applied to the Load*—It is important to conduct the film test at the same amount of time after the load is wrapped, and at the same temperature and the same stretch percentages, to obtain the most reproducible results.

16. Application Devices

16.1 Stretch film may be applied either by machine or by hand. Machine application provides more consistency and control for wrapping and unitizing a load. Hand application is more variable due to operator control of film coverage, placement of the film, and the amount of tension applied. For the safety of both handlers and load contents, when hand wrapping there should be a careful inspection of the finished unitized load for the placement, tension and coverage of film so that the load is securely held to the pallet.

16.2 *Machine Application*

16.2.1 *Turntable:*

16.2.1.1 Semi-Automatic or automatic (see Fig. 1),

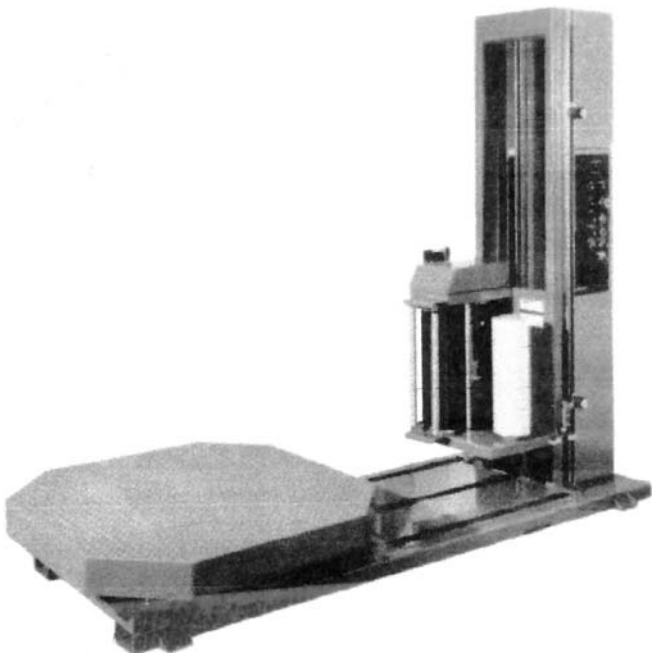


FIG. 1 Turntable Stretch Wrap System (shown as defined in 16.2.1 - semi-automatic)

16.2.1.2 Load turns on a spinning table,

16.2.1.3 Machine does stretching and wrapping,

16.2.1.4 Film elongation as measured on load typically range from 100 to 300 %,

16.2.1.5 Post Stretch/Force to Load controlled by machine setting, and

16.2.1.6 Products are typically wrapped at speeds of 10 to 20 loads per hour (semi-automatic) and 20 to 60 loads per hour (automatic).

16.2.2 *Orbital/Bundling (see* Fig. 2*):*

16.2.2.1 Semi-Automatic or automatic,

16.2.2.2 Film is stretched and applied in a vertical circle around a horizontal load,

16.2.2.3 Film elongation as measured on load typically range from 50 to 200 %,

16.2.2.4 Post Stretch/Force to Load controlled by machine setting, and

16.2.2.5 Products wrapped typically range from 20 to 100 loads per hour.

16.2.3 *Rotating Arm* (see Fig. 3)*:*

16.2.3.1 Semi-automatic and automatic,

16.2.3.2 Film is stretched and applied in a horizontal circle around a stationary load,

16.2.3.3 Film elongation as measured on load typically range from 100 to 300 %,

16.2.3.4 Post Stretch/Force to Load controlled by machine setting, and

16.2.3.5 Products are typically wrapped at speeds of 25 to 35 loads per hour (semi-automatic) and 35 to 70 loads per hour (automatic).

