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Standard Guide for Selection and Use of Flat Strapping Materials¹

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This standard has been approved for use by agencies of the U.S. Department of Defense.

INTRODUCTION

This guide covers two common categories of flat strapping materials: steel and nonmetallic. Within each of these two broad categories there are distinct types that lend themselves in differing degrees to particular applications.

The goal of this guide is to help the user focus on the desired elements of performance or service, and the unique properties of each strapping material in order to judge which of these strapping products is best suited for the intended strapping application. For further information, consult with your strapping supplier, your carrier, and any packaging and loading regulations applicable to your products. It is of particular importance, for both safety and satisfactory performance, that the user informs the strapping supplier of all intended uses and usage conditions that may differ from industry custom and practice or from intended strapping applications. Likewise, the user needs to inform the strapping supplier of any practice of the user's carrier that the user believes may differ from any requirement or recommendation of the carrier's association or of any applicable ASTM or regulatory provisions. The user also should inform the strapping supplier of the following expected conditions: load, unit, or package characteristics (rigid, expanding, shrinking, or combination); severity of handling; nature of transport equipment; storage conditions (stacking height and weight); exposure to environmental conditions; extreme temperatures (particularly if prolonged outdoor exposure is anticipated); exposure to chemicals; exposure to abrasive surfaces; and exposure to sharp or pointed objects that can cause nicks, scratches, or holes in the strapping. There are other materials not covered by this guide, which may also offer acceptable solutions or may be used in conjunction with flat strapping to provide acceptable solutions for the user's intended application. Examples of accessories, such as, edge protectors, seal protectors, etc. are shown in Fig. 1.

Strapping may be recyclable but must never be reused. Contact your supplier for further information.

1. Scope

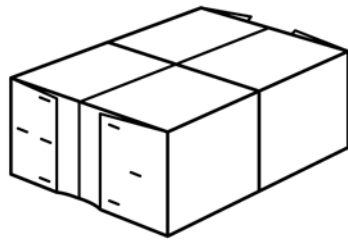
1.1 This guide covers information on flat strapping materials (steel and nonmetallic) for the prospective user wanting initial guidance in selecting a strapping material and information on suggested application methods for use in packaging (closing, reinforcing, baling, bundling, unitizing, or palletizing) and loading applications (load unitization and securement to transport vehicle). The use applies to handling, securement, storage, and distribution systems.

1.2 Carrier associations have established certain packaging and loading requirements that (in some cases) specify the type of strap, the minimum size or strength, the type of joint or seal, and the number of straps, seals, and joints that must be used for particular types of shipments or under certain conditions. Users should consult with their carriers initially to determine if there are applicable published requirements. Individual carriers may establish their own requirements. (See 2.2.)

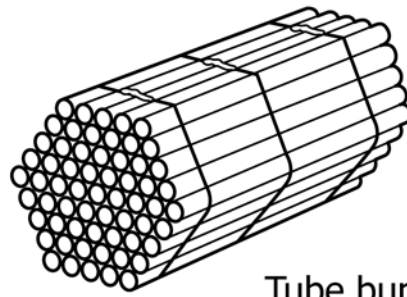
1.3 *Limitations*—This guide is not intended to give specific information as to how strapping must be used in any particular packaging or loading situation. Rather, it is intended to be informational in nature and is offered as a starting point for testing of strapping being considered by the user. Thorough user testing is essential, as is a review of pertinent regulations that can influence strap selection (size and type), and application methods.

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.

