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Standard Guide for Selection and Use of Flat Strapping Materials¹

This standard is issued under the fixed designation D4675; 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.

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

^{e1} NOTE—The layout of Table 2 was adjusted editorially in November 2010.

INTRODUCTION

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

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 materials is best suited for the application. Contact your supplier for further information.

It is recognized that there are other materials (not covered) that may also offer acceptable solutions or may be used in conjunction with flat strapping. Also, examples of ancillary materials are shown in Fig. 1.

Strapping may be recyclable. Contact your supplier for further information.

1. Scope

1.1 This guide covers information on flat strapping materials (steel or nonmetallic) for the prospective user wanting initial guidance in selecting a strapping material and applied configuration for use in packaging (closing, reinforcing, baling, unitizing, or palletizing) and loading (load unitization and securement to transport vehicle) applications. 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 a type of strap, the minimum size or strength, or both, and type of joint or seal, or both, that must be used for certain 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. The need for thorough user testing is to be emphasized

as is a review of pertinent regulations that can influence the selection of sizes, types, and possibly, application methods.

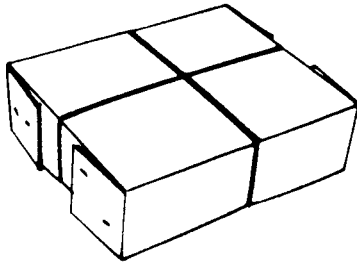
1.4 The sections in this guide appear in the following order:

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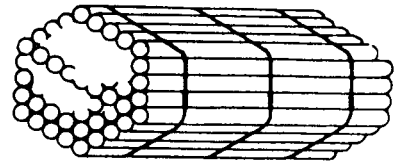
1.5 The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.

¹ 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.

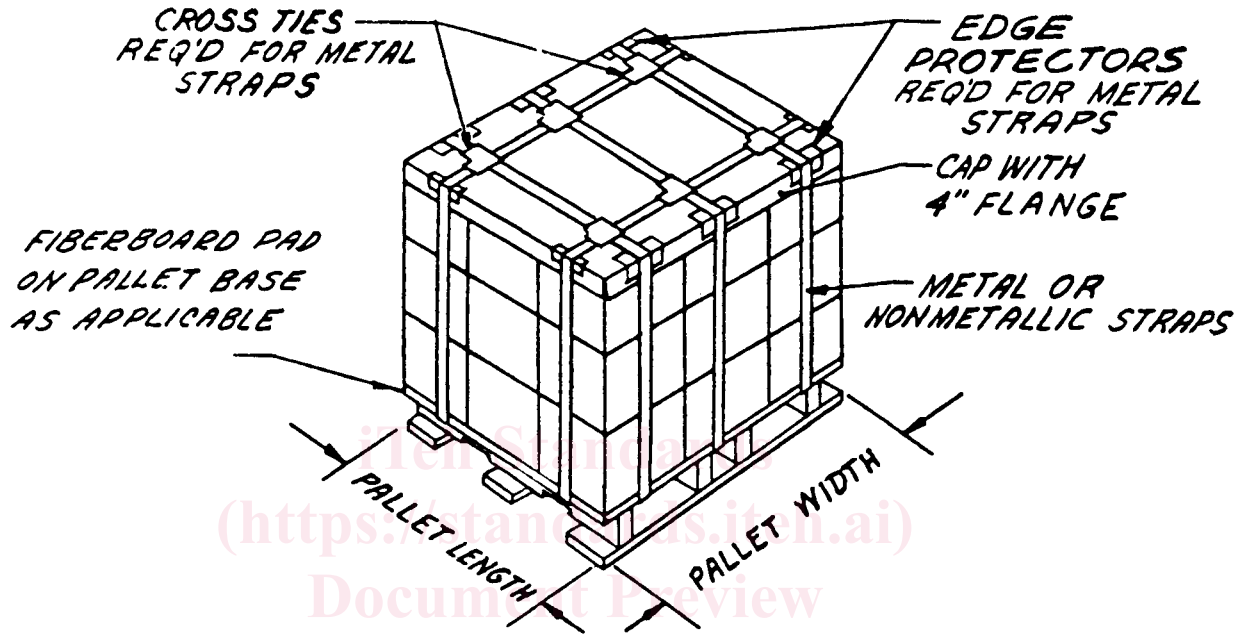
Current edition approved March 1, 2009. Published March 2009. Originally approved in 1987. Last previous edition approved in 2006 as D4675 – 06 ^{e2}. DOI: 10.1520/D4675-09E01.