16.3 *Hand Application*

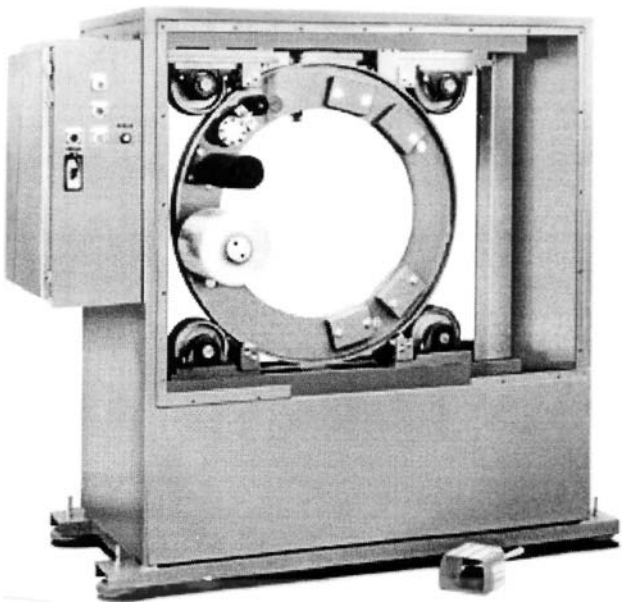


FIG. 2 Horizontal Stretch Bundling System (as defined in 16.2.2)

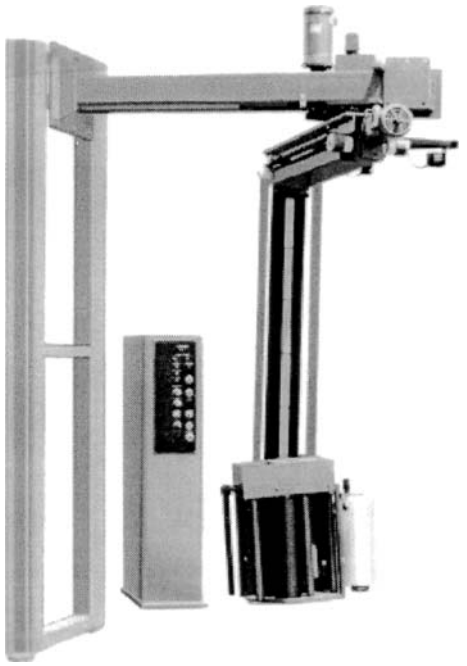


FIG. 3 Rotating Arm Stretch Film System (as defined in 16.2.3)

16.3.1 *Extended Core* (see Fig. 4)*:*

16.3.1.1 Core typically extends 5 in. from film edge,

16.3.1.2 An operator manually grips core extensions, and

16.3.1.3 Film elongation as measured on load typically range from 20 to 80 %.

16.3.2 *Hand Wrap Dispenser* (see Fig. 5)*:*

16.3.2.1 Tension controlled by adjusting knob for resistance of roll turning, and

16.3.2.2 Film elongation as measured on load typically range from 20 to 150 %.

16.3.3 *Manual Hand Application* (see Fig. 6)*:*

16.3.3.1 No handles or machines used, and

16.3.3.2 Tension and stretch controlled with pressure from the hand on core or film edge.

16.3.4 *Hand Bundling Film* (see Fig. 7)*:*

16.3.4.1 Extended core or handle insert typically used to apply film,

16.3.4.2 Tension and stretch controlled by grip on core or handle, and

16.3.4.3 Film elongation as measured on load typically range from 20 to 150 %.

17. Keywords

17.1 stretch wrap materials

FIG. 4 Extended Core Hand Film (as defined in 16.3.1)

FIG. 5 Hand Wrap Film Dispenser (as defined in 16.3.2)

