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Standard Guide for ~~Selection and~~ Use of Stretch ~~Wrap Films~~Films and Wrapping Application[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.

1.1.1 Performance characteristics of stretch film may be negatively affected by extreme temperatures.

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

1.4 *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
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~~D1898 Practice for Sampling of Plastics (Withdrawn 1998)[3]~~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

[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~~standard's Document Summary page on the ASTM website.

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
D5748 Test Method for Protrusion Puncture Resistance of Stretch Wrap Film
D8314 Guide for Performance Testing of Applied Stretch Films and Stretch Wrapping
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.)~~

~~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~~film 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 Film Uses*—The following are general uses of stretch films.

5.1.1 Used to bundle multiple smaller goods into a single larger entity.

5.1.2 Used to secure a handling base (skids, platforms, pallets, slip sheets, etc.) to a load to expedite handling.

5.1.3 Used to secure cushioning, edge protection, or other package components to an individual item (office furniture, windows, etc.).

5.1.4 Used as an environmental protection and tamper evidence for a load.

5.1.5 Used as a primary protective wrap for individual products (rolled products, metal coils, metal extrusions, wood molding, etc.).

5.2 *Stretch Film Types*—The following are general types of stretch film.

5.2.1 *Machine Stretch Film*—Typically sold in widths ranging from 20 in. to 30 in. and in a variety of thicknesses. It is typically sold on a 3-in. core and can be purchased in any length, although 3000 ft to 10 000 ft is most common.

5.2.2 *Hand Stretch Film*—Typically sold in widths ranging from 10 in. to 20 in. and in a variety of thicknesses. It is typically sold on a 3-in. core and can be purchased in any length, although 1000 ft to 2000 ft is common.

5.2.3 *Prestretched (oriented) Stretch Film*—Hand films that are stretched during the manufacturing process either in-line (oriented) or in a secondary operation (prestretched).

5.2.4 *Stretch Tape*—Typically sold in width ranging from 3 in. to 5 in. and comes in a variety of thicknesses. It can be used to bundle a series of objects, wrap a load that requires airflow or to handle goods temporarily for internal transport. It is generally applied by hand and the devices for application vary widely from grabbing an extended core to apparatuses that aid in the application of the film.

5.2.5 *Ventilated Stretch Film*—A film that has holes formed into it that allow airflow to enter and exit the load. It can be applied with all application methods discussed in Section 12.

5.3 *Stretch Film Classifications*—~~Stretch wrap films may have the following types:~~The following are general classifications of stretch films.

5.3.1 ~~Hand applied film versus machine applied film,~~*Application Methods:*

5.3.1.1 *Hand Film*—For use in hand application of stretch film.

5.3.1.2 *Machine Film*—For use in powered stretch film application.

5.3.2 ~~Fabrication (blown, cast),~~*Fabrication Methods:*

5.3.2.1 *Blown Extrusion*—Implies the bubble forming extrusion process used to manufacture the film.

5.3.2.2 *Cast Extrusion*—Implies the flat die extrusion method of manufacturing the film.

5.3.3 *Cling Mechanisms*—~~Cling Mechanism (two side, one side, no cling, migratory, non-migratory, one side slip, differentiated), and~~ The cling should be facing inward on the load to prevent different loads from sticking to each other. If the cling side is not known, fold the film over on its self in either direction to determine which side has more cling.

5.3.3.1 *Two Sided*—Similar cling properties are found on both sides of the film.

5.3.3.2 *Differential Cling*—Superior cling properties are found on one side of the film and lower cling on the other.

5.3.3.3 *One Sided*—Cling properties are found on one side and no cling is found on the other side. Some one sided cling films have a slippery, non-cling side.

5.3.3.4 *No Cling*—No cling is found on either side of the film. These films' tails typically have to be tucked under a layer of film in the wrap pattern or heat sealed to ensure the film does not come unraveled in the transportation process.

