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PACKAGING OF MATERIEL

PACKING

DEPARTMENTS OF THE ARMY, THE NAVY, THE AIR FORCE,
AND THE DEFENSE LOGISTICS AGENCY

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**DEPARTMENTS OF THE ARMY,
NAVY, AND AIR FORCE, AND THE
DEFENSE LOGISTICS AGENCY**

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CHAPTER **PAGE**

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CHAPTER 2 - FIBERBOARD AND PAPERBOARD CONTAINERS

CHAPTER 3 - WOODEN CANTAINERS AND PALLETS

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INTRODUCTION

PURPOSE AND SCOPE

PURPOSE

This publication contains information on the fundamental principles and approved methods and techniques used in the protection of military supplies and equipment against deterioration and damage during shipment and storage. It is published as an official document for use in operations and in the training of military and civilian personnel from all segments of the Department of Defense (DOD) and supporting agencies, as well as for interested industrial personnel. It contains information based on specifications, standards, and other pertinent documents, current as of the date of preparation and coordination of the publication.

NOTE

For Air Force use, the publication is non-directive in nature.

SCOPE

This manual emphasizes the importance of packing of military supplies and equipment. It contains detailed information concerning the requirements to accomplish packing operations. The requirements include use of exterior shipping containers; the assembling of items or packs into the container; anchoring, blocking, bracing, and cushioning of items or packages within the container; weatherproofing; strapping of containers; the testing of exterior packs; palletization and unitization of loads; parcel post; and related subject matter. General exterior marking in accordance with MIL-STD-129 is discussed.

CHANGES AND PROVISIONS

Changes or revisions to this manual are due to major changes in packing concepts, policies and doctrine, and revision of specifications and other official publications, will be made on a continuing basis, as required. Information contained herein is current as of June 1996.

Users are encouraged to submit recommended changes or comments to improve this manual. Comments should be keyed to the specific page, paragraph, and line of the text in which the change is recommended. Reasons should be provided for each comment to insure understanding and complete evaluation. Comments should be prepared using DA Form 2028 (Recommended Changes to Publications and Blank Forms) or appropriate service form and forwarded direct to Dean, U.S. Army Ordnance School of Military Packaging Technology, ATTN: ATSL-MPT, 360 Lanyard Road, Aberdeen Proving Ground, MD 21005-5003.

OBJECTIVES OF MILITARY PACKAGING

The objectives for achieving uniform packing of items of military supply are to--

- Insure optimum life, utility and performance of materiel through prevention of deterioration or damage.
- Support the materiel readiness posture of DOD.

- Provide for efficient receipt, storage, inventory, transfer and issue of materiel.
- Assure that marking requirements are kept at the minimum necessary for effective identification, handling, shipment and storage.
- Effect economies by requiring the use of packs which yield lowest overall cost to the total DOD distribution system consistent with known or anticipated shipment handling and storage conditions. Considerations will include--

    - o Minimization of materials, methods of preservation, and documentation.
    - o Accomplishment with optimum amount of automated operations.
    - o Minimum weight and cube.
    - o Use of modular containers.
    - o Handling by unitized load configuration.
    - o Use of containerization.
    - o Exploitation of new materials, methods, and techniques.
    - o Disposability of packaging materials.

HAZARDS ENCOUNTERED IN TRANSPORTATION, HANDLING, AND STORAGE

Military supplies and equipment must be protected against pilferage and damage due to force and exposure, not only until they reach their ultimate destination, but until the items are placed into actual use or service. Force and exposure will reduce the useful lifespan of the item or cause the item to be damaged beyond repair. The objective of packing is to extend the lifespan of the item so that depreciation starts, not when it leaves the manufacturing plant, but when it is placed into service.

Force

Damage may result from hazardous forces encountered in transportation, handling, and storage (figure 1). Transportation hazards involve forces encountered through rail, truck, boat, or air shipments. The damage caused can result from abrupt starts, stops, vibration, and jolting.

Handling hazards involve those damaging forces received through loading, unloading, and handling during storage operations. Examples of handling where damage often occurs are--

- Manual handling--dropping and puncture.
- Forklift truck handhng--dropping and puncture.
- Cargo nets--dropping, crushing, and wracking.
- Grab hooks--crushing and puncture.
- Slings--crushing, dropping, and wracking.
- Conveyers--jarring, smashing, and dropping.

Storage hazards involve those forces resulting from the crushing effect of superimposed loads through stacking.

Exposure

Exposure to the different climatic conditions and weather hazards, such as high humidity, rain, salt spray, extreme cold, dry intense heat, and the cycling of these weather conditions, will tend to accelerate the breakdown or deterioration of unprotected items.

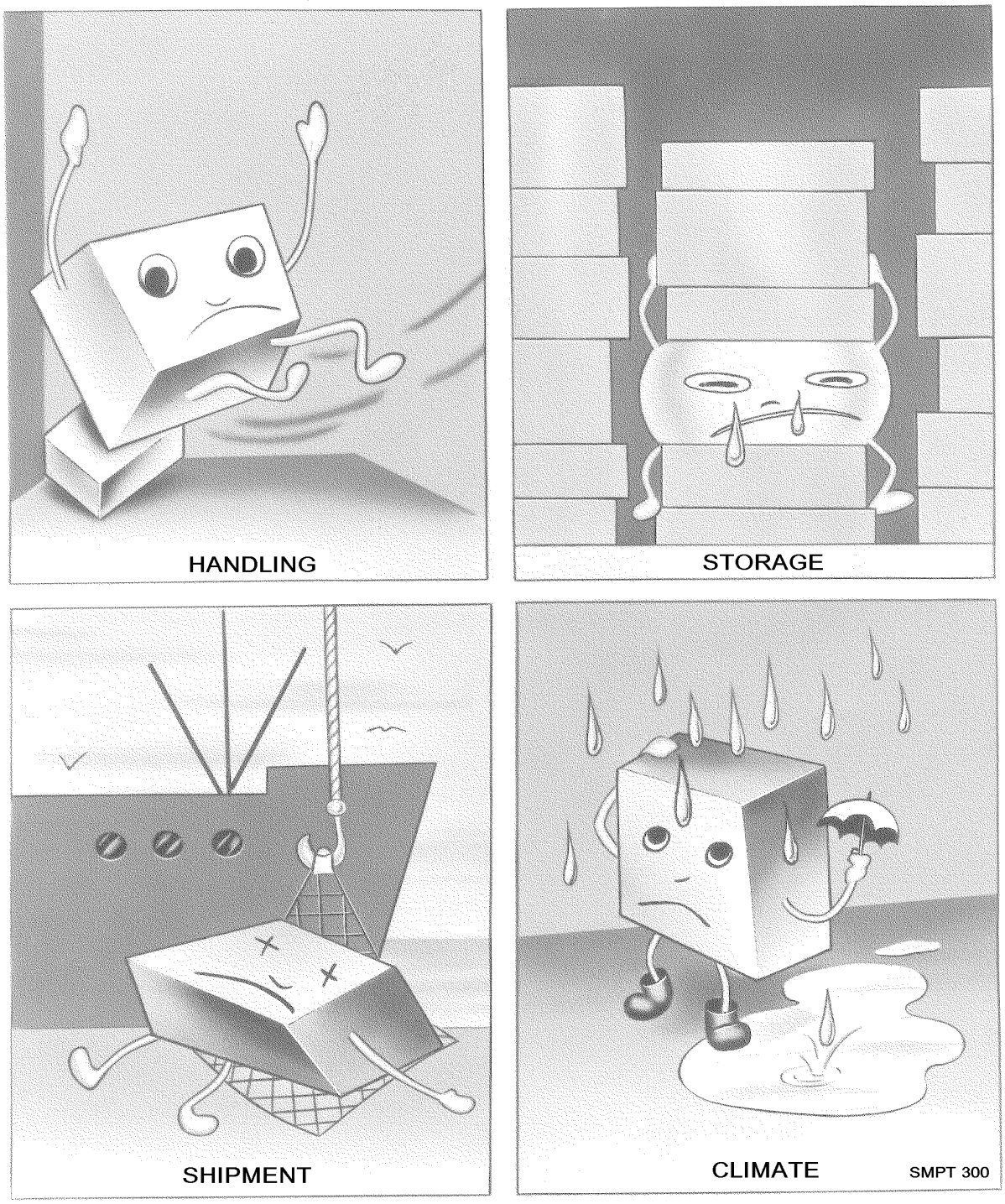


Figure 1. Hazardous forces encountered in transportation handling, and storage.

Pilferage

Theft of military supplies and equipment while in transit or storage is a significant problem for the military. Small items of high value are especially vulnerable to pilferage and should be protected as much as possible through packing techniques.

Countermeasures To Hazards Of Pack

Items which are packed properly will resist the damaging effects of force and exposure. Force is counteracted by--

- Using rigid shipping containers.
- Immobilizing the item within the container through anchoring, blocking, and bracing.
- Damping forces through the use of cushioning materials and devices.
- Reinforcing shipping containers with metal and nonmetallic strapping or reinforcement tape as appropriate.

Exposure is counteracted by the use of--

- Weather-resistant shipping containers.
- Waterproof barrier materials in various applications.

NECESSITY FOR A PACKAGING POLICY

To attain economy, efficiency, and uniformity in packing, and to provide a uniform procedure in connection with procurement, the services and agencies of the Department of Defense must have a common packing policy. This is provided by the Department of Defense (DOD) 4140.1-R, Materiel Management Regulation.

MILITARY REGULATIONS

The Joint Regulation AR 700-15/NAVSUPINST 4030.28C/AFJMAN 24-204/ MCO 4030.33D/DLAD4145.7, applies to all Department of Defense components (Army, Air Force, Navy, Marine Corps, and the Defense Logistics Agency) responsible for packaging an item throughout its life cycle.

This regulation on the packaging of materiel implements DOD 4140. 1-R and covers packaging requirements, American Society for Testing and Materials Standards (ASTM) specifications, levels of protection along with policies and procedures for Performance Oriented Packaging (POP) and the protection of electrostatic discharge sensitive items.

MILITARY PACKAGING LEVELS OF PROTECTION

Concept of Military Levels of Protection

In regard to requirements for packing, the military services for many years relied heavily on the terms "domestic" and "overseas". Experience proved that for military purposes, these words were vague generalities with no clear-cut meaning to them. Suppliers were often perplexed when confronted with overseas requirements for items destined for domestic installations. It was not apparent to them that the domestic destinations were merely initial receiving points for projected overseas shipments, or that storage and handling conditions were severe enough to justify an overseas type of packing regardless of destination. To permit the military services to state their requirements more objectively, the concept of levels of protection was adopted. As defined in MIL-STD-2073-1C, levels of protection are a means of specifying the level of military preservation and packing that a given item requires to assure that it is not degraded during shipment and storage (see figure 2). Specific levels of protection are as follows:

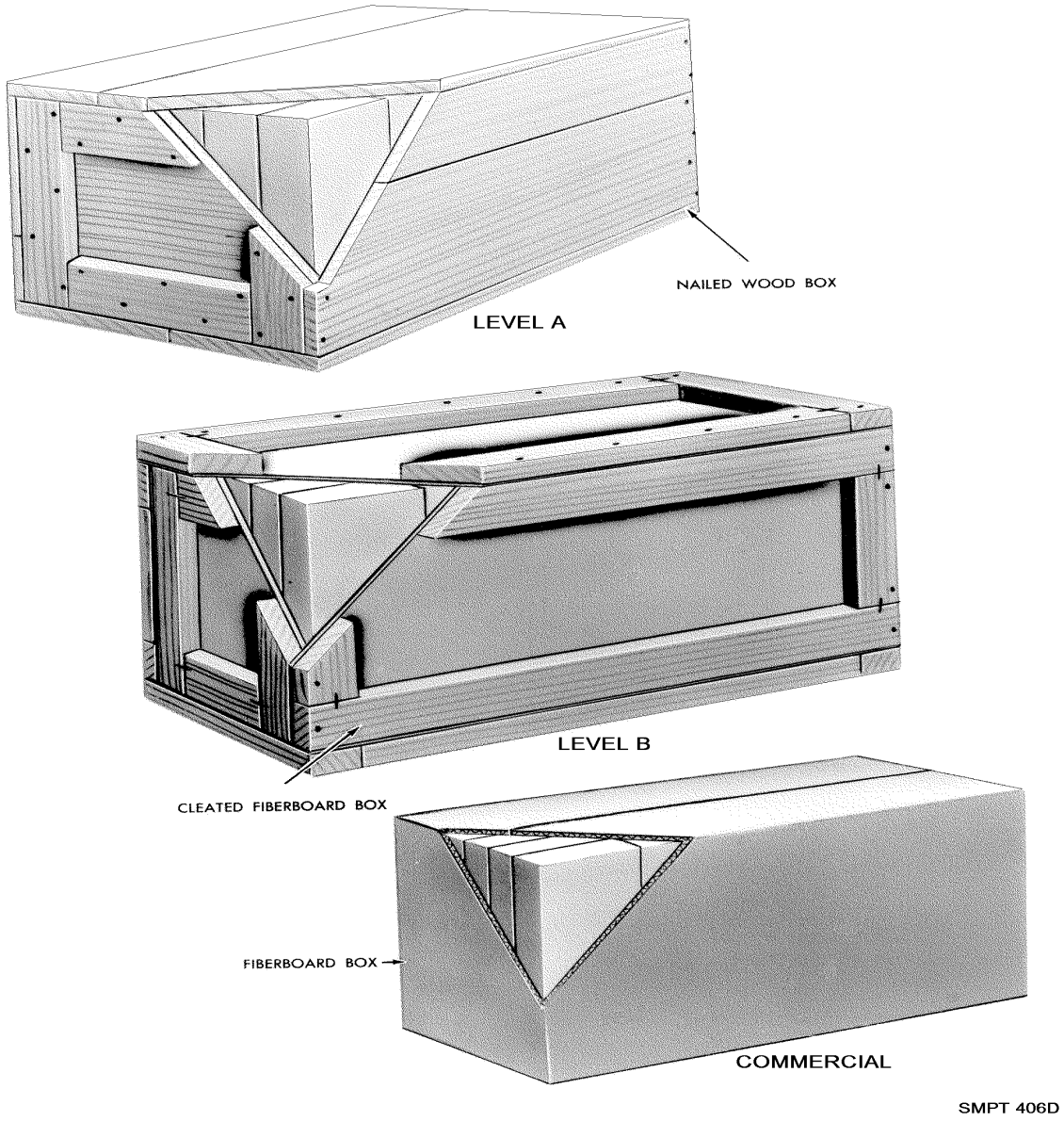


Figure 2. Examples of protection.

- **Military level of preservation.** Preservation designed to protect an item during shipment, handling, indeterminate storage, and distribution to consignees worldwide.
- **Military levels of packing.**

  - **Level** A. Protection required to meet the most severe worldwide shipment, handling, and storage conditions. Level A pack must, in tandem with the applied preservation, be capable of protecting material from the effects of direct exposure to extremes of climate, terrain, operational and transportation environments. Examples of situations which indicate a need for use of a Level A pack are: War Reserve Material, mobilization, strategic and theater deployment and employment, open storage, and deck loading. Examples of containers used for Level A packing

requirements include, but are not limited to, overseas type wood boxes and plastic and metal reusable containers.

- **Level** B. Protection required to meet moderate worldwide shipment, handling, and storage conditions. Level B pack must, in tandem with the applied preservation, be capable of protecting material not directly exposed to extremes of climate, terrain, and operational transportation environments. Examples of situations which indicate a need for use of a Level B pack are: security assistance (e.g., Foreign Military Sales (FMS)) and containerized overseas shipments. Examples of containers used for Level B packing requirements include, but are not limited to, domestic wood crates, weather-resistant fiberboard containers, fast pack containers, weather-resistant fiber drums, and weather-resistant paper and multi-wall shipping sacks.

Commercial Packaging. Commercial packaging is defined as the materials and methods used by the supplier to meet the requirements of the distribution systems serving both DOD and commercial consumers. The requirements of MIL-STD-2073-1C shall only be applied to the packaging of items that are expected to enter the military distribution system. Commercial packaging is to be used to the maximum extent possible for all other items. Items not going into stock shall be packaged in accordance with ASTM D 3951, Standard Practice for Commercial Packaging.

Commercial packaging will be acceptable for any level of protection when the technical design of the package meets all conditions of the level of protection specified. It will be marked to the level it meets. Use of commercial packaging is contingent upon no increase in packaging changes, size, weight, or delay in delivery.

Bulk practices used in interplant and intraplant movements or shipments to jobbers are not acceptable unless they are the usual trade practices for individual commodities such as coal, textiles. petroleum, and subsistence.

The packaging details will be incorporated into standardization and acquisition documents when applicable.

NATO STANAG 4280, LEVELS OF REQUIREMENTS FOR PACKAGING

Participating nations agree to adopt the NATO levels of requirements - defined in this STANAG as the basis for negotiation for the procurement of packaged materiel between nations. In defining levels of requirements it is necessary to take into account: The characteristics of the environment and constraints imposed by the environment; the technical considerations to define package tests; the four levels of packaging used in NATO; and, it also shows comparison of these NATO levels against the nearest national packaging requirement.

Type of Load. The term "type of load" refers to the physical characteristics of the item, including the nature of the item as it contributes to the support of, or damage to the container. The same kind of container can be designed to provide adequate protection to various items by adjusting the constructional requirements. This may result in a light, medium, or heavyduty container, as necessary. The design of the shipping container to be used is influenced by the type of load. There are three types of loads: Type 1, Type 2 and Type 3. The types of loads will be mentioned under the various shipping containers and in section I (figure 3).

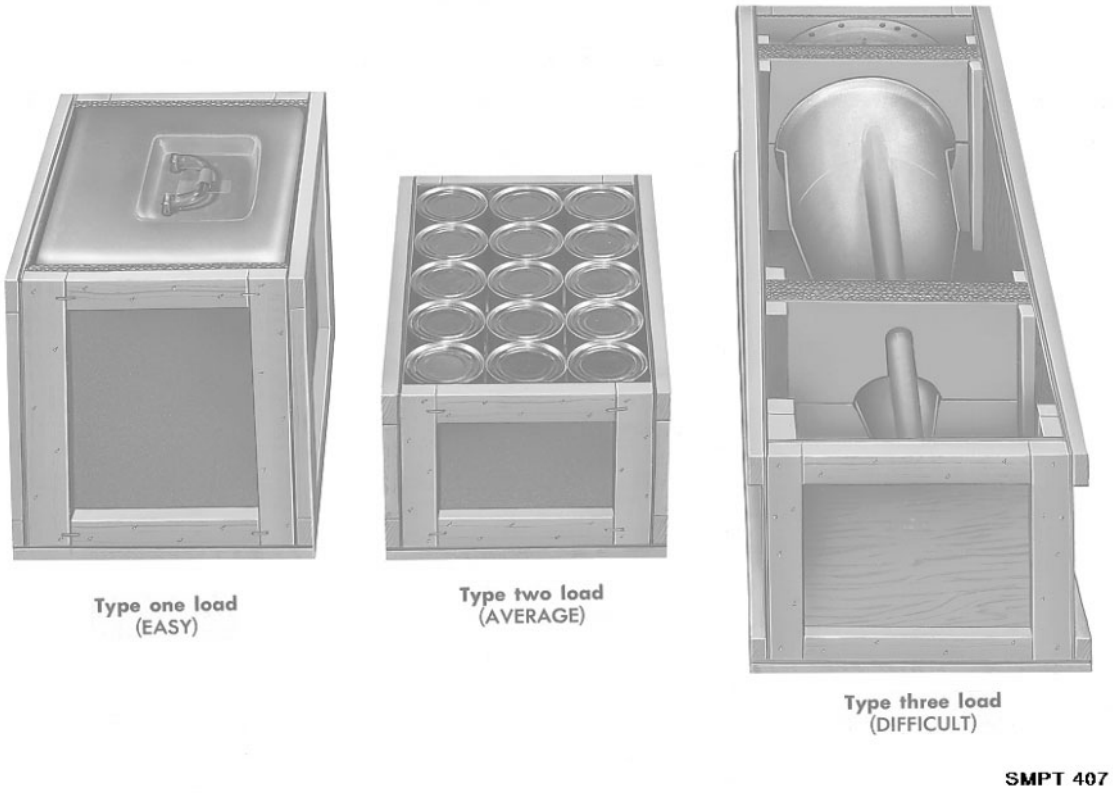


Figure 3. Types of loads

Type 1 - easy load. The load is a single item or single interior container which provides complete and uniform support to all faces of the shipping container. Bulk practices used in interplant and intraplant movements or shipments to jobbers are not acceptable unless they are the usual trade practices for individual commodities such as coal, textiles, petroleum, and subsistence.

Type 2 - average load. The load is composed of more than one item or interior container which give some support to all faces of the shipping container. The contents are of moderate density and relatively sturdy. Some examples are goods in metal cans which are not packed in an interior container, bottles individually cushioned, and hardware in cartons.

Type 3 - Difficult load. The load gives little or no support to the shipping container. The contents can be extremely heavy, very fragile, very irregular in shape, bulk materials which are free to shift. and flow, or a combination of several of these factors. Some examples are rivets, bolts, and nuts, delicate instruments and machined parts and assemblies.

ECONOMY IN PACKING

The military concept of economy in packing is to obtain maximum output of adequately protected items at a minimum cost. Economy measures, consistent, with the degree of protection required by an item or package should be of prime concern to individuals engaged in the establishment of packing requirements, and to personnel in charge of, or performing packing

operations. Significant savings can be accomplished by reducing the tare weight, cubage, and packing cost of a commodity through proper reengineering of the unit and exterior containers, use of newly developed materials, and employment of alternate methods and techniques.

REFERENCES

Throughout this manual, packing materials, equipment, processes, methods, etc., are referred to by their common names together with the appropriate specification, standard, or other publication symbols. Copies of specifications and other documents required by activities of the Defense Logistics Agency, the Department of the Army, Navy, and Air Force, and the Marine Corps are obtained from supply sources through established channels. Copies of specifications, standards, and drawings required by contractors connection with specific procurement functions should be obtained from the procuring activity or as directed by the contracting officer. Military and Federal Specifications and Standards are available from: Standardization Document Order Desk, 700 Robbins Avenue, Building #4, Section D, Philadelphia PA 19111-5094. Information pamphlet titled "A Guide for the Private Industry" provides more detailed information and is available upon request.

CHAPTER 1

PACKING

GENERAL

PACKING OF GENERAL SUPPLIES

Some commodity items require preservation by procedures and materials described in FM 38-700/MCO P4030.31D/NAVSUP PUB 502/AFJPAM 24-237/DLAI 4145.14, Packaging of Materiel – Preservation, which provide unit containers suitable for shipment without further packing. Other items may require further packing in containers suitable for shipment. This chapter relates to the packing of commodity items directly in shipping containers with whatever protection is required to prevent damage in shipment, handling and storage. The container alone cannot always provide full protection for military items. Items must be properly anchored, braced, blocked, or cushioned in the container to provide adequate protection. A container is often blamed for damage to its contents when the cushioning, blocking, or bracing are at fault (fig. 1-1). Every packing operation, including the final closure, strapping, and marking of the container, must be carefully planned and executed to ensure that the contents will arrive at its destination in a usable condition.

PACKAGING OF HAZARDOUS ARTICLES

Commodities classified as hazardous materials come within the scope of TITLE 49 Code of Federal Regulations which incorporates Department of Transportation Regulation for the Transportation of Explosives and other Hazardous Articles by all modes. International Shipments must be packaged in accordance with the International Air Transport Associations Dangerous Goods Regulation (IATA) and the International Maritime Organization Dangerous Goods Code (IMDG) codes. In addition, hazardous materials which are to be shipped via military aircraft must be packaged in accordance with the joint service manual AFJMAN 24-204/TM 38-250/NAVSUP PUB 505/MCO P4030.19/DLAM 4145.3, Preparing Hazardous Materials for Military Air Shipments.

SEQUENCE OF PACKING OPERATION

The general sequence of military packing is divided into a series of basic operations which may include some or all of the following steps, not necessarily in the order given below:

Determine the Packing Requirements

Knowing the item characteristics helps to determine the protection required and the best way to provide it through the use of an adequate container, suitable blocks, braces, and cushions, and appropriate barrier materials. This study will include consideration of the characteristics of the item, its size, shape, fragility, etc.; the types of loads (easy, average or difficult); the mode of transportation (rail, ship, truck, or aircraft); the storage facilities (covered or uncovered); the destination (domestic or overseas in the arctic, temperate, or tropic zones); and the levels of protection required.

Select the Container

Select and use an exterior container that will comply with the requirements outlined in applicable chapters of this manual. This selection should consider all factors pertinent to giving adequate protection at the minimum cost such as the characteristics and limitations of the container; its initial cost and upkeep expenses; its weight and cube; its availability or obtainability in appropriate quantities; and its reusability.

Prepare protective barriers

Prepare an appropriate barrier to give weatherproofing protection not obtainable from the container alone.

Insert and Secure the Item to the Container

Insert the item and secure it to the container to control or prevent movement by means of adequate cushioning, blocking, and bracing. The distinction between cushioning and blocking is that cushioning permits controlled movement of the item within the container, while blocking and bracing usually is designed to prevent movement of the item within the container.

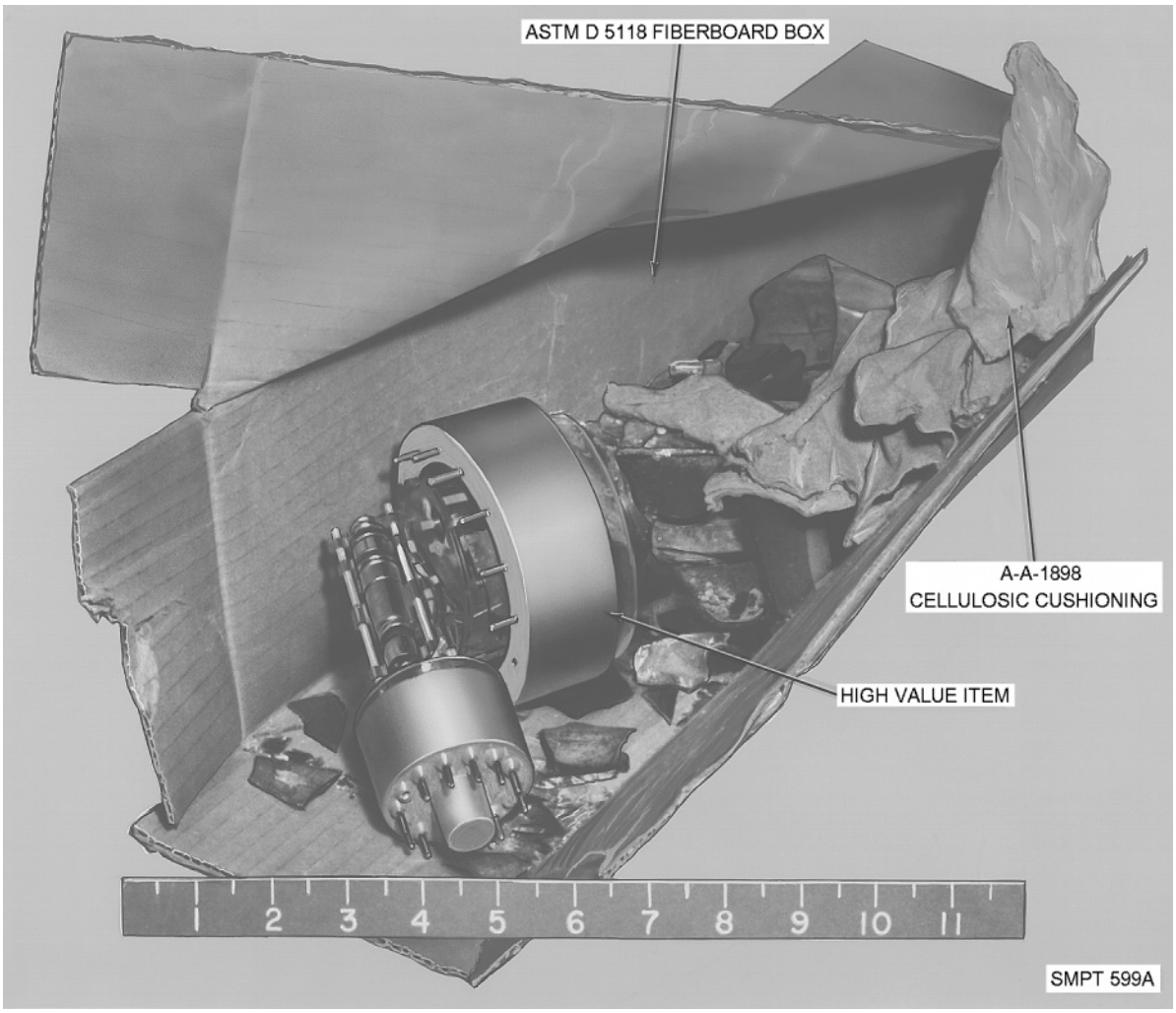


Figure 1-1. Damaged items as a result of improper/inadequate packing.

Seal the Barrier if Used

Seal the barrier material by means of adhesives, heat seals, pressure seals, or sealing tape to provide weatherproofness of the seams, joints, and closures equal to that of the barrier material itself.

Close the Container

Close the container following the detailed requirements outlined in the section of this manual which describes the container selected.

Reinforce the Container. Reinforce the container with metal or plastic strapping or reinforced tape as appropriate and as required for the container selected.

Mark the Shipping Container. Mark the container as appropriate to identify the contents and to ensure movement to its destination.

DETERMINATION OF PACKING REQUIREMENTS

The different types of items procured by the Department of Defense require a wide variety of packing operations. Items vary from strong, rugged ones that fit the container well and require no cushioning, blocking or bracing, to others that are irregular in shape, delicate, or fragile, and require special cushioning, blocking or bracing.

BASIC FACTORS

To determine packing requirements, several basic factors must be considered, namely, the item characteristics, the load characteristics, the mode of transportation, the storage and handling facilities, the destination and field conditions.

BASIC REFERENCE

The basic reference for blocking, bracing, and cushioning is MIL-STD-1186, Cushioning, Anchoring, Bracing, Blocking, and Waterproofing, with Appropriate Test Methods. This standard, approved by the Department of Defense and mandatory for use by the Armed Forces, provides general requirements and procedures concerning the arrangement of the contents within the shipping container for the prevention of physical damage.

SCOPE OF MIL-STD-1186

The standard covers common packing requirements which may be omitted from detail specifications for items or categories of items when this standard is referenced in the detail specification. It does not contain requirements for shipping containers, themselves or for unit packing, both of which also provide physical protection.

ITEM CHARACTERISTICS

The first step in any packaging operation is a careful study of the item to be packed. It is necessary to consider the shape, size, weight, strength, and degree of fragility of the item in all directions. The availability of mounting provisions, the degree of disassembly permissible for shipment, corrosion prevention requirements and special use requirements which affect the packing operations must also be considered.

SHAPE

The shape of the item to be packed is an important factor to consider in designing blocking and bracing. A regular-shaped item with rectangular surfaces requires a minimum of blocking, while an irregular-shaped item with uneven surfaces, including projections, often require an elaborate blocking system. Curved surfaces require carefully fitted blocking to prevent damage caused by concentrated stresses at contact points, and to distribute internal forces over a greater area of the faces of the container (fig 1-2). Long, slender items, particularly if heavy, exert a tremendous concentrated force on the ends of the container during handling. This force may be counteracted by securely blocking the item to the sides, top, or bottom of the container, and by increasing the thickness of the ends of the container (fig 1-3). Relatively heavy, irregular-shaped small items present a particularly difficult problem when they must be cushioned as well as blocked. Generally, in solving this problem, it is desirable to even out the surfaces by means of pads and blocking to increase the bearing area. This in turn decreases the load per unit area of bearing on the cushion (fig 1-4).

SIZE AND WEIGHT

A large item may require more extensive blocking and larger amounts of cushioning than a smaller one. The blocking may be necessary to bridge the relatively wide spans of the container faces, or it may be required to distribute the cushioning over larger areas of the item. Since the impact force developed by the abrupt stopping of a moving object is directly proportional to its weight, the weight of an item is very important in considering the blocking and cushioning. In studying the item, consider the distribution of the weight with respect to the size and bearing areas. Where the weight is concentrated, it may be necessary to distribute it over a larger area. This may be done by transferring some of it from one container face to the edges or corners of the container by the use of end blocks.

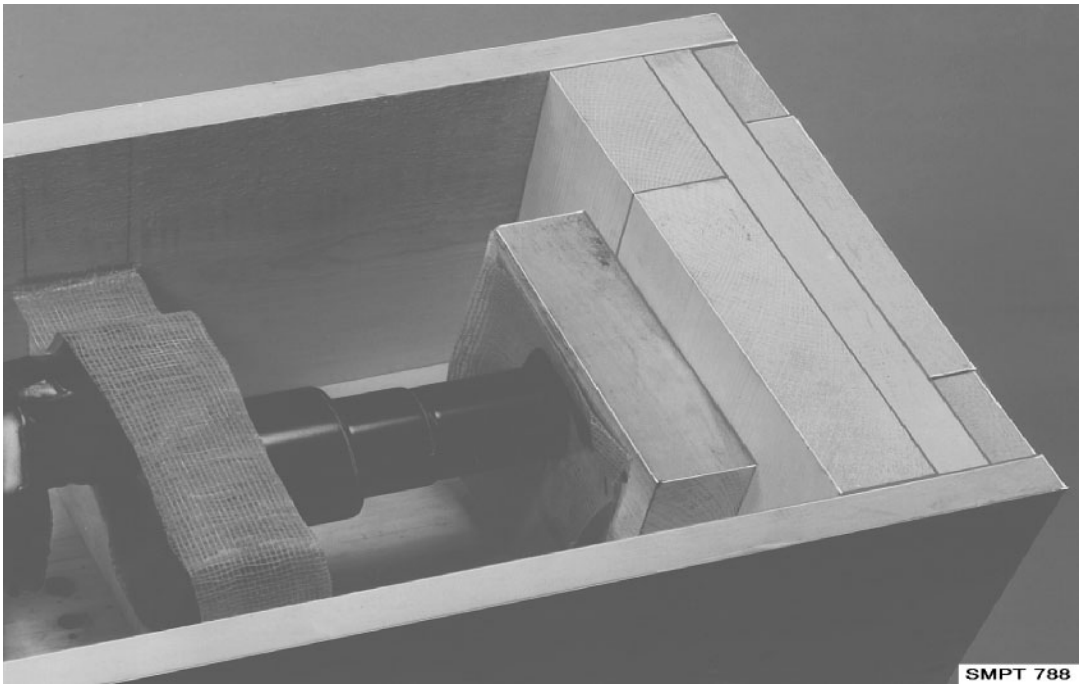


Figure 1-2. Interior blocking for an irregular shaped item.