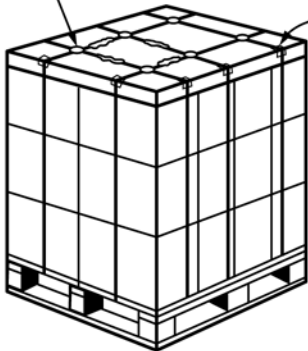
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Carton closure
Intersection or Cross tie seals (See Figure 18)

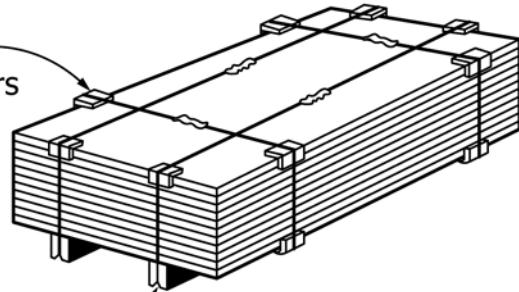


Tube bundle



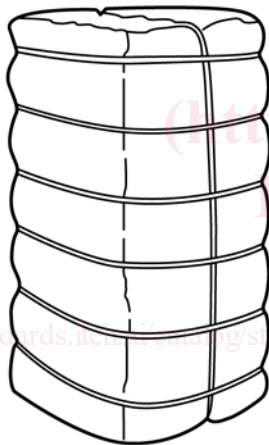
Palletized unit

Edge protectors



Runner with strap slot

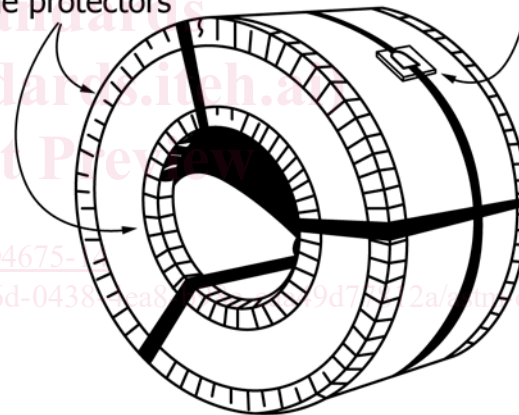
Unitized sheets



Textile fiber bale

Edge protectors

Seal protector



Metal coil

FIG. 1 Various Strapping Applications

1.4 The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI (metric) units.

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 and health practices and determine the applicability of regulatory limitations prior to use. Specific safety hazard guidelines, however, are provided in Section 5.*

2. Referenced Documents

- 2.1 *ASTM Standards*:²
D996 Terminology of Packaging and Distribution Environments

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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National Motor Freight Classification 100-L, Item 222, Section 7⁴
 ISTA, International Safe Transit Association, Pre-Shipment Test Procedure⁵
 Association of American Railroads (AAR/TTCI)—Closed Car Loading Methods and Open Top Loading Rules⁶
 IMO/ILO/UN ECE Guidelines for Packing or Cargo Transport Units (CTUs)⁷
 Driver's Handbook on Cargo Securement⁸

3. Terminology

3.1 *Definitions*—For general definitions of packaging and distribution environments. (See Terminology D996.)

3.2 *Definitions of Terms Specific to This Standard*: The following refers to the characteristics and properties of strapping materials. These can be objectively measured to some extent and are used to rank the relative effectiveness of different strapping materials in different applications. The definitions given here are for the purposes of this guide only and do not necessarily reflect general usage or ASTM standard definitions. Some properties are common to both steel and nonmetallic strapping. Other properties pertain to just nonmetallic strapping or to steel strapping only.

3.2.1 *break strength, n*—the longitudinal tensile force that is applied to cause a strap to rupture. (See Specifications D3950 and D3953.)

3.2.2 *chemical contamination, n*—exposure to chemicals which may degrade the strap's physical properties. (See Section 13).

3.2.3 *corner break strength, n*—the reduced break strength due to the strapping being bent around a corner or edge. (See Specification D3953.)

D3950 Specification for Strapping, Nonmetallic (and Joining Methods)

D3953 Specification for Strapping, Flat Steel and Seals

D4169 Practice for Performance Testing of Shipping Containers and Systems

2.2 Other Standards (most current revisions):

Uniform Freight Classification Code, Rule 41, Section 9³

⁴ Available from National Motor Freight Traffic Association (NMFTA), 1001 N. Fairfax St., Alexandria, VA 22314, <http://www.nmfta.org>.