5.3.4 ~~Layer (monolayer, co-extruded).~~*Layering During Extrusion:*

5.3.4.1 *Monolayer*—Single layer of material.

5.3.4.2 *Co-Extruded*—Multiple layers of material where used during extrusion.

5.3.5 *Ultraviolet Protective Film*—Protects the film from breaking down in the presence of the sun's ultraviolet rays.

5.3.6 *Anti-corrosive Films*—Works to prevent corrosion on metal products.

5.3.7 *Opaque/Tinted Films*—Colorants are an option as a load identification alternative or as a method to hide the product being transported.

~~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:~~The following are typical materials included in the extrusion process of stretch film:

~~6.1.1 Low-density polyethylene (LDPE),~~

~~6.1.2 Medium-density polyethylene (MDPE),~~

6.1.1 Linear low-density polyethylene (LLDPE),

6.1.2 ~~Metallocene/m~~Metallocene linear low density polyethylene ~~(mLLDPE):~~(mLLDPE),

~~6.1.5 Ethylene vinyl acetate copolymer (EVA),~~

~~6.1.6 Poly(vinyl chloride) (PVC),~~

6.1.3 Polypropylene (PP),

6.1.4 ~~Other polymeric materials or blends that meet the requirements of this guide. High density polyethylene (HDPE),~~ Polyisobutylene (PIB) (tackifier),

6.1.5 Ethylene ~~methyl acrylate copolymer (EMA),~~Vinyl Acetate (EVA).

~~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.~~

TABLE 1 Physical and Mechanical Properties of Materials

Property	Common Unit	SI Unit	ASTM Test Method
~~Breaking factor~~	~~1 lbf/in.~~	~~kN/m~~	~~D882~~
Breaking factor	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~~
Coefficient of friction at approximately 72 and 100°F (22 and 38°C)	...	...	D1894
~~Density~~	~~lb/in.^{3}~~	~~g/cm^3~~	~~D1505~~
Density	lbf/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~~
Force at elongation (50, 100, 150, 200 %)	lbf/in.	kN/m	D5459
Gloss	...	...	D2457
Haze	%	%	D1003
~~Protrusion puncture~~	~~in./lb~~	~~M/kg~~	~~A~~
Protrusion puncture	in./lbf	Nm	D5748
Static electrification	V	V	D4470
Stress retention	%	%	D5459
Tear resistance (Elmendorf)	gm	N	D1922
~~Ultimate tensile strength~~	~~lb/in.^{2}~~	~~Pa~~	~~D882~~
Ultimate tensile strength	lbf/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.~~

~~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.~~

7. Stretch Film and ~~Additives'~~Additives' Characteristics

7.1 *Physical and Mechanical Properties:*

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

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

7.1.3 Some of the test methods described in Table ~~1~~2 may be applied to multiple wraps or stretched specimens, or both, to aid in assessing their performance characteristics.

7.1.4 Other tests that may be of value for evaluating actual performance are given in ~~Annex A1~~Guide D8314.

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

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

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 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 Horizontal Impact Performance of Stretch Wrap Materials	D5414
Test Method for Evaluation of Mechanical Handling of Unitized Loads Secured with Stretch Wrap Materials	D5331

7.4 *Static Discharge*—Some ~~plastic packaging wrap materials~~ stretch films 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.

7.5 *Unwind Noise*—Some stretch films are noisier than others during the application process. This may be a characteristic that needs to be considered for some applications.

8. Dimensions, Mass, and Permissible Variations

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

8.1.1 Thickness ~~(caliper, gage)~~ (gauge, microns, inches) 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,~~decimal form. For example, 80-gauge is also equal to 0.0008 inches. The 80-gauge film multiplied by 0.254 to equal 20.3 micron.

~~9.1.1.1 As determined by Specification D2103, and~~

8.1.1.1 The actual wrap material thickness shall not vary more than ~~±25 %~~±10 % 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.~~width.