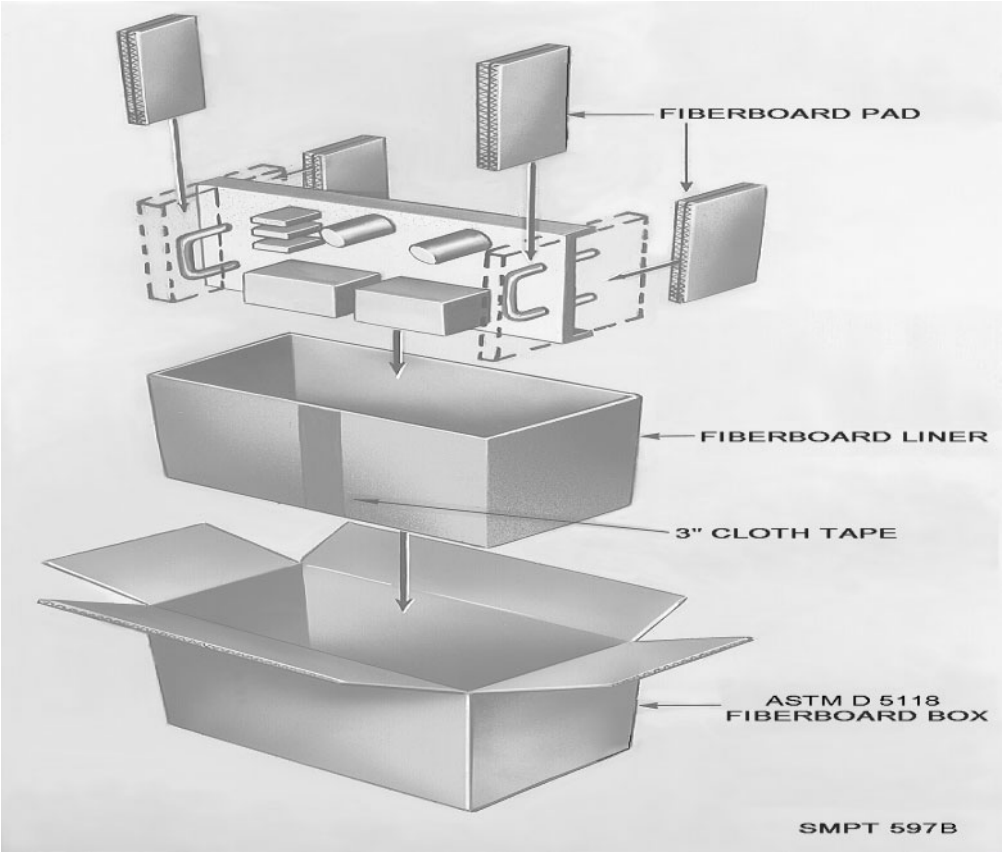


Figure 1-3. Use of corrugated fiberboard pads and liner.

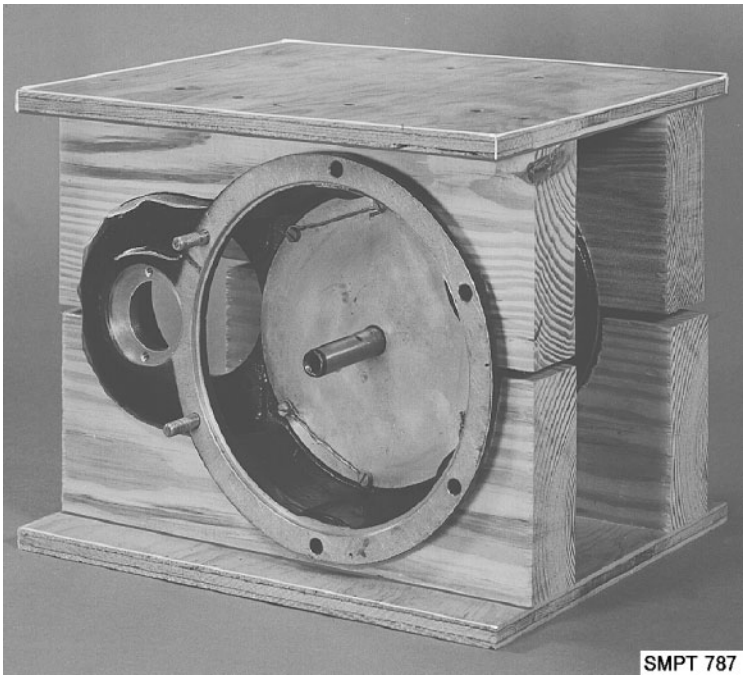


Figure 1-4. Interior blocking to protect container against end thrust.

STRENGTH AND FRAGILITY

Some items are rugged enough to withstand greater stacking loads and handling forces than their containers. Various components of vehicles and tanks, in particular, require little protection against shipping hazards, but are placed in containers for ease of handling, stowage, and storage. On the other hand, there are numerous items that require the maximum protection afforded by packing materials. Equipment is considered rugged or highly resistant to shock when bracing and blocking within the container is all that is needed for protection. Items that require cushioning for protection are considered to be fragile. The degree of fragility of an item determines the amount and type of cushioning required to protect it from damage during handling and shipment. Some items are inherently strong and rugged except for one or more fragile components. When the fragile components cannot be removed for separate packing the entire item must be treated as fragile, even though this may result in an unavoidably large, cumbersome pack.

AVAILABILITY OF MOUNTING PROVISIONS

An important factor to consider in packing is the availability of brackets and holddowns on the item that can be used to mount it within the container. Frequently, it is possible to mount an item within the container by using the same brackets and holddowns that are used for positioning and securing it in place when it is permanently installed. Mounting facilities should be examined to determine if they are adequate, especially if the container is likely to be tipped on end (fig 1-5). Compressors, engines, engine components, generators, starters, and carburetors are often secured in this manner.

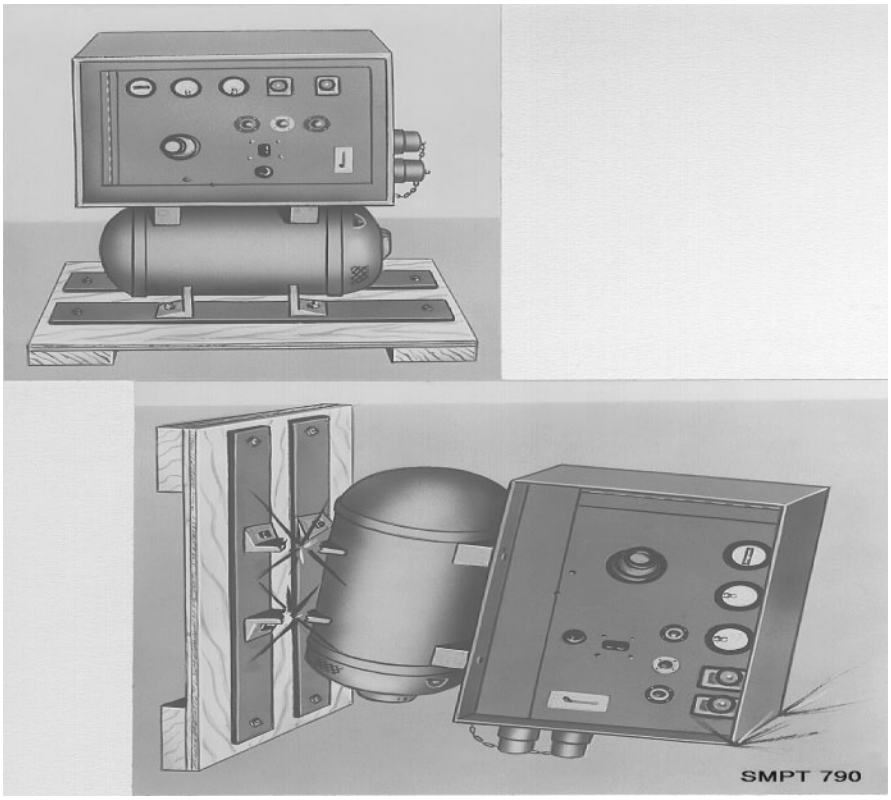


Figure 1-5. Mounting facilities of item must be adequate.

DISASSEMBLING OF AN ITEM

Items should be thoroughly investigated to determine if disassembly of simple parts can reduce the size of the container required and/or simplify the packaging. Proper authorization must be obtained before disassembling any portion of an item that would require technical skills or special tools to reassemble, realign, or recalibrate. The disassembly of simple-to-remove components with standard tools (i.e.., handles, wheels) does not require prior authorization.

Disassembled Parts

When practicable, items should be disassembled to afford protection of components, attachments, and accessories against damage and pilferage and to reduce cubage. Disassembled parts should be wrapped, packaged, anchored, braced, blocked, or cushioned within the shipping container so that parts or protective devices within the shipping container cannot be damaged by mutual contact. Disassembled parts should be clearly and legibly marked as to identity and proper location on the assembled item. All fasteners removed during disassembly should be secured in one of the mating parts. A part should not be removed from an assembly unless it can be reassembled readily in the field without special tools.

CAUTION

Proper authorization must be obtained before disassembling any portion of an item that would require technical skills or special tools to reassemble, realign or recalibrate. Disassembly of simple-to-remove components such as handles, wheels, etc., requiring standard tools, does not need authorization.

SPECIAL PACKING REQUIREMENTS

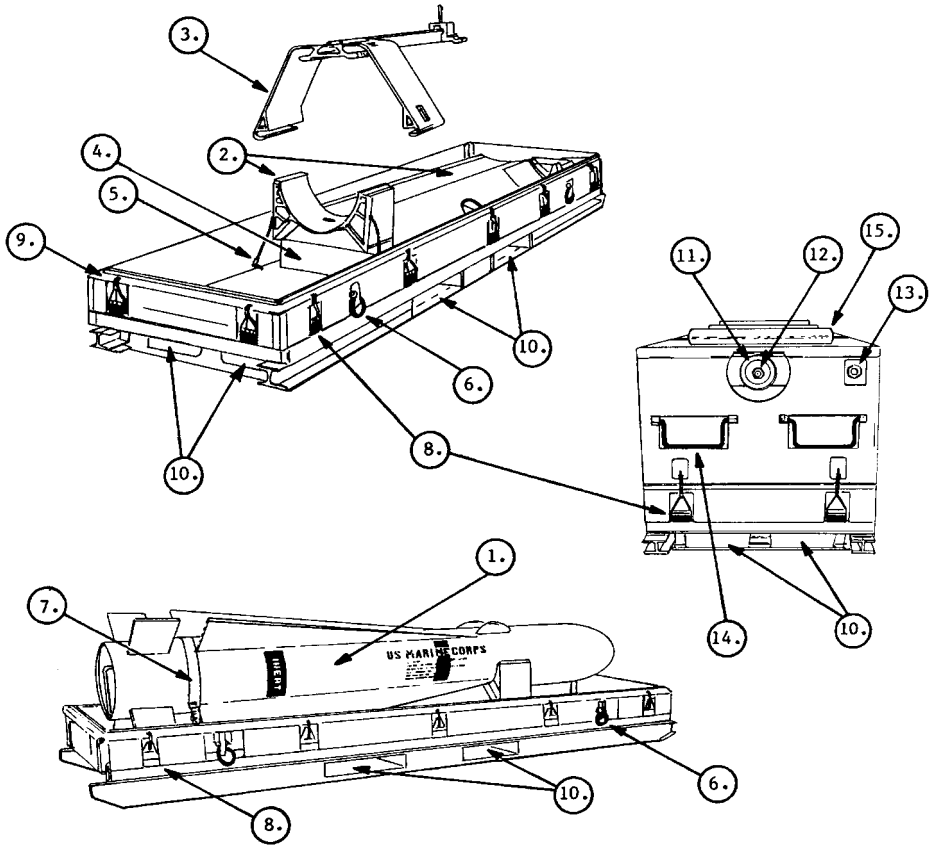
Reusable and other special purpose containers usually require special consideration of the packing of the contents in the container. For instance, in reusable containers, the blocking and cushioning must be arranged so that it may be easily removed, and when replaced, it will adequately protect the contents. However, reusable and special purpose containers should be considered for use, especially if their use results in reduced weight, cube, or cost. For example, the reusable container for a missile nose cone, shown in figure 1-6 while expensive to procure, may more than pay for itself through its reusability and its designed protection features.

LOAD CHARACTERISTICS

The proper selection of the shipping container for a given load is of the utmost importance. The kind of container must be determined by the weight, size, shape, and fragility of the load. To aid in this selection, the various loads have been classified as Type 1-Easy Load, Type 2-Average Load, and Type 3-Difficult Load. (See fig. 3 of the Introduction.)

MODES OF TRANSPORTATION

The mode of transportation is an important factor in determining the packing requirements. The hazards of handling and shipping vary greatly between motor, rail, ship, or aircraft. As an example, there could be considerable difference in the amount of handling that an item being transshipped from truck to rail to ship would receive, and the amount of handling an item delivered by air freight would receive. Likewise, an item



1. MISSLE	6. HOISTING/TIEDOWN/TOWING RINGS	11. DESICCANT PORT
2. CRADLE	7. RESTRAINT STRAP	12. PRESSURE RELIEF VALVE
3. UPPER RESTRAINT	8. LATCH	13. HUMIDITY INDICATOR
4. FOAM CUSHIONING	9. GASKET	14. COVER LIFT HANDLE
5. QUICK-PIN WITH CABLE	10. FORKLIFT POCKETS	15. STACKING INTERFACE

SMPT 444A

Figure 1-6. Protection features of a reusable missile container.

to be delivered by airdrop would require much more protection than one to be delivered by truck.

STORAGE CONSIDERATIONS

To assure serviceability of the contents after prolonged exposure to deteriorating elements, not only the supplies, but the packing materials which enclose them must be protected. There may be a considerable period from the time the material leaves the manufacturer until it is used. It may be stored outdoors in domestic depots, then shipped to staging areas or ports of embarkation to await transportation overseas. Finally arriving, it may again be stored in depots or supply areas which could be improvised shacks, native huts, tents, caves, or even in the open. At oversea supply points, the packs are often broken open and smaller intermediate packs distributed to forward areas. On the other hand, items may be shipped directly from the supplier to the user with a minimum of delay. In this instance, the protection provided by the pack could be considerably reduced from the amount required for the oversea pack.

DESTINATION AND FIELD CONDITIONS

The ultimate destination of items is generally unknown when they leave a packing facility. Some items may be used domestically while the rest will eventually go overseas. They may be shipped to the arctic regions, the islands of the seas, or the tropical jungles. They may be subjected to the cold, heat, humidity, aridity, or the extreme temperature changes of the various regions, all of which must be considered in planning the pack to assure adequate protection through the time of delivery and after arrival at destination when they may be subjected to unfavorable field conditions.

FUNCTIONS AND SELECTION OF SHIPPING CONTAINERS

FUNCTIONS

A shipping container is any exterior box, crate, drum, etc., which is required to enclose one or more items during transit or storage. The basic functions of a shipping container are to protect the contents and to provide for ease of handling. Shipping containers assist in the handling of a number of items by consolidation, and of a single item which is difficult to handle. The degree of protection derived from the shipping container depends upon its type, the materials used in its fabrication, its construction features, its final destination, the nature of the contents, and the anticipated hazards. Chapters 2 through 7 of this manual contain information on approved containers for military shipments and should be consulted when making selection of the appropriate containers.

SELECTION

The shipping container is usually established by specifications, directives, technical orders, or other authorized publications. Where a group of containers is authorized, or when the proper container is not specified, the packing supervisor is responsible for the selection of the appropriate container. They must base their selection upon the physical characteristics of the item; its destination; whether domestic or overseas; the level of protection required; the type of load; the initial cost of the container; the weight and cube of the container; the simplicity, economy and ease of assembly and closure; the availability; and need for reusability of the container (fig 1-7). Nailed wood boxes or similar heavy wooden containers will not be used unless fully justified by past experience or environmental, geographical, or security considerations.

ARRANGEMENT OF CONTENTS

The contents of a pack should be arranged within the shipping container so as to provide maximum protection to its contents and the container. Where applicable, the arrangement should permit a container fabricated of materials that will result in low tare weight, smallest practical cube, convenient handling, and suitability for palletization. Contents should completely fill the container or be secured therein with suitable clearance. Packs of like items should contain like quantities and should be uniform in size, shape, and weight.

MOVABLE PARTS AND PROJECTING PARTS

Articles with moving external parts or projecting parts that might become damaged by shock or vibration encountered in shipment should have these parts made secure against movement by means of blocking, bracing, tiedown, or other adequate provisions, or should be disassembled, if practicable.

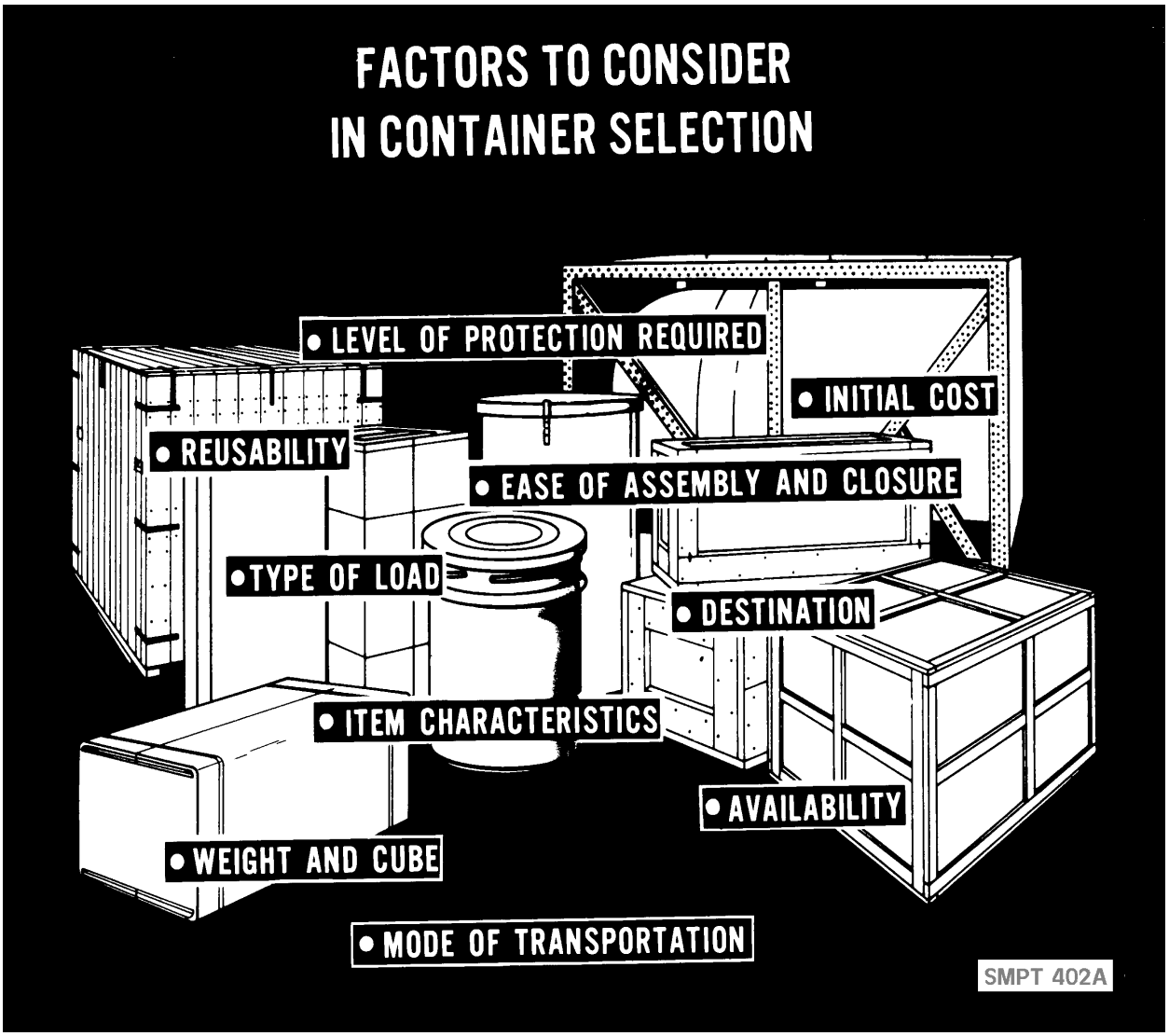


Figure 1-7. Container selection factors.

SEGREGATION OF PACKED CONTENTS

So far as practicable, contents of shipping containers should be segregated in the following order: (a) the order on the packing list; (b) items of the same contract; (c) items of the same National Stock Numbers; and (d) items of the same Federal Supply Class.

CONVERSION OF TYPE 3 LOADS

Where practicable, type 3 loads should be converted to type 1 or type 2 loads.

BLOCKING AND BRACING

BLOCKING AND BRACING DEFINED

Blocking and bracing is the process of providing physical and mechanical protection to an item by means of materials, other than cushioning materials, intended to prevent any free movement of the item within the container, and distribute or transfer concentrated loads of the item to larger areas of other faces of the container.

FUNCTIONS OF BLOCKING AND BRACING

Items which do not completely fill the shipping container should be blocked, braced, anchored, or otherwise immobilized within the container. Blocking and bracing should be used to secure items or components so that they will not shift within a container; to make irregular shaped items fit a regular container; to distribute the weight of irregular items over all edges and faces of the container; to protect projections from injury; to prevent projections from damaging the barrier or container; to provide space for spare parts or make room for desiccant; and to reinforce weak portions or mountings. Blocking and bracing modifies the original shape of an item so that it is protected adequately and so that it fits the container. The materials used for this purpose differ from cushioning in that they are not intended to absorb shocks. Items having legs or other projecting portions which may become loose or broken, or which might puncture the container, must be supported by adequate blocking and bracing. The blocks and braces should be applied against portions of the container that are strong enough to resist forces tending to distort them. Likewise, the bracing should be arranged to distribute forces to several reinforced sections of the surface of the item (fig 1-8). Items with movable parts, items mounted springs or other flexible supports should be braced securely to prevent movement, except where such mounting is part of the package cushioning or is designed to protect against shock and vibration during shipment.

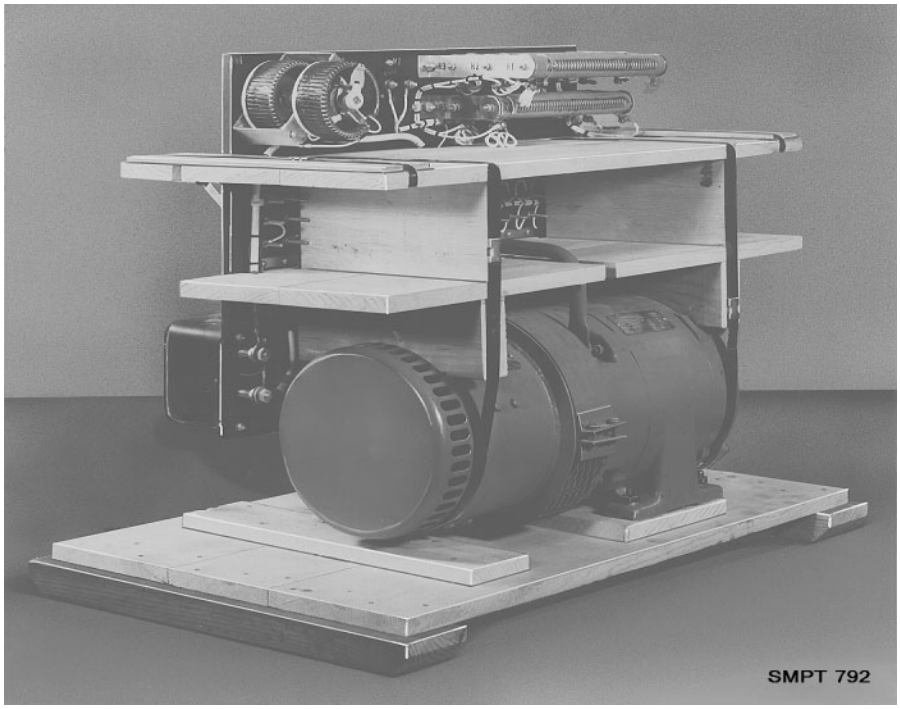


Figure 1-8. Blocking and bracing to prevent movement.

ABRASION PROTECTION

Protection should be provided when the surface of the item in contact with the blocking an bracing can be damaged by relative motion between the contacting surfaces or could become corroded as a result of such continuous contact. Protection against abrasion should be provided for highly finished or easily marred surfaces by wrapping or covering with cushioning material. Surfaces that might be damaged by contact with cushioning material should be separated by a covering of noncorrosive paper conforming to MIL-P-130 or greaseproof barrier material conforming to MIL-B-121, grade A.

APPLICATION OF BLOCKING AND BRACING MATERIALS

The materials selected for all blocking and bracing, the design and application of the blocking and bracing should be compatible with the load to be supported and the size, shape, and strength of bearing areas of the item. The heavier the load needing support, the stiffer and stronger the materials for blocks and braces must be. Hence, the choice of materials depends upon the size and shape of the areas against which the blocking and bracing will be placed, as well as the size and weight of the item being secured. Since a shipping container may be dropped on any of its faces or corners, blocks and braces must be designed to withstand the thrust and impact applied on any direction. The choice of materials used for blocking and bracing vary widely. The chief materials used are corrugated fiberboard in cells, trays, pleated pads, and flat pads, for relatively lightweight items or for supplementary primary blocking of heavy items. Wood, plywood, rigid plastic foams, and metal are used as the primary blocking materials for large and heavy items.

Fiberboard

Open-end cells and trays of corrugated fiberboard. When used as blocking, corrugated fiberboard must be designed to fit the bearing area of the item to support and evenly distribute the load. Common forms of corrugated fiberboard blocking are die-cuts, open end cells, trays, pleated pads, and flat pads (fig 1-9). Frequently, various combinations of these forms are employed. They can be used to provide spaces for, and restrain the movement of, disassembled parts, as well as provide openings for bags of desiccant. Generally, cells and trays should be held in shape with tape or staples.

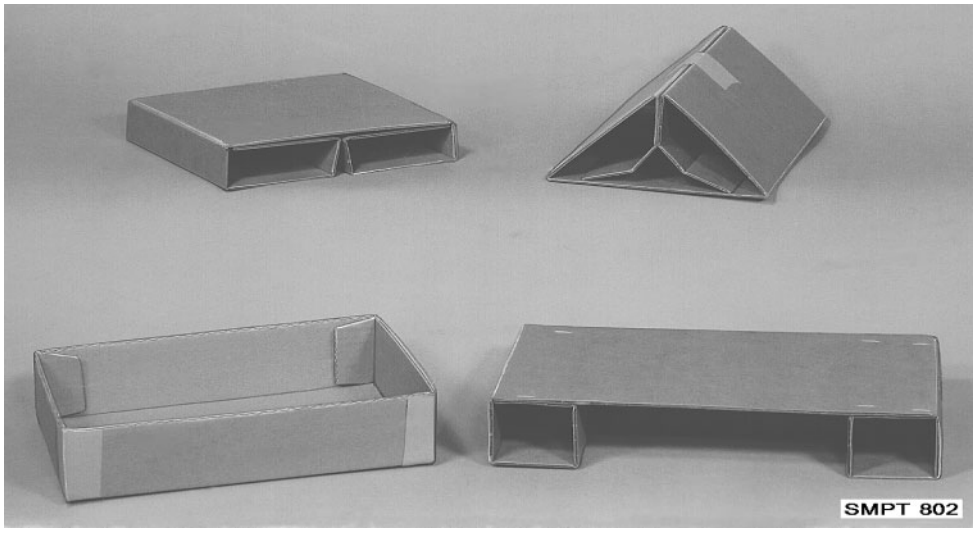


Figure 1-9. Cells and trays made of corrugated fiberboard.

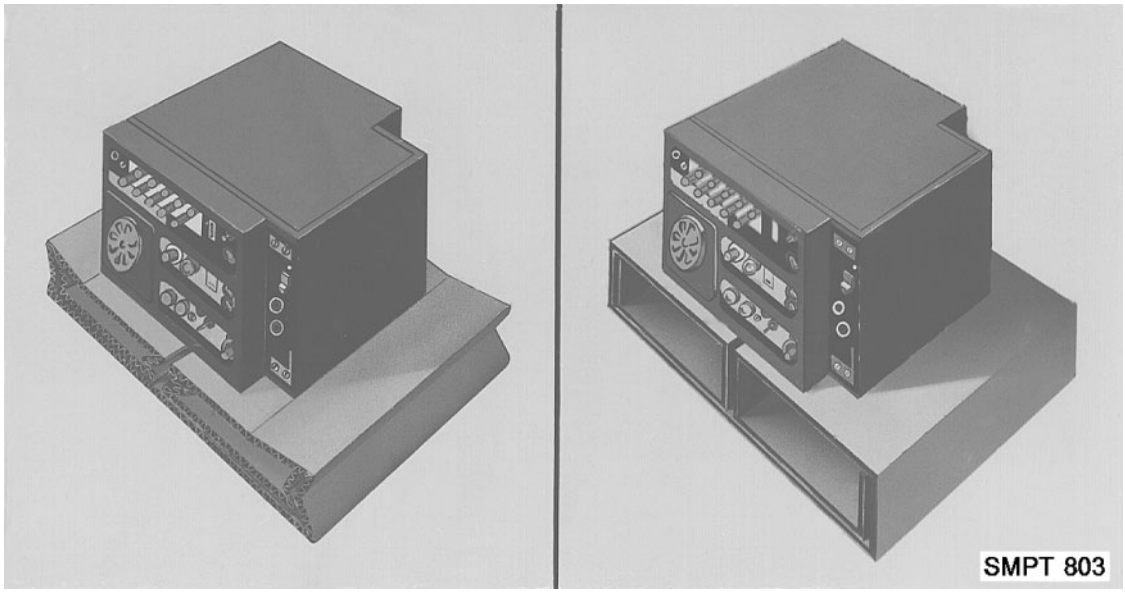


Figure 1-10. Incorrect and correct direction of corrugation.

Those surfaces of the cell or tray which are perpendicular to the contacting surface of the item are called bracing supports and are the load bearing members. No bracing support allowances should be made for the other surfaces. To utilize all of the strength of these bracing supports, they should bear directly on the item. The weight of the item must be exerted in the same direction as the corrugations. If not, the item is inadequately supported and damage may result (fig 1-10). Open-end cells and trays should be used for blocking and bracing deep recesses; bridging long projections; providing spaces for disassembling parts, accessories, and dessicants; and providing clearance between item and container. Bracing supports should bear directly on the article. Allowable loads for bracing supports of open-end cells loaded in the flute direction should be in accordance with table 1-1. If flute direction is at right angles to the direction of the load, the allowable loads should be 50 percent of the values of table 1-1. Trays should be scored and folded parallel to the flute direction and should not exceed 4 inches in height.

CORRUGATED FIBERBOARD FORMS

Corrugated fiberboard used for blocking and bracing should conform to ASTM D 4727. Blocking and bracing forms should be loaded in the direction parallel to the flutes wherever possible. The cutting, slotting, scoring, and folding of fiberboard blanks to make blocking and bracing supports or forms shall be such as to assure proper fitting and distribution.

FOLDED PADS

Folded pads of corrugated fiberboard may be used for blocking greater loads than are feasible to support with cells and trays. The pads should be designed to fit against a flat surface (flat pads) or along an edge (corner pads). Connecting webs between flat pads should always contact the container and not the item. All scores and folds should be made at right angles to the flute direction. Flat pads should be a minimum of 2 inches wide. Portions of folded pads in direct contact with the item are bearing areas. The maximum loads for these bearing areas should be in accordance

Table 1-1. Allowable loads for corrugated fiberboard. Columns loaded in the flute direction.

Material	Allowable loads per lineal inch of bracing support or column	
	Height up to 4 inches	Height over 4 inches
	Pounds	Pounds
Double-faced fiberboard:		
200-pound bursting strength	2	1
275-pound bursting strength	2.5	1.5
350-pound bursting strength	3	2
Double-wall fiberboard:		
275-pound bursting strength	2.5	1.5
350-pound bursting strength	3	2
500-pound bursting strength	4	2.5
Triple-wall fiberboard:		
1,100-pound bursting strength	5	4

Note. When a greater load is imposed than that permitted by the table, use wood blocking and bracing

with table 1-2. Accordion folded pads have greater resistance to breakdown than open end cells because the load is spread over a large area rather than on bracing supports. Accordion folded pads with tight folds distribute the load more evenly to the container. The connecting web between the folded pleats should be placed in contact with the container rather than the item. Creases for accordion folded pads should be made across the corrugations, and the pleat should be at least 2 inches in width. If necessary, a pleat 1 1/2 inches wide may be made, but extreme care must be exercised when folding the pad to prevent crushing the corrugations. Tape should be used to keep accordion folded pads in shape. The load bearing capacity of a pad is based on the initial compressibility of the corrugated material. Increasing the number of pleats does not increase the safe load limit; numerous pleats increase the cushioning value only. Wide or long items are better supported by several accordion folded pads, placed side by side, than by one pad having extremely wide folded pleats.

FLAT PADS

Flat pads of corrugated fiberboard may be used to block very shallow projections, such as hinges or slight offsets on surfaces; to level off projecting screw heads; to fill in the space between ends of inner flaps of slotted fiberboard boxes to provide additional protection to contents at top and bottom of boxes; and to separate items within a container. Allowable loads should be in accordance with table 1-2. Maximum allowable loads per square inch of bearing area on a flat pad are the same as those for a pleated pad. Flat pads can be slotted to form partitions, or they may be die cut or punched to fit items or irregular shape. Figure 1-11 shows the assembling of slotted fiberboard partitions.

Table 1-2. Allowable loads for folded corner and flat pads of corrugated fiberboard

Flute design	Maximum allowable load for bearing areas
	Pounds per square inch
A-flute (36"3 corrugations per foot)	2.0
B-flute (50"3 corrugations per foot)	3.0
C-flute (42"3 corrugations per foot)	2.5

Note. The flat crush resistance of the corrugations shall determine the load that may be carried in flat loading of corrugated fiberboard. This shall not be construed to meet the bursting strength of the material.

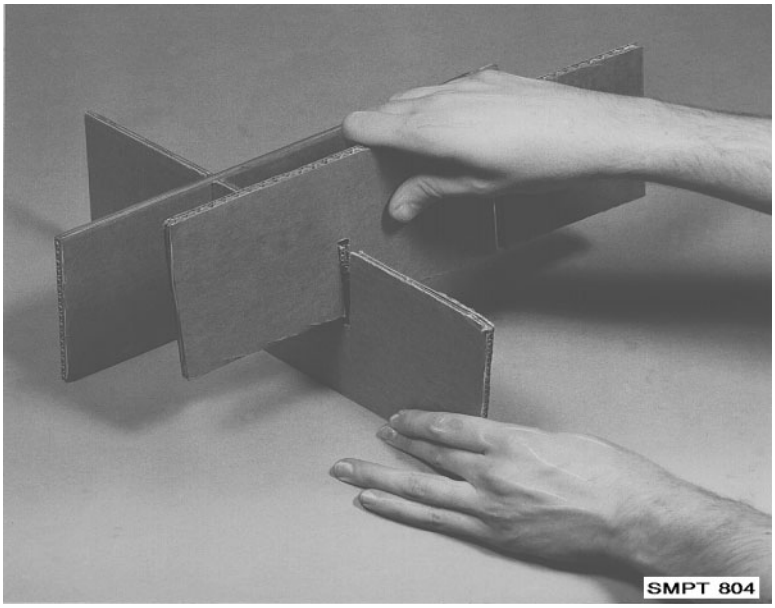


Figure 1-11. Assembling of slotted fiberboard partitions.

CORNER PADS

The use of corner pads made of multiple layers of corrugated fiberboard shall comply with the load requirements of table 1-2. The pads shall provide required clearances and support for rectangular shaped items or for an inner box in which items are packed.

TUBES

Fiberboard tubes should be used as blocking when items mounted on an auxiliary base are packed on fiberboard boxes. The bottom of the tube shall contact the top of the auxiliary base and the top of the tube shall contact the top inside surface of the container. The flutes shall be oriented in the top-to-bottom direction of the tube. The weight of the item plus auxiliary base, in pounds, divided by the perimeter of the tube, in inches, shall not exceed the appropriate values given in table 1-2 for column heights over 4 inches.

CORRUGATED FIBERBOARD LINERS

A liner is a continuous pad, bent to fully contact two or more inner faces of a container. Liners are used to reinforce a container against crushing by forces imposed during stacking, or to take the place of two or more flat pads. A liner may also be used as a holddown for base mounted items weighing not more than 20 pounds. The creases in a liner should be made parallel to the

direction of the corrugations of the fiberboard, in order that the resistance to forces ordinarily encountered in stacking be the greatest.