(a) Fiberboard Box Closure

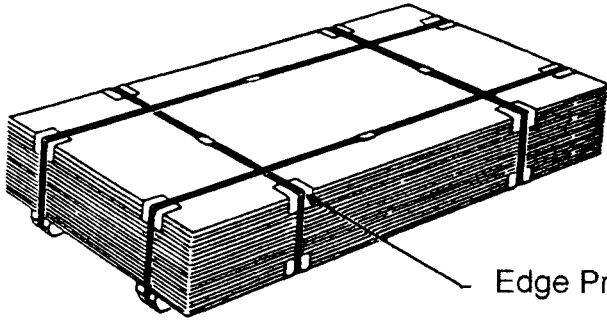


(b) Bundles of Tubing

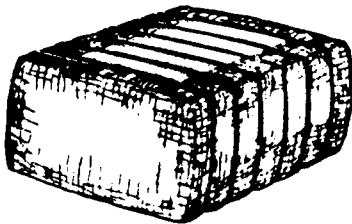


LOAD WITH CAP AND STRAPPING.

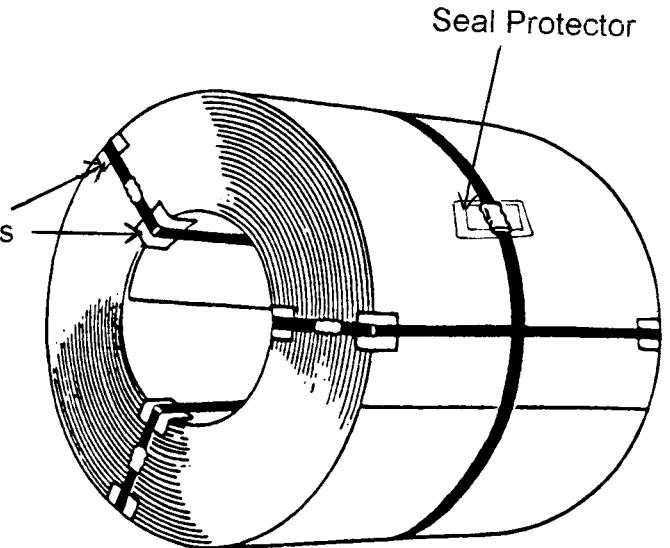
(c) Pallet



(d) Unitized Sheets



(e) Bales of Textile Fiber



(f) Coils

FIG. 1 Applications for Steel and Nonmetallic Strapping

1.6 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 statements are given in Section 5 and Note 13.1 and 15.3.

2. Referenced Documents

2.1 ASTM Standards:²

D996 Terminology of Packaging and Distribution Environments

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:

Uniform Freight Classification Code, Rule 41, Section 9³
National Motor Freight Classification 100-L, Item 222, Section 7⁴

ISTA, International Safe Transit Association, Pre-shipment Test Procedures⁵

Association of American Railroads— Railing⁶

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:*

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

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.

3.2.1 The following refer 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 are peculiar to nonmetallic only, or to steel only.

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

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

3.2.4 *dead stretch (creep), n*—permanent deformation, resulting from the application of tension over time.

3.2.5 *ductility in bending (resistance to “work hardening”), n*—ductility is the opposite of “brittleness”. This quality is related to corner break strength and closely allied with strength and elongation in determining impact resistance. It is also important in tensioning applications requiring the strap to be bent double, and in loop joint applications. (Specification **D3953** contains test procedures and specifications.)