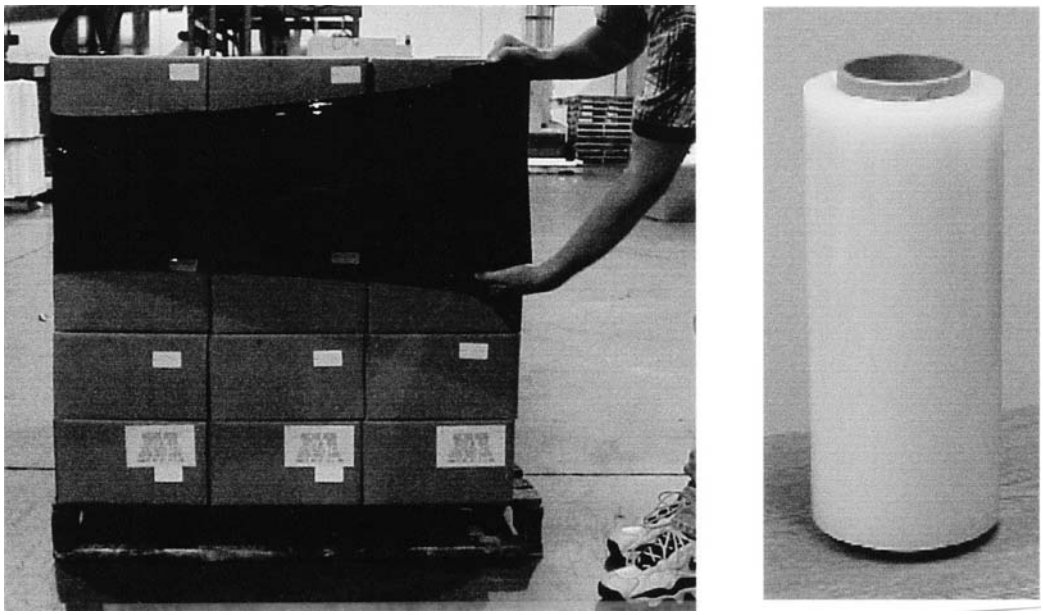


FIG. 6 Manual Hand Film Application (as defined in 16.3.3)

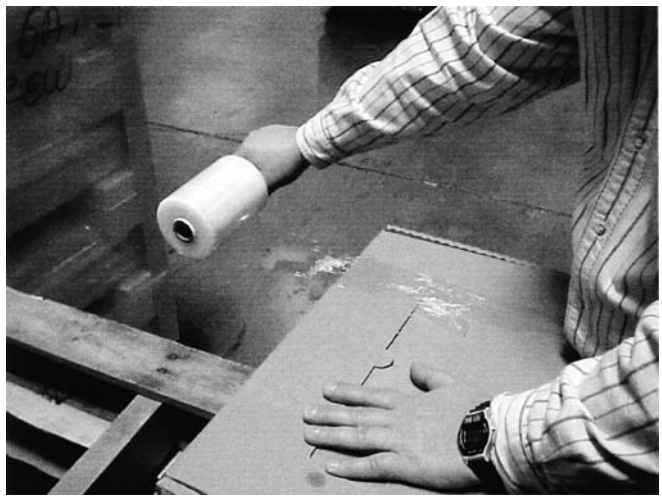


FIG. 7 Hand Bundling Film Application (as defined in 16.3.4)

ANNEX

(Mandatory Information)

A1. TEST METHOD FOR GENERAL EVALUATION OF STRETCH WRAP MATERIALS UNDER NON-LABORATORY CONDITIONS

A1.1. Scope

A1.1.1 This test method is intended to be used as a means of comparing the wrapping performance of stretch wrap films.

A1.2. Significance and Use

A1.2.1 This test method can be used to compare the relative effectiveness of stretch wrap films in various wrapping cycles.

A1.2.2 Film thickness and width must be considered in reaching comparative conclusions, that is, a 100-gage 30-in. (762-mm) wide roll will perform differently than a 50-gage 20-in. (510-mm) wide roll.

A1.3. Typical Apparatus

A1.3.1 *Stretch Wrapping Apparatus With Desired Braking*—The various braking methods are referred to as conventional, mechanical prestretch, and powered prestretch.

A1.3.2 *Pallet Load Frame*—Typical dimensions for frame are 48 in. (1220 mm) high by 40 in. (1020 mm) wide by 48 in. (1220 mm) long with adjustable protrusions.