CORNER POSTS

Fiberboard corner posts should be used to reinforce the shipping container and provide blocking for platform-mounted equipment. The flutes should be oriented in the top-to-bottom direction. The bottom end of the corner post shall bear uniformly on the platform, and the top end of the corner post shall bear on the inner flap of the container or top member of a crate. Corner posts, when installed, must so interlock with the contents and other inner padding pieces in order not to become displaced during transportation.

WOOD OR PLYWOOD

Wood or plywood may be used alone or in combination for blocking and bracing. Wood or plywood blocking and bracing members should bear against only those parts of the packed item capable of withstanding the applied dynamic forces or should bear against blocking pads or pressure strips that adequately distribute these forces. Wood or plywood blocking and bracing should be designed to permit easy removal without damage to the item. Both wood and plywood are used for blocking and bracing because of their high strength-weight ratio, general availability, and ease of cutting and fastening. Lumber has certain weaknesses, such as low splitting resistance parallel with the grain, and a tendency to shrink or swell with change in moisture content.

Plywood has high resistance to splitting and high dimensional stability with changes in moisture content. Because they are more resistant to splitting than solid wood, plywood panels are more often used in thinner dimensions than lumber, and are readily nailed or fastened with screws near the edges. Plywood is more apt to have a lower moisture content than lumber because of the manner in which it is manufactured and stored. Plywood, being constructed of alternate plies at right angles to each other possesses more uniformly distributed strength properties than lumber. When considering lumber and plywood of comparable sizes and quality, it is generally true that the strength properties of lumber parallel to the grain are greater than the respective strength properties of plywood parallel to the grain of the face ply. It is also true that the strength properties of lumber perpendicular to the grain are generally less than the respective strength properties of plywood perpendicular to the grain of the face ply.

WOOD

Wood members of each size and type used in the blocking and bracing should be tested for moisture content. Structural members (those subject to critical bending stresses) shall conform to class 1. All other blocking and bracing members shall conform to class 3. Whenever possible, wood blocks or braces shall be placed so that the load is applied against the end grain of the member. Ends of braces shall be socketed or fitted and secured into appropriate notches in load-bearing members.

PLYWOOD

Plywood used for blocking and bracing should conform to A-A-55057.

WOOD BLOCKING AND BRACING

The species of woods differ greatly in strength and related properties and, accordingly, have been separated into four groups. Certain species, such as those of Group IV, excel in toughness and shock resistance, but care must be exercised in nailing them to avoid splitting. Other species, such as southern yellow pine and Douglas fir of Group II, are high in bending strength and stiffness; and nailing is a lesser problem. The characteristics of the groups of wood may be used to advantage in various forms of blocking and bracing (fig. 1-12). Thin pieces of lumber split more easily than thick pieces; hence, thin pieces for blocking should be avoided if possible. If the dimensional limits of the item require that the blocking be thin, it is preferable to use plywood.

MOISTURE CONTENT

The moisture content of lumber employed as blocking and bracing material should not exceed 19 percent nor be less than 12 percent of its oven dry weight at the time of fabrication. Shrinkage is objectionable because it allows movement of the item and the item may actually break loose. Moisture in lumber is objectionable because it is apt to evaporate into the pack, thus raising the humidity of the pack and causing corrosion of metals or decay of organic materials.

CAUTION

Lumber, plywood, or other hygroscopic materials should never be placed in direct contact with critical metal surfaces since such materials tend to absorb and retain moisture next to the surfaces, finally causing corrosion. Provide always a water-vaporproof barrier between any critical metal surfaces and hygroscopic packing materials, and a waterproof or moisture-resistant barrier between all metal surfaces and hygroscopic materials.

DEFECTS IN BLOCKS AND BRACES

Wooden members used for blocking and bracing are often subjected to great stress and careful consideration must be given to any weakening defects. If the member functions as a beam or column, defects such as divergence of grain, knots, splits and decay should be avoided. This is especially important if the defect is located near the center of the piece, because of the great reduction in shock resistance. If a piece with a knot is used, the load is placed so that the knot is in compression as shown in ②, Figure 1-12. Lumber having knots of a diameter exceeding one-fourth the width of the piece should not be used (fig 1-12). The slope of grain in each piece should not exceed 1 inch in 10 inches of length, or splitting is likely to occur. Decayed wood is avoided under all circumstances because there is not way of determining how much the decay may have weakened the wood. For additional information on wood knots, see chapter 3 and figure 3-3.

Size of Wood Braces of Holddowns

Braces or holddowns must be of sufficient size to withstand the shocks encountered. The size of a brace varies with the weight of the item, the length of the brace, and the type of loading. Table 1-3 used with figure 1-13 gives the recommended allowable load in pounds for the various sizes of braces and the various types of loading. For example, assume that the weight of the item is 60 pounds, the length of the brace is 24 inches, and the type of loading is the third type illustrated in figure 1-13 (loading in the

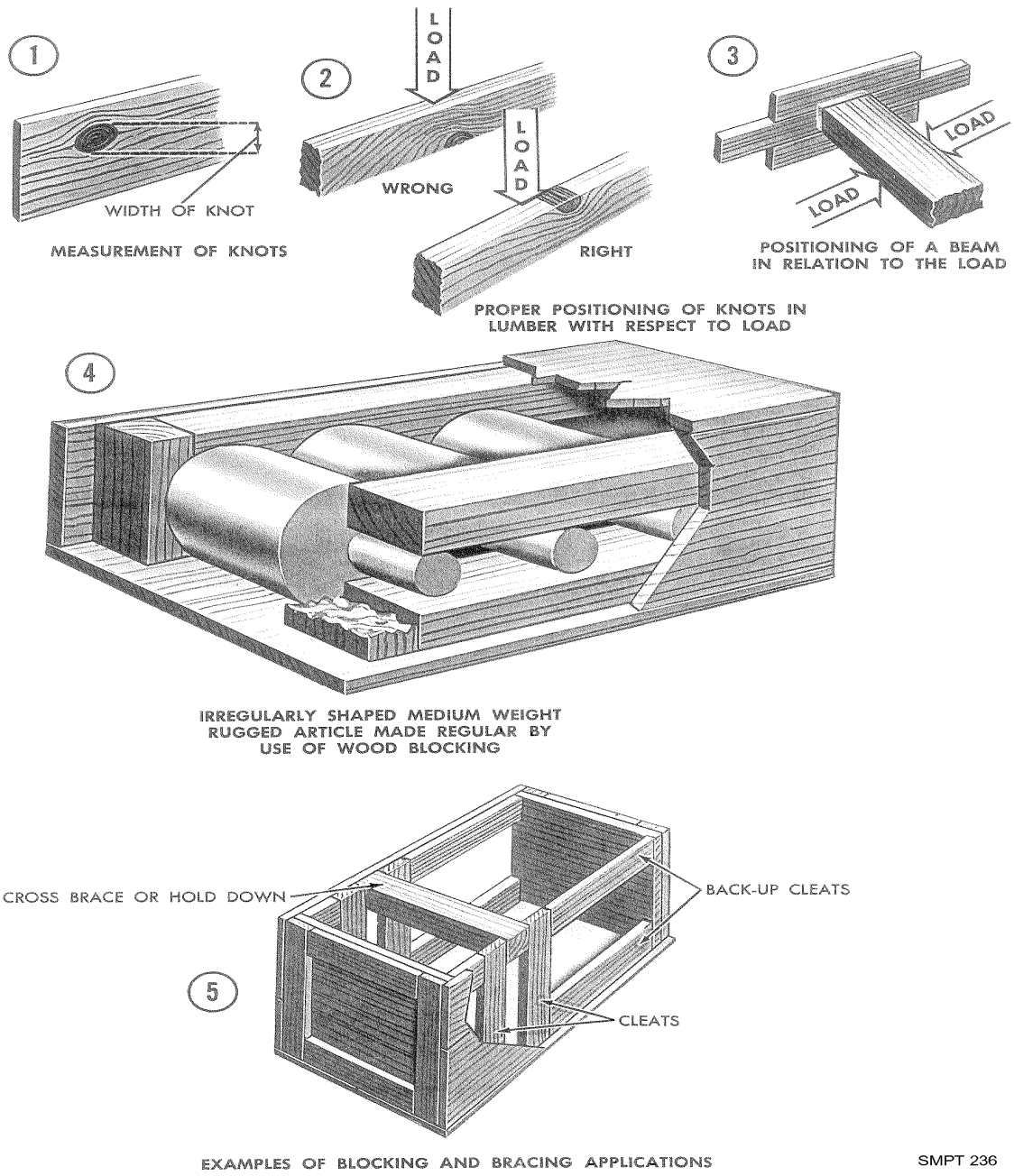


Figure 1-12. Application of wooden blocks and braces.

Table 1-3

THE ALLOWABLE LOAD IN POUNDS IS FOR GROUP II WOODS

LENGTH OF BRACE IN INCHES	1 X 1		1 X 2		1 X 3		1 X 4		1 X 6		1 X 8		2 X 2		2 X 3		2 X 4	
12	23	23	47	94	78	225	109	315	172	495	227	653	187	187	313	450	438	630
18	16	16	31	63	52	174	73	315	115	495	151	653	125	125	208	347	292	630
24	12	12	23	47	39	130	55	255	86	495	113	653	94	94	156	260	219	510
30	10	10	19	37	31	104	43	204	69	495	91	653	75	75	125	208	175	408
36	8	8	16	31	26	87	36	170	57	420	76	653	62	62	104	174	146	340
42	7	7	13	27	22	74	31	146	49	360	65	626	54	54	89	149	125	292
48	6	6	12	23	20	65	27	128	43	315	57	548	47	47	78	130	109	255
54	5	5	10	21	17	58	24	113	38	280	50	487	42	42	69	116	97	227
60	5	5	9	19	15	52	22	102	34	252	45	438	37	37	63	104	88	204
66	4	4	8	17	14	47	20	93	31	229	41	398	34	34	57	95	80	186
72	4	4	8	15	13	43	18	85	29	210	38	365	31	31	52	87	73	170
78	4	4	7	14	12	40	17	78	26	194	35	337	29	29	48	80	67	157
84	3	3	6	13	11	37	16	73	25	180	32	313	27	27	45	74	62	146
90	3	3	6	13	10	35	15	68	23	168	30	292	25	25	42	69	58	136
96	3	3	6	12	10	33	14	64	22	158	28	274	23	23	39	65	55	128
102	3	3	6	11	9	31	13	60	20	148	27	258	22	22	37	61	51	120
108	3	3	5	10	9	29	12	57	19	140	25	243	21	21	35	58	49	113
114	2	2	5	10	8	27	12	54	18	133	24	231	20	20	33	55	46	107
120	2	2	5	9	8	26	11	51	17	126	23	219	19	19	31	52	44	102

LENGTH OF BRACE IN INCHES	2 X 6		2 X 8		3 X 3		3 X 4		3 X 6		3 X 8		4 X 4		4 X 6		4 X 8	
12	688	990	906	1305	750	750	1050	1050	1650	1650	2175	2175	1470	1470	2310	2310	3045	3045
18	458	990	604	1305	579	579	810	1050	1273	1650	1678	2175	1470	1470	2310	2310	3045	3045
24	344	990	453	1305	434	434	608	851	955	1650	1259	2175	1191	1191	1872	2310	2467	3045
30	275	990	363	1305	347	347	486	681	764	1650	1007	2175	953	953	1497	2310	1974	3045
36	229	840	302	1305	289	289	405	567	637	1400	839	2175	794	794	1248	1961	1645	3045
42	196	720	259	1251	248	248	347	486	546	1200	719	2086	680	680	1069	1681	1409	2920
48	172	630	227	1095	217	217	304	425	477	1050	629	1825	595	595	936	1470	1234	2555
54	153	560	201	973	193	193	270	378	424	934	559	1622	529	529	832	1307	1096	2271
60	138	504	181	876	174	174	243	340	382	840	503	1460	476	476	749	1176	987	2044
66	125	458	165	796	158	158	221	309	347	764	458	1327	433	433	681	1069	897	1858
72	115	420	151	730	145	145	203	284	318	700	420	1217	397	397	624	980	822	1703
78	106	388	139	674	134	134	187	262	294	646	387	1123	366	366	576	905	759	1572
84	98	360	129	626	124	124	174	243	273	600	360	1043	340	340	535	840	705	1460
90	92	336	121	584	116	116	162	227	255	560	336	973	318	318	499	784	658	1362
96	86	315	113	548	109	109	152	213	239	525	315	913	298	298	468	735	616	1278
102	81	297	107	515	102	102	143	200	225	494	296	859	280	280	440	692	580	1202
108	76	280	101	487	96	96	135	189	212	467	280	811	265	265	416	654	548	1136
114	72	265	95	461	91	91	128	179	201	442	265	768	251	251	394	619	519	1075
120	69	252	91	438	87	87	122	170	191	420	252	730	238	238	374	588	493	1022

LUMBER CROSS SECTION SIZES AS SHOWN IN TABLE ARE NOMINAL.

THE ALLOWABLE LOAD IN POUNDS AS SHOWN ARE FOR ACTUAL OR DRESSED SIZES - EXAMPLE : 11/2 x 31/2 = 2 x 4 ETC.

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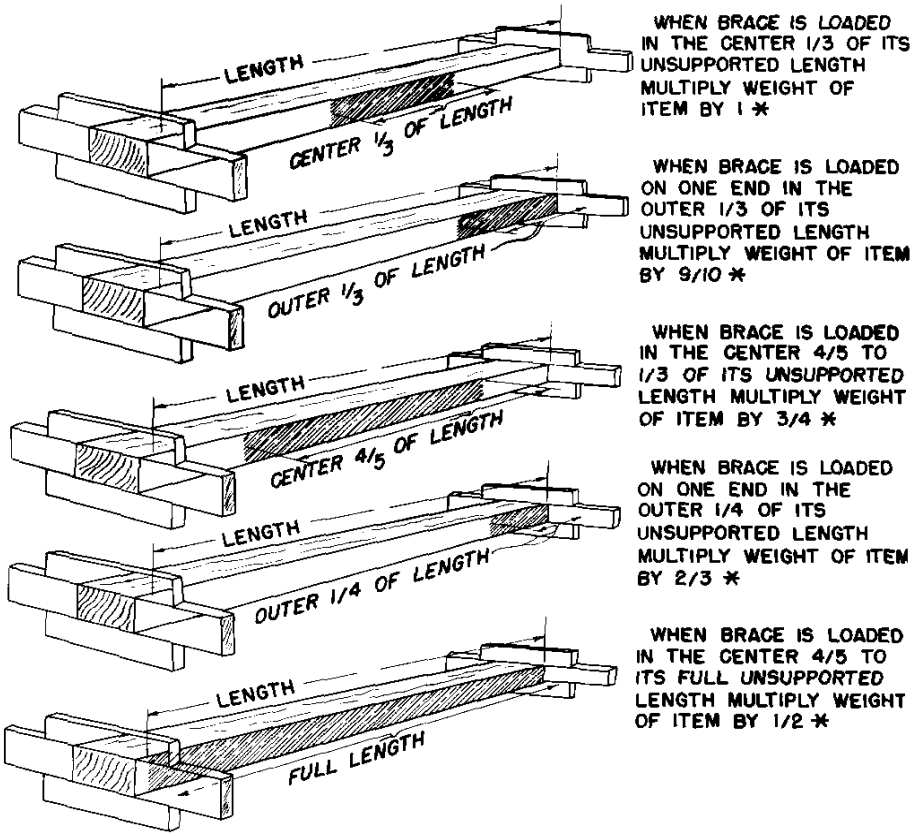

Figure 1-13. Types of loading (use with table 1-3).

center 4/5 to 1/3 of the unsupported length of the brace). For this type of loading, multiply the weight of the item by the factor 3/4, as shown in figure 1-13. Three-fourths times 60 equals 45. In the column headed "Length of brace in inches", of table 1-3, find 24 inches and read to the right until a value near 45 is found. The heading for this column shows that the proper size of member and direction of loading is a 1 x 2-inch member used on edge, or a 1 x 4 inch member used flatwise.

POSITIONING LOADS ON BLOCKS AND BRACES

When wood blocking and bracing is used to secure heavy items, place the block so that the load rests on the end grain of the piece, whenever possible. If this cannot be done, the load should bear on the edge grain. When so placed, the maximum strength of the brace is used (fig 1-14). Since wood is relatively stable in dimension along the grain, there is little effect from shrinkage or swelling with a change in moisture content. The brace should, if possible, have its narrow face against the item so that its maximum stiffness is utilized. If a larger bearing area is required, and it becomes necessary to have the flat face of the brace against the item, the size of the brace against

the item, must be increased (table 1-3). Lumber which is relatively wide for its thickness must be reinforced throughout its length to prevent twisting or buckling.

USING LUMBER AS A MOUNTING BASE

If an item is to be secured to a base, and plywood is not available, use dimensional lumber. Bases of dimensional lumber should be constructed with sufficient cleats at right angles to the grain of the baseboards, and fastened with clinched nails to prevent the boards from splitting at the bolt holes. Strength of the bases must be adequate to withstand any rough handling the pack may be likely to receive.

SECURING LUMBER BLOCKING

Securing lumber blocking properly is the most essential factor in blocking and bracing. Wooden braces positioned between two faces of a container should never be secured with end grain nailing, toenailing, or similar methods, nor should they ever be inserted into notches cut into the container faceboards. Instead, the braces should be secured by cleats fastened to the faces of the container with a sufficient number of clinched nails. When pressures are great or an increased nailing area is required, backup blocks are used to reinforce the cleats and give increased nailing area. When pressure is from more than one direction, a pocket cleat arrangement is used to hold the braces in position ③ fig 1-12. The backup blocks are positioned with their end grain in contact with the brace in order to make use of the high strength property of wood in compression parallel to the grain. The cleats and backup cleats ⑤ fig 1-12 are secured with clinched nails properly staggered at intervals along their length. Sometimes, however, bolts are used to fasten these members in place. This is especially desirable when the entire weight of the item thrusts against the block, or when the cleat supports a framework attached to one or more faces of the container.

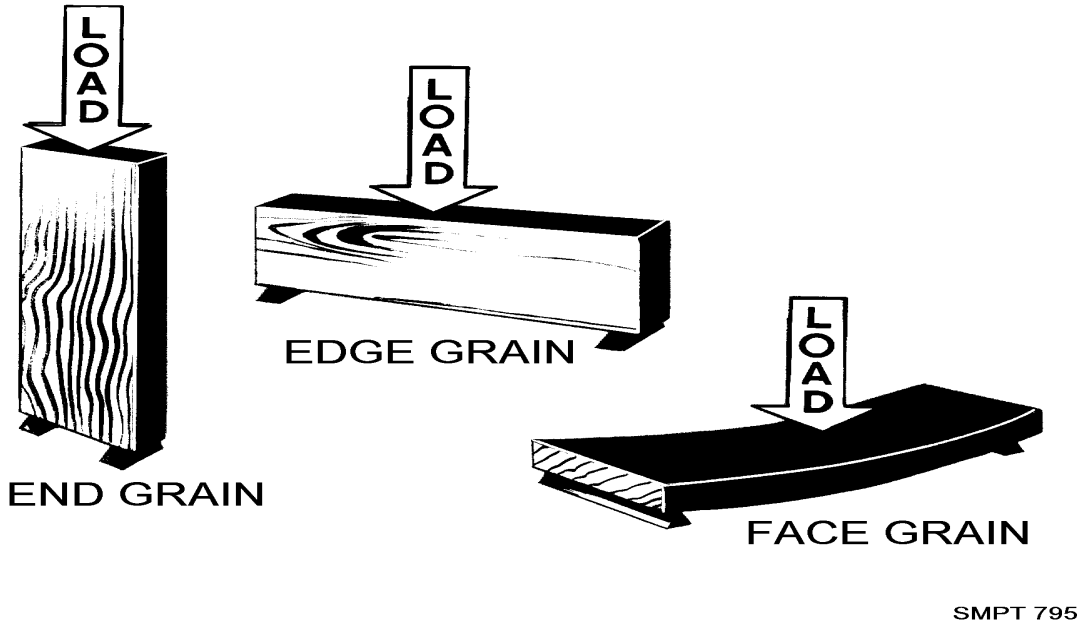

Figure 1-14. Positioning load according to grain of wood

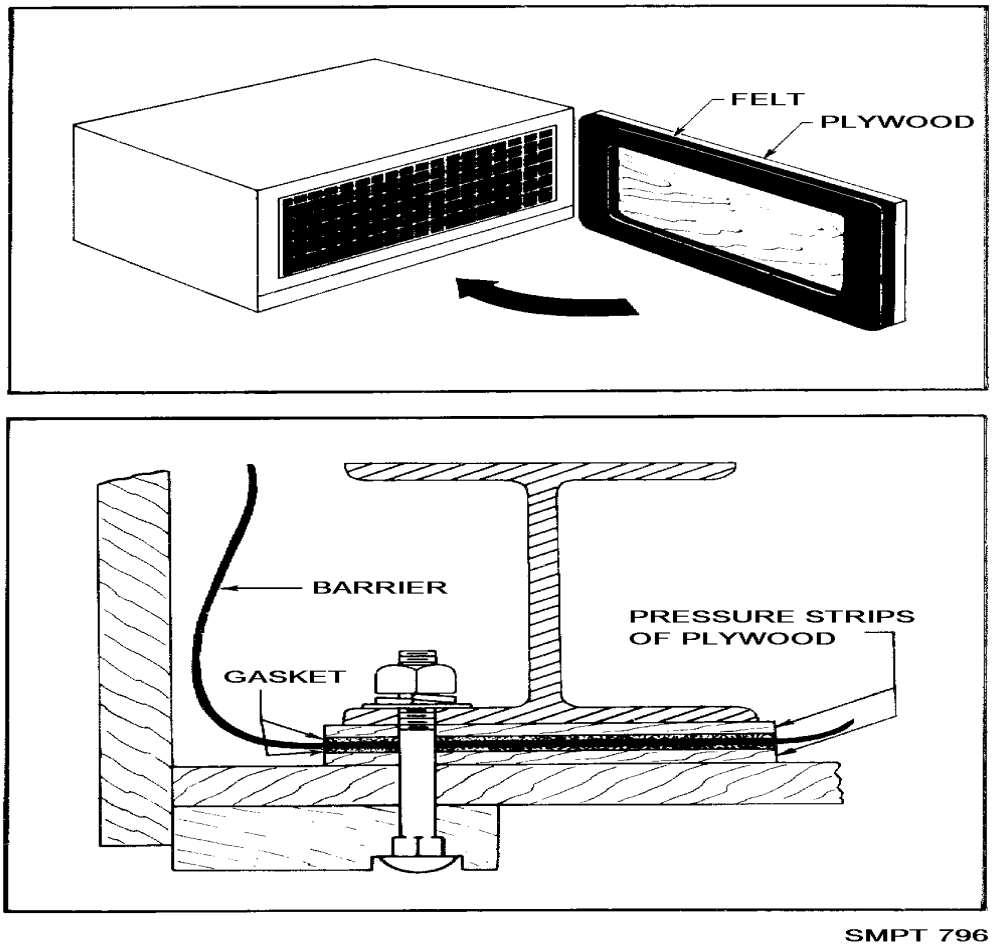

Figure 1-15. Protection for barrier and item surfaces.

PLYWOOD BLOCKING AND BRACING

Plywood is used to distribute the load when the face of an item is flat but structurally weak and the weakness prevents that face from being used as a bearing area. By covering the face of the item with a sheet of plywood, so that the plywood bears on stronger portions of the face, the load of the item is distributed uniformly against the container and injury to the weak face is prevented. The edges of the plywood sheet are padded with felt, if necessary, to prevent the plywood from marring the surface of the item (fig 1-15). Plywood can be used for making pressure strips to distribute the load of an item on the gaskets when a floating water-vaporproof barrier is used. This method, which minimized the possibility of barrier damage during shipment, is illustrated in figure 1-15. When it is not practical to block an irregular item to transfer the load evenly to all faces of the container, it is wise to secure the item to a solid base which may in turn be blocked to evenly distribute the load. If the container is of fiberboard, plywood serves as a good pallet to which the item may be bolted or strapped. The plywood, in turn, is securely blocked into the container by a holddown or top pad. Thin plywood is used to advantage where the blocking must be flexible to conform to a curved surface.

Plywood is used where thin material is required as a brace in tension. When an item is to be bolted to a base or auxiliary base, plywood is used for the base because of its resistance to splitting (fig 1-16). Since plywood is obtainable in wide panels, it is especially useful in base construction. For light items, 1/2-or 3/4-inch plywood should be used. For medium and heavy items, two or more pieces of plywood can be fastened together, or a series of strengthening cleats can be added to the panel. The cleats also may be of plywood to reduce the possibility of splitting.

COMBINED PLYWOOD AND LUMBER BLOCKING AND BRACING

Plywood and lumber, combined into a blocking and bracing assembly, unite the advantages of a strong, lightweight sheet material with a material that is easily cut and nailed. Plywood is used as a sheet with wooden blocks nailed to the sheet. The number, dimensions, and placement of the wooden blocks depend upon the shape of the item, its depth, the position of any projections, and the loads to be supported at the various bearing areas. The required thickness of the plywood depends upon the span between the blocks and the load to be distributed. The sheet of plywood must be stiff enough to resist bending so as to evenly distribute the weight of the item. Position the blocks upon the plywood sheet at places where the item can withstand concentrated loads. Wherever possible, locate the blocks and braces against the stronger portions of the item. Choose nails that are long enough to permit clinching after being driven through the wooden blocks and the plywood sheets. If clinching is impractical, drive the nails through the thinner piece first. Cover all surfaces of wood blocks contacting the item with felt and glue in place. Where the felt-covered blocks normally contact critical surfaces of the item, use greaseproof or water-vaporproof barrier material between the felt and the item. Eliminate time consuming construction of a framework at the time of packing by using prefabricated blocking.

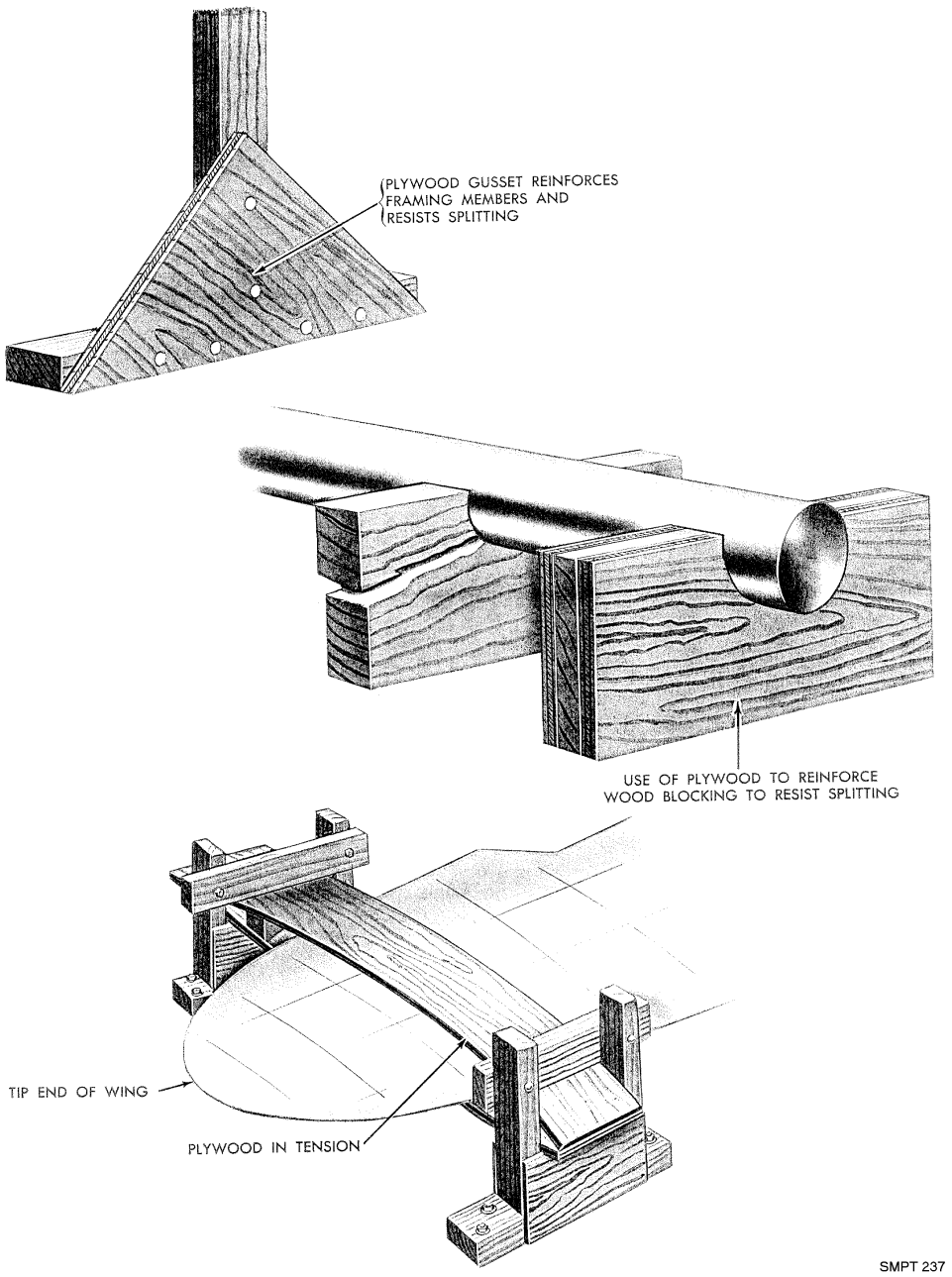

Figure 1-16. Uses of plywood for blocking and bracing.

NAILS AND NAILING

Nails shall conform to the requirements of ASTM F 1667-95. All nails that are not clinched shall be cement coated, etched or mechanically deformed (helically or annularly threaded). Unclinched nails shall be as long as practicable without splitting the material, but not shorter than three times the thickness of the member holding the nailhead for tenpenny nails and smaller, or not shorter than the thickness of the same member plus 1 1/2 inches for twelvepenny nails and larger. Nails loaded transversely to their length (lateral) in blocking and bracing joints need not be clinched. End

grain nailing in solid wood or edge nailing in plywood shall not be permitted. Nails shall be driven through the thinner member into the thicker member wherever possible. Nails shall not be subject to withdrawal stresses. Nails shall be driven not closer to the end of a piece of lumber than the thickness of the piece and not closer to its side than one-half its thickness. There shall be at least two nails in each joint. Lateral loading of nails for blocking and bracing shall be in accordance with table 1-4. Ends of blocks and braces shall not be fastened to a wood container by end-grain nailing methods. Blocking and bracing shall be applied against areas of item(s) that are of sufficient strength and rigidity to resist damage. A description of the various types of nails and general requirements for their use are given in chapter 3. Standard sinker and cooler nails are particularly well suited for use in blocking and bracing and should be coated or chemically etched etched especially if the nails cannot be clinched. If nails fail when subjected to forces of direct withdrawal, apply nails so that they are subjected to forces of lateral displacement rather than direct withdrawal, that is, the direction of the nails is perpendicular to the direction of the load, rather than in line with the direction of the load.

BOLTS AND BOLTING

Carriage or step bolts shall be used as fastenings for wood or plywood blocking and bracing where necessary to facilitate disassembly for removal of container contents. Bolts shall also be used for fastening blocking and bracing members that are too thick for proper fastening with nails. Bolt holes in wood or plywood shall be of the same diameter as the bolts. Bolts commonly used for blocking and bracing are machine bolts, carriage bolts, and step bolts.

Step bolts are preferred for this use because of their larger head diameter. J- or U-bolts are used for special conditions where regular bolts cannot be applied (fig 1-17). Tie rods and J-bolts are actually extended bolts, applied in pairs either vertically (fig 1-18) or diagonally (fig 1-19), and are used where standard length bolts would not apply. See table 1-5 for the suggested allowable load for the various sizes of bolts. The following precautions should be observed in the use of bolts:

Items such as machines or subassemblies having bolt holes in parts which are sturdy enough to resist breakage when rough handling should, if practical, be bolted to one face of the container. If nonprecision bolt holes are involved, the diameter of the bolt should be the nearest standard size consistent with the diameter of the hole.

Table 1-4. Allowable lateral loads for unclinched cement-coated or etched common wire nails when used for blocking or bracing.

Species of wood	Load, pounds per nail								
	4d	6d	8d	10d	12d	16d	20d	30d	40d
White pine, ponderosa pine, spruce and other group I woods	14	17	21	25	26	29	38	42	48
Southern yellow pine, Douglas fir, western larch, and other group II woods	21	26	32	39	40	45	58	65	73
Oak, maple, birch, beech, ash, and other group III and IV woods	26	32	40	48	49	55	71	80	90

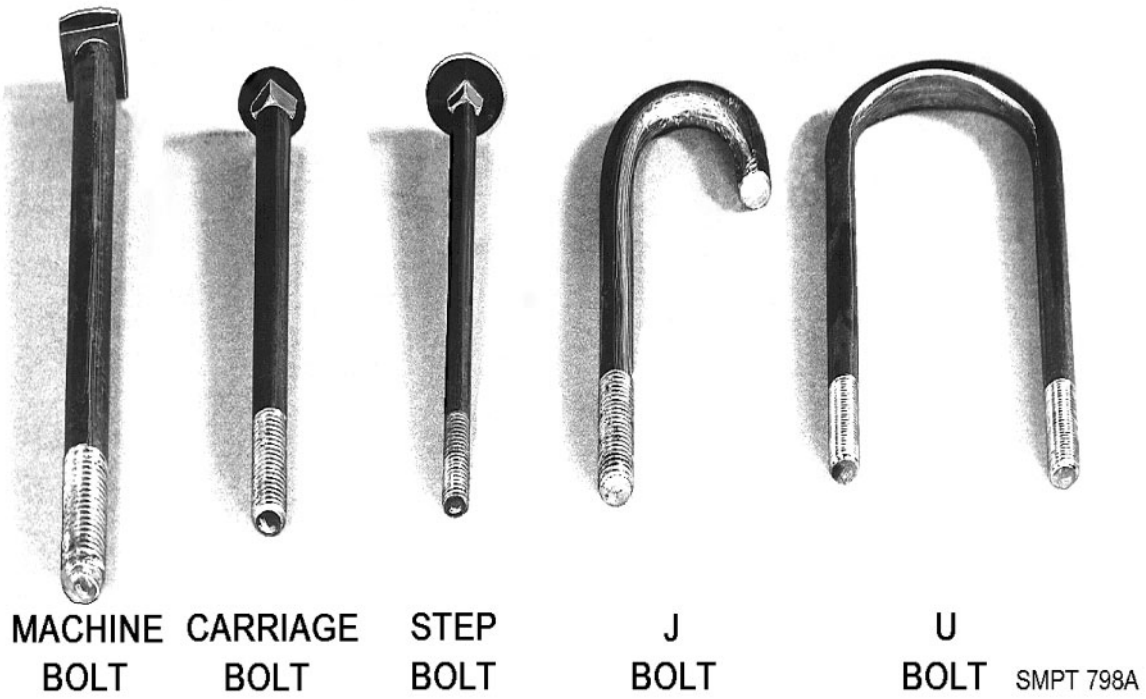

Figure 1-17 Bolts for blocking and bracing.