⁵ Available from International Safe Transit Association (ISTA), 1400 Abbot Road, Suite 160, East Lansing, MI 48823-1900, <http://www.ista.org>.

⁶ Available from Association of American Railroads—Railing, Association of American Railroads—Railing Highwoods Center, 7001 Weston Parkway, Suite 200, Cary, NC 27513.

⁷ Available from International Maritime Organization, Publishing Service, 4 Albert Embankment, London, SE1 7SR, United Kingdom, <http://www.imo.org>.

⁸ Available from Driver's Handbook on Cargo Securement, 1200 New Jersey Avenue, SE, Suite W60-300, Washington, DC 20590, <http://www.fmcsa.dot.gov/documents/cargo/cargosecurement-16-04.pdf>.

³ Available from National Railroad Freight Classification, available from Uniform Classification Committee, 222 South Riverside Plaze, Chicago, IL 60606.

3.2.4 *dead stretch (creep)*, *n*—strain (elongation) resulting from constant tensional stresses over time.

3.2.5 *ductility in bending (resistance to “work hardening”)*, *n*—refers to the ability of steel strapping to deform without rupture under the tensile stress resulting from bending, or its resistance to work hardening; it is the opposite of “brittleness.” Ductility is related to corner break strength and closely related to strength and elongation. (See Specification **D3953**.)

3.2.6 *elongation at break*, *n*—the increase in strapping length (strain) when the tensional loading (stress) gets high enough to cause strap failure. (See Specifications **D3950** and **D3953**.)

3.2.7 *energy-to-break*, *n*—the energy/force (total area under the stress-strain curve), resulting from strength and elongation properties required to break a strap.

3.2.8 *environmental resistant properties*, *n*—the ability of steel or nonmetallic strapping to withstand degradation from (but not limited to) exposure to sunlight, low and high humidity, and caustic chemicals.

3.2.9 *initial applied tensions (IAT)*, *n*—highest amount of stress induced into the strap while the tensioning mechanism is still engaged.

3.2.10 *initial retained tension (IRT)*, *n*—the stress that remains in the strap immediately after completion of the joint and removal of the tensioning equipment.

3.2.11 *joint efficiencies*, *n*—joint strength divided by the minimum acceptable breaking strength of the strap, expressed as a percentage (For minimum acceptable percentage values, see Section **12**, Specifications **D3950** and **D3953**.)

3.2.12 *joint strength*, *n*—the highest longitudinal tension (strain) that must be applied to cause a strap joint to fail. A failure at the gripper marks (outside of the joint) made by the hand tool or strapping head, is not to be considered the strength of the joint.

3.2.13 *lubrication*, *n*—a substance on the strap surface that lowers the lower coefficient of friction.

3.2.14 *mechanism*, *n*—devices used in application of strapping, such as tensioner, sealer, combination tools, and power strapping equipment.

3.2.15 *moisture sensitivity*, *n*—the degree to which mechanical properties degrade due to the presence of moisture or moisture vapor. (See Section **13**.)

3.2.16 *notch sensitivity*, *n*—the measure of a strapping material’s ability to resist tearing or breaking due to a nick or cut.

3.2.17 *settling tolerance*, *n*—the ability of a strap to remain taut when used to confine a dimensionally shrinking load, unit, or package.

3.2.18 *shear plane*, *n*—the contact surface area between two items at which they move relative to one another when parallel and opposing forces are applied to these areas. The parallel application of forces causes the items to slide against one another.

3.2.19 *system strength*, *n*—the strength of an applied strap (closed loop) including both the strap and joining method.

3.2.20 *temperature sensitivity*, *n*—the degree to which the mechanical properties degrade due to extreme low or high temperatures.