A1.3.3 *Marking Wheel.*

A1.3.4 *Means of Weighing Film Samples*—The device must be accurate to 0.1 oz (3 g).

A1.3.5 *Micrometer.*

A1.3.6 *Tape measure or tapeless measure.*

A1.3.7 Fish type scale and pull-plate (see Fig. A1.1).

A1.3.8 Strain gauge, such as bathroom scale (see Fig. A1.2).

A1.4. General Procedures

A1.4.1 Maintain and record the following:

A1.4.1.1 Number of wraps at the top and bottom,

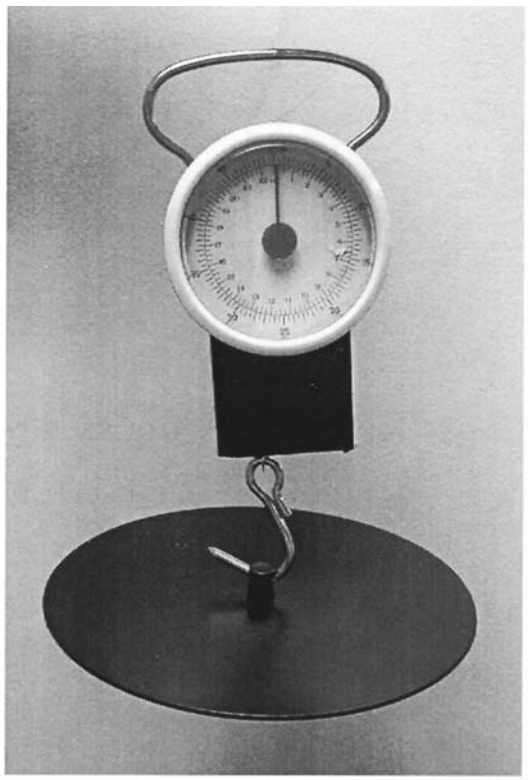
A1.4.1.2 Carriage speed (upward and downward), and

A1.4.1.3 Turntable speed.

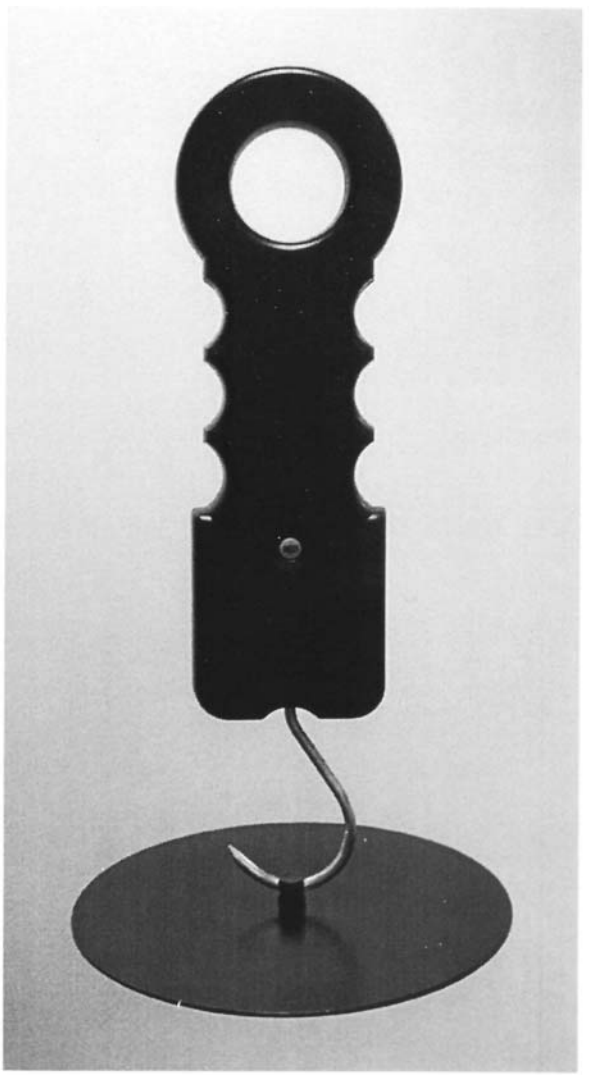
A1.4.1.4 Carriage should be adjusted to wrap at a constant overlap above the pallet cube. The bottom adjustment should not allow any coverage below the frame.