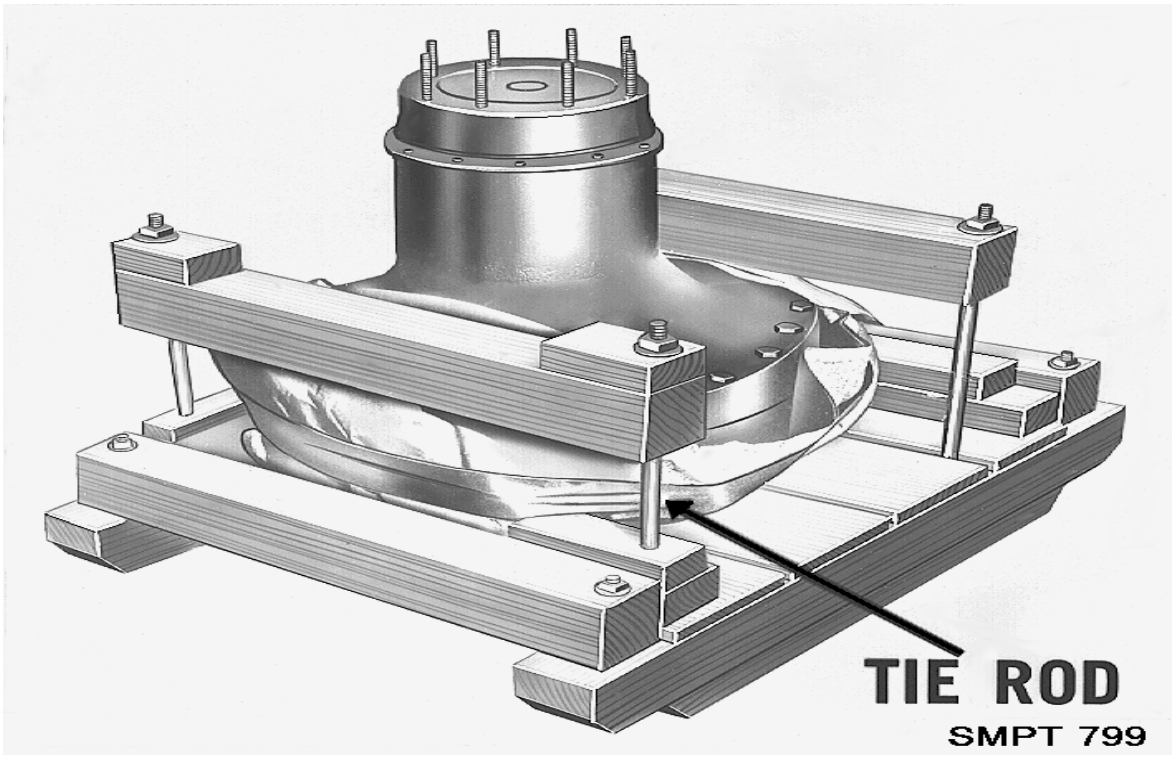

Figure 1-18. Vertical use of tie rods.

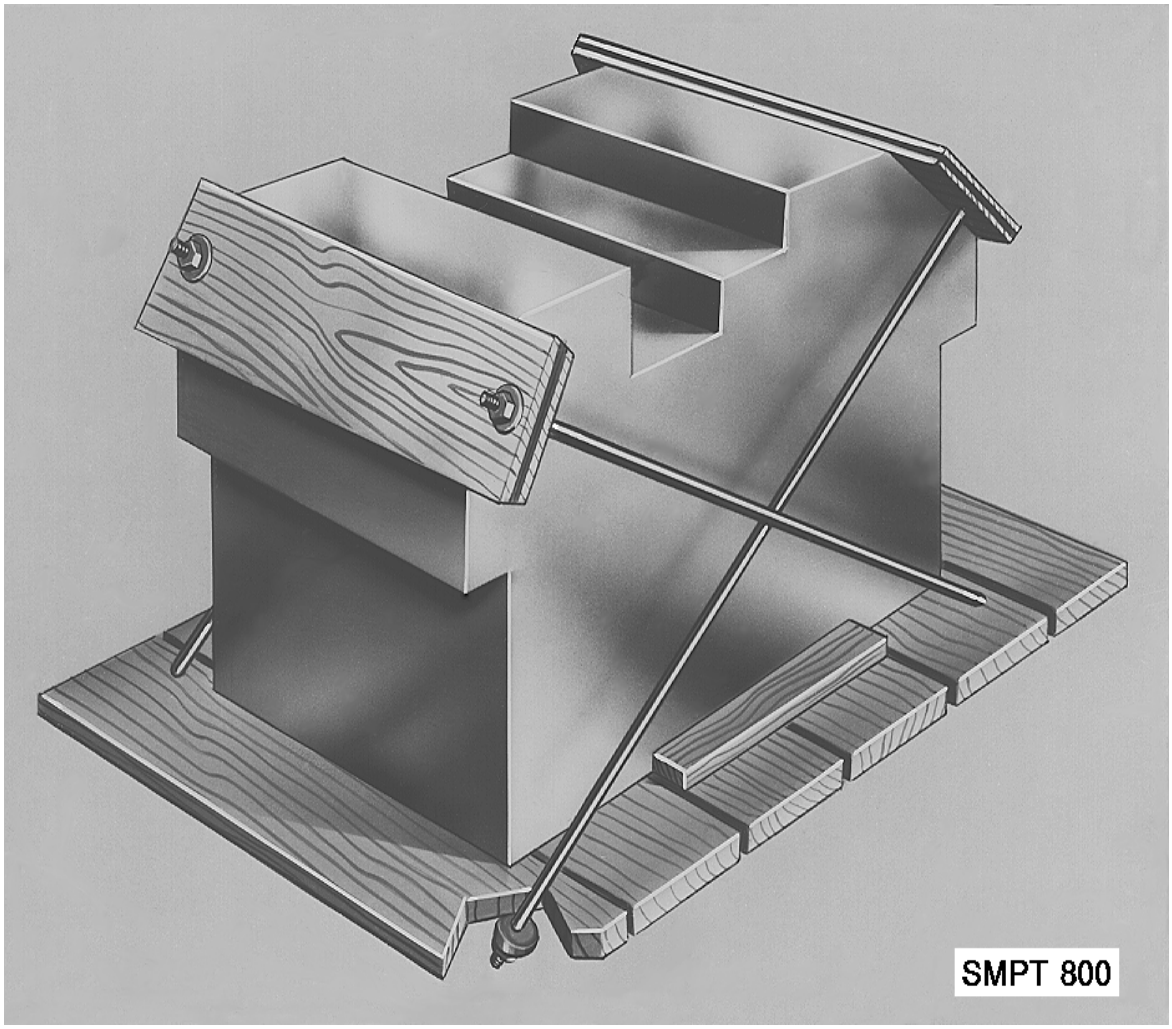

Figure 1-19. Diagonal use of tie rods.

Table 1-5. Suggested allowable lateral loads for bolts-impact loading

Diameter of bolt (inch)	Allowable load (pounds)
3/8.....	35
1/2.....	90
5/8.....	150
3/4.....	200

If precision bolt holes are involved, precautions should be taken to insure that precision fitting bolts of the proper fit and characteristics are used to prevent marring or elongation.

Lag bolts should not be used for blocking and bracing.

Holes bored through containers or mounting bases must be the same size as the diameter of the bolts to be used. When mounting items to container bases equipped with skids, extend the bolts through the skids, whenever practical, and in such instances countersink the bolt in the outer surface of the rubbing strip. Use standard cut washers under the nuts to decrease the possibility of the bolt pulling through the wood. Make sure that the nuts do not come loose intransit by turning the nut securely on the bolt, and either upsetting or nicking the threads of the bolt beyond the nut; applying asphaltum, paint, or lacquer on the threads; using lock nuts; or using cotter pins with the nuts; or lock washers. Metal plates or flat washers are used between lock washers and wood to prevent direct contact.

Bolts and nuts that are not corrosion-resistant must be completely covered with corrosion preventative compounds. The compound must be thoroughly set before the bolts are used.

Where the item has strong frame members fairly close to the face of the container, consider using U- or J-bolts. Whenever feasible, the nut end of the U- or J-bolt should be on the outside of the container. In such cases, it is especially important to upset the threads or otherwise prevent the nuts from loosening.

Use tie rods as extended bolts to secure items when J- or U-bolts are unsuitable. Place tie rods in pairs, either diagonally or vertically as may be necessary. Attach the tie rods to a reinforced point of the container and use them with washers bearing against the wood. Be sure the tie rods pass through the base at an angle which will not cause bending or kinking of the rod. Any kinking will weaken the rods and increase the possibility of failure.

ANCHORING

Anchoring of heavy items should be accomplished by securing the item to a base by tension devices, either by bolts through mounting bolt holes on the item (bolting down); or by metal strapping, cables, tie rods, chains, wire, or other tension devices attached to, or applied over, the item (tiedown or holddown); or by both. The same washer requirement as specified for bolts of equal diameter should apply to tie rods.

ANCHOR BOLTS

Carriage or step bolts should be used. Articles having mounting holes in areas that can withstand rough handling without breakage shall be bolted to either the base of the container or an auxiliary base. The bolt heads of anchor bolts (those holding the item to the container base or the auxiliary base) should be on the outside of the container, otherwise on the underside of the auxiliary base. The heads of all anchor bolts shall bear against a wide washer conforming to FF-W-92, type A or B, grade I, class A, medium size, except that the minimum diameter or minimum size of square bolts shall be as specified in table 1-6 when the member adjacent to the bolt head is wood. Bolts through mounting bolt holes shall form a snug fit, except that precision holes shall be bushed to prevent damage by anchor bolts. In a crate where the item is bolted to a skid-type base, the anchor bolts shall pass through the

skids or through loadbearing members that are bolted to the skids. Bolt holes in wood should be of the same diameter as the bolts. The maximum allowable load for anchor bolts required and the minimum size of wood-bearing washers should be as specified in table 1-6. When the weight of the item exceeds that shown which can be anchored adequately using allowable loads in table 1-6 and all of the available mounting bolt holes on the item, the excess weight shall be taken care of by tiedown provisions specified herein. After the nuts have been tightened, the exposed bolt thread should be painted with asphalt unless locknuts or cotter pins are used. The required size and quantity of bolts used as tie rods or for anchoring the ends of the tiedown tension members should be in accordance with table 1-6. Lag bolts should not be used in lieu of carriage or step bolts.

METAL BRACKETS OR FRAMES

Many items have attachment points which provide facilities for bolting, but often these points are not located on the base, so that brackets must be used to fasten the item to the container. In those situations where tie rods or U- or J-bolts cannot be used, specially constructed brackets, sleeves, or frames made entirely of metal, wood, or a combination of these, are used to act as intermediate connections between the item and the container. These frames or brackets must be designed with sufficient strength and fastening facilities to hold the item to the container securely. Select sleeves that will fit the interior of the container snugly and will have sufficient structural strength to support the load (fig 1-20).

Table 1-6. Maximum allowable loads and minimum sizes of wood-bearing washers for anchor or tiedown bolts.

Diameter of bolt	Wood-bearing washers		Maximum allowable load per bolt		
	Minimum diameter of round	Minimum size of square	Items weighing 200 pounds and less	Items weighing 200 to 3,000 pounds	Items weighing over 3,000 pounds
Inch	*Inch*	*Inch*	*Pounds*	*Pounds*	*Pounds*
1/4	1.35	1.00	10	----------	----------
5/16	1.75	1.25	30	----------	----------
3/8	2.10	1.50	50	75	----------
2	2.85	2.10	100	150	300
5/8	3.60	2.65	150	225	450
3/4	4.70	3.25	----------	375	750

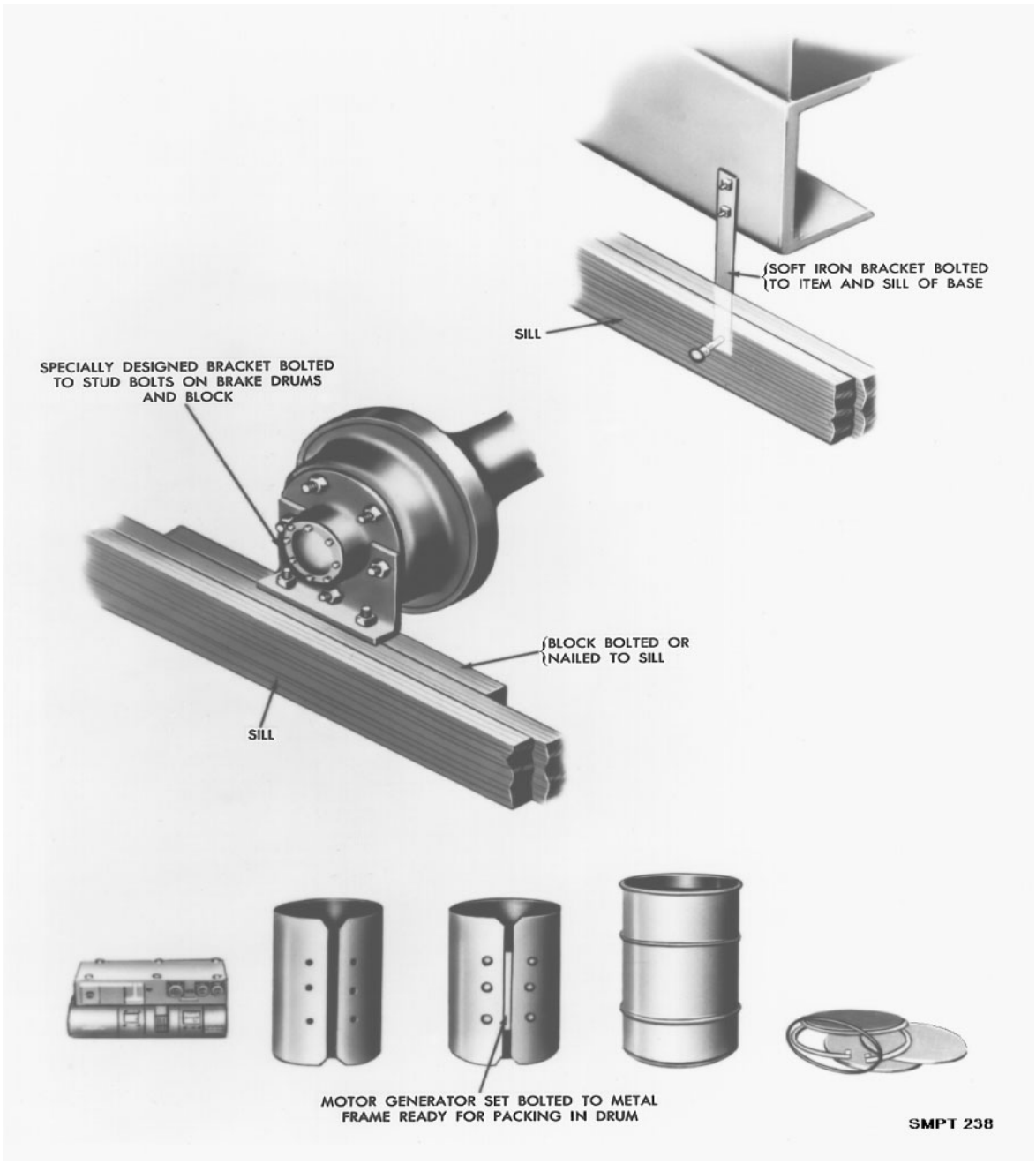

Figure 1-20. Use of metal brackets, frames, and sleeves.

METAL STRAPPING

Metal strapping used to tie down an item to the base or other face of the container or to an auxiliary base should be flat steel strapping material conforming to ASTM D 3953 and ASTM D 4675. Tiedown strapping shall be securely attached to fig 1-20 or looped over the item. It shall be anchored to the container or auxiliary base either by looping around a load bearing member or by utilizing steel slotted anchor plates for flat strapping secured to the container or auxiliary base. Padding material or suitable edge protectors, as applicable, shall be used under the straps to prevent damage to the item. Whenever possible, all strands holding down an item shall be of

approximately the same length. Maximum allowable loads for each strand of tiedown strapping shall be in accordance with ASTM D 4675. Each tiedown strap passed over an item should be considered as one strand. All tiedown strapping shall be tensioned and sealed or tied securely.

STRAPPING PRECAUTIONS

Metal strapping may be the only convenient way in which an item or container can be secured or reinforced (fig 1-21). Metal strapping may be flat steel material. Strapping is tensioned and preferably sealed with specially designed tools. If this is not possible, flat strapping can be held in place with anchor plates. General precautions on the use of metal strapping which applies to flat steel are as follows-

Where possible, the item and its support must be completely encircled. When it is impossible to do this, anchor the two ends of the metal strapping as follows:

- For flat strapping, anchor the two ends of the strap to the container base with anchor plates, or if the strap is designed for nailing, nail the ends of the strap to the container base. Place the nails so that the straps exert a pull at right angles to the nail axis. For round wire, anchor the two ends of the round wire to the container with drivescrews and staples. Loop the wire around the shank of the drivescrew and further anchor the wire by means of staples. Be sure the wood is thick enough to hold the entire length of the drivescrew and that the drivescrew is of adequate gauge to carry the load. When drivescrews are used, place them so that the wire exerts a pull right angles to the drivescrews axis. Apply tension to the strap with a tension tool and seal the strap in the customary manner. Use a one-piece strap wherever possible. Straps should be placed only on those strong portions of the item which can withstand the impact load and weight of the item. Where strapping passes over a sharp edge of the item, use corner protectors, if necessary, to prevent the strapping from becoming fractured.
- Protective materials should be used between the item and the strap if the strap is likely to scratch or otherwise injure the item. Arrange strapping on the container, where possible, to further reinforce blocking and bracing or anchoring of the item within the container. Use annealed strapping only for lighter items, since it stretches more readily than the more highly tempered tension strapping.

MINIMUM LENGTHS OF STRAPS

The minimum total length of straps shown in table 1-7 does not include that portion of material used to make a secure fastening at the ends of each strand but is the sum of, and does include, all lengths of material between such fastenings. Overall lengths of each strand shall be adequate to permit fastening as specified above.

MAXIMUM ALLOWABLE LOADS

The maximum allowable loads are based on available energy of 8,640 inch-pounds per cubic inch of strap in tension and an assumed drop height of 30 inches, as established by ASTM D 3953. If greater loads are to be tied down or if other sizes of strap are used, additional strapping shall be applied on the basis of 300 pounds of load per cubic inch of strap in tension.

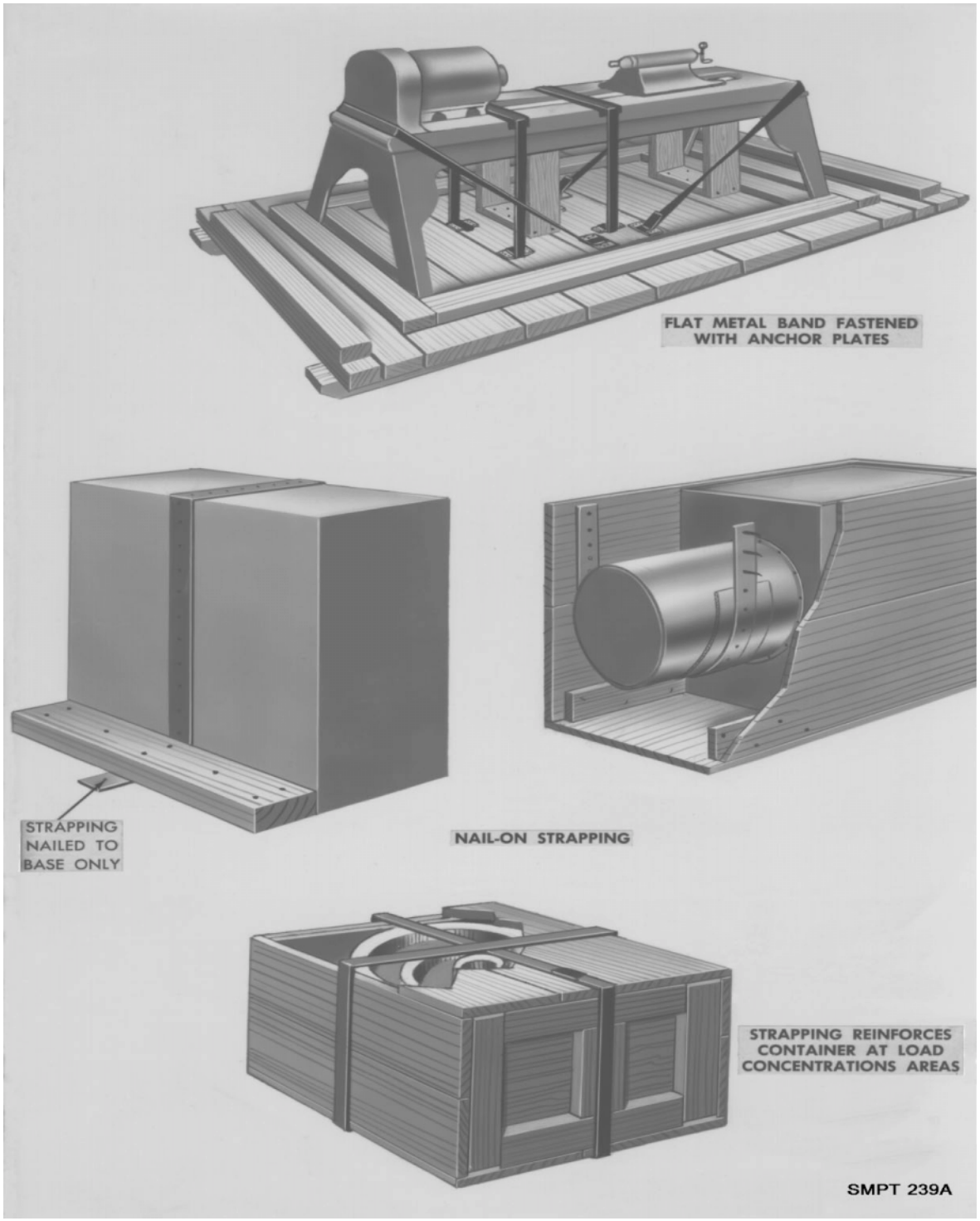

Figure 1-21. Use of metal strapping for bracing and anchoring.

Table 1-7. Tape strips used in handling rigid materials[1]

	Type III tape band width in inches (minimum)									
Gross weight of bundle	Number of encirclements (Example: Three encirclements could refer to either three separately located single wrapped bands or to one band which completely overlaps itself three times)									
Pounds	1	2	3	4	5	6	7	8	9	10
Up to 20 incl.....	3/4	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2
Over 20 to 40 incl.....	1	3/4	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2
Over 40 to 60 incl.....	1 1/4	1	3/4	1/2	1/2	1/2	1/2	1/2	1/2	1/2
Over 60 to 80 incl.....	1 1/2	1 1/4	1	3/4	3/4	1/2	1/2	1/2	1/2	1/2
Over 80 to 100	.....	1 1/2	1 1/4	1	3/4	3/4	3/4	3/4	3/4	3/4
incl.....	.....	.....	1 1/2	1 1/4	1	3/4	3/4	3/4	3/4	3/4
Over 100 to 150	.....	.....	.....	1 1/2	1 1/4	1	3/4	3/4	3/4	3/4
incl.....	.....	.....	.....	.....	1 1/2	1 1/4	1	3/4	3/4	3/4
Over 150 to 200	.....	.....	.....	.....	.....	1 1/2	1 1/4	1	1	1
incl.....	.....	.....	.....	.....	.....	.....	.....	1 1/2	1 1/4	1
Over 200 to 300 incl.....										
Over 300 to 400 incl.....										
Over 400 to 500 incl.....										

[1] If material to be bonded is somewhat flexible, tape widths may be reduced by 25 to 50 percent. In no case should less than 1/2 inch tape be used.

STRAPPING REINFORCEMENT FOR CONTAINERS.

STRAPPING REINFORCEMENT FOR CONTAINERS

In additions to the use of metal strapping as reinforcement for blocking or bracing, its widest use is for reinforcement of exterior wooden containers. Only tempered high tensile strength, flat steel strapping should be used as wood container reinforcement, except in limited instances such as reinforcing of a crate corner where annealed nail-on-type flat steel strapping is employed. For export shipments, bare metal strapping should not be used due to its lack of corrosion resistance. Each military and commercial container specification has a section or an appendix devoted to closure and strapping. It is important that the instruction contained in these publications be observed.

WEB STRAPPING

The use of web strapping to tie down an item to a base, to other faces of the containers, or to built up frame, is NOT considered a good practice. Web strapping has a tendency to shrink or stretch with change in moisture content, thereby losing its ability to hold the item firmly in place. It is hygroscopic, and may cause corrosion to contacting metal surfaces, and it is often difficult to anchor properly.

REINFORCED TAPES FOR PACKING

Various kinds of tapes have been developed with longitudinal filament reinforcing strands to provide high tensile strength. When such tapes are properly applied to containers or bundled items, significant increases in resistance to rough handling are attained. These tapes consist of either a paper or plastic backing, which has been coated on one side with an insoluble pressure-sensitive adhesive, or a gummed adhesive that is activated by a solvent. The high tensile strength of the tape is produced by filaments of

nylon, rayon, glass, or otherfibers that have been lineally aligned and embedded in the backing material. When the tape is applied to the container so that the direction of the rough handling stresses are parallel to the embedded filaments of the tape, considerable container strengthening results. Longitudinal tensile strength of these tapes may be over 500 pounds per inch of width. Some of the advantages claimed for their use are that sufficient tensile strength and elastic properties are present to enable a package or pack to be highly resistant to shock loads. The adhesive holds the tape to the area of application and thus prevents slippage during handling. These tapes do not easily snag and do not interfere with stacking and handling of containers. No special equipment is needed for their application. They provide a means of reducing pilferage.

REINFORCED PAPER, GUMMED TAPE A-A-1492, A-A-1671

There are three types and two classes available. Type I (reinforced, asphaltic laminated) and Type II (reinforced, nonasphaltic laminated) are intended for use in so called single strip closure under the Uniform Freight Classification Rule 41, section 7. Types I and II are used for closure of fiberboard boxes for domestic shipment and storage and for securing wrappers of packages. Type II shall be used where the presence of asphalt would have a deleterious effect on the contents, such as food products. Type III is intended for use in general sealing of cartons, fiberboard boxes, and wrappers and for banding paper and paper products. Class 1 (strippable) is used when ease of opening and removal of the tape is desired. Class 2 (non-strippable) is used when removal of the tape from boxes is not necessary for reuse.

FILAMENT REINFORCED, PRESSURE TAPE ASTM D 5330

These tapes are supplied in four types based on tensile strength. Type I (low tensile strength) has a minimum tensile strength of 160 pounds per inch of width. Type II (medium tensile strength) has a minimum tensile strength of 240 pounds per inch of width for Class A, and 300 pounds per inch of width for Class B. Type III (high tensile strength) has a minimum tensile strength of 425 pounds per inch of width. Type IV (high tensile strength, weather-resistant) has a minimum tensile strength of 400 pounds per inch of width. Only Type II has two classes, based on the transparency of the tape. Class A is opaque or nontransparent, and Class B is transparent enough to allow reading of printed matter through one layer of the tape. These tapes are intended for use in securing packages and reinforcing bundles and containers.

REINFORCED TAPE APPLICATION GUIDELINES

Individual container specifications, and appropriate standards should be checked for the proper use of reinforced tapes. Some basic rules that may be helpful are as follows:

- Do not use a wide tape if a narrower tape is strong enough to accomplish the intended purpose.
- If it is anticipated that high humidity conditions or excessive moisture will be encountered in shipment or storage, use tapes with water insoluble adhesives.

The adhesion of tapes to the surface of a container will depend upon the condition of the surface. Hence, in strip applications, the strips should be long enough to provide sufficient adhesion to take advantage of the full potential strength of the tape. This should require at least 6 or more inches

of good contact between the tape and the container surface. The tape length should be equally divided over a seam, scoreline, or other point of application. In using reinforced paper gummed tape (A-A-1492, A-A-1671) for sealing containers shipped under the jurisdiction of the Interstate Commerce Commission, only the center seam of a container needs to be sealed. This is accomplished by using a strip at least 3 inches wide which must extend no less than 2 1/2 inches over each end of the container.

In using filament reinforced, pressure-sensitive tape ASTM D 5330, the following information will serve as a guide in its use. It should be recognized that special conditions will necessitate occasional deviations from these recommendations in the interest of economy or good practice. The filament reinforced, pressure sensitive tapes are intended for use in reinforcing fiberboard or fiberboard surfaced containers, strapping, bundling, and other miscellaneous applications. Type I, characterized by high elongation and low tensile strength, is best suited for strip reinforcement of containers and anchoring moving parts. Type II with lower elongation but high tensile strength, is also suited for closures. Type III, with higher tensile strength and low elongation, is most effectively used in complete wraparounds such as bundling and other forms of circumferential binding. Type IV should be used where weather resistance is required and should be used in the same length as the type it replaces. These tapes should be applied in continuous strips. Typical application are shown in figure 1-22. Tape should be smoothly and firmly adhered to surfaces which are relatively smooth and nominally free from dust, dirt, grease, and moisture. Care should be taken to avoid excessive handling of tape adhesive surfaces, particularly at the ends of the strips. Such excessive handling might contaminate the surface of the adhesive and reduce its ability to bond firmly.

The high tensile strength tapes are also used for bundling of rods, shafts, or tubular objects for easier handling. Table 1-7 shows the correct amounts of Type III ASTM D 5330 tape for use in bundling. The tape should be applied with sufficient hand tension to "snug" the bundle and secure maximum contact between the tape and the bundled items.

CUSHIONING

CUSHIONING DEFINED

Cushioning is the protection given to items against physical and mechanical damage by means of appropriate materials which absorb the energy of shocks and vibrations through a gradual but increasing resistance to the movement of the item. The energy from shocks and impact is absorbed when the cushioning material is compressed, which in turn increases the pressure upon the entrapped air within the cushioning material, resulting in a damping or minimizing of the force to the item.

CUSHIONING VERSUS BLOCKING AND BRACING

The distinction between cushioning and blocking and bracing is that cushioning permits controlled movement of the item within the container, while blocking and bracing usually are designed to prevent movement of the item within the container.

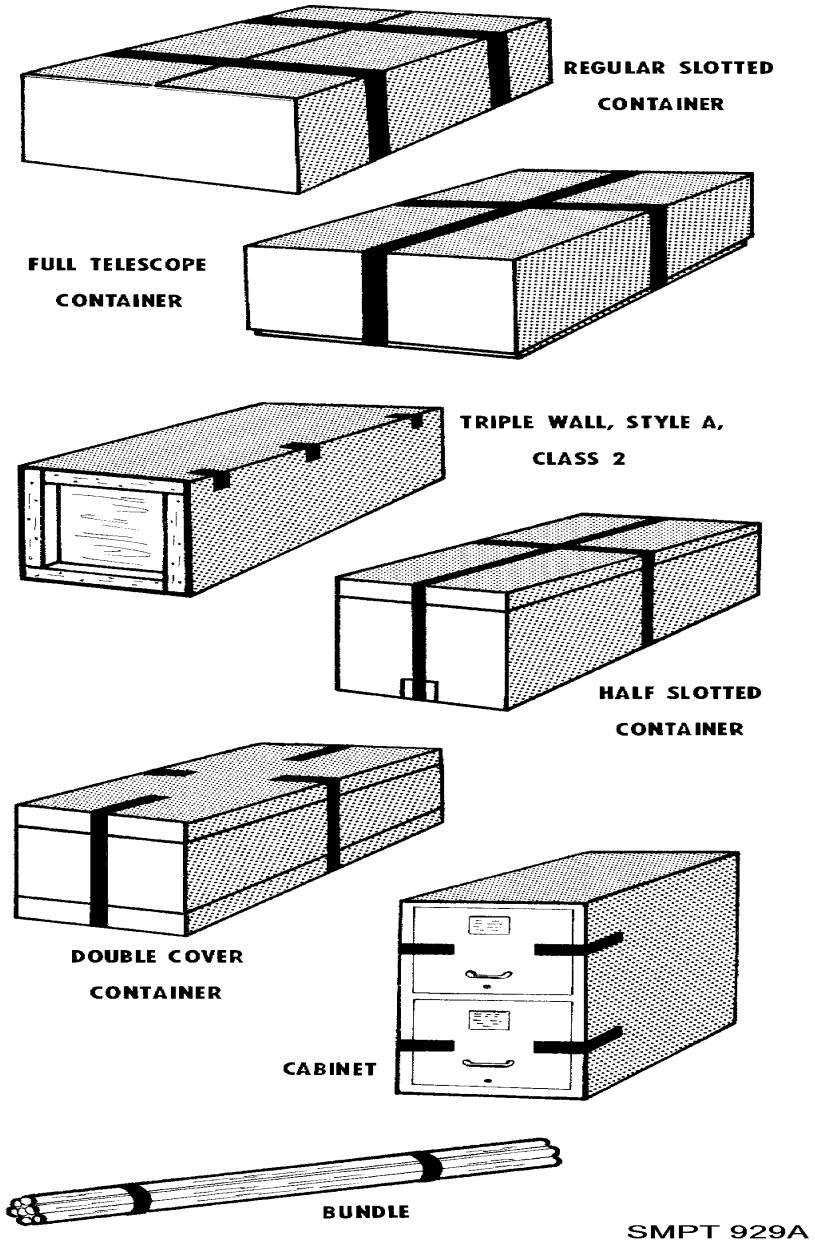

Figure 1-22. Use of filament reinforced tape.

CUSHIONING AND CORROSION

Where applicable, cushioning should be used in one or more of the following ways to provide necessary physical protection. Cushioning materials shall be separated from surfaces which might be corroded at points of contact by either noncorrosive wrapping paper conforming to Specification MIL-P-130 or greaseproof barrier material conforming to Specification MIL-B-121, grade A. If a noncorrosive cushioning material is used, the wrap is not required. Cushioning materials containing asphalt shall not be permitted to come in direct contact with highly finished, varnished, or lacquered surfaces.

FLOTATION OR SUSPENSION

Delicate or fragile items should be protected against shock and vibration by flotation or suspension within the shipping container by suitable cushioning materials. These materials may be in sheet form applied to give support at top, bottom, sides, and ends of the item. For items in sturdy cabinets, cases, consoles, or packed in an inner box, the cushioning material may be in the form of prefabricated corner pads. Materials shall be bound fiber conforming to PPP-C-1120; fiberboard conforming to ASTM D 4727; cellulosic material conforming to A-A-1898; expanded polystyrene conforming to PPP-C-850; prefoamed polyurethane conforming to MIL-P-26514; foam-in-place materials complying with MIL-F-83671; or such other materials as specified in the procurement documents.

ABRASION PROTECTION

Protection against abrasion should be provided for highly finished or easily marred surfaces by wrapping or covering with cushioning material. Surfaces damaged by contact with cushioning material should be separated by a covering of noncorrosive paper conforming to MIL-P-130 or MIL - P-17667 or greaseproof barrier material conforming to MIL-B-121, Grade A.

COATINGS AND BARRIERS

Protection should be provided for strippable compound coatings and for greaseproof, waterproof, or water vaporproof barriers at points of contact with blocking, bracing or projecting members of containers. Cushioning materials should be applied to reduce the static pressure at points of contact of 30 pounds or less per square inch.

MOISTURE RESISTANCE

Unless otherwise specified in the product specification, cushioning material conforming to A-A-1898 should be of the water resistant type.

DUSTING

Cushioning materials that are not dust producing should be used for packing items that are adversely affected by dust, unless a dustproof barrier is used to prevent dust from reaching the item.

FACTORS INFLUENCE CUSHIONING SELECTION AND USE

Shock resulting from rough handling or dropping of a shipping container is the usual cause of mechanical damage to the contents. The purpose of package or item cushioning is to reduce the intensity of the shock reaching the packed item to a level which the item can withstand. Factors influencing cushion design are the fragility and weight of the item, the load-bearing area of the cushion, the dynamic, force deformation characteristics of the cushioning material, and the equivalent height of drop (usually 30 inches) for which protection is desired. Among these, the fragility and weight of the item are fixed values for any particular item. The load-bearing area of the cushion can be altered by suitable blocking or by packing the item in an inner container, if desired.