3.2.6 *elongation at break, n*—the increase in strapping length due to tensile load at the time of break. (See Specifications **D3950** and **D3953**.)

3.2.7 *energy to break, n*—the maximum force required to break a strap as measured by the area under the stress-strain curve.

3.2.8 *environmental resistant properties* (see **Table 1**):

3.2.9 *atmospheric contamination, n*—the presence of chemicals in the atmosphere which degrades strap properties. (See Section 14.)

3.2.10 *mechanism, n*—includes application, tool, tooling, tensioner, sealer, and power strap equipment.

3.2.11 *moisture sensitivity, n*—the degradation of properties caused by presence of moisture or moisture vapor.

3.2.12 *temperature sensitivity, n*—the deterioration of properties caused by high or low temperatures.

TABLE 1 Strapping Preference as a Function of Handling Severity of Elements

Type	Specification D3953			Specification D3950				
	Regular-Duty Steel	Regular-Duty High Strength Steel	Heavy-Duty Steel	Bonded Rayon Cord	Bonded or Woven Polyester Cord	Polypropylene Plastic	Nylon Plastic	Polyester Plastic
Ultraviolet ^A	x	x	x	...	x	...	...	...
Moisture	x	x	x	...	x	x	...	x
Elevated temperatures	x	x	x	x	x	...	x	x
Low temperatures	x	x	x	x	x	...	x	x
Exposure to corrosives	...	...	...	x	x	x	x	x
Concern for damage to unit surface	...	...	...	x	x	x	x	x

^A UV inhibitors are available for polypropylene, nylon, and polyester plastics.

3.2.13 *ultraviolet light sensitivity, n*—the degradation of strapping caused by ultraviolet rays from sunlight or electric lamps.

3.2.14 *joint efficiencies, n*—joint strength divided by the minimum acceptable breaking strength of the strap, expressed as a percentage. (See Specifications **D3950** and **D3953** for minimum acceptable percentage values.)

3.2.15 *joint strength, n*—the highest longitudinal tensile force that must be applied to cause a strap joint to fail.

3.2.16 *notch sensitivity, n*—a measure of the ability of a strapping material to resist “nick or cut” propagation.

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

3.2.18 *shear plane, n*—a shear plane is the surface area between two contiguous items that will allow the items to slide relative to each other when a force is applied.

3.2.19 *tension transmission, n*—the ability of strapping to transmit tension around an edge.

3.2.20 *yield point, n*—when a strap is subjected to load beyond its elastic limit, the point at which a strap reaches permanent deformation or continues to deform without an increase in load.

4. Significance and Use

4.1 This guide assists the user in selecting a strapping material and configuration for initial handling, transit, and storage tests. It describes general unit (load) types, strapping properties, unit-strapping interaction, weight considerations, unit shear planes, component frictional characteristics, and unit geometry.

5. Safety Hazards

5.1 *Cutting Strap*—All working strapping is under tension when in use. Sudden 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 strap itself, or both, may spring toward operator when strap tension is suddenly released. *Cutting tensioned strap is hazardous.* Use caution and follow approved safety procedures.

5.1.1 When cutting a tensioned strap, always stand to one side of the strap being cut, pressing the strap against the package above the cutter.

5.2 Excessive tensioning may cause strap breakage. Always position yourself to one side of strap being tensioned. Never stand directly over or in front of a strap being tensioned.

5.3 Never operate the tool in such a manner that a hand could slip resulting in a loss of balance.

5.4 *Reuse*—Since mechanical properties of strapping may be altered by tensioning or during physical distribution cycles, the reuse of strapping is discouraged.

5.5 *Altering or Improper Use of Tensioners*—Do not extend length of handle on manual tensioner, nor exceed the manufacturer’s recommended maximum air pressure on pneumatic tensioners to gain increased strap tension. To do so could result

in sudden strap failure or breakage of tensioner with potential severe injury to the operator.