A1.4.1.5 At startup, a pallet side must be perpendicular to and centered with the wrapper's main axis. This will standardize the film tail at approximately 3 ft (0.9 m). Care must be taken to verify that the wrapper returns to its starting position.

A1.4.2 Wrap the pallet having the desired puncture profile, as defined in A1.4.6, using the film at the desired stretch setting. Use the normal wrap cycle unless otherwise specified.

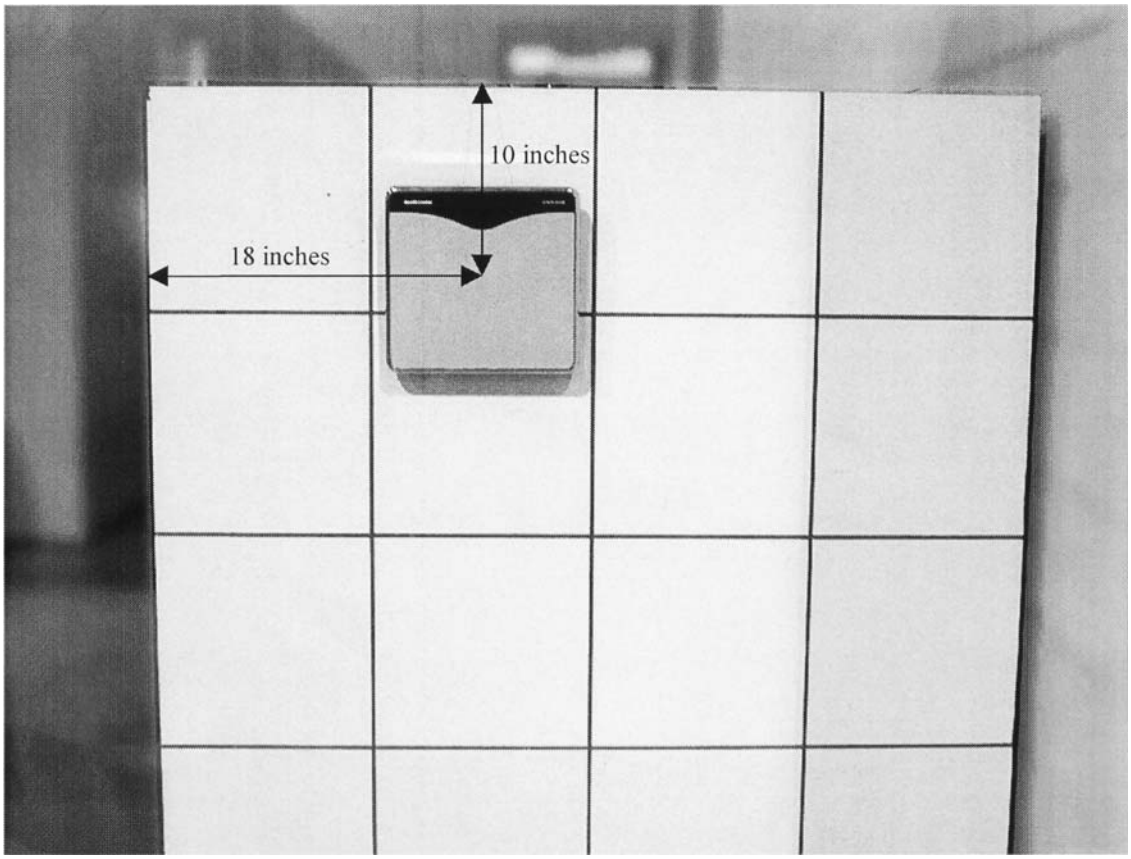


SPRING FILM FORCE SCALE with 6 INCH PLATE
TYPICAL CAPACITY: 50 lb. (22.7 kg)



DIGITAL FILM FORCE SCALE with 6 INCH PLATE
TYPICAL CAPACITY: 50 lb. (22.7 kg)

FIG. A1.1 Peel Plate Test Devices



NOTE 1—Position bathroom scale 10 in. from top of load and 18 in. from left corner on a rigid flat surface of the load where possible.