CONCEPT OF CUSHIONING

Cushioning is the protection from physical and mechanical damage afforded an item by means of compressible and resilient materials, known as cushioning materials, designed to absorb the energy of shocks and vibration caused by external forces. Details on "Package Cushioning Design" may be obtained in MIL-HDBK-304.

FUNCTIONS OF CUSHIONING

In order to properly utilize the many cushioning materials available in the military supply system, it is necessary to understand the functions of cushioning. Among these functions (fig 1-23) the more important are--

- Controls movement and prevents damage caused by vibration. Cushioning, when properly applied, controls the movement of the item within the barrier or container and dampens vibration.
- Protect fragile or delicate components. When fragile or delicate components form a part of an otherwise rugged item, they may be disassembled and packaged separately. If disassembly is not permitted and they must be left in place, cushioning is applied to give them protection.
- Prevent rupture of barriers and containers. Many items have sharp corners or projections which could puncture the barriers or containers in which they are packaged, resulting in the entry of moisture or water. Cushioning is applied to these projections or corners to insure that waterproof or water-vaporproof barriers are not rendered useless by such damage.
- Distribute forces. Cushioning materials reduce the shock to an item by distributing forces over a large area, thus lowering the stress concentration at any one point on the surface of the item.
- Prevent abrasion. Items with highly finished surfaces which may be marred by blocking, strapping, contact with container surfaces, or contact with other items in the container, must be protected against abrasion by cushioning. Usually, lesser amounts and thickness of cushioning materials are employed to accomplish this cushioning function.
- Absorb shocks. Perhaps the most frequent and important use of cushioning is to absorb the energy resulting when an impact shock strikes a container. This shock energy is absorbed as the cushioning material is compressed by the impact.

MULTIPURPOSE CUSHIONING

The foregoing functions of cushioning should not be considered separately because cushioning is often used for more than one purpose in the same package. Material selected to protect an item against shock may at the same time minimize movement, prevent abrasion, protect barriers, and cover sharp projections. Many cushioning materials also act as good insulation to protect items against drastic temperature changes. Cushioning may be required to absorb liquids and consequently must have liquid-absorbing qualities to prevent liquid flow in case of breakage of the containers.

REQUIREMENTS FOR THE USE OF CUSHIONING MATERIALS

In addition to the requirements established in cushioning specifications in regard to material quality, construction, and performance, other important requirements must be met when cushioning materials are used within waterproof or water-vaporproof barriers. Sound packaging design practices dictate placing only the minimal required amount of cushioning material within water-vaporproof barriers, thereby minimizing the barrier area and the desiccant requirements. in addition,

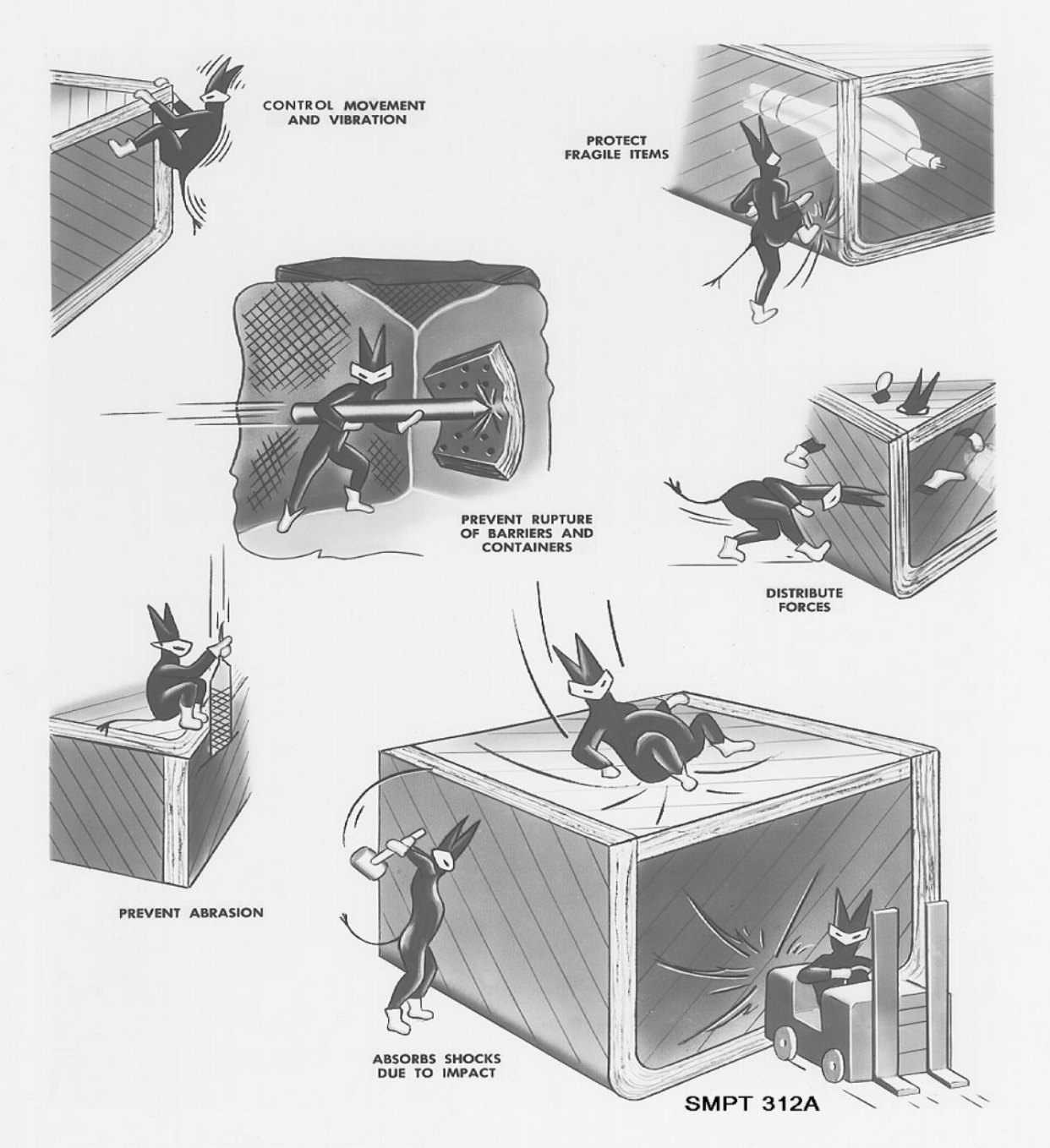

Figure 1-23. Functions of cushioning.

- Cushioning shall be as dry as practicable.
- If the item is coated with a preservative, the preserved item must first be wrapped in a barrier conforming to MIL-B-121, Grade A, QQ-A-1876, or MIL-B-22191, Type I or II, before applying the cushioning material.

CUSHIONING SELECTION FACTORS

There are several factors that must be considered in selecting the appropriate cushioning material for a given application. The nature and physical limitations of the item, the favorable and unfavorable characteristics of the

cushioning material, the destination of the packages, and the means of transportation must all be taken into consideration before an item can be properly cushioned.

NATURE OF THE ITEM

In planning to cushion an item, the nature and physical limitations of the item must first be considered. The shock resistance, size, weight, shape, surface finish, and the degree of disassembly permitted will influence the way an item is to be cushioned (fig 1-24).

SHOCK RESISTANCE OR FRAGILITY

Fragility may be observed, but cannot be measured accurately by eye. The tendency is to overcushion seemingly fragile items and to undercushion seemingly sturdy items. Fragility-the greatest amount of dynamic force an item can withstand without destruction--can be measured with scientific instruments. The term "G-factor" has been accepted as indicating the shock resistance of an item. This resistance is determined by measuring the peak acceleration (deceleration) an item will withstand during impact and dividing this acceleration value by the acceleration due to gravity (32.16ft/sec/sec). This is expressed as--

$$\text{G-factor} = \frac{\text{Acceleration of the Item}}{\text{Acceleration due to Gravity}}$$

The G-factor values of many military items are being determined. In the absence of known G-factor values, the selection of cushioning must be based on experience with previous shipments and testing of similar items, or by assuming a G-factor for drop test purposes.

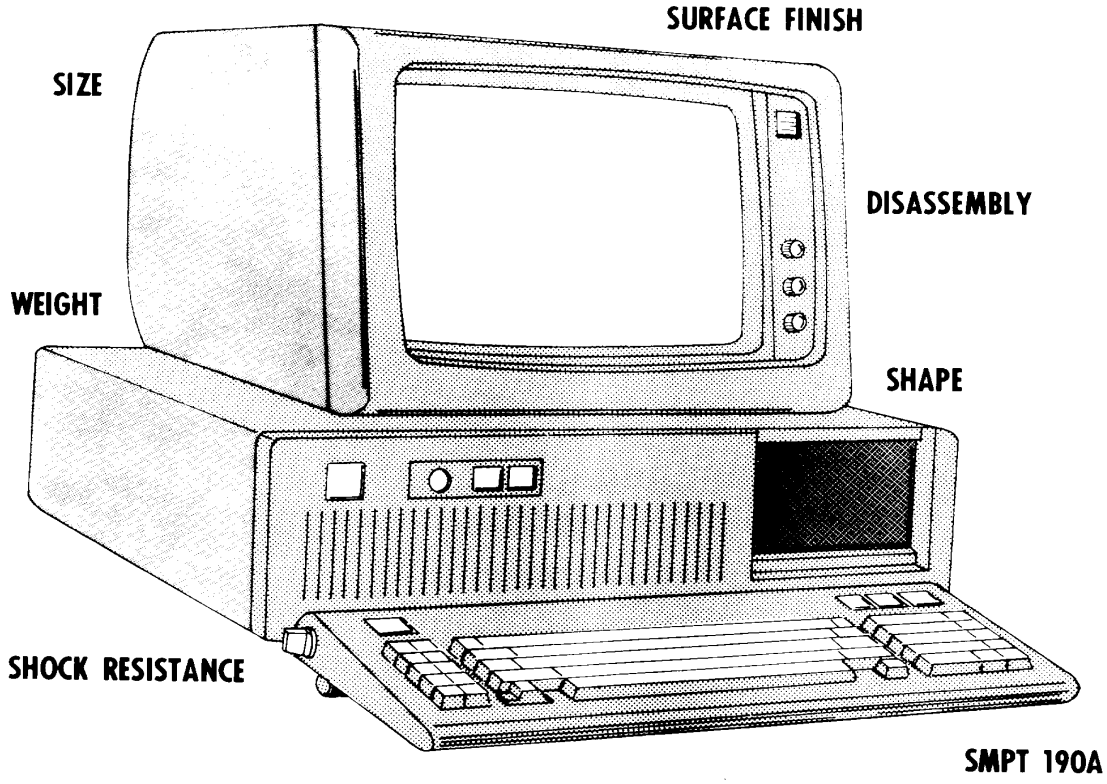

Figure 1-24. Item characteristics determines the selection of cushioning materials.

SIZE

A large item may require a thinner layer of cushioning than a smaller item of the same weight because there is less load per square inch applied to the cushioning. This should be kept in mind when an item is irregular in shape- more cushioning may be required at the small end than at the large end.

WEIGHT

Weight in motion results in force, and force can cause damage. Thus, the weight of an item controls the thickness, quantity, and firmness of the cushioning material to be used. Generally, the heavier the item, the firmer the cushioning must be.

SHAPE

A regular-shaped item will ordinarily fit snugly into a container with a minimum of cushioning, while an irregular-shaped one may require a complicated arrangement of pads and cells or foamed-in-place cushioning to bring it to a more regular shape. Light, small items which are irregular in shape can be made regular and at the same time positioned and held in the container merely by a wrap of cushioning material. Large, irregular items may make it impractical to use cushioning materials to make them regular. Blocking and bracing will have to be employed to adequately protect such items.

SURFACE FINISH

An otherwise sturdy item may have highly finished surfaces which could be damaged by the rubbing action of harsh abrasive cushioning material, or the surfaces may be corroded and pitted by chemical action due to the presence of moisture and acidic or basic elements in the cushioning material.

CHARACTERISTICS OF CUSHIONING MATERIALS

The chemical and physical properties of cushioning materials are many and may display both desirable and undesirable characteristics. These characteristics vary in importance for different applications. What might be a highly desirable characteristic in one application, may be detrimental in another. For instance, high moisture absorbency is required for packaging liquids, but is not desirable when packaging corrodible metal items.

Compression set (fig 1-25) is the difference between the original thickness of a cushioning material and the thickness of the same material after having been released from compression under a standard load for a given period of time. This is important in determining whether a cushioned item can remain in storage for an extended period of time without causing the cushioning to lose its resiliency. Permanent compression set is undesirable when it creates free-moving space in the container.

Resilience (fig 1-25) is the ability of a material to absorb a series of shocks and return to its original shape and thickness after each shock. Few materials are completely resilient and this quality is often greatly altered by changes in temperature. Rubber, for instance, is highly resilient in temperate zones, but loses its resilience under extreme climatic conditions. Rate of recovery (fig 1-25), or the time it takes for a cushioning material to return to its original shape after compression, is also important as some materials have too rapid a rate of recovery and "spring back" so quickly that damage to the item may result.

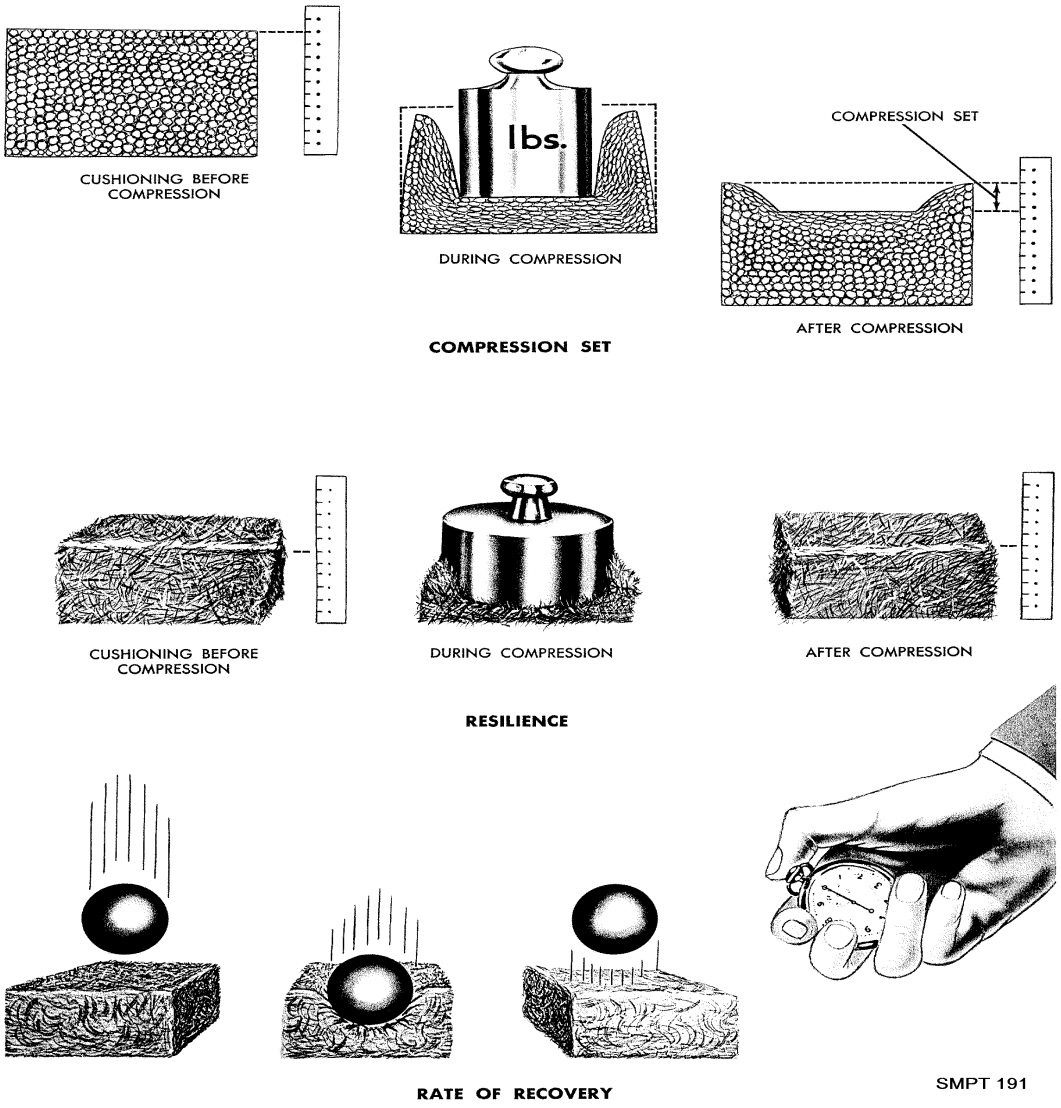

Figure 1-25. Characteristics of cushioning compression set, resilience, and rate of recovery.

Dusting, which results from the breakdown and disintegration of certain materials used for cushioning, allows small particles to become detached and work into crevices and critical working surfaces of the cushioned item (fig 1-26).

The corrosive effect of some cushioning materials is undesirable when packaging items with critical surfaces. When this cannot be avoided, the item must be shielded from such materials by a neutral wrap or liner. Cushioning materials with a high acidic or basic content must not be enclosed within waterproof or water-vaporproof barriers (fig 1-26). When cushioning material contains natural hair, it shall be treated with insecticide to prevent carpet beetle infestation.

Fungus resistance of some materials is low and allows for the growth of mold, mildew, and other fungi. Many materials can be treated to inhibit such growth. However., such treated materials are often very corrosive to metal surfaces and must be isolated from them (fig 1-26).

The abrasive characteristics of some materials are factors which must be considered when protecting precision surfaces such as the lenses of optical instruments. Some cushioning material are soft-textured and generally can be placed in contact with easily marred surfaces. Coarse textured materials should not be used on such surfaces (fig 1-27).

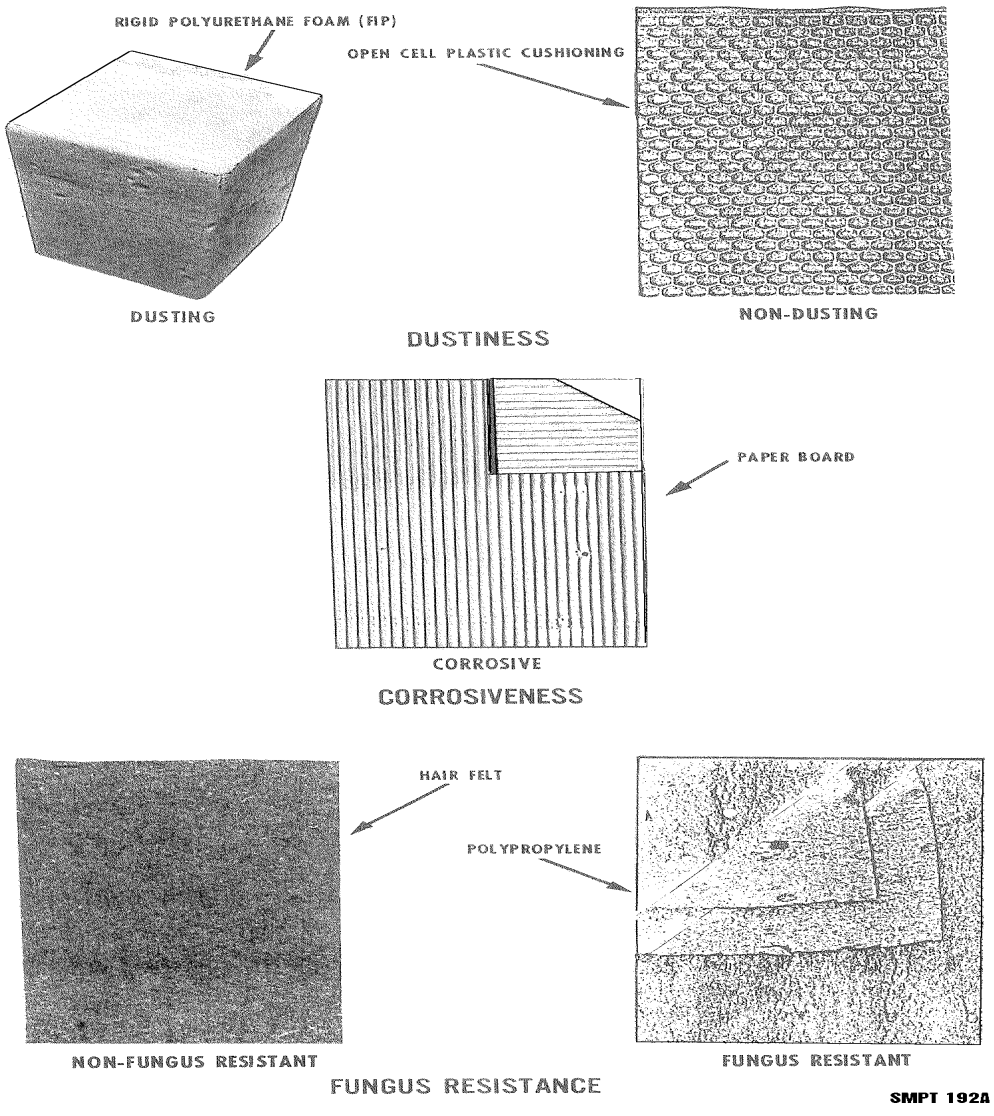

Figure 1-26 Characteristics of cushioning dustiness, corrosiveness, and fungus resistance.

Low temperature performance of certain cushioning materials makes them suitable for use in high altitude transport and in shipments to cold regions because they remain relatively soft and resilient (fig 1-27).

Other characteristics which should not be neglected in choosing cushioning materials are fire resistance or flammability (fig 1-27), and the possibility of the materials causing skin irritation to personnel who come in contact with it.

Destination of the Item

The destination of the item is a factor in cushioning. Many cushioning materials change their characteristics under extreme climatic conditions. Some materials become so rigid or brittle at extremely low temperatures as to make them useless as cushioning materials. In tropical climates, some materials soften and lose their cushioning qualities. In jungles or rainy locations, some materials will pick up excessive moisture which will result in the loss of resilience and will lead to growth of fungus and accelerated corrosion.

Means of transportation. The means of transportation must not be overlooked. Hazards and handling situations vary greatly between air, motor, rail, and ship. For example, there may be considerable difference between the amount of handling that an item being transshipped from truck, to rail, to ship would get and one that is being shipped by air freight. Likewise, an item to be delivered by air drop would require different protection from one that would be delivered by truck.

REPRESENTATIVE CUSHIONING MATERIALS

Cushioning Material, Uncompressed Bound Fiber (PPP-C-1120)

This material may consist of any suitable natural hair, vegetable fiber, or synthetic fiber bound with an elastic material. Horsehair, sisal, and cactus fibers sprayed with latex are examples. It is furnished in five types and two classes and three grades. Type I is soft, Type II is medium soft, Type III is medium firm, Type IV is firm, and Type V is extra firm. When specified, each type shall be identified with a color matching as closely as possible to colors shown in Federal Standard 595, as follows: Type I, brown; Type II yellow; Type III, orange; Type IV, red; and Type V, black. Class A is water-resistant and Class B, a commercial class, is not necessarily water-resistant. Grade 1 is a flame resistant material; Grade 2 provides low temperature characteristics; and Grade 3 is a standard material. This material may be supplied as uncompressed sheets and rolls and in molded shapes to fit the contours of the item. The materials have a high degree of resilience, low compression set, fair damping quality, and do not disintegrate easily. They are neutral and have a low water-soluble acidity so that their corrosive effects are slight. Moisture content and moisture absorption are both low; however, the materials may need to be treated for fungus resistance. Their performance is good at low temperature. They are intended to protect items against vibrational and impact shocks where resilient and water-resistant cushions are required.

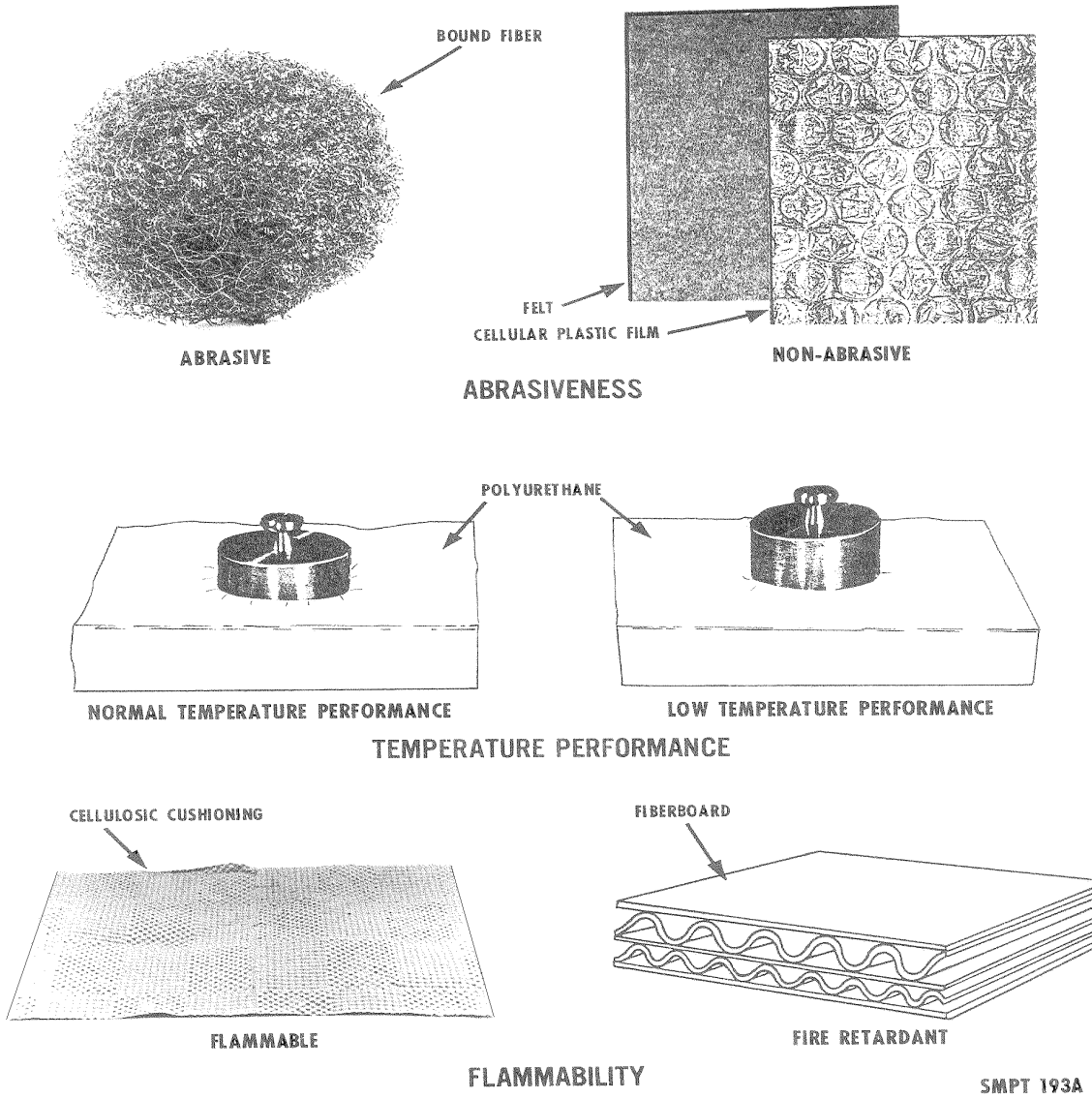

Figure 1-27. Characteristics of cushioning abrasiveness, temperature performance and flammability.

Cellulosic Cushioning Material (A-A-1898)

This material may be made of any kind of cellulosic matter which will result in a product meeting specification requirements. The cellulosic matter used may be cotton, bonded fibers, natural fibers, or creped wadding. The material is furnished in two types--Type I, water absorbent, and Type II, water resistant. It is available in three classes-Class A, low tensile strength, Class B, high tensile strength, and Class C, very high tensile strength. Cellulosic cushioning material is readily moldable and fairly resilient. Its compression set is high, its damping ability excellent, but dusting is great enough to require an excluding wrap around items susceptible to dust damage. Its performance in cold temperature is good. This material is intended for use in packaging lightweight, fragile items; as a protection against abrasion; and Type I, specifically, for absorbing liquids from containers broken in transit.

Solid And Corrugated Fiberboard (ASTM D 4727)

Both solid and corrugated fiberboard are used in cushioning, but corrugated is more frequently used because it has greater cushioning value. The most common forms of fiberboard applications are die-cuts, open end cells trays, pleated pads, and flat pads (fig 1-28). Generally, cells and trays should be held in shape with tape. Those surfaces of the cell or tray which are perpendicular to the contacting surface of the item are called bracing supports and are load bearing members. To utilize all of the strength of these bracing supports, they should bear directly on the item. Pleated pads have greater resistance to breakdown than open end cells because the load is spread over a large area rather than bracing supports. Therefore, they should be used to cushion heavier loads (up to 2 pounds per square inch). Flat pads are used to block shallow projections, to level off projecting screw heads, and to separate items within a container. They can be slotted to form partitions, or may be die-cut or punched to fit articles or irregular shape. Application of fiberboard cells, trays, and pads is illustrated in figure 1-29.

Unicellular Polypropylene Foam (PPP-C-1797)

This material is a low density, resilient, unicellular (closed cell) polypropylene foam material for use in cushioning and packing applications in the form of rolls or flat sheets. Type I electrostatic discharge is required. It is useful throughout a temperature range from minus 65°F to 160°F. It is intended for use as a cushioning wrap for low density items. The foam can be laminated to a wide range of products including paper, paperboard, and may be used for the protection for optical lenses, equipment with critical surfaces, electrical and electronic equipment, glassware, ceramics, and magnetic tape rolls. When stored in closed containers it produces no trapped volatiles which could cause fire or explosions. Polypropylene, by its nature, is unaffected by most exposures to grease water and most acids, bases and solvents. It contains no plasticizers, solvents, or lubricants.

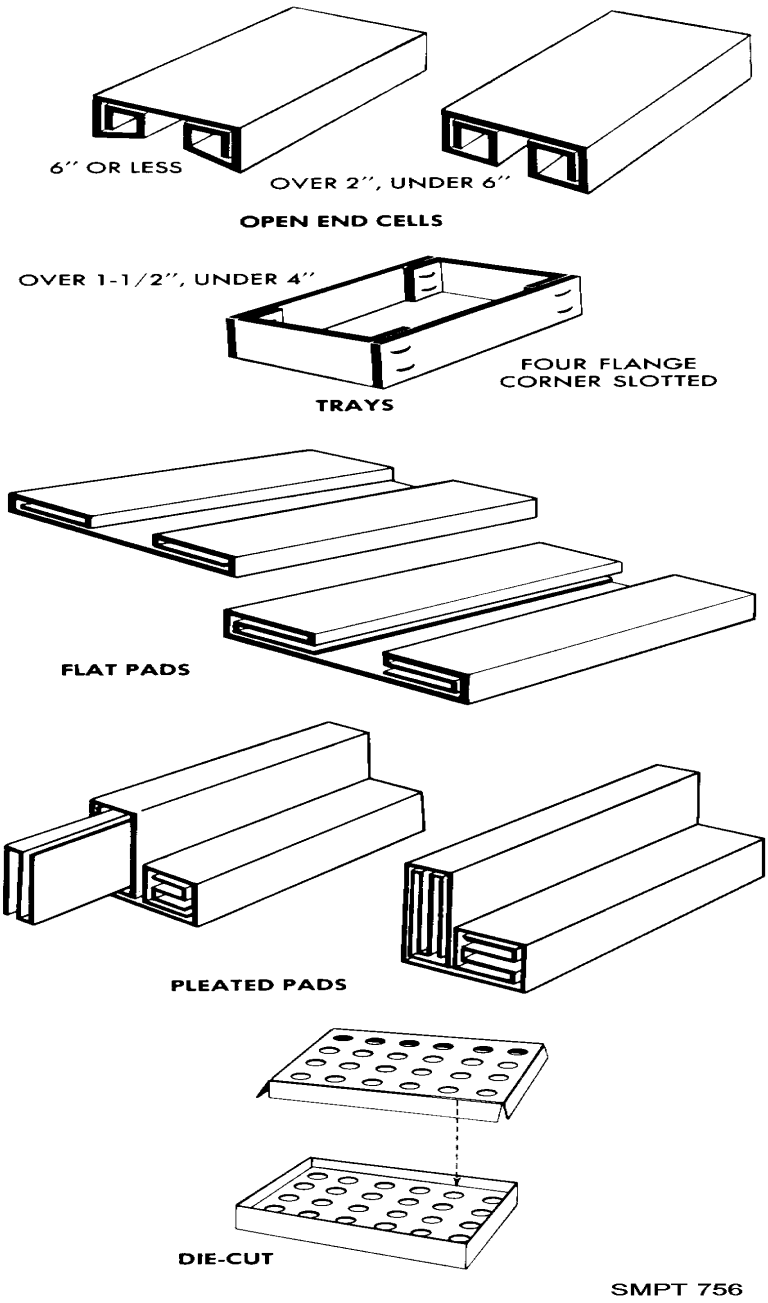

Figure 1-28. Examples of fiberboard trays, opened end cells, pads, and die-cuts

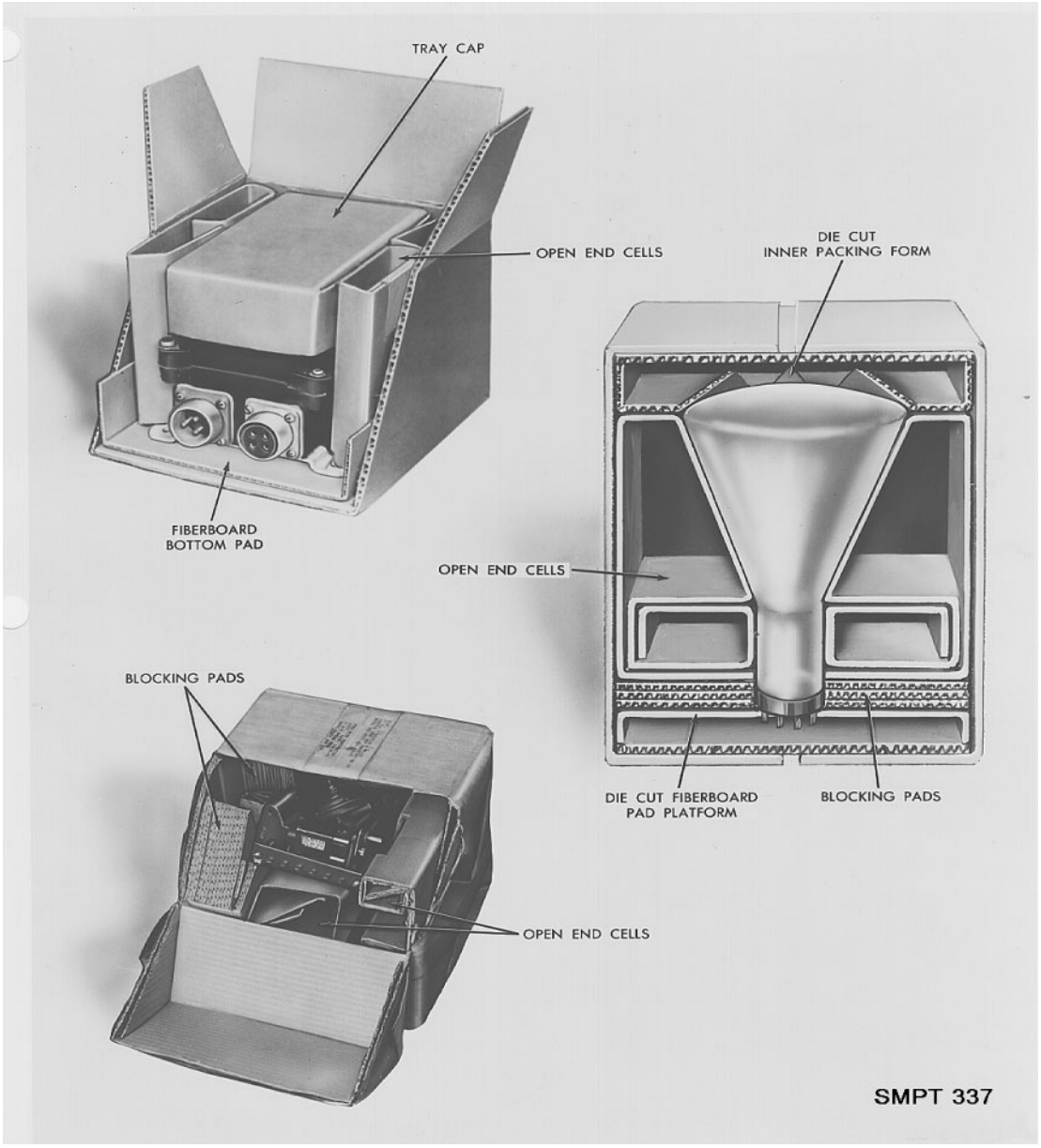

Figure 1-29. Application of fiberboard die-cuts, open end cells, trays, and pads.