5.6 *Improper Use*—Strapping should be used only as intended.

5.6.1 *Punching or Nailing*—Never punch strapping with nails, staples, or other sharp objects. This may cause premature strap failure. Also, attempting to nail through steel strapping may present a hazard especially when power nailing or stapling. Type 2 steel strapping has pre-punched holes intended for nail-on applications.

5.6.2 *Pulling or Dragging*—Never use strapping as a means of pulling or dragging any packages or unit.

5.6.3 *Lifting*—Never use strapping as a means of lifting unless applied using the Unit Strap Lifting Method (USLM) system.

5.7 *Unit Strap Lifting Method (USLM) Hazards*—USLM is a specialized application of USLM steel strapping for overhead lifting and transport of large, heavy packages. Before considering a USLM application consult a USLM system vendor and transportation or port regulatory authorities for rules and considerations in application. Note the following warnings:

5.7.1 *Compliance and Training*—Compliance with all safety aspects of USLM application is critical to protect personnel. Always train all users before using the USLM or handling USLM loads.

5.7.2 *Specified Strapping and Seals*—Always use correctly marked USLM steel strapping and seals (see Specification **D3953**). Strapping and seals must be applied so that markings are visible.

5.7.3 *Lifting Capacity*—Consult transport or port regulations and your USLM system supplier to determine the lifting capacity of strapping. Do not exceed the calculated lifting capacity.

5.7.4 *Damaged or Used Straps or Seals*—Never use damaged or used USLM strap or seals.

5.7.5 *Stand Clear*—Before lifting, be sure all personnel are away from the unit load. Never stand underneath or near a load being lifted.

5.7.6 *System Audit*—USLM systems require periodic performance audit. Consult your USLM system vendor.

GENERAL CONSIDERATIONS

6. General Properties of Strap Types (See Table 2, Table 3, and Table 4)

6.1 *Steel Strapping*—This product is described in Specification **D3953** and is generally classified into regular-duty, regular-duty high strength and heavy-duty strapping. Of all the types of strapping, steel strapping has the highest tensile strength (break strength for a given cross-sectional area) and resistance to tension decay or creep. It is better suited to expanding or rigid units than it is to units that settle because it has a low settling tolerance. Regular-duty high strength strap is suggested for applications where high strength alone is the overriding consideration. Heavy-duty and USLM steel strapping are suggested for applications where both break strength and elongation are overriding considerations. Heavy-duty steel strapping is also suggested for high-temperature applications.

TABLE 2 Strapping Applications Commonly Used for Packaging, Unitization, and Load Securement

		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			
		Type I Steel Regular Duty High Strength	Type I Steel Heavy Duty	Type IA Bonded, Woven or Composite Polyester Cord	Type I Bonded Rayon Cord	Type II Polypropylene (Plastic)	Type III Nylon (Plastic)	Type IV Polyester (Plastic)	
General	Appliances	3/8" & 1/2"				7/16"	7/16"	5/8"	
	Carton Closure				3/16", 1/4" & 3/8"	1/4" & 3/8"	3/8"		
	Flat Glass		5/8" & 3/4"	5/8" & 3/4"				5/8" & 3/4"	
Agriculture	PVC Pipe	3/4"	5/8" & 3/4"	1/2" to 3/4"		7/16"	7/16"	1/2", 5/8" & 3/4"	
	Food Products in Wood Blins		3/4"	5/8" & 3/4"				5/8"	
	Hay Baling					1/2"		1/2"	
	Cotton		3/4"						3/4"
	Tobacco					1/2"			
	Fibers (Manmade & Natural)	5/8" & 3/4"	1/2", 5/8" & 3/4"					5/8" & 3/4"	
Beverage	PET Bottles						3/8"	3/8"	
	Cans								7/16" & 1/2"
Corrugated	Glass Bottles								7/16" & 1/2"
	KD Boxes	3/8"				7/16"		7/16"	
	Corrugated Sheet Load	3/8", 5/8" & 3/4"				7/16"		7/16"	
Graphic Arts	Signature Logs					7/16" & 1/2"		7/16" & 1/2"	
	Magazines					5mm, 3/16" & 1/4"			
	Newspapers					5mm, 3/16" & 1/4"			
	Palletized Printed Loads		1/2" & 5/8"	1/2" & 5/8"				7/16", 1/2" & 5/8"	
Masonry	Brick		1/2"					5/8"	
	Block/Pavers		1/2" & 5/8"					5/8" & 3/4"	
	Roof Tiles					7/16"			