FIG. A1.2 Wrap-Strain Gauge-Scale-In Method

When wrapping, measure the stretched film web width. After the wrapper has cycled, cut the film web. Evaluate and record observed cling, slit growth, observed puncture, and measured stretch. Measure the unstretched film gage and weight of film used.

A1.4.3 *Measuring Stretch on the Load Frame:*

A1.4.3.1 *Marking Wheel Procedure*—The marking wheel places marks of a known distance on the film (unstretched or original length). As the film is stretched, the distance between the marks changes. A measurement of these marks (stretched or new length) and a comparison to the original length will indicate the percentage of stretch:

$$\text{measured stretch, \%} = \frac{\text{new length} - \text{original length}}{\text{original length}} \times 100 \quad \text{(A1.1)}$$

Examples:

$$\frac{22 - 10 \text{ in. } (570 - 255 \text{ mm})}{10 \text{ in. } (255 \text{ mm})} \times 100 = 120\,\% \text{ stretch} \quad \text{(A1.2)}$$

$$\frac{16 - 5 \text{ in. } (405 - 125 \text{ mm})}{5 \text{ in. } (125 \text{ mm})} \times 100 = 220\,\% \text{ stretch} \quad \text{(A1.3)}$$

A1.4.3.2 *Tapeless Measure Procedure* —Measure the total perimeter around the load to be wrapped. If load is nonsymmetrical, measure the path of greatest wrap perimeter. As the load is being wrapped, measure the total film length being used by applying the tapeless measure to the roll surface as the film is being unwound:

$$\text{total wrapped length} = \text{wrap perimeter} \times \text{total number of turns of turntable} \quad \text{(A1.4)}$$

$$\%\ \text{stretch} = \frac{\text{total wrapped length} - \text{total film length}}{\text{total film length}} \times 100 \quad \text{(A1.5)}$$

Example:

$$\text{total perimeter} = 14 \text{ ft } (4.3 \text{ m}) \quad \text{(A1.6)}$$

$$\text{number of turns} = 9 \quad \text{(A1.7)}$$

$$\text{tapeless measure reading of film length} = 63 \text{ ft } (19.2 \text{ m}) \quad \text{(A1.8)}$$

Therefore:

$$\text{total wrapped length} = 14 \times 9 = 126 \text{ ft } (38 \text{ m}) \quad \text{(A1.9)}$$

$$\%\ \text{stretch} = \frac{126 - 63}{63} \times 100 = 100\,\% \quad \text{(A1.10)}$$

Assuming the same perimeter, a tapeless measure reading of 60 ft (18 m) would yield the following:

$$\%\ \text{stretch} = \frac{126 - 60}{60} \times 100 = 110\,\% \quad \text{(A1.11)}$$

A1.4.4 *Observed Cling*— After completing the wrapping cycle, cut the film web. Take the resultant film tail, and smooth

this tail onto the wrapped film. Pull the end of the film tail off the pallet and away from the film body with an approximate angle of 20°. As the film tail is pulled from the pallet, it will require some force to be pulled. A judgment of this force is used to evaluate the film's cling. If the force is noticeable, the cling is judged as GOOD. EXCELLENT cling is a very noticeable force. If the force is not noticeable, but the film remains against the film body on the pallet, the cling is judged FAIR. If the film tail, when brushed on the film body barely attaches to the film body, the cling is judged POOR. If the tail doesn't stick to the film body, even when brushed, the cling is judged as NONE.