EXPANDED POLYSTYRENE (PPP-C-850)

This resilient cushioning material consists of expanded polymers or copolymers of styrene for use in packaging applications. It is furnished in two types. Type I is in sheet form and Type II is in roll form. Both types come in four classes and two grades. Class 1 is soft, class 2-medium, class 3-firm, class 4-extra firm. Grade SE is self-extinguishing. This cushioning material is used within packages to protect items from damage due to shock, vibration, abrasion, and concentrated forces during handling and shipment. It is especially suited where a high degree of energy absorption is required in a minimum space and with a minimum weight of cushioning. It can also be used to provide temperature insulation or when cushioning material must perform at extremely low temperature.

CUSHIONING, WRAPPING PAPERBOARD (A-A-1051)

This is a paperboard composed of a corrugated sheet or a solid molded pulp sheet firmly cemented to a backing flat sheet of unbleached sulfate fiber paper. The paperboard is furnished in two types--light and heavy-duty, and in two styles. Style 1 material must have a backing sheet. The backing sheet is optional for Style 2. It is furnished in sheets or rolls, as desired. Both styles are flexible in all directions. This material has high compression, low resilience, excellent damping, and some dusting. The moisture content and moisture absorption are high. The moisture is not neutral and hence has a high corrosion effect. Its performance in cold weather is poor, and it is neither fungus nor flame resistant. Critical metal items must first be wrapped in a chemically neutral or greaseproof barrier.

RIGID OR FLEXIBLE POLYURETHANE FOAM (MIL-PRF-26514)

This material consists of both rigid and elastic types of foamed products obtained through the proper blending of complex synthetic chemical compounds. By proper combinations, reaction mixtures can be poured or pumped into various shaped cavities. Volatilization of the blowing agent causes rapidly stiffening resin to expand, completely filling the space. The material then sets rapidly to a lightweight, cellular structure that has excellent cushioning properties. The material is furnished in a form suitable for foaming in-place application or it may be performed and supplied in rolls, sheets, or molded shapes. Strong rigid foams, tough elastic foams, soft flexible foams, and spongy water absorbent foams can be obtained by the different choices of ingredients. Foams with densities as low as .5 pounds per cubic foot may be obtained. These foams can be adjusted to give a high or low compression set, excellent or poor damping, and high or low resilience. In other words, the material can be tailor made to meet the requirement of any type of cushioning required. There is no dusting problem; moisture content is negligible. The material is flame and fungus-resistant, and it performs well in cold climates. For further details regarding procedures and equipment used with polyurethane foam, see MIL-HDBK-775 and MIL-F-87075 respectively.

LATEX FOAM SPONGE RUBBERS

These materials are made by incorporating into the rubber an inflating agent such as baking soda, that gives off a gas which expands the mass during the vulcanization process. The rubber is made from slab rubber into sheets, strips, molded or special shapes. These materials may be supplied in cored or uncored types; soft, medium, firm, and extra firm, classes; and in flame resistant and nonflame-resistant grades. The materials have a very high resilience, low compression set, fair damping properties, high moisture content, and high moisture absorption. They produce some dusting. If kept dry, the corrosive effects are slight. Their low temperature performance is poor. The materials have a high density and are expensive to use. The molded forms are often used in conjunction with reusable containers and the initial cost is reduced by the amount of reuse obtained.

PLASTIC FILM, HEAT SEALABLE, FLEXIBLE, CELLULAR (PPP-C-795)

This material is constructed of a composite of two or more sheets of plastic film, one face having uniformly distributed closed cells (bubbles), the other a flat surface. It is available in three classes: class 1-regular; class 2-antistatic, tinted; and class 3-fire retardant. All are used as cushioning for packaging applications. Material is furnished with various cell sizes (air bubbles). It is intended for use within packages to protect items from damage due to shock, vibration, concentrated forces, corrosion, contamination, and abrasion during handling and

shipment and is especially suitable for use as inserts within transparent bags. The use of class 1 material, due to its transparency, permits inspection of the contents without opening the pack. The flexibility of the material permits it to be used as pads, bags, wraps, dunnage, or as a filler. Class 2 material protects sensitive electronic devices from electrostatic discharge damage. When fire-retardancy is required, class 3 material is selected.

Note: Many of the materials made under this specification are laminates of chlorinated plastic and polyethylene. Chlorinated organic materials give off vapors of hydrogen chloride which can combine with water to form highly corrosive hydrochloric acid.

UNICELLULAR POLYETHYLENE FLEXIBLE FOAM (PPP-C-1752)

This specification covers six types and four classes of cushioning material. Type refers to the density range of the material. For example, type VII has a density of .9 to 2.0 pounds per cubic foot while type V has a density range of 6.0 to 10.0 per cubic foot. The class generally describes the form the material takes and may be solid or laminated planks, sheets, cut shapes, rounds, or molded shapes. In addition, type VII, class 4, materials are antistatic. Temperature performance has a useful range of minus 65^{o} to plus 165^{o}F. Compression set is low and the materials are noncorrosive, nonabrasive, and virtually dust free.

OPEN CELL PLASTIC CUSHIONING (PPP-C-1842)

This material is made of one sheet of plastic film or a composite of two or more sheets of film, formed into a network of uniformly distributed open cells. The cells may be a hexagonal or fluted shape, depending upon whether a facing or reinforcing top film laminate is required. The hexagonal form is used when a reinforcing top laminate is applied to the open face of the cells. The fluted form is used when a facing is applied to the crowns of the formed cells. The resulting material is lightweight, transparent, flexible, and heat sealable. There are three types; Type I, hexagonal; Type II, fluted; and Type III, hexagonal, electrostatic free. The two styles describe whether or not the material has a top laminate or facing. All three types are available with or without a top laminate or facing and are furnished in rolls or sheets. The material is noncorrosive, nonabrasive, has low compression set, and performs well at low temperatures. The cushioning is intended for use within packages as inserts within transparent bags, wraps, dunnage, and filler.

METHODS OF CUSHIONING

Cushioning is generally accomplished by one of the following methods:

- Floated item. The item is floated in cushion material and placed within a unit container (fig 1-30). This is perhaps the method most commonly used for cushioning small, lightweight, fragile items against shock, vibration, and abrasion. Dryness and noncorrosiveness of cushioning materials are most important since both the item and the cushioning material will be inclosed in the unit container. Greaseproof barriers are required if the item is preserved. Cushioning materials must be secured about the item. Loose cushioning may result in either the displacement of the material when the pack is subjected to shock, its disintegration under repeated vibration, or the production of dust or loose particles which will be entrapped within the pack. Since a container may be dropped on any of its faces, edges, or corners, the cushioning material must be designed to withstand the full impact of the entire weight of the item in any direction.

- Floated Pack. The item is packed in an interior container which in turn is floated in cushioning materials (fig 1-30). This method is generally used in connection with semifragile items of medium size and weight. The item is initially packed (which may include cushioning or blocking) in an interior container, then floated in cushioning and placed into an exterior container. In this method, the noncorrosiveness and moisture content of the cushioning materials are not critical since the materials will not come in contact with the item. The use of absorbent cushioning materials, when used in this method, should be governed as follows:

When both the interior and exterior containers are water-resistant, the cushioning material may be simply placed between the two containers. When either container is nonwater-resistant, the cushioning material must be placed in the form of packs wrapped in a water resistant barrier material. An alternative for the second case is to provide the interior container with a sealed water-resistant wrap and the exterior container with a sealed liner. The cushioning material is then placed between the two barriers.

SHOCK MOUNTS

The item is cushioned by means of shock mounts. This method is used to cushion fragile items and sensitive instruments or mechanisms that can be damaged by shock and vibration. The weight and size of the item may vary from light and small to heavy and large. The shock mounts may consist of elastomeric springs or rubber blocks. This method of cushioning may be accomplished in four main ways.

The item may be suspended directly by means of elastomeric springs. The item may be blocked in a cradle and the cradle suspended by means of elastomeric springs. The item may be boxed in an intermediate container and the intermediate container suspended by means of elastomeric springs. The item may be boxed in an intermediate container and the intermediate suspended by means of rubber shock mounts.

PACKING PROBLEMS

The basic reason for packing any item is to provide enough protection against the hazards it is likely to encounter during shipment. This minimizes the chances that damage will occur during the interval between the time the pack leaves the shipper and when the item is placed in use by the receiving activity. It is, of course, an impossibility to evaluate all the hazards that might be encountered in transit, as there are too many variables which can affect the condition in which an item may be found upon arrival at its destination. The guidelines to packing presented herein have indicated the principles and practices that have been found satisfactory in giving protection under average handling and storage conditions. If the solution of a specific packing problem is not located in this section, the following procedures are recommended for shipment from depots:

DOMESTIC SHIPMENTS

If an item is being shipped domestically, pack the item in a manner which closely duplicates the pack in which the item was received.

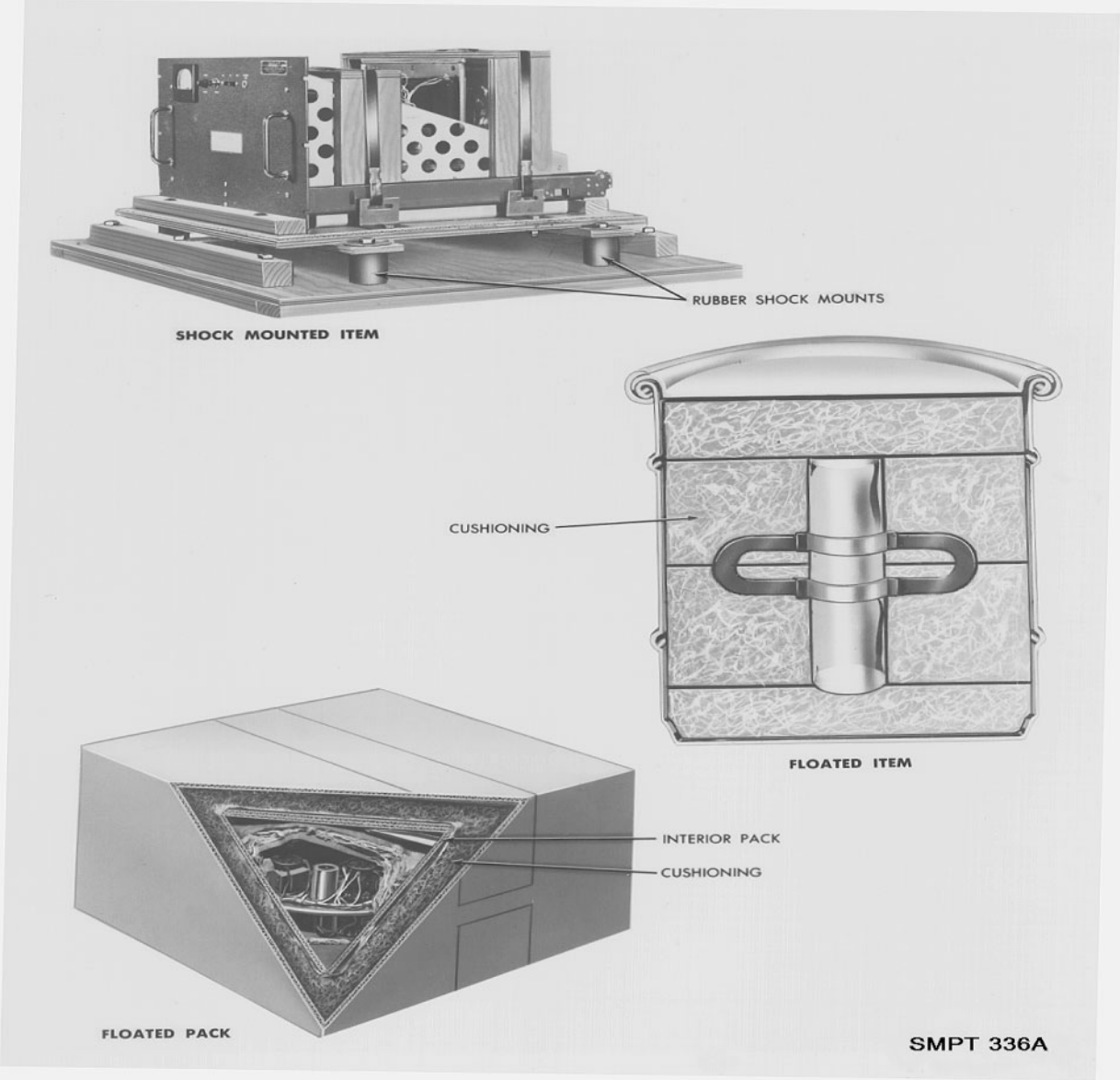

Figure 1-30. Methods of cushioning.

OVERSEA SHIPMENTS

If shipment overseas is involved, and no previous history of a container in which the item had been shipped to a similar destination is available, construct a pack embodying as many as possible of the principles outlined in this section. This pack should be prepared exactly as it would be shipped including complete preservation and interior packing. It is then tested by subjecting it to the applicable performance tests. The tests are based upon the size as well as the gross weight of the container since both influence the amount of rough handling the container will receive. Small, light packages are easier to move than the larger and heavier packs, and consequently, they can be expected to receive a greater amount of handling. Performance tests are required for the primary purpose of determining the adequacy of all the operations entering into preparation of a pack. At the conclusion of the tests, performance is based on the condition of the container, its contents, the blocking and bracing, cushioning, preservation, and other packing materials. The pack should be examined for any

damage, noting in particular any obviously weak points which might need to be strengthened. Usually the container, if constructed according to specifications, will withstand the rough handling. If, however, the container is damaged, a study should be made of the causes. Deficiencies in the blocking and bracing may result in damage to the container, in which case these deficiencies should be corrected. Other times the nature or shape of the item may cause the container to fail. Then, the container should be reinforced. In any event, when deficiencies become obvious, either in the containers, the contents, the blocking and bracing, cushioning, preservation, etc. the pack should be appropriately modified and the test repeated until no damage occurs which affects the utility of the pack.

PACKING SMALL, LIGHTWEIGHT ITEMS

As previously pointed out, cushioning materials are frequently employed to block lightweight items. In some instances, however, cushioning materials such as fiberboard, are primarily used for blocking. The effectiveness of fiberboard as blocking and bracing depends upon its strength and its resistance to moisture when not protected by suitable moisture barriers. The domestic class of fiberboards will rapidly absorb moisture with a resulting loss of strength. The weather-resistant class on the other hand, retains a greater proportion of its strength in the presence of moisture. Fiberboard is most frequently employed as blocking in fiberboard containers because the items packed in them are usually small and lightweight and do not require heavier types of blocking. Also, the container manufacturer can provide and fabricate pads, cells, trays, or partitions of the same material a low cost.

Both solid and corrugated fiberboard are employed as blocking material, but the corrugated is used more frequently because it has a greater cushioning value and because of its lower cost. Occasionally, a pack will contain a comparatively large void which will necessitate blocking to prevent shifting of the item, In such cases, a fiberboard carton may be used for blocking the item in place. The carton used for blocking should be closed and sealed, and must be strong enough to provide adequate strength in all directions.

PACKING LARGE ITEMS

Large items require special attention to adequately secure them within the container. Such items are anchored to the base of the container and blocked and braced into a secured position on the base. A clearance of a least 1 inch is provided between the end, side, and top panels and the item is seldom blocked and braced to these panels. Thus, the container must have a rigid base and the rest of it be must free to distort without placing stresses directly on the contents.

ANCHORING TO BASE OF CONTAINERS

Crates for large and heavy items should have sturdy bases to which the items can be adequately secured. Many ingenious methods have been developed to hold items to crate bases. For sill and skid type crates, it is essential that the load be carried primarily by the outside skids or sills. This means that loads that cannot be secured to the side sills or bases must be provided with load bearing members that transmit the load to them.

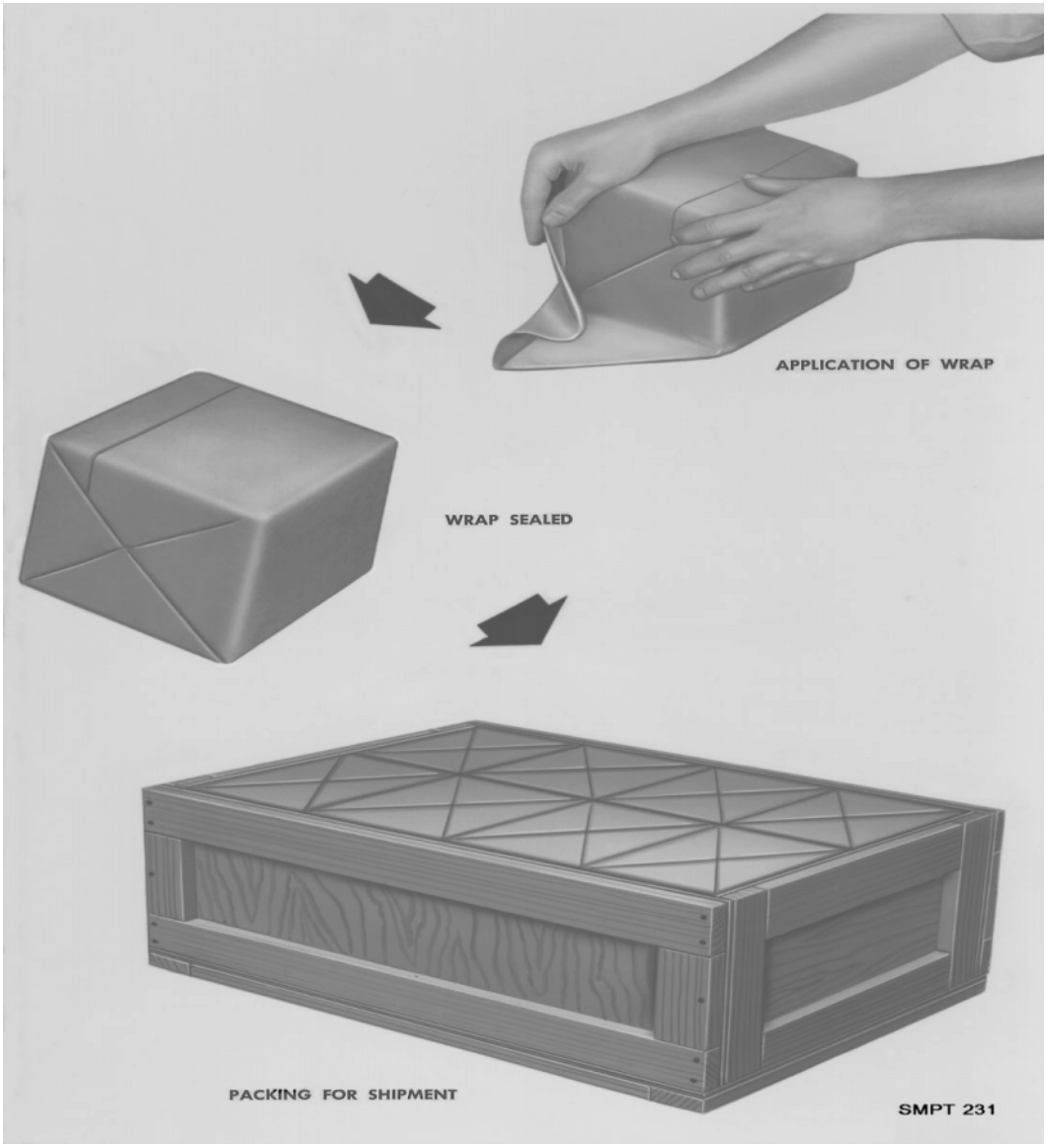

Figure 1-31. Waterproofing of individual packages.

BLOCKING AND BRACING A LARGE ITEM

After the item has been anchored to the base of the container to prevent its movement in a vertical direction, it is blocked and braced to prevent its movement in a horizontal direction. An item should be anchored only to the base, hence all bracing and blocking should be so secured.

CLEARANCE BETWEEN ITEM AND CONTAINER

When an item is blocked, braced, anchored, or tied down to the inside of one face of a container or to an auxiliary base which, in turn, is so secured, a clearance of not less than 1 inch should be provided between the item and all members of the faces of the container. A minimum clearance of 2 inches should be provided around fragile parts of the item that might be damaged due to slight distortion of the container. A minimum 2 inch clearance should be provided between items within floating bag barriers and adjacent members of the container.

WEATHERPROOFING THE PACK

At this point in the sequence of packing operations, it is assumed that a careful study has been made of the item to be packed; a suitable container has been selected; blocking, bracing, and cushioning have been designed; and the contents are ready to be placed into the container. The next step is to provide, when necessary, a protective barrier in the form of a case liner, crate liner, shroud, wrap, or tarpaulin fabricated from one of several materials. The barriers are intended to prevent deterioration of the item, and the preservation and packing materials used to protect it, by excluding the entry of water, by limiting the entrance of water vapor, or by diverting water from the materials which are subject to water damage. In addition, barriers will afford protection from dust, dirt, and other foreign matter. Barriers designed to prevent the entry of water (waterproof barriers) will not be used when the interior packs have been individually waterproofed as shown in figure 1-31, nor when the asphaltum in the barrier material or sealants may prove injurious to the inclosed items. The water-vaporproof protection afforded by caseliners differs from that afforded by a Method 50 package in that water absorbing desiccant is not used with caseliners.

WEATHERPROOFING (CASE LINERS, WRAPS, AND SHROUDS)

Except as provided herein, weatherproof liners, wraps, shrouds or other suitable means shall be provided in shipping containers as necessary to shield the contents from the effects of water, water vapor, dust, dirt, and other harmful matter. When a completely inclosed barrier is provided as in the case of liners and wraps, all seams should be completely and continuously sealed to offer protection equal to the barrier material itself. Barrier materials and sealants constructed with asphaltum shall not be used in the presence of mothproofing chemicals such as paradichlorobenzene and naphthalene. Barrier materials and sealants constructed of asphaltum shall not be used to protect items subject to stain or other damage caused by asphalt unless such items are initially protected to exclude asphalt.

TYPES OF WEATHERPROOFING BARRIERS

The particular type of barrier to be used depends on the type of exterior container or the intended use of the barrier (table 1-8). In selecting the type of barrier to be used, consideration should be given to the following:

- Sealed case liners and sealed wraps are used to resist the passage of water and water-vapor. Fabrication of case liners is covered below.
- Sealed case liners will not be used in the packing of material unless specifically authorized.
- Crate liners and shrouds are used to shed water from the top and sides of the item, allowing free circulation of air. Shrouds are fabricated from waterproof barrier material conforming to PPP-B-1055, Class E or heavier. The seams are sealed with water-resistant adhesive conforming to MMM-A-260. Shrouds also may be made of material conforming to L-P-378.

It is important that shrouds be secured to prevent damage or loosening by storms. They should be weighted if necessary and arranged to avoid formation of water pockets. Shrouds should never extend entirely to the base of a crate or to the ground since the free circulation of air around the enclosed equipment is thereby prevented.

Table 1-8. Application of weatherproofing barrier materials for packing

Use	Barrier Materials				
	L-P-378	PPP-B-1055	MIL-B-121	MIL-B-131	MIL-B-22191
Case Liner	.....	Classes H-2, H-3(a), H-4, H-5, L-2(b), and M-1 Waterproof	Types I and II, Grade A, Class 1 Waterproof	Classes 1 and 2 Watervaporproof	
Sealed Wraps and Plastic Bags	Type I Water-proof	Classes B-1, B-2, B-3, C-1, C-2, C-2(a), E-1, and E-2 Waterproof	.....	Classes 1, 2, and 3 Watervaporproof	Types II or III Waterproof
Crate Liner	.....	Classes C-2(a), E-1, E-2, E-2, H-5, L-2(b), and M-1 Watershed			
Shroud	Types I and II Watershed	Classes E-2, H-5, and M-1 Watershed			
Baling	.....	Classes B-1, B-2, B-3, and E-2 Watershed			
Temporary Tarpaulin	Type I Watershed	Class L-4 Water-shed Class P-1			

CASE LINERS, OVERWRAPS, AND PLASTIC BAGS

Flexible waterproof or watervaporproof case liners, overwrap sheets, and plastic bag liners should be fabricated and closed in accordance with MIL-L-10547.

They shall be furnished in the following types: Type I, high-top case liner (fig 1-32); Type II, double-top pad liner (fig 1-33); Type III, overwrap sheet, and Type IV, plastic bag. Type II liners may be used when a level, rigid surface exists or when the depth of the case liner exceeds 36 inches. Type III overwrap sheets are barriers used around intermediate boxes. Type IV plastic bag liners are used in the same manner as Type I and II case liners.

They are available also in six grades as follows: Grade A, watervaporproof; Grade B, waterproof, all temperatures; Grade C, waterproof, asphalt laminated kraft; Grade D, waterproof and greaseproof; Grade E, waterproof, greaseproof, transparent, all temperatures, and Grade F, waterproof, transparent, all temperatures.

Table 1-9 shows the barrier material to use depending on the type and grade of case liner, overwrap, or bag liner required and whether they are to be used for subsistence or nonsubsistence items.

Case liners should be made large enough so that the weight of the load will be borne entirely by the container, not by the liner. There should be no tension in the walls or joints of the liner after it has been closed around the contents.

Experience has shown that under some conditions, especially when the contents do not fill the case liner completely, waterproof case liners do more harm than good by trapping and holding water rather than preventing its entry. It is not essential that there be openings in the sealed liner for this to happen. If the liner material has low resistance to watervapor transfer (a common occurrence) water can enter in the form of vapor and condense on items within the liner. At the end

of an extended outdoor exposure period, sealed case liners have been opened and found partially filled with water. When packed items need protection against water, it is preferable to incorporate the protection in the individual unit packages in lieu of using case liners.

Linings for Drums, Kegs, Barrels, and Bags. Linings should be provided for drums, kegs, barrels, or bags when their contents require protection not otherwise provided by the containers against sifting, contamination, or free water. The lining material should conform to PPP-B-1055 or MIL-B-22191. Fabrication and closure seams should be heat sealed or sealed with adhesive conforming to MMM-A-260, as applicable.

WATERPROOF AND WATERVAPORPROOF WRAPS

Waterproof and watervaporproof wraps shall be fabricated and sealed in accordance with MIL-L-10547.

UNSEALED WATERPROOF WRAPS

Unsealed waterproof wraps should be applied to shed water while permitting breathing and circulation of air.

Table 1-9. Barrier materials for case liners, overwraps, and plastic bag liners

Use	Liners, overwraps, and bag liner		Specification	Barrier materials
	Grade	Types		Classification
Subsistence item	C F	I, II, III IV	PP-B-1055 L-P-378	Classes H-2 thru H-5, M-1 Type I
Nonsubsistence item	A	I, III	MIL-B-131	Classes 1, 2 and 3
	C D E	I, II, III I, II IV	PPP-B-1055 MIL-B-121 MIL-B-22191	Classes E-1, E-2, H-1 thru H-5, L-2, M-1 Types I and II, grade A, class 1 Type II

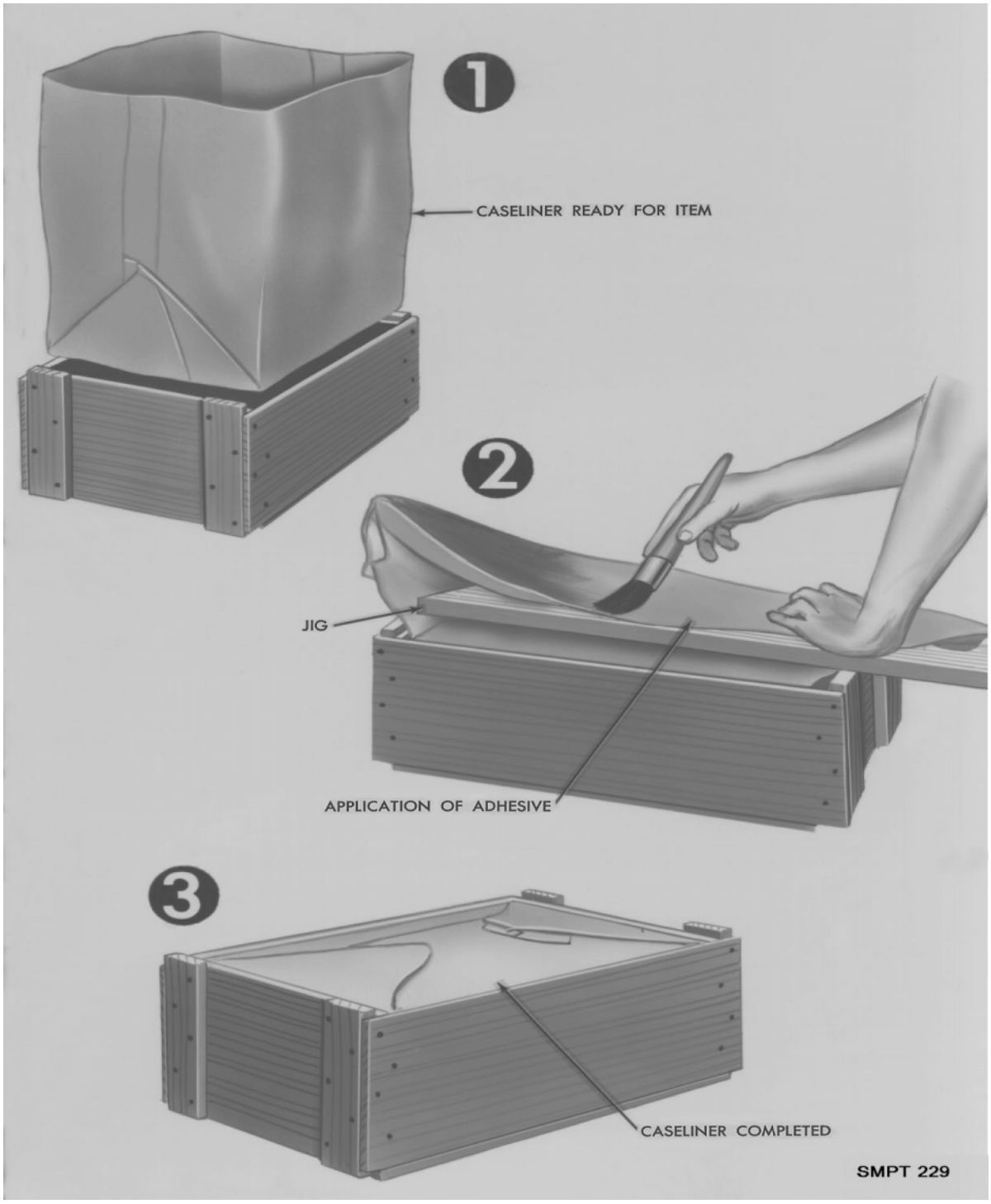

Figure 1-32. Using and closing of high top caseliner.

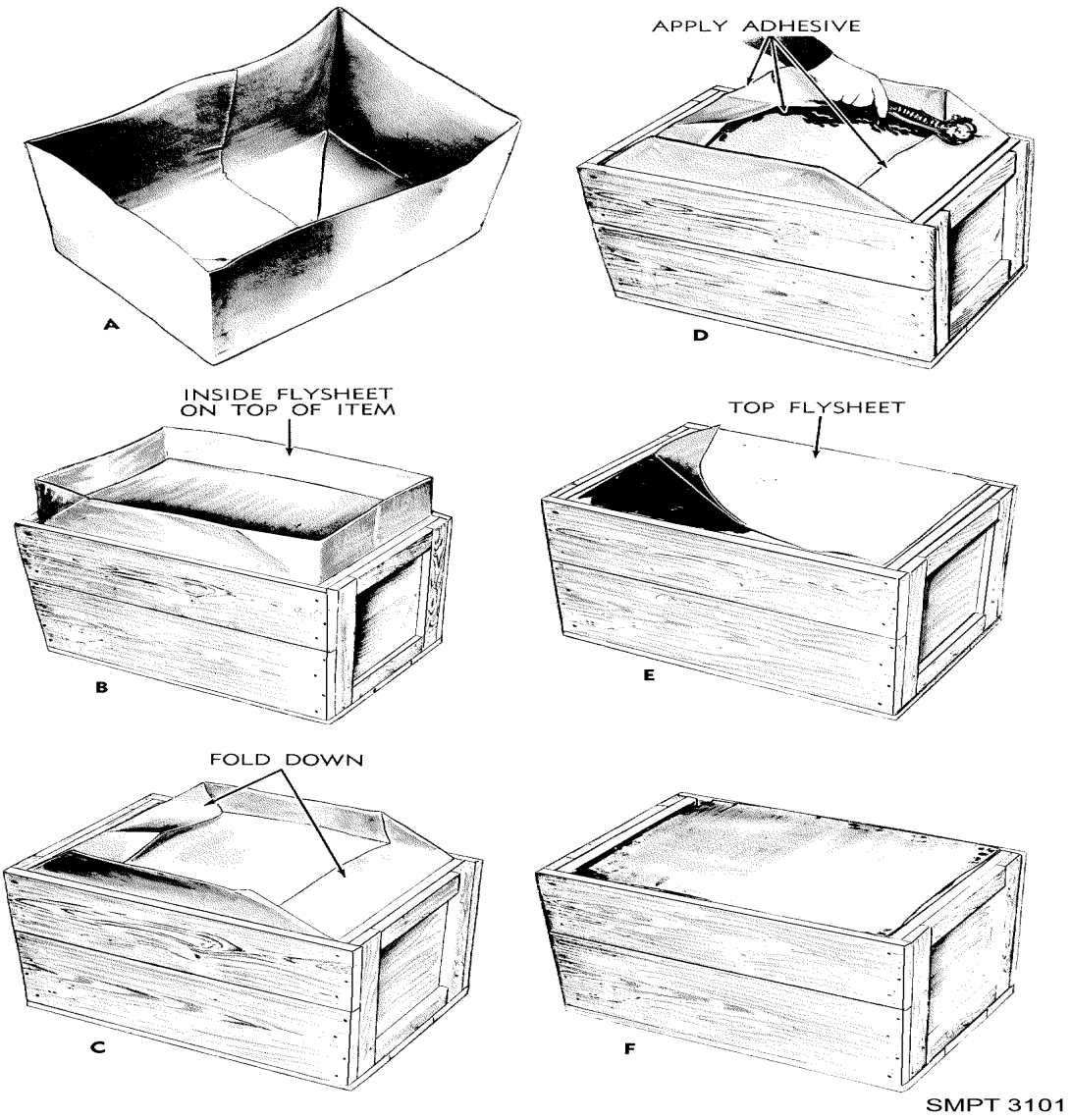

Figure 1-33. Double top pad closure caseliner.