3.2.21 *tension transmission*, *n*—the ability of strapping to slide around a corner/edge during tensioning.

3.2.22 *ultraviolet (U.V.) light resistance*, *n*—the degree to which the mechanical properties degrade due to ultraviolet ray exposure. U.V. inhibitors are available for all types of nonmetallic strapping.

3.2.23 *unit strap lifting method (USLM)*, *n*—a specialized application for overhead lifting and transport of large and heavy loads, units, or packages primarily at port facilities. (See **Table 4**.)

3.2.24 *yield point*, *n*—the stress at which a material begins to deform physically. Prior to the yield point, the material will deform elastically and will return to its original shape when the applied stress is removed. Once the yield point is passed, some fraction of the deformation will be permanent and non-reversible.

4. Significance and Use

4.1 This guide is intended to assist the user in selecting strapping material(s) and application method(s), for evaluation, when subjected to handling, transit, and storage tests. It describes general load, unit and package types, strapping properties, strapping performance, weight considerations, shear planes, component frictional characteristics, and geometry.

5. Safety Hazard Guidelines

5.1 Safety guidelines need to be followed to avoid personal injury or death. Examples of safety guidelines are shown below. Users should consider engaging an individual qualified by training to conduct a risk assessment on all strapping applications to determine best safety practices.

5.2 *Strap Cutting*—When straps are under tensional loading, the release of this tension will produce a hazard when the loose ends snap free after being intentionally or accidentally cut, frayed, or otherwise released. Contents under restraint or the snap itself, or both, may spring toward or fall upon the operator or a bystander when strap tension is suddenly released. *Cutting tensioned strap is hazardous*. Use caution and follow approved safety procedures. (See **Fig. 2**.)

5.2.1 Strap Cutting Techniques:

(1) Wear safety gloves and eye protection when working with steel or nonmetallic strapping.

(2) Keep a safe distance away from the danger zone. (See the Gray Area in **Fig. 2**.) Bystanders need to be in an area where they will not be struck by flying or flailing strap ends when the strapping is being cut. When tensioned straps that secure a load, unit, or package are cut, the contents could shift or fall.

(3) Never stand under a strapped load, unit, or package, except as necessary to cut a strap. Never stand directly in front of a load, unit, or package secured by a strap being cut.

TABLE 4 Strapping Applications Commonly Used for Packaging, Unitization, and Load Securement

NOTE 1—For guidance purposes only. The strapping types and sizes indicated for specific applications are typical. The table is not intended to recommend or specify.