NOTE A1.1—Static may distort observed cling results. Static is evident if the tail is held and released approximately 2 to 3 in. (50 to 75 mm) from the wrapped load and the released tail is attracted to the film body. Allow the static to dissipate before evaluating cling.

A1.4.5 *Observed Tear Slit Test*—Five minutes after wrapping, place a 10-in. (255-mm) vertical slit in the film. The tear performance of a film is affected by the amount of time after wrapping and the start of the tear procedure. Slit through all of the layers of film at a consistent central location on the pallet frame. Allow the slit to propagate for 10 min. Measure the resultant hole. Report the measured vertical distance. If the slit propagates through the entire wrap or one end propagates through the wrap, report the results as zippers.

A1.4.6 *Observed Puncture*—The typical pallet load frame has provision to evaluate a film's puncture resistance. The pallet has two mounting rails located near a 40-in. (1020-mm) side corner and a 48-in. (1220 mm) side corner. Both rails allow infinite vertical mounting of the protrusion(s). There are three protrusion configurations. To simulate an extreme A Load, a 1 ½ in. (38-mm) square tube protrudes 1 in. (25 mm). A 3-in. (75-mm) protrusion is used for B Load and a 5-in. (125-mm) protrusion for C Load. Other protrusion shapes may be used, for example a 2 by 4-in. (50 by 100-mm) board. The protrusions are usually placed in one of several of the following patterns:

A1.4.6.1 *Pattern Number 1*—Three of one size evenly spaced vertically. Minimum spacing to be 6 in. (150 mm).

A1.4.6.2 *Pattern Number 2*—One of each size evenly spaced vertically with decreasing protrusion size from top to bottom. Minimum spacing to be 6 in. (150 mm).

A1.4.6.3 *Pattern Number 3*—One of each size evenly spaced vertically with increasing protrusion size from top to bottom. Minimum spacing to be 6 in. (150 mm).

A1.4.6.4 *Pattern Number 4*—One of any size individually located.

A1.4.6.5 To evaluate a film for puncture resistance, mount the desired load pattern. Wrap the film on the pallet load and pattern. A film fails if the protrusion penetrates all layers of the film. Unless specified, puncture is evaluated with the normal wrap cycle and Pattern Number 2 mounted on the 40-in. (1020-mm) side. The reported data indicates the largest protrusion which was successfully wrapped.

A1.4.7 *Cut and Weight Per Pallet Determination*—Remove all film from the pallet and weigh. Repeat weight per pallet determination five times. Average the five weights, and report the results. Various film densities will affect pallet wrap-weight determination. Weight per pallet is not necessarily correlatable to the length of film used.

A1.5 *Typical Film Failures*:

A1.5.1 *Over-Braking*—When the braking (stretch) force is greater than the film's strength, the web will break. The resultant break is a nominal perpendicular break to the machine direction (MD) usually at the point of overstress.

A1.5.2 *Over Stretch*—Over stretch failure is indicated by extreme web neckdown and extreme film stretch.

A1.5.3 *Edge Failure*—If an edge problem (damaged, poor slitting, film fold over, etc.) causes web failure, the resultant tear will start at the problem and travel diagonally across the web. The film roll may exhibit a barber pole appearance.

A1.5.4 *Prestretch Failure*—The mechanism of prestretching opens a small hole within the film web. As this hole travels to the pallet, it may propagate through the web causing film failures. The failure tail exhibits a diamond-shaped (<>) pattern.

A1.6 *Prestretch Failure Rate (Breaks Per Pound) (Breaks Per Roll)*:

A1.6.1 Determine a measurement of a film's ability to stretch without failure at a given level of prestretch with the following procedure:

A1.6.2 Set the prestretch wrapping equipment to the desired prestretch setting (or gear ratio). Place a 40-in. (1020-mm) wide, 48-in. (1220-mm) long load with no protrusions on the turntable. Spiral wrapping is not necessary. There is to be no pallet corner overlap at the top or the bottom.

A1.6.3 Weigh the film roll before starting.