TESTING OF PACKS

PURPOSE OF TESTING

The purpose of testing is to prove the adequacy of packaging design and the workmanship of fabrication. Testing may be performed in the research and development phase or by tests at the operational level. Since containers in the storage and shipment cycle are subjected to various and constantly changing storage and shipping hazards, it is difficult to develop complete data for their design by merely observing the containers in service. Examinations of failures will reveal the weaknesses and suggest the specific principles of design to overcome such failures. Since service tests are not performed under controlled conditions, laboratory tests are necessary to simulate field hazards. Each test is designed to reproduce one or more of the stresses encountered in the field. During the test cycles the sequence of failures can be observed, classified, and the

weaknesses from which the failures result determined. By means of such tests any number of containers can, in turn, be subjected to exactly the same actions, thus providing the data necessary to produce balanced construction and workmanship. On the following pages are described a number of methods that have been devised for subjecting containers to hazards similar to those encountered in the field. Both laboratory and field testing are necessary since there are certain conditions inherent in each method of testing that cannot be duplicated in the other.

TYPES OF TESTS

Development and testing of packs and containers should be started as soon as possible after initiation of item development. Some of the tests most commonly used in proving design adequacy include the vibration, rough handling, and cyclic exposure tests (fig 1-34). One or more of these tests are usually applicable to the design of military packs. In many cases the technical activity having design responsibility, has intervals tests and procedures that are applicable to a specific design problem. The documents most generally used for test guidance are MIL-STD-1186. ASTM D 4169, Performance Testing of Shipping Containers and Systems, and ASTM D 5276, Drop Test of Loaded Containers by Free-Fall, should be referenced.

TESTING (MIL-STD-2073-1)

After an item has been packed in accordance with one of the MIL-STD-2073-1 methods, tests are conducted to determine the effectiveness of the pack. The types of tests conducted will depend on the particular method used. The tests called for in MIL-STD-2073-1 are not all-inclusive, however, and additional or different tests are sometimes required. The types of tests specified in MIL-STD-2073-1 for proving the adequacy of unit protection are the leakage test, rough handling tests, cyclic exposure tests, and the heat-seal seam tests.

TESTING (MIL-STD-1186)

When packs prepared for shipment in accordance with the detailed requirements of MIL-STD-1186 are tested for any rough handling required, there should be no settlement or shifting of contents. Further, the testing should cause no damage to the contents and should not loosen, break, or displace the anchoring, blocking, or bracing. The testing should not render the interior containers, wraps, liners, barriers, or cushioning ineffectual in providing continued and adequate protection to the contents.

TYPES OF ROUGH HANDLING TESTS

The various types of rough handling tests include: free-fall drop test; cornerwise drop test; pendulum impact test; incline-impact test; edgewise drop test; vibration test; and others. The particular tests employed usually depend upon the size and shape of the package. Completed packages as prepared for shipment are given a rough handling test when specified. When a rough handling test is required, it precedes applicable tests specified to detect leaks and inadequate seals or closures and preservative retention.

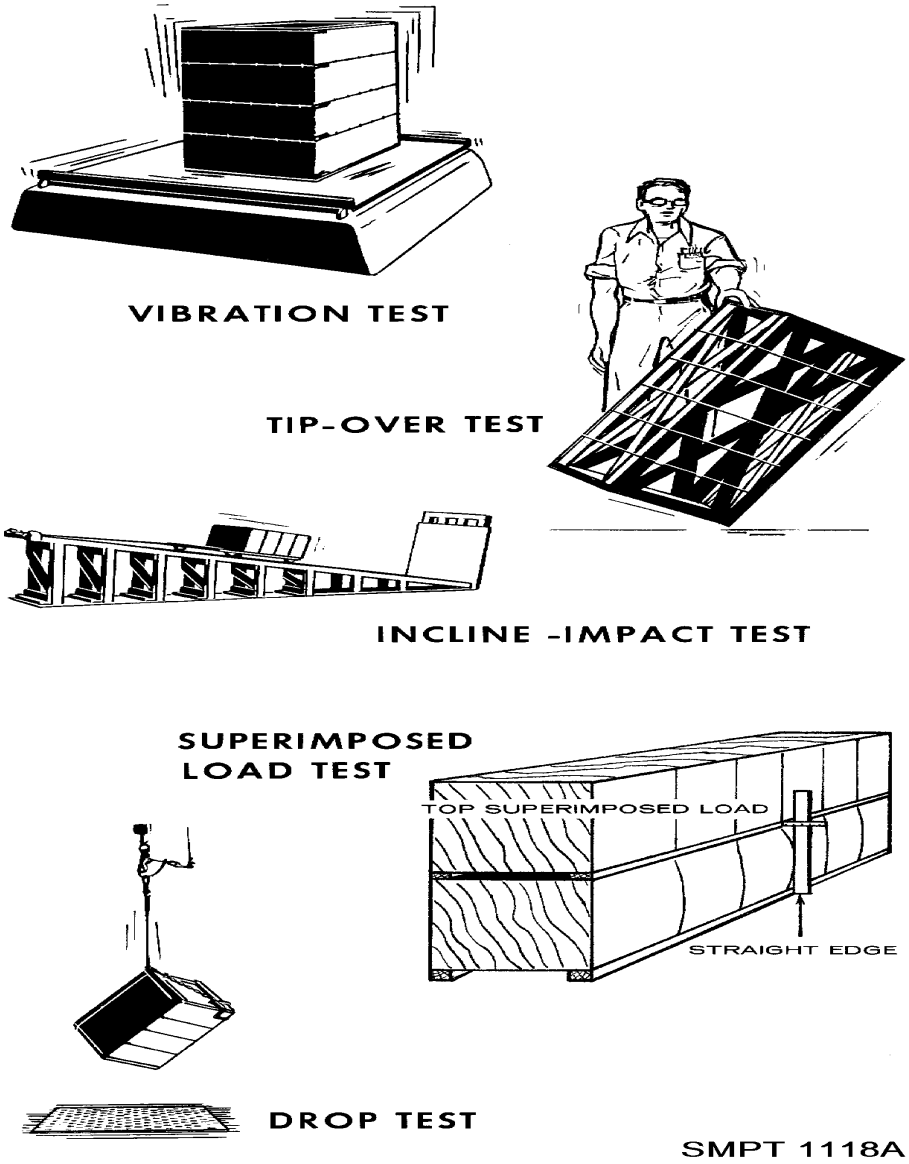

Figure 1-34. Examples of container test.

Inspection and tests for leaks in barrier materials, seals and closures, and preservative retention, when required, are performed on the contained unit pack(s) following the rough handling test to determine existence or extent of detrimental effects. Unless a particular test is specified, selection of the applicable rough handling test should be in accordance with ASTM D 5639, Selection of Corrugated Fiberboard Materials and Box Construction Based on Performance Requirements.

SMALL CONTAINERS

Only free-fall drop tests and vibration tests shall apply to small containers; both or either vibration test shall be conducted at the option of the contractor. Small containers are those having a gross weight of 110 pounds or less. Any container with skids is tested as a large container. Any container holding an item that has a net weight of more than 100 pounds and which is fastened to a base within or to the base of the container will be tested as a large container.

LARGE CONTAINERS

All rough handling tests, except for free-fall tests, shall apply to large containers; both or either vibration test shall be conducted at the option of the contractor. However, tipover tests will apply only when additionally specified. Either impact test shall be conducted at the option of the contractor. Large shipping containers are those measuring more than 60 inches on any one edge or diameter, or those which when loaded, have gross weights in excess of 150 pounds or those which have skids.

FREE-FALL DROP TEST (FIG 1-35)

The pack may be tested in accordance with ASTM D 5276. A drop tester is any suitable apparatus which will allow an absolutely free, unobstructed fall of the container at the orientation and the direction required. A lifting device that will not damage the container will be used and a level steel or cement surface to absorb all shock without displacement will be provided. The height from which the specimen should be dropped is dependent upon the weight, size, kind of container, and level of pack. This test is meant to simulate the fall of an item dropped by a person from a height they would normally use to lift and carry an item of that size.

The container should be dropped from the designated height onto a steel, concrete or stone surface of sufficient mass to absorb the shock without deflection in such a manner that the designated surface of the container absorbs the full force of the fall (fig 1-35). This test should be repeated until the designated number of drops have been made. (The height refers to the distance from the steel, concrete, or stone surface to the nearest surface of the container when suspended prior to the fall.) The fall shall be a free fall, in that no ropes or other suspending media are attached to the container during the fall. If the container is of the drum type, the top and bottom of the drum should be marked so that the circle of the top and bottom is quartered, and the test should be applied to each quartered section.

TIPOVER TEST (FIG 1-34)

The loaded container is placed on its bottom and slowly tipped until it falls freely (by its own weight) on its side to a smooth level, concrete slab or similarly unyielding surface. Structural damage to the exterior shipping container which would result in either spilling of contents or failure of the container in subsequent handling is cause for rejection. This test is meant to simulate the impacts of accidentally tipping over a container. It is intended that the tipover test be used only on containers that are susceptible to accidental tipovers.

EDGEWISE DROP TEST (FIG 1-36)

The loaded container should be supported at on end of its base on a sill or block 6 inches in height and at right angles to the skids. The opposite end of the container should be allowed to fall freely from the specified height onto a steel, concrete, or stone surface of sufficient mass to absorb the shock without deflection. The test should be applied twice to each end of the container. If the size of the container and the location of the center of gravity are such that the drop tests cannot be made from the prescribed height, the height of the sill will be increased.

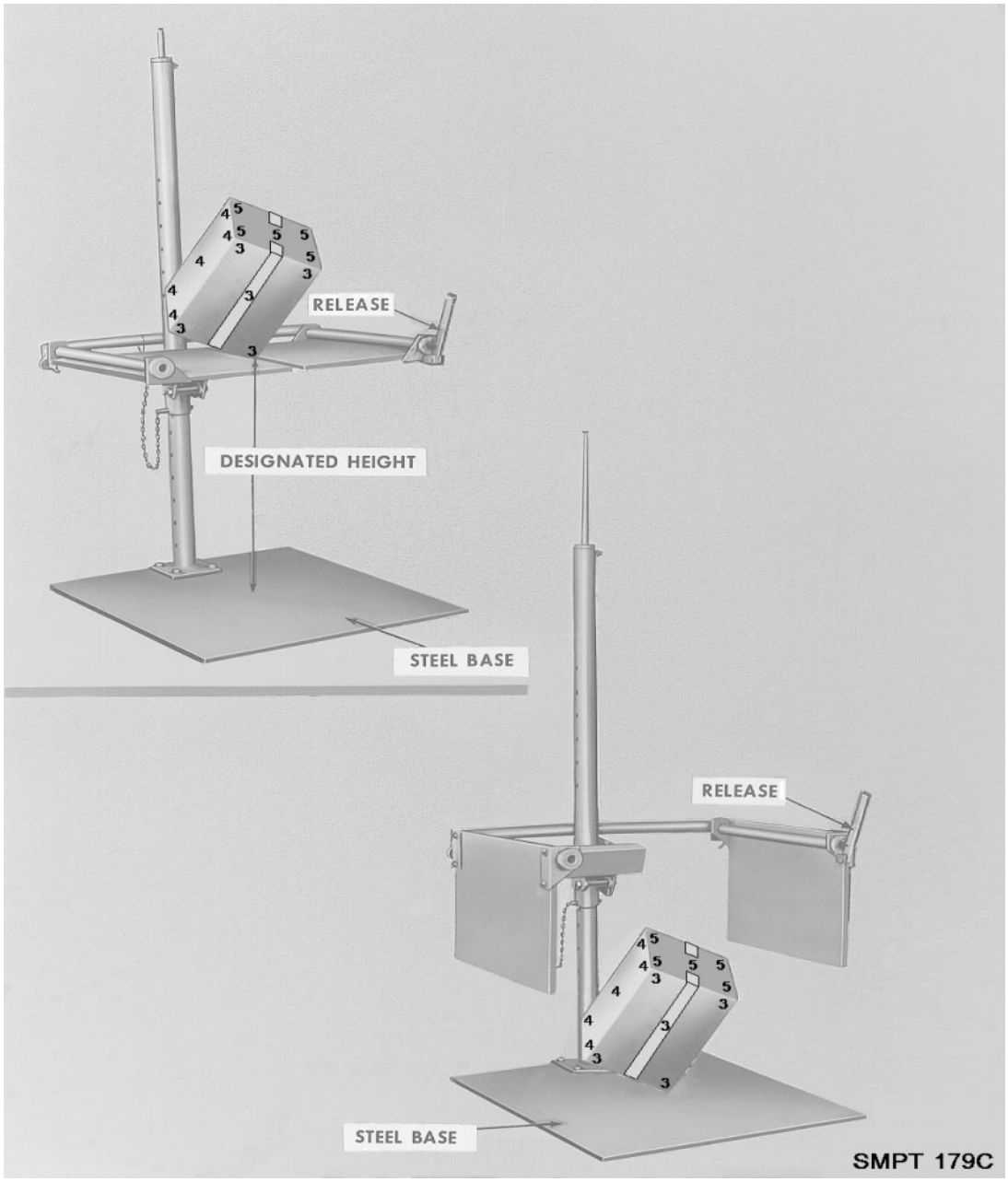

Figure 1-35. Free fall drop test.

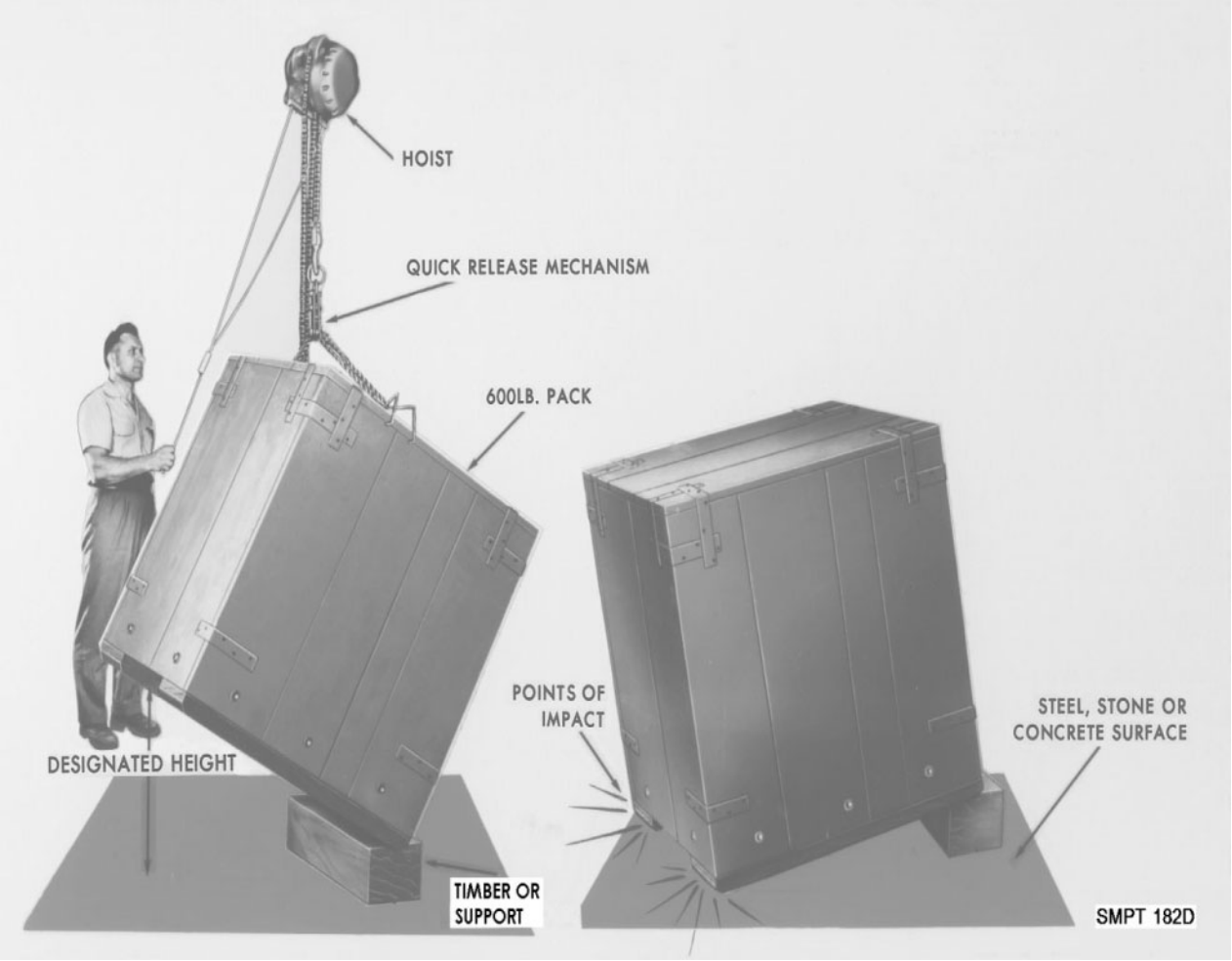

Figure 1-36. Edgewise-drop test.

CORNERWISE-DROP TEST (FIG 1-37)

The container should be supported at one corner of its base on a block 6” in height. A 12” block should be placed under the other corner of the same end of the container. The lowest point of the opposite end of the container should then be raised to the specified height for the weight and allowed to fall freely onto a steel, stone, or concert surface of sufficient mass to absorb the shock without deflection.

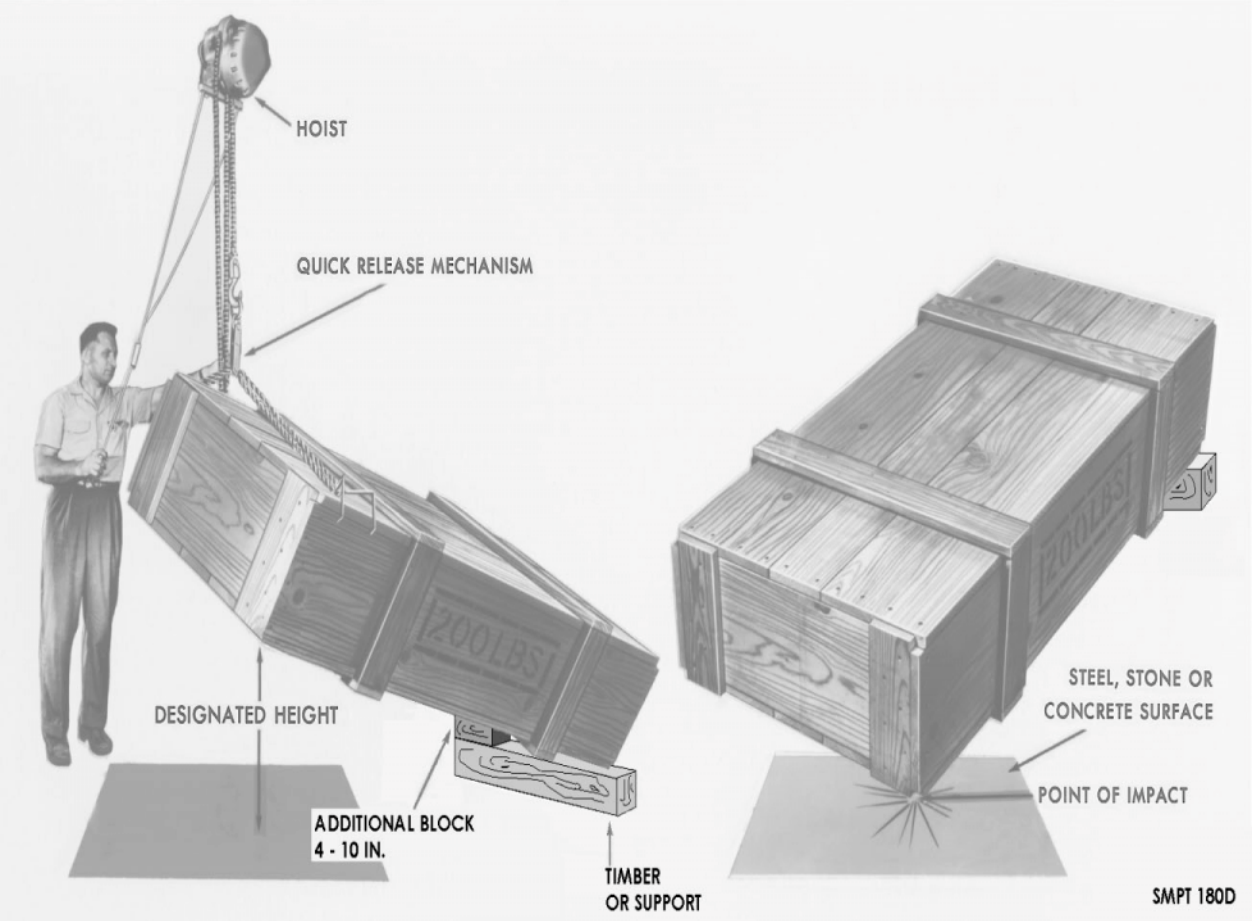

Figure 1-37. Cornerwise-drop test.

IMPACT TESTS

Packs having a gross weight exceeding 150 pounds or any dimension exceeding 60 inches, closed for shipment, may be subjected to one of the following guided impact tests. A single impact should be applied to each of two opposite ends. The tests are performed to simulate railroad jumping or other accidental impacts, evaluating the adequacy of the blocking, bracing and tie downs used to secure a load on or a in a rail car.

INCLINE-IMPACT TEST (FIG 1-34)

This test in accordance with ASTM D 5277 simulates the abuses encountered by packs in freight cars or trucks when the vehicles are subjected to the sudden starts and stops.

The pack, mounted on a movable platform dolly which rides on a plane inclined 20 degrees from the horizontal, is released from a known distance up the incline an permitted to strike against a fixed backstop at the bottom of the plane. The magnitude of impact shock is varied by using different release points.

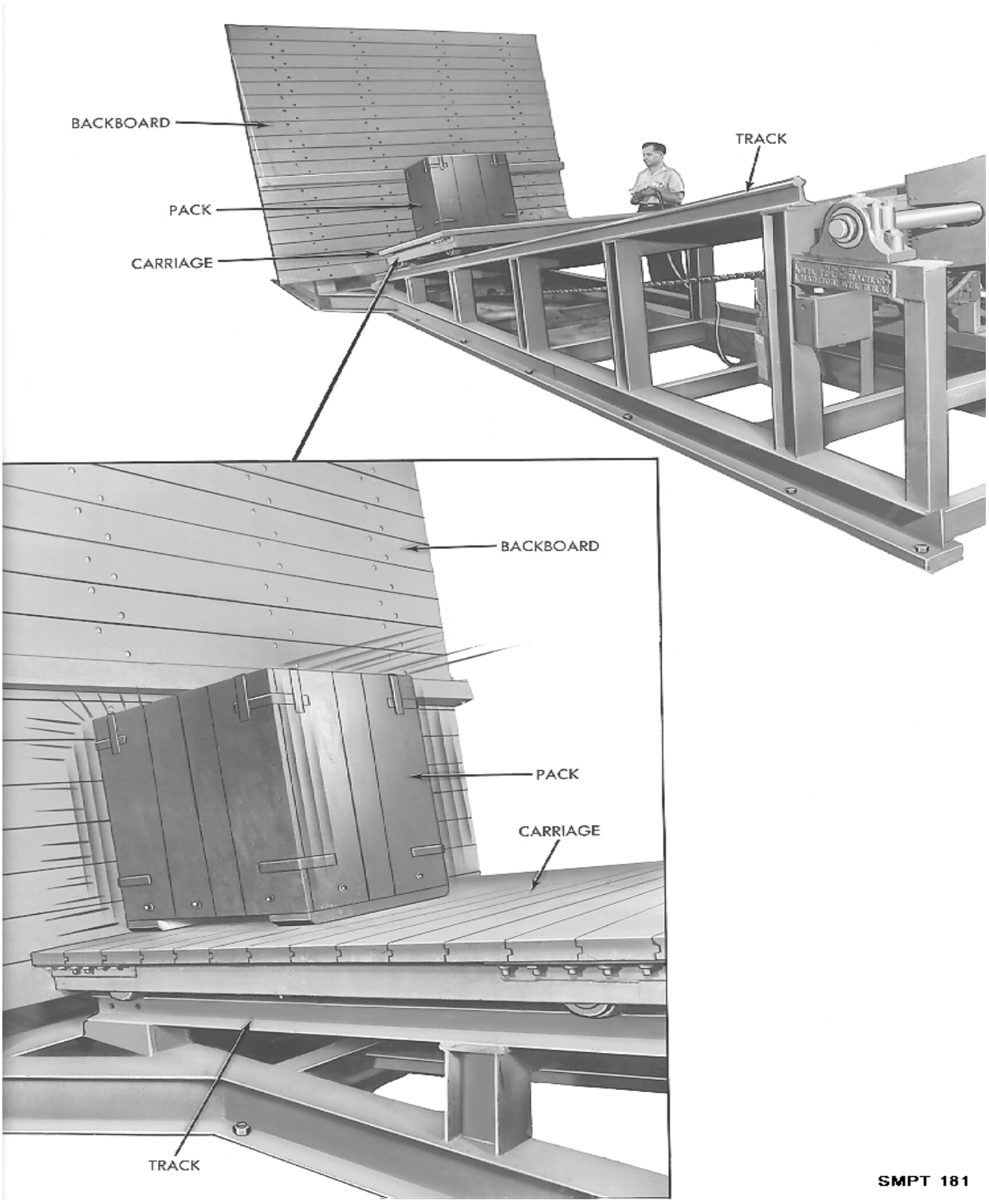

Figure 1-38. Impact test.

SUPERIMPOSED-LOAD TEST (FIG 1-34)

The procedure is applicable for determining the ability of shipping containers to resist loads such as imposed on the bottom container of a stack of similar container in storage, or on a container supporting top dunnage and superimposed lading. Test is applicable for determining the ability of shipping containers to resist loads superimposed on their tops as imposed by piling without top dunnage many small, heavy packs on a container.

Stackability, with dunnage tests, are conducted by placing a prescribed load on the top of the container in a manner simulating the effect of similar containers being stacked on top, and the load shall be allowed to remain in place for 1 hour. A check shall be made of any changes or breaks in the container, such as apparent buckling or failure of members in the sides or ends. Observations should be made to determine if the distortions are enough to damage or dislodge the interior packing or contents.

The uniformly distributed, without dunnage superimposed load test is conducted by placing weights not greater than 10 x 10 inches in outside length and width, on top of the container in a symmetrical pattern approximating uniform load and allowed to remain in place for 1 hour. Measurements of distortions shall be made immediately before the load is removed. Checks should be made of any changes or breaks in the container, such as apparent buckling of failure of members in the top, sides or ends.

VIBRATION TEST (FIG 1-34)

The forces and motions typical of railroad cars, motor trucks, and air transportation can result in vibration which frequently produces deterioration or partial crushing of unit or interior packing which reduces resistance to other shocks, such as impact from dropping, jolting, or bumping. Testing can disclose weakness in assembly of the packed item. The pack may be vibration tested in accordance with ASTM D 3580.

VIBRATION (REPETITIVE SHOCK) TEST

Test is used to indicate whether or not a package and its contents will withstand transportation shocks and vibration without damage when the shipment is not securely tied down to the floor of the vehicle. The package is placed on, but not fastened to, a platform supported on a mechanism that will maintain the surface essentially horizontal as it vibrates the platform. The amplitude of the vibration will be 1 inch total. The frequency will be variable within as approximate range from 3 to 5 Hz. Fences, barricades, or blocking can be attached to the platform to keep the package in position without unnecessarily restricting the vertical or rational movement of the package. Unless failure occurs, total time of vibration will be 2 hours if the package is tested in one position; 3 hours if tested in more than one position.

VIBRATION (SINUSOIDAL MOTION) TEST

Test in accordance with ASTM D 4169 is used to determine the adequacy of packages that contain items susceptible to damage from vibration encountered during shipping and are tied down to the floor of the carrier. The package is attached securely to a platform supported on a mechanism that will maintain the surface essentially horizontal as it vibrates the platform vertically. Controls are provided to vary the frequency form 2 to 500 Hz as specified. If the package might be shipped in more than one position, the package will be tested in each position.

SIMULATED CONTENTS

Simulated contents of the same dimensions, weight, center of gravity, and physical properties as the actual contents may be substituted in the tests described above. A shock-recording instrument of an acceptable type should be appropriately installed within the shipping containers. This provision is intended to avoid unnecessary damage or complete destruction of valuable commodities.

INTERPRETATION OF RESULTS

All materials and components shall be free from damage or evidence of displacement which affects the utility of the pack. When specified, functional tests should be conducted on the items or equipment to determine freedom from operational malfunction.

MARKING OF PACKS

Marking permits ready identification of military supplies and equipment for shipment and storage. No matter how well an item is made or packed, it is valueless if it cannot be identified upon reaching its destination.

ASTM D 996, Standard Terminology of Packaging and Distribution Environments, defined marking as "the applications of numbers, letters, labels, tags, symbols, or colors to provide identification and to expedite handling during shipment and storage".

MARKING STANDARD

The publication that provides the requirements for the uniform marking of military supplies and equipment is Military Standard 129, Marking for Shipment and Storage. This publication is approved for use by all Department and Agencies of the Department of Defense. It accommodates the requirements for coded and in the clear data and the forms required by DOD 4500.25-1-M, Military Standard Requisitioning and Issue Procedures (MILSTRIP); DOD 4000.25-2-M Military Standard Transaction Reporting and Accounting Procedures (MILSTRAP); and DOD 4500.32-R, Military Standard Transaction and Movement Procedures (MILSTAMP).

All required marking and any additional special marking which may be required depending upon the item and container being shipped (fig 1-39) can be found in MIL-STD-129.

ECONOMY IN PACKING

STANDARDIZATION

Economy in packing is the responsibility of everyone concerned with military supply. The Secretary of Defense has established policies on packaging that must be followed. These policies emphasize that the military services standardize their preservation, packaging, and packing. For example, the services, by using packaging standards, assure the same requirements for the same type of items, thus reducing the number of materials, methods, and procedures - whether these requirements are performed by the contractor or by the depot.

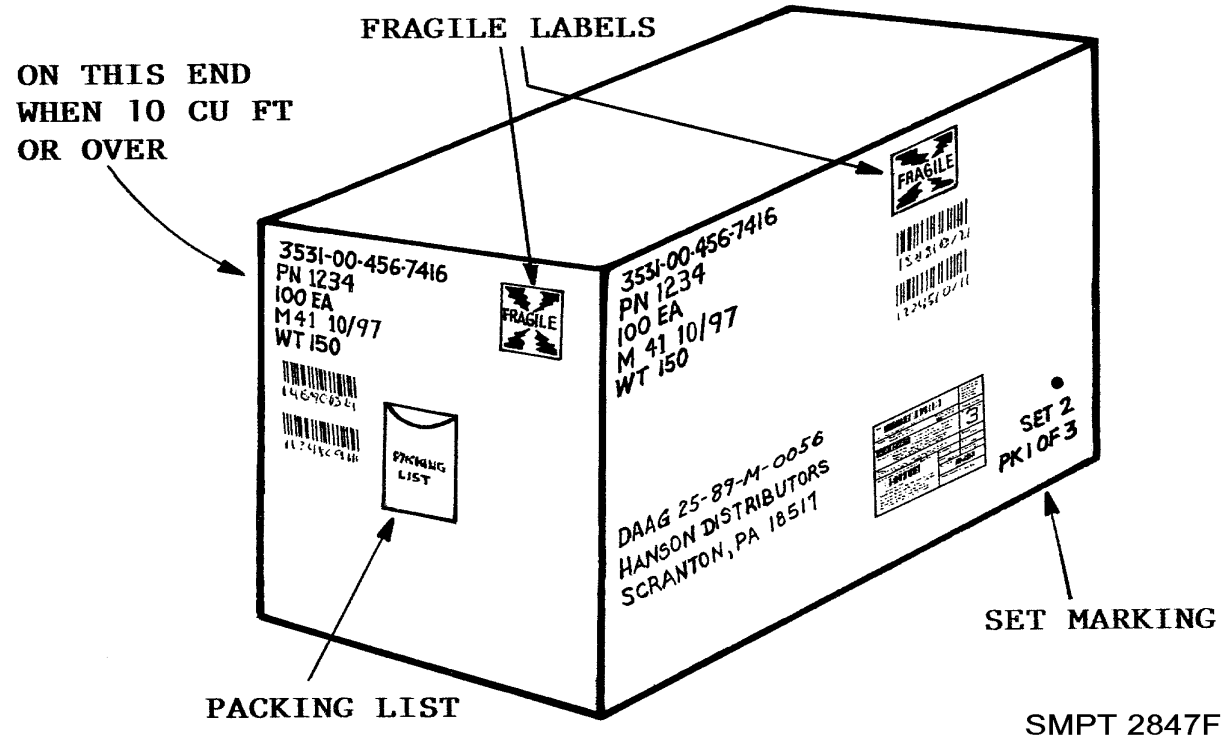

Figure 1-39. Shipping container identification, address, and special markings.

FALSE ECONOMY

Defense material must be protected against all hazards at the lowest possible cost, with the tare weight and cube kept to a minimum. Any attempt, however, to relax standards to anything less than adequate, is false economy. To associate the size and price of an item with the cost of packing is also false economy. Items of small size or low monetary value are often essential to the proper function of a million dollar assembly. To use more material or more expensive material than is essential is also false economy.

REDUCING TARE WEIGHT AND CUBE

One important way to reduce overpacking is through the use of pilot packs carefully engineered and tested for a particular item. The redesigning of established packs and the use of standardized processing forms may result in substantial savings. Wherever the selection of the container is optional, study the comparative initial cost, the labor handling and storage costs, and any possible reduction in tare weight and cube. Probably no area is more fruitful in realizing savings than in the reduction of tare weight and cube.

POTENTIAL AREAS FOR ECONOMY

There are two areas of great saving potential. One is repair parts and general stores items which account for the greatest shipping volume through high turnover. The other is items of large cubic volume on which shipping charges are high, such as pontoons, fuel tanks, electronic equipment, and machine tools. Figure 1-40 shows an example where savings in weight and cube, together with reduction in top heaviness, were achieved by remounting the item on its side. The length of the crate framing members and diagonals was reduced, and the basic strength of the crate was increased by having the angles of the diagonals nearer to the ideal 45 degree.

Figure 1-40. Savings achieved through crating of an item.

Use the most economical container that will adequately handle the load. For example, do not use a Style 2 wooden box having a load limit of 1000 pounds, when a Style 4 box with a load limit of 400 pounds will give all the protection needed. Do not use a wooden box when a lighter container is adequate for the pack.

Develop an active training program for packing supervisors and personnel to alert them to the constant need for the reduction of weight and cube. Figure 1-41 shows how saving in weight, cube, and materials resulted from a simple redesign of the pack.

Make available a greater selection of light weight containers on the packing lines. Operators will not be as likely to use heavier containers when fiberboard or other lightweight containers are available and can do just as well.

Consolidate multipack shipments into low cost containers to eliminate the shipping weight of smaller individual containers. The wood, wirebound, and triple wall fiberboard pallet boxes are all light in weight, are economical and suitable for consolidating materials for domestic and air shipments.

OTHER ECONOMY AREAS

There are several other areas in which economies can be achieved.

MANPOWER

Any reduction in manpower cost will have a definite bearing on the economy of packing. One way to reduce manpower cost is to recognize that the well trained packer is the economical packer. This means using the right man on the right job.