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

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

8.1.3 The film roll width tolerance for wrap materials is ±¼ ~~in. (6 mm)~~ 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.~~

8.1.3.1 Roll ~~width, measured by a~~width tolerance is ±⅛ ~~steel tape having an accuracy of ±~~in. (3 mm) of the width~~⅛ in. (3 mm).~~as marked unless otherwise agreed upon between the buyer and the seller.

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

8.1.5 The length per roll of film wrap materials shall be ~~within + 4 – 0 %~~within ±5 % of the length as marked, or as otherwise agreed between the buyer and the ~~seller,~~seller as measured by a ~~tapeless measure.~~wheel counter that presses on the film roll as it is being unwound from the roll but before the film is pulled off the roll. (Films may extend or contract after the film is removed from the roll. This may produce an inaccurate length measurement.)

8.1.6 A unit conversion table is found in Table 4.

TABLE 3 Average Weight/Yield Tolerances for Stretch Wrap Material

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

TABLE 4 Unit Conversion Factors

Unit Conversion	
Gauge * 0.254 = Micron	Inch * 25.4 = Millimetres
Micron * 3.937 = Gauge	Millimeter * 0.0394 = Inches
Feet * 0.3048 = Metres	Pound / 2.2 = Kilograms
Meter * 3.2808 = Feet	Kilogram * 2.2 = Pounds
Pound Force * 4.44822 = Newtons	Newton /4.44822 = Pounds Force
Pound/in^3 * 27.6799 = g/cm^3	Pound/ft^3 * 0.0160184 = g/cm^3
Mil * 25.4 = Micron	Mil = 100 Gauge
Pound Force/in^2 * 6.895 = kPa	

9. Workmanship, Finish, and Appearance

9.1 ~~Wrap materials~~ Films shall be generally free from ~~defects~~imperfections that may affect the ~~serviceability~~performance such as wrinkles, ~~fold-over~~ creases, soft spongy areas, ~~and gels.~~damaged edges, and inconsistent thicknesses.

9.1.1 No splices are allowed.

10. Sampling

10.1 ~~Sampling shall be in accordance with Practice~~Samples should not be taken within the initial ~~D1898.~~2 % or the last 2 % of the length of the roll; regardless remove enough film to ensure that damaged or poorly wound film is not used for test samples.

~~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.~~

11. ~~Preparation for Delivery~~ Ordering and Shipping Information

11.1 ~~Lot or serial number must appear on the individual roll, pallet or case.~~The following should be included when ordering stretch film.

11.1.1 Film thickness.

11.1.2 Film width.

11.1.3 Film length per roll.

11.1.4 Core dimensions (inside diameter and extension).

11.1.5 Identification of machine or hand film.

11.1.6 Identification of any other classifications found under Section 5.

11.1.7 Quantity.

11.1.8 Delivery locations.

11.1.9 Where necessary, ordering information may be expanded per customer request.

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

11.2.1 Product ~~name,~~name.

11.2.2 ~~Thickness,~~Thickness.

11.2.3 Material ~~width in inches or millimetres,~~width.

11.2.4 Material length per ~~roll in feet or meters,~~roll.

11.2.5 Material weight per ~~roll in pounds or kilograms, and~~roll.

11.2.6 Manufacturer's or seller's name.

11.2.7 ~~Manufacturer's or seller's name.~~Lot or serial number on the individual roll, pallet, or case.

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

~~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)~~

12. ~~Film Force Applied to the Load~~ Considerations for Application

12.1 ~~*Concept of Load Containment—*~~*Wrap Patterns*—~~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.~~Infinitely variable but typically consist of:

12.1.1 *One-Way Spiral*—Typically started on the bottom or the top of the load. The stretch wrapper makes a single spiral pass over the load with overlap varying from 20 % to 80 %.

12.1.2 *Two-Way Spiral*—Typically started on the top or bottom of the load. The stretch wrapper makes two complete spiral passes (for example, up and down) over the load without breaking the film web. Overlap is between 20 % and 80 %.