TABLE 2 Strapping Applications Commonly Used for Packaging, Unitization, and Load Securement (continued)

		ASTM D3953 Standard Specification for Strapping Flat Steel and Seals				ASTM D3950 Standard Specification for Strapping Nonmetallic (and Joining Methods)			
		Hand or Machine Applied		Hand Applied		Hand or Machine Applied			
Industry	Product	Type I Steel Regular Duty	Type I Steel Regular Duty High Strength	Type I Steel Heavy Duty	Type IA Bonded, Woven or Composite Polyester Cord	Type I Bonded Rayon Cord	Type II Polypropylene (Plastic)	Type III Nylon (Plastic)	Type IV Polyester (Plastic)
Forest Products	Lumber	5/8" & 3/4"	1/2", 5/8" & 3/4"	5/8" & 3/4"	5/8", 3/4", 1" & 1-1/4"				5/8" & 3/4"
	Hardwoods	3/4"		3/4"	5/8" & 3/4"				3/4" & 1"
	Hardboard Siding	5/8" & 3/4"		5/8" & 3/4"	5/8" & 3/4"				5/8"
	Pressure Treated Lumber	5/8" & 3/4"	5/8" & 3/4"	5/8" & 3/4"	5/8" & 3/4"				5/8"
Panel Products	Landscape Timbers	3/4"		3/4"	5/8", 3/4" & 1"				5/8"
	Flakeboard, MDF, OSB, Particleboard & Plywood		5/8"	5/8"	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"
	Paper Rolls	3/8" & 1/2"							7/16"
Paper	Copy Paper in Cartons			3/4" & 1-1/4"		3/16", 1/4" & 3/8"	1/4" & 3/8"	3/8"	5/8", 3/4", 1" & 1-1/4"
	Aluminum Ingots			3/4"					3/4", 1" & 1-1/4"
	Aluminum Billets			5/8" & 3/4"	1/2", 5/8" & 3/4"				5/8"
	Aluminum Extrusions			5/8" & 3/4"	5/8" & 3/4"				5/8" & 3/4"
	Scrap Aluminum			3/4" & 1-1/4"	5/8", 3/4" & 1"				3/4" & 1"
	Aluminum Rod			1-1/4"	3/4", 1" & 1-1/4"				3/4" & 1"
	Coiled Copper Rod			1-1/4"	3/4", 1" & 1-1/4"				5/8" & 3/4"
	Steel Wire			1-1/4"	5/8", 3/4", 1" & 1-1/4"				3/4" & 1"
	Steel			3/4" & 1-1/4"	5/8", 3/4", 1" & 1-1/4"				5/8", 3/4", 1" & 1-1/4"
	Structural Shapes			5/8", 3/4" & 1-1/4"	5/8", 3/4", 1" & 1-1/4"				3/4" & 1"
Metals	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" & 1-1/4"	3/4", 1" & 1-1/4"				
	Truck Tie Down			1-1/4"					
	Railcar Doorway Protection			3/4" & 1-1/4"	1-1/4" & 1-1/2"				
Unit Strap Lifting Method	Open Top Railcar Tie Down			3/4", 1-1/4" & 2"					
	Unit Strap Lifting Method			1-1/4" USLM					