A1.6.4 Follow the wrapper manufacturer's instructions to thread the film. Start the wrapper. Record all film web breakage. If desired, note failure mode and causes. A typical prestretch failure will cause a "V-" shaped film tear off. These should not be confused with edge failures.

A1.6.5 At ten failures, at the end of the roll or any other designated point, end wrapper operation. Remove and weigh film. Report results as a ratio of the number of breaks per pound of film used. The results can be normalized to the equivalent weight of a full roll of the type film tested and reported as the number of breaks per roll.

A1.7 *Conventional Stretch Evaluation*:

A1.7.1 *Determining the Maximum Stretch*—Place film in wrapping equipment. Determine maximum possible brake setting that can be used without film breakage. Note the brake settings, measured stretch, and the type of film failures. Typical are over stretch and edge failure.

A1.7.2 *Film Evaluation and Examples*—After determining the maximum brake setting, reduce the setting slightly so that the film will wrap the load. Evaluate stretch percentage, cling, puncture, tear, slit growth, film weight, and wrapping force. Measure unstretched gage, stretch gage, and stretch film width. A series of reduced brake settings could also be evaluated.

A1.8 *Mechanical Prestretch Evaluation*:

A1.8.1 With mechanical prestretch, the percentage of film elongation is fixed by wrapping equipment. The common evaluation ratio is 100 % stretch. Other ratios can be used for evaluation.

A1.8.2 With the designated ratio installed in the wrapping equipment, begin film evaluation. Record roll numbers and unstretched gage. Using the normal wrap cycle, measure stretch and evaluate observed cling, puncture, tear, stretched web width, stretched gage, and wrapping force and film weight per pallet. Prestretch failure rate of the film should be determined in accordance with A1.6.

A1.9 *Powered Prestretch Evaluation*:

A1.9.1 Powered prestretch equipment has the ability to be adjusted to various percentages of film elongation and wrapping forces (film force).

A1.9.2 Run film evaluation at various film elongation and film force settings on the wrapper. Evaluate stretch percentage, cling, puncture, slit growth, film weight, and wrapping force at each wrapper setting. Measure unstretched gage, stretched gage, and stretched web width. Prestretch failure rate at each desired film elongation and film force setting should be recorded.

A1.10 *Film Force Measurement Procedures*

A1.10.1 *Pull-Plate Method*—Stretch wrap the load according to wrapping techniques. Allow the stretch wrapped load to stand undisturbed for 5 min before testing the film force. Insert the 6-in. diameter non-yielding plate with an eyelet from the top edge of the film between the film and the load, at a measured location 10 in. (250 mm) from the top of the load and 18 in. (460 mm) from the corner of the left side of the load. Cut a 1 in. (25 mm) wide horizontal slit in film to allow eyelet to protrude through the film. Cut a second 1 in. (25 mm) wide horizontal slit, for tape measure insertion, 4 in. (100 mm) to the left of the first slit. Attach the film scale hook through the eyelet of the film force plate. Using the scale, pull the attached film force plate 4 in. (100 mm) away from the load. Record the pounds (kilograms) of force required to pull the plate 4 in. (100 mm) for the load. (See Fig. A1.1).

A1.10.2 *Wrap-Scale-In Method*—Securely support and attach a strain gauge, such as a bathroom scale, to a rigid flat surface of the load, centered at a measured location 10 in. (250 mm) from the top of the load and 18 in. (460 mm) from the corner of the left side of the load (where possible). (See Fig. A1.2). Zero the strain gauge. Stretch wrap the load according to wrapping techniques, wrapping the film over the strain gauge. Allow the stretch wrapped load to stand undisturbed for 5 min. Record the pound (kilograms) of force applied to the strain gauge.

A1.10.2.1 The strain gauge must be responsive to load force reduction over time. A scale that records only maximum force will not work for this test, as it is not responsive to load force reduction over time.

A1.11 *Precision and Bias*

—No statement is made about either precision or bias of this test method since results merely state whether this is in conformation to the criteria for success specified by the user of the test method.