12.1.3 *Additional Top and Bottom Wraps*—Multiple layers of overlap on the top and bottom of the load are applied in addition to a cross spiral pattern (12.1.2) base.

12.1.4 *Top Overwrap*—The amount that the film is allowed to wrap over the top surface of the load.

~~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.~~

12.2 ~~*Film Force Measurement Procedures:*~~ *Stretch Roping—*

~~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.~~Roping is achieved by taking either part or the entire film web and curling or bunching into a single "strand" of film. This technique is used for stabilizing heavy loads and to better connect the contents on the load to the pallet. Note that by using roped stretch film it is very easy to create a high point load on corners of a load, potentially damaging delicate goods during the wrapping process.

12.2.1 ~~*Wrap-Scale-In Method*—~~*Hand Application of Rope*—~~A strain gauge such as a bathroom type scale is attached to the load and the stretch~~ The film roll is held sideways (roll is parallel to the floor) as the 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.~~

12.3 *Percent Prestretch and Post-Stretch*—In general, the more stretch imparted on a given film, the more stiff (harder to stretch further) the film will become. As the film is stretched generally the film stiffness, cling levels, load containment, and puncture resistance may change. This is due to the aligning of the polymer chains during the stretching process.

12.4 *Shelf Life of Film*—Depending on storage conditions the quality of the film or the core can degrade over time, utilize first-in-first-out inventory management when possible. Exposure to extreme temperatures, sunlight, and humidity can significantly affect the length of this period.

12.5 *Securing the Pallet*—Securing the pallet and the load together with stretch film helps to keep the load together, reducing the potential for load shift during transit.

12.6 *Wrapping Consistency Evaluation*—Film stretch and containment force should be reevaluated on a minimum quarterly basis to ensure machine operation is consistent with the standard operating procedure.

12.7 *Methods of Securing the Film Tail:*

12.7.1 The cling properties of the film are used to secure the tail in place, recommended length is ½ to ¾ the width of a load.

12.7.1.1 The film tail can be tucked under a previous wrap(s).

12.7.1.2 The film tail can be heat sealed to the wrap(s).

NOTE 1—Clockwise from left, Pole applicator, end plugs to protect hands during application, and film applicator with tensioner.

FIG. 1 Hand Wrap Film Dispensers (see 13.3)

13. Application Devices

13.1 Stretch film may be applied either by machine or by hand. Machine application provides more consistency and control for wrapping ~~and unitizing~~ of 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.~~Any method of application can be used in conjunction with a conveyor.

13.2 *Types of Stretch Devices*

13.2.1 *Brake Devices*—A brake device stretches film using only tension between the film roll (or application device) and the load to be wrapped on more basic wrappers.

13.2.2 *Non-Powered Prestretch*—A set of fixed gears is used to stretch film to a percentage of its original length. The levels of stretch that can be selected are limited to the ratios which can be achieved by changing out machine parts in the film carriage.

13.2.3 *Powered Prestretch*—A power assisted version of non-powered prestretch, again using fixed gears.

13.2.4 *Variable Prestretch*—An adjustable stretch version of the powered prestretch where the percent stretch can be changed by the operator either between wraps or mid wrap pattern.

13.3 *Hand Wrap Dispenser* (see Fig. 1). Will range from handling the core directly to an apparatus that holds the film and can control tension during application. For the safety of both handlers and load contents, a clear Standard Operating Procedure should be composed and followed. Film is typically stretched between 0 % and 50 % during application. When applying film by hand, attempt to emulate the wrap patterns stated in Section 12.

13.3.1 *Optional Techniques beyond the standard wrap patterns include:*

13.3.1.1 *Butterflying*—Rotating the roll on its vertical axis during the application process. If this is part of the SOP, it is not recommended that single sided cling film is used as the cling will only be on the inside 50 % of the time.

13.3.1.2 *Over the Corner*—Pulling the film over the corner during the application process to help secure the corner of the load.

13.3.1.3 *Band Wrap*—Wrapping around the top of the unit load to temporarily secure the load.