		ASTM D3953 Standard Specification for Strapping Flat Steel and Seals				ASTM D3950 Standard Specification for Strapping Nonmetallic (and Joining Methods)				
Industry	Product	Hand or Machine Applied		Hand Applied		Hand or Machine Applied		Hand or Machine Applied		
		Type I Steel Regular Duty	Type I Steel Heavy Duty	Type I Steel High Strength	Type I Steel Regular Duty	Type I Steel Heavy Duty	Type I Steel High Strength	Type II Polypropylene	Type III Nylon	Type IV Polyester
General	Appliances	3/8" & 1/2"						7/16"	7/16"	5/8"
	Carton Closure Flat Glass		5/8" & 3/4"	5/8" & 3/4"	3/16", 1/4", & 3/8"	7/16"	1/4" & 3/8"	3/8"	5/8" & 3/4"	5/8" & 3/4"
	PVC Pipe	3/4"	5/8" & 3/4"	5/8" & 3/4"		7/16"	7/16"	7/16"	1/2", 5/8" & 3/4"	5/8"
Agriculture	Food Products in Wood Bins									
	Hay Baling									
	Cotton		3/4"	3/4"				1/2"		1/2"
	Tobacco		1/2", 5/8" & 3/4"	1/2", 5/8" & 3/4"				1/2"		5/8" & 3/4"
Beverage	Fibers (Manmade & Natural)	5/8" & 3/4"	5/8" & 3/4"	5/8" & 3/4"						5/8" & 3/4"
	PET Bottles									
Corrugated	Cans									
	Glass Bottles									
Corrugated Bundles	KD Boxes	3/8"						7/16"	7/16"	7/16"
	Corrugated Sheet Bundles	3/8", 5/8" & 3/4"						7/16"	7/16" & 1/2"	7/16"
Graphic Arts	Signature Logs									
	Magazines									
Masonry	Newspapers									
	Palletized Printed Loads		1/2" & 5/8"	1/2" & 5/8"				7/16" & 1/2"	5 mm, 3/16" & 1/4"	7/16" & 1/2"
Forest Products	Brick		1/2"	1/2"						
	Block/Pavers		1/2" & 5/8"	1/2" & 5/8"						
Lumber	Roof Tiles		5/8" & 3/4"	5/8" & 3/4"				7/16"		5/8" & 3/4"
	Lumber	5/8" & 3/4"	1/2", 5/8" & 3/4"	1/2", 5/8" & 3/4"						5/8" & 3/4"
Lumber	Hardwoods	3/4"	3/4"	3/4"						3/4" & 1"
	Hardboard Siding	5/8" & 3/4"	5/8" & 3/4"	5/8" & 3/4"						5/8"
Lumber	Pressure Treated Lumber	5/8" & 3/4"	5/8" & 3/4"	5/8" & 3/4"						5/8"
	Landscape Timbers	3/4"	3/4"	3/4"						5/8"

TABLE 4 Continued

Panel Products	Flakeboard, MDF, OSB< Particle-board & Plywood	5/8"	5/8" & 3/4"	5/8" & 3/4"	5/8" & 3/4"
Engineered Wood Products	I-Joists, LVL, PSL & LSL	3/4" & 1 1/4"	5/8", 3/4", 1" & 1 1/4"	5/8", 3/4", 1" & 1 1/4"	5/8" & 3/4"
Paper	Paper Rolls Copy Paper in Cartons	3/8" & 1/2"	3/4" & 1 1/4"	3/16", 1/4" & 3/8"	3/8"
	Aluminum Ingots		3/4" & 1 1/4"		5/8", 3/4", 1" & 1 1/4"
	Aluminum Billets		3/4"		1 1/4"
	Aluminum Extrusions		5/8" & 3/4"	1/2", 5/8" & 3/4"	3/4", 1" & 1 1/4"
	Scrap Aluminum		5/8" & 3/4"	5/8", 3/4" & 1"	5/8" & 3/4"
	Aluminum Rod		3/4" & 1 1/4"	3/4", 1" & 1 1/4"	3/4" & 1"
	Coiled Cooper Rod		1 1/4"		5/8" & 3/4"
	Steel Wire		1 1/4"	3/4", 1" & 1 1/4"	3/4" & 3/4"
	Steel Structural Shapes		3/4" & 1 1/4"	5/8", 3/4", 1", & 1 1/4"	3/4" & 1"
	Cut-to-Length Flat Sheet Stock		5/8", 3/4" & 1 1/4"	5/8", 3/4", 1" & 1 1/4"	5/8", 3/4", 1" & 1 1/4"
	Steel Tubing		5/8", 3/4" & 1 1/4"	5/8", 3/4", 1" & 1 1/4"	3/4" & 1"
Load Securement	Steel Coils	1/2", 5/8" & 3/4"	5/8", 3/4" & 1 1/4"	3/4", 1" & 1 1/4"	5/8", 3/4" & 1"
	Truck & Railcar Unitization		3/4" & 1 3/4"	3/4", 1" & 1 1/4"	
	Truck Tie Down Railcar Doorway Protection		1 1/4"	1 1/4" & 1 1/2"	
	Open Top Railcar Tie Down		3/4", 1 1/4" & 2"		
	Unit Strap Lifting Method		1 1/4" USLM		