MECHANIZATION

Savings of considerable importance can be derived from the proper use of mechanization. Powerized conveyor belts, mechanized handling systems, and automatic packing machinery, all help to reduce handling and speed up operations.

REUSE OF MATERIALS

Another field in which savings can be effected is through the salvage and reuse of materials. Lumber, cushioning, blocking and bracing materials, containers, and metal fasteners can be reused with a little careful planning (fig 1-42).

Parcel Post

One other area for achieving savings is the more efficient use of parcel post. Frequently, parcel post reduces the need for documentation, allows a lowering of the level of protection, cuts down on marking requirements, and permits faster delivery. Remember, to obtain the maximum value for each Defense dollar, one must be awake to every new idea that may lead to the reduction in packing costs.

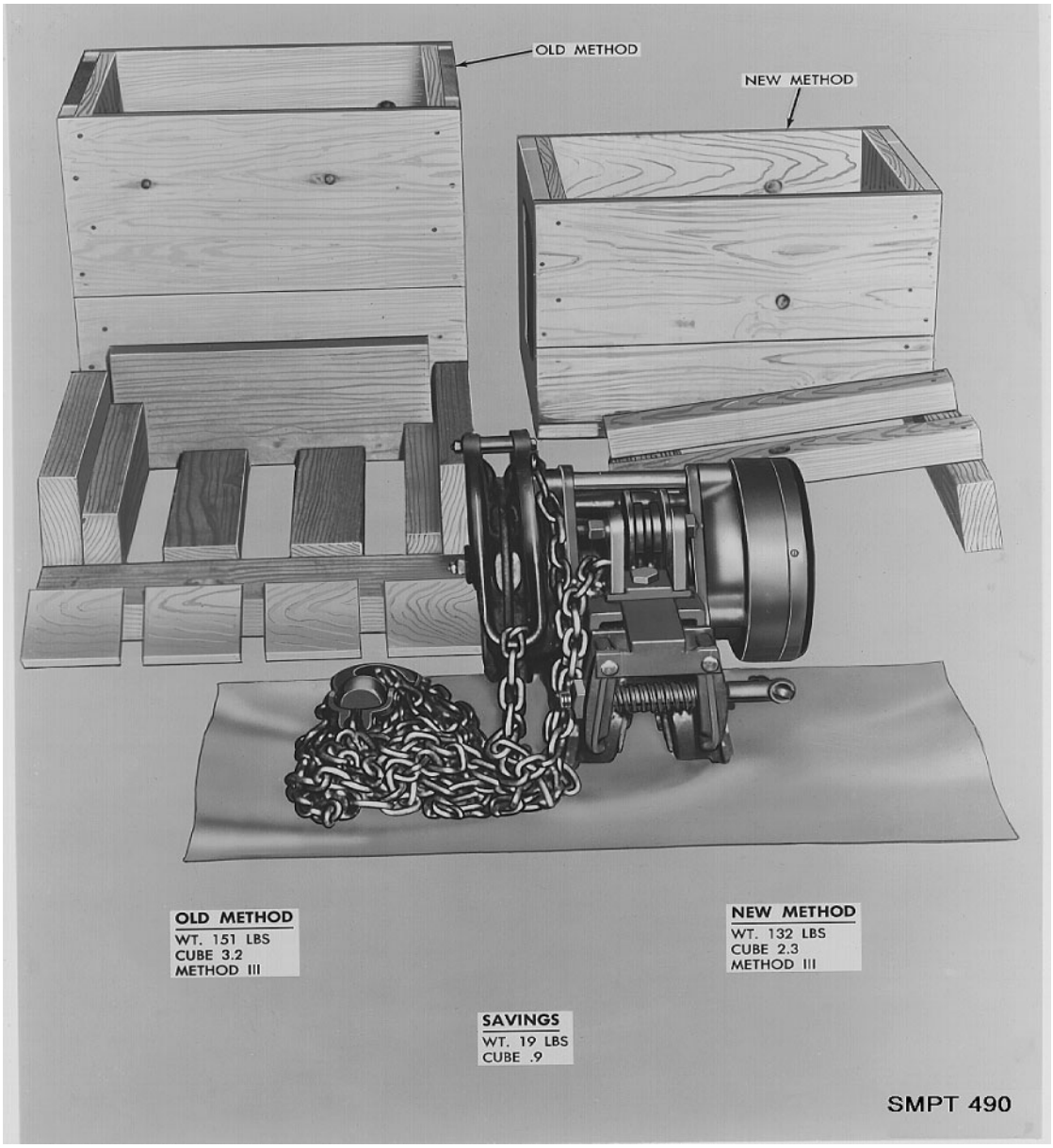

Figure 1-41. Savings achieved by redesigning a container.

PARCEL POST REQUIREMENTS

GENERAL SUPPLIES

Military requirements for parcel post shipments must conform to the Postal Service Manual and the various Armed Service regulations.

Nonmailable Matter

Nonmailable matter includes all matter which is by law, regulation, or treaty stipulation, prohibited from being sent in the mail or which cannot be forwarded to its destination because of illegible, incorrect, or insufficient address.

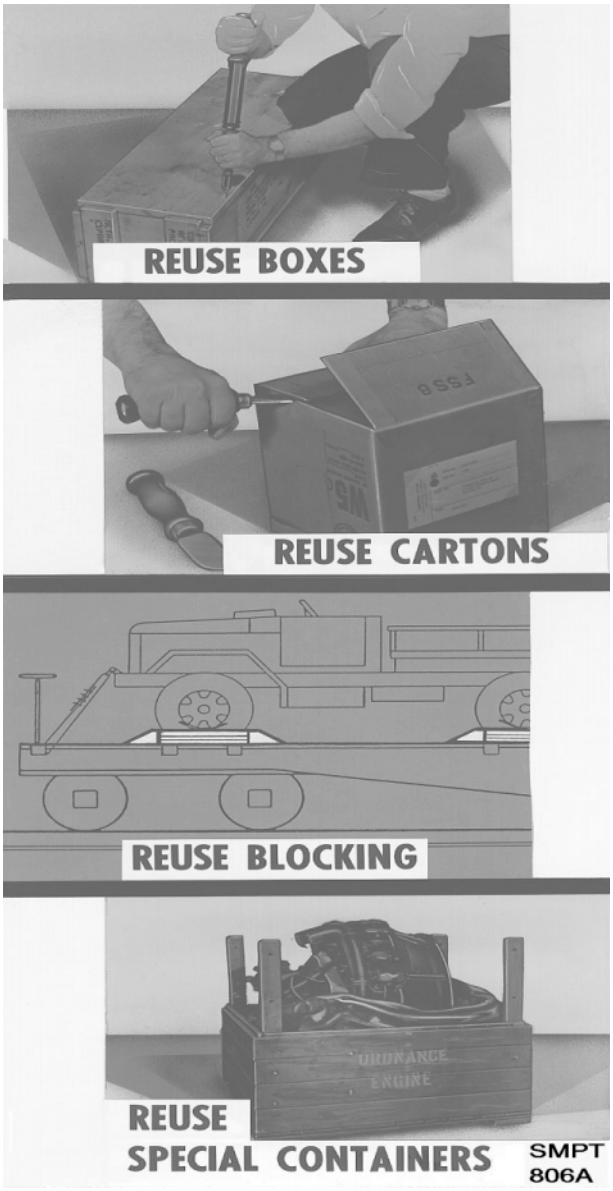

Figure 1-42. Reusing packaging materials means economy.

Harmful Matter

With certain exceptions, any articles, compositions, or materials, which may kill or injure another or injure the mail or other property, are nonmailable. This includes but is not limited to--

- All kinds of poisons, including controlled substances.
- All poisonous animals, except scorpions, all poisonous insects, all poisonous reptiles, and all kinds of snakes, turtles and spiders.
- All disease germs and scabs.
- All explosives, flammable material, internal machines, and mechanical, chemical, or other device or compositions which may ignite or explode.

GENERAL EXAMPLES OF HARMFUL MATTER

Harmful matter includes, among other things, that which is likely to destroy, deface, or otherwise damage the contents of the mailbags or harm the person of anyone engaged in the Postal Service, such as caustic poisons (acids and alkalis), oxidizing materials, or highly flammable solids; or which is likely under conditions incident to transportation to cause fires through friction, through absorption of moisture, through spontaneous chemical changes or as a result of retained heat from manufacturing or processing; explosives or containers previously used for shipping high explosives having a liquid ingredient (such as dynamite), ammunition; fireworks; highly flammable liquids or substances; radioactive materials; matches; or articles emitting a bad odor.

HARMFUL MATTER REQUIREMENTS

Harmful items should not be shipped parcel post without prior approval of the Postal Service. Whenever there is doubt about the mailability of a particular item, a request for a ruling should be made to the local postmaster. Mailability rulings may also be obtained from a nearby mail classification center or from the Office of Mail Classification, US Postal Service, Washington, DC 20260.

TYPES OF SHIPPING CONTAINERS

General

Postal regulations require containers strong enough to retain and protect their contents from the weight of other mail.

Common Containers Used

The following containers, with applicable specification are most commonly used, depending on size, weight, and nature of the article(s): Cotton Mailing Bags (A-A-2714); Burlap Cotton and Waterproof Laminated Textile Shipping Bags (A-A-881); Folding Boxes (PPP-B-566); Fiberboard Boxes (ASTM D5118); Sacks, Shipping, Paper, Cushion (A-A-1588) and Cans, Fiber, Spirally-wound (MIL-C-3955).

Mailbags

Mailbags may be used as containers for consolidated shipments of unbreakable or nonfragile items going to the same location, provided projections are cushioned to prevent rupture of the bag during shipment. Use of one of the three available sizes of mailbag should be based on volume of material going to individual customers.

Used Containers

Used containers in good rigid condition with all flaps intact are acceptable. If a container of desired size cannot be found, a large one may be cut down to meet the needs.

Size and Weight of Container

The shipping containers must be of the proper size to accommodate the item(s) being shipped. Sufficient space for cushioning material should be allowed at the time of container selection, avoiding both the underpacking and overpacking of the item and remaining within the weight limitations. The size and weight of packages mailed at most post offices is limited to 108 inches, length and girth combined, and 70 pounds.

Measurement

Compute the size of a parcel as follows (see Figure 1-43):

- Measure the longest side.
- Measure the distance around the parcel at its thickest part (girth).
- Add both measurements.

Some military post offices overseas have more restrictive size and weight requirements. The weight of an addressed piece of parcel post must be 16 ounces or more.

Reusable Containers

The use of reusable containers may be determined by considering the following factors:

- When the military characteristics of the item are such that a reusable type container is necessary. When the container can serve a dual purpose of shipping container and case while the item is in use. When the item is designated as recoverable-repairable item.
- The cost of a reusable container is offset by multiple use as compared to the cost of single trip, disposable containers.
- When the cost of the item and/or its critical characteristics, or the need for periodic inspection or exercising justifies the use of a reusable container.

Reusable drums with protruding closure devices, such as locking rings, shall be cushioned to prevent injury to postal employees, equipment or other mail.

Outside Wrapping and Closure

When a box itself is an adequate shipping container, paper wraps should be omitted. If a paper wrap is used as an outside cover for boxes, the paper should have at least 60 pounds basis weight. Closure and reinforcement should be made by the use of tape.

Closure and reinforcement is accomplished by using gummed and pressure-sensitive tapes, adhesive, strapping, and staples for boxes and bags. Various friction closures, screw caps and locking devices for cans and similar containers. General purpose transparent mending tape and masking tape shall not be used for closure or reinforcement, but may be used to augment adhesive closure on envelopes or to cover staples on bags. Pressure sensitive filament reinforced tape or reinforced paper tape is recommended for closure and reinforcement. Except for pressure sensitive filament tape, tapes used for closure and reinforcement shall be not less than 2 inches wide.

When strapping is used for closure and reinforcement, it should encircle the length an girth of the package at least once. Twine and cord should not be used. Loose strapping is not acceptable because it presents a hazard to employees and equipment and does not reinforce the container.

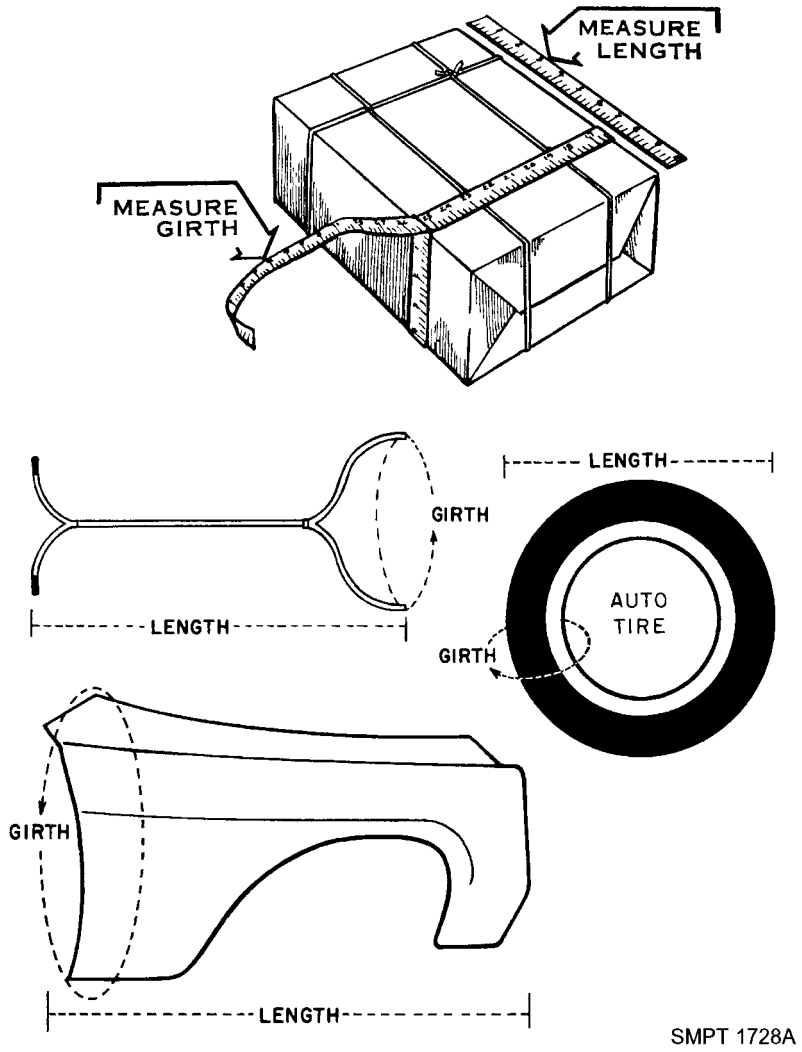

Figure 1-43. Post office measurement requirements.

Marking of Parcels and U.S. Mailbags

Parcels shall be marked to show the consignor; consignee; Transportation Control Number (TCN); and required delivery date, project code, and mark for, when specified.

Marking of U.S. mailbags shipped both domestically and overseas should be tagged in the space located on the locking device to prevent possible opening in transit. Suggested wording of the tag is "OFFICIAL MAIL FOR ORGANIZATION OF ADDRESS. DO NOT OPEN IN TRANSIT."

In addition to the postage tag located on the locking device of the mailing bag, an additional tag will be attached. The tag will notify the local postal authorities that the bag is to be delivered intact to its destination and will contain the complete address to which the bag is destined and the return address.

CHAPTER 2

FIBERBOARD AND PAPERBOARD CONTAINERS

FIBERBOARD BOXES

DESCRIPTION OF FIBERBOARD BOXES

A fiberboard box is a container made of one or more pieces of corrugated or solid fiberboard. The pieces are creased, slotted, joined, and folded according to standard styles described in ASTM D 5118, ASTM D 1974 and illustrated in figures 2-6, 2-7, 2-8, and 2-9.

USE OF FIBERBOARD BOXES

The quantity of fiberboard boxes used in military shipments are increasing steadily and rapidly. A fiberboard box weighs considerably less than a wooden box of the same capacity. This difference in weight is a factor when large shipments are involved, as any saving of weight is reflected in lower shipping cost and easier handling. The main requirements for a shipping container are light weight, low cost, ability to withstand rough handling, and ability to protect the contents against loss or damage. Motor trucks, airplanes, container cars, skid platforms, lift trucks, platform slings, and palletized loads have been important factors in reducing transportation and handling hazards, thus expanding the use of lightweight fiberboard boxes.

Advantages in the Use of Fiberboard Boxes. Fiberboard boxes are adaptable to a great variety of packaging and packing conditions. They offer the following advantages:

- They are made of materials of exactly the specified strength and water resistance.
- They are prefabricated.
- They are made in several styles to suit different shapes and sizes of items.
- They are shipped and stored in the flat, and hence save shipping and storage space.
- They are easy to assemble and handle.
- They are light in weight and relatively strong.
- They are neat in appearance and easy to mark.
- When packed, they occupy less space than most other containers of the same inside dimensions.

CLASSIFICATION OF FIBERBOARD BOXES

Fiberboard boxes, for domestic and oversea shipments, have been consolidated under ASTM D 5118 and ASTM D 1974. Fiberboard material must conform to ASTM D 4727. Boxes may be procured or fabricated in the following types and classes:

- Types (see fig 2-1)
    - o Type CF Boxes - Type CF boxes are fabricated from corrugated fiberboard (CF) stock. Corrugated fiberboard has

two varieties: Single-wall (SW) and double-wall (DW) construction.

- o Type SF Boxes - Type SF boxes are fabricated from solid fiberboard (SF).

- CLASSES

  - o Domestic class boxes are made to meet the requirements of table 1, ASTM D 4727 for bursting strength and the weight of the facing materials. (See figure 2-1, table 2-1.)

- Corrugated fiberboard, class weather-resistant (WR), and waterproof and water vapor resistant (WWVR) - The WR and WWVR boxes, both single and double wall, will meet the bursting strength and thickness for the grade and variety as described in table 2, ASTM D 4727. (See figure 2-1, table 2-2).

Grades of fiberboard

Different strengths of fiberboard are indicated as grades. Grades of fiberboard for class domestic are types CF and SF. Type CF is differentiated by PSI (pounds per square inch) of bursting strength (tables 2-1 through 2-4).

Weather-resistant grades of fiberboard are identified by a letter-number combination such as V2, V3, W5, and W6 which represent different bursting strengths. The numeral in each combination represents the grade of material and the letter in each combination represents a kind of fiberboard (V- or W-board). V-board is a heavy-duty, highly weather-resistant board, and W-board is a lower strength, highly weather-resistant board (see table 2-2).

Type CF (corrugated fiberboard) can be obtained in grades 3, 5, 6, 11, 13, and 15, with compliance symbols of V3c, W5c, W6c, V11c, V13c, and V15c. The small “c” indicates corrugated fiberboard.

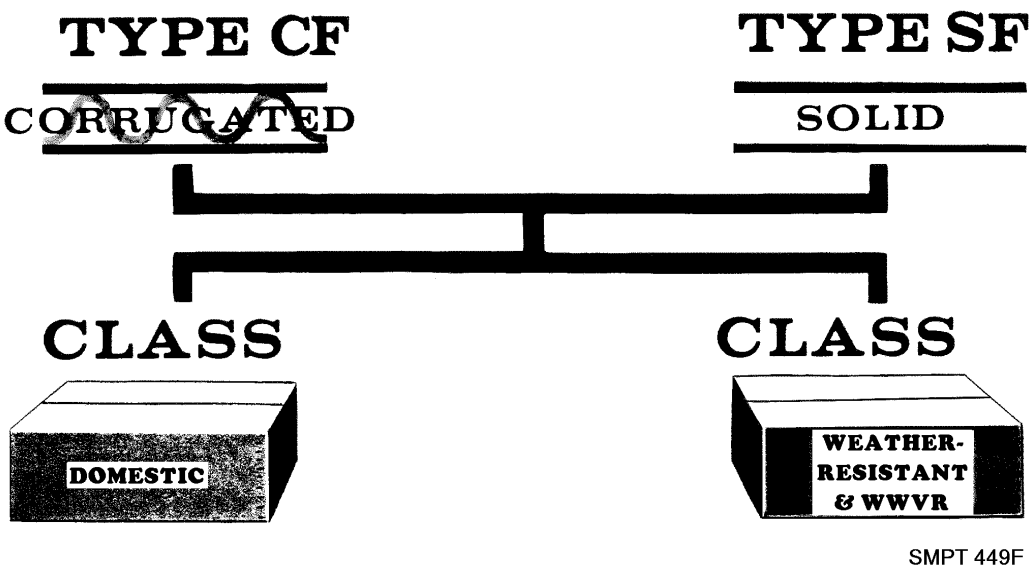

Figure 2-1. Classification of fiberboard boxes.

Type SF (solid fiberboard) can be obtained in grades 125, 175, 200, 275, 350, 500 and 600 with compliance symbols of V2s, V3s, V4s, W5s, and W6s, as shown in figure 2-1, tables 2-3 and 2-4, which are taken from ASTM D 4727. The small “s” indicates solid fiberboard.

Waterproof and water vapor resistant (WWVR) grades of fiberboard are identified by a letter-number combination followed by the letter "WWVR". Waterproof and water vapor resistant boxes are fabricated from type CF (corrugated fiberboard) and can be obtained in grades V3c, W5c, V15c, and W6c (each followed by “WWVR) in the single wall variety and grades V11 and V13 (each followed by “WWVR”) in the double-wall variety.

Table 2-1. Type CF (Corrugated Fiberboard), Domestic

Variety	Grade	Combined Weight Facings Only, min	Bursting Strength, Dry, min[A]	
		lb/1000 ft^2 (g.m^2)	psi (kPa)	
SW	125	52(254)	125(862)	
SW	150	66(322)	150(1034)	
SW	175	75(366)	175(1207)	
SW	200	84(410)	200(1379)	
SW	275	138(674)	275(1896)	
SW	350	180(879)	350(2413)	
DW	200	92(449)	200(1379)	
DW	275	110(537)	275(1896)	
DW	350	126(615)	350(2413)	
DW	500	222(1084)	500(3447)	
DW	600	270(1318)	600(4137)	
			Puncture	
			in. oz/inches of tear	(J)
TW	1100	264(1289)	1100	(33)

[A] Only one burst of the initial six may fall beneath the minimum required. Domestic board failing to pass this test will be accepted if, in a retest consisting of 24 bursts (12 from each side of the board), not more than 4 bursts fall below the minimum value required.

Table 2-2 Type CF (Corrugated Fiberboard), Weather-Resistant, and Water and Water Vapor Resistant Classes (WWVR)

		Thickness, in. (mm)[B]		Bursting Strength, psi (kPa), min avg	
Variety	Grade[A,C]	Corrugating Medium	Outer Facings	Dry	Wet[D]
SW	V3c	0.010(0.254)	0.023(0.584)	400(2758)	150(1034)
SW	W5c	0.010(0.254)	0.016(0.406)	275(1896)	100(689)
SW	W6c	0.010(0.254)	0.010(0.254)	175(1207)	50(345)
DW	V11c	0.010(0.254)	0.023(0.584)	600(4137)	300(2068)
DW	V13C	0.010(0.254)	0.016(0.406)	400(2758)	200(1379)
DW	V15c	0.010(0.254)	0.010(0.254)	300(2068)	100(689)

[A] Includes WWVR grades.
[B] A - r%, or unlimited plus tolerance shall be permitted.
[C] For doublewall fiberboard, the inner facing shall be the same thickness as the outer facing.
[D] After 24 h immersion (see 9.2.1)

Table 2-3 Type SF (Solid Fiberboard): Class Domestic, All Grades

Grade	Combined Weight of Plies Before Lamination, lb/1000 ft^2(g/m^2), min	Bursting Strength, psi (kPa),min[A]
125	114(557)	125(862)
175	149(727)	175(1207)
200	190(928)	200(1379)
275	237(1157)	275(1896)
350	283(1382)	350(2413)
500	330(1611)	500(3347)
600	360(1758)	600(4137)

[A] Only one burst of the initial six may fall beneath the minimum required. Domestic board failing to pass this test will be accepted if, in a retest consisting of 24 bursts (12 from each side of the board), not more than 4 bursts fall below the minimum value required.

Table 2-4 Type SF, Class Weather-Resistant, All Grades

Grade	Thickness, in. (mm)[A]	Bursting Strength, psi (kPa)	
V2s	0.090(2.29)	550(3792)	500(3447)
V3s	0.090(2.29)	400(2758)	150(1034)
V4s	0.080(2.29)	400(2758)	150(1034)
W5s	0.075(1.91)	275(1896)	100(689)
W6s	0.060(1.52)	175(1207)	50(345)

[A] A" 10% tolerance shall be permitted.

Capabilities of Fiberboard Boxes

The three principal factors affecting the carrying capacity of corrugated and solid fiberboard boxes are resistance to compression, strength at the score lines, and resistance to puncture. A fourth factor that should be taken into consideration is the ability of fiberboard to resist the weakening effect of moisture. The importance of the first three factors varies according to the commodity for which a particular box is designed, and the type of interior packing employed.

Resistance to compression, for example, is a relatively minor factor when the contents support the walls of the container or when the interior packing furnishes the necessary support. When these factors are not present, the shipper must make certain that the container has sufficient resistance to compression to prevent it from caving in when it is placed in the bottom tier of a pile of similar boxes. Corrugated and solid fiberboard boxes may be used to ship articles that are not readily susceptible to damage resulting from ordinary distortion of the container. The manner in which a commodity is packed governs to a great extent its condition on arrival at destination. Therefore, the selection of the proper style, class, and grade of fiberboard box should be carefully considered to ensure the commodity against the hazards of storage, shipment, and handling.

The items normally packed in fiberboard boxes are type 1 or type 2 loads. Type 3 loads should be converted to type 1 or type 2 loads by proper interior packing.

Uses and Limitations of Class Domestic Fiberboard Boxes

The uses of fiberboard boxes are essentially as indicated above. Many variations of special die-cut inserts, scored pads, and partitions can be fabricated to give additional protection to the item. The columns for corrugated and solid fiberboard (CF and SF) show the minimum bursting strength of the fiberboard in pounds per square inch which determines the grades.

Uses and Limitations of Class Weather-resistant and WWVR Fiberboard Boxes

V-board was developed primarily for the fabrication of exterior containers for oversea shipment. W-board was developed primarily for the fabrication of interior containers which are packed in exterior containers for oversea shipment. At oversea points, the exterior pack is sometimes removed and the W-board boxes become the exterior containers. When W-board boxes are used as exterior containers, their weight and dimensional limitations should

not be exceeded. Although both V- and W-boards are highly water resistant, boxes made from these materials will permit the entrance of water through the corners and joints. When packed items are of such a nature as to be damaged by water, waterproofing is provided by the use of individual wraps of material conforming to PPP-B-1055; by the use of case liners conforming to MIL-L-10547; or by the use of waterproof, pressure-sensitive tape conforming to ASTM D 5486, applied as shown in figure 2-2 after proper closure of the box. In accordance with ASTM D 5118, tables 2-5 and 2-6 are used to determine the weight and size limitation when class weather-resistant fiberboard boxes are required. Compliance symbols are given in the first column.

Figure 2-2. Sealing Method B.

Table 2-5 Size and Weight Limitations for Types CF[A] and SF[A] Domestic Fiberboard Boxes

Type CF Variety		Type SF	Max Weight of Boxes and Contents		Max Inside Dimensions Length + Width + Depth
SW[4]	DW[4]				
Grade	Grade	Grade	lb	(kg)	in.
125	.....	125	20	(9.1)	40
150	.....	.....	30	(13.6)	50
175	.....	175	40	(18.1)	60
200	200	200	65	(29.5)	75
275	275	275	90	(40.8)	90
350	350	350	120	(54.4)	100
	500	500	140	(63.5)	110
	600	600	160	(72.6)	120

[A] Explanation of abbreviations in Table 1
CF - Corrugated Fiberboard
SF - Solid Fiberboard
SW - Singlewall Fiberboard
DW - Doublewall Fiberboard

Table 2-6 Size and Weight Limitations for Class Weather-Resistant (WR) and Water/Vapor Resistant (WWVR) Fiberboard Boxes Used as Exterior Containers[A]

NOTE - The gross weight and size limit expressed in the circular or rectangular boxmaker's certificate shall conform to the requirements of the Uniform Freight Classification or National Motor Freight Classification Rules, as applicable, and may not necessarily be the same as those stipulated in Table 2.

Grade[B] (Compliance Symbol)	Max Weight of Boxes and Contents		Max Inside Dimensions Length + Width + Depth	
	lb	(kg)	in.	(mm)
V2s	120	(54.4)	100	(2540)
V3s, V4s, and V3c	90	(40.8)	90	(2286)
W5s and W5c	65	(39.5)	75	(1905)
W6s and W6c	30	(13.6)	30	(762)
V11c	160[C]	(72.6)	120	(3048)
V13c	120	(54.4)	100	(2540)
V15c	90	(40.8)	90	(2286)

[A] Not applicable to interior boxes
[B] Reference Specification D 5118/5118M for specific details of construction
[C] Maximum weight may be increased to 225 lb (102 kg) provided the manufacturer's body joint is fastened with metal fasteners spaced not more than 1 in. (25 mm) apart (see 8.1.8)

MATERIALS

Corrugated Fiberboard

Corrugated fiberboard is fabricated of flat sheets of paperboard (called facings) glued to the crowns of a corrugated sheet of the same material. Strength requirements are obtained by varying caliper, number, and quality of the component facings and the corrugated medium. Corrugated fiberboard has low resistance to puncture but affords a high degree of resilience and cushioning. Single-wall (SW, also called double-faced), corrugated fiberboard consists of two outer paperboard facings laminated to a corrugated sheet between them (fig 2-3). Double-wall (DW) corrugated fiberboard consists of three flat facings and two corrugated sheets, a center facing, a corrugated sheet, and a facing (fig 2-3). It is this combination of flat and corrugated sheets that gives corrugated fiberboard its qualities of strength and resilience. Corrugated fiberboard is constructed with different kinds and arrangements of flutes. The "A" flute, with 36 plus or minus 3 flutes per linear foot, is generally used where cushioning of contents is desired. The "B" flute, with 50 plus or minus 3 flutes per linear foot, is used where the contents that support the box are of low fragility. The "C" flute, with 42 plus or minus 3 flutes per linear foot, can be made to serve either propose. The "E" flute is 94 flutes per foot, plus or minus 4 flutes (fig 2-4). The "A" flute is the largest of the three and its strength is realized in stacking applications. Its ability to withstand impact as well as its resistance to flat crushing is the lowest of the four flute sizes due to the lesser number of flutes per linear span. The smallest standard flute size, "E", is the weakest in terms of stacking strength, but it performs very well under puncture and flat crush stress. The "C" flute, which is the middle size flute, will perform moderately well in all three areas--stacking, puncture, and flat crush. It is used where maximum strength in any one area is not required, but where weakness in no area can be tolerated.

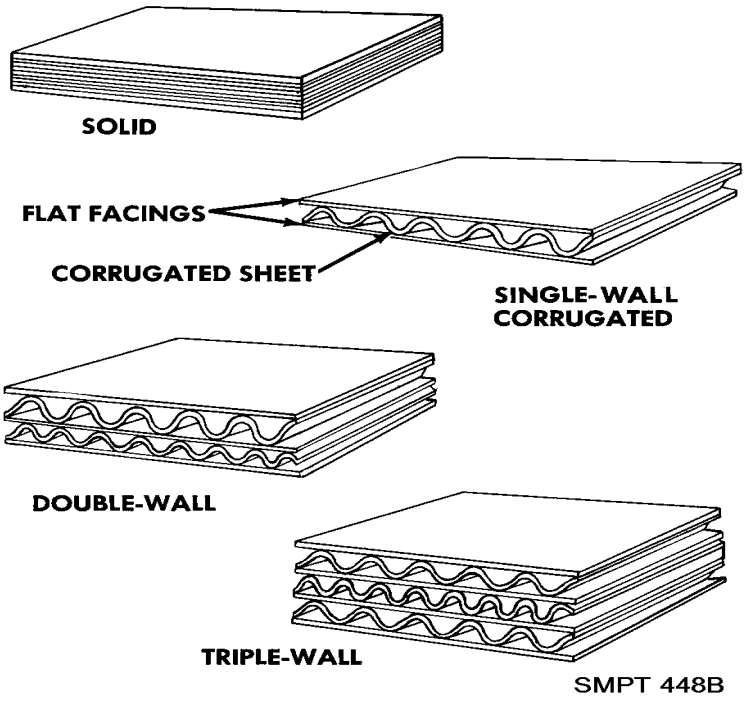

Figure 2-3. Types and varieties of fiberboard.

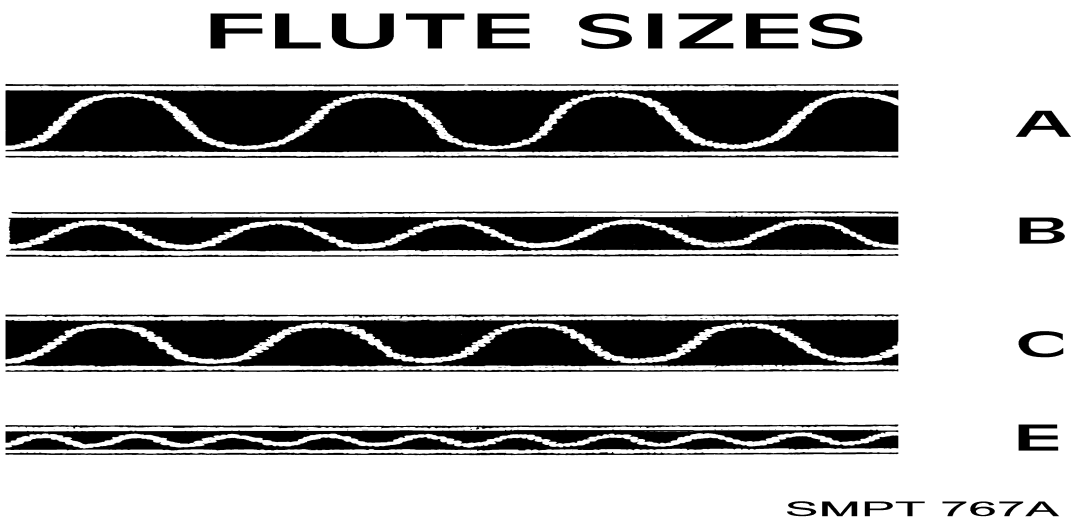

Figure 2-4. Corrugated fiberboard flutes.

Domestic Fiberboard Boxes

Variety SW fiberboard used to fabricate type CF boxes will be A, B, C, or E flute at the option of the supplier. Variety DW fiberboard used to fabricate type CF boxes will be any combination of A, B, C, or E flutes, except they shall not be BB, EE, or BE flute. Type CF boxes, fabricated from variety SW or DW fiberboard shall have the flutes running perpendicular to the scores of the box openings. When specified, the flutes for variety SW or DW fiberboard will run horizontal to the scores of the box openings for boxes of a size that the top and bottom openings are on the smallest panels.

Weather-Resistant And WWVR Fiberboard Boxes

Variety SW fiberboard used to fabricate type CF boxes will be either A, B, or C flute as specified. Conventional slotted type CF boxes shall have the flutes run perpendicular to the scores of the box openings. When specified, the flutes for these boxes shall run horizontal to the scores of the box openings for boxes of a size and style that the top and bottom openings are on the smallest panel. For Styles DBLCC and IC boxes (fig 2-7), they shall have the flutes run the depth of the box perpendicular to the opening.

Solid Fiberboard, Type SF

Solid fiberboard consists of two or more flat plies of paperboard laminated together with an adhesive applied over the entire area of contact between the sheets (fig 2-3). The combined material is solid, hard, and rigid, and boxes fabricated from it resist puncture to a high degree but offer little cushioning to their contents. They do, however, offer greater resistance to rough handling and wear, and are better adapted for use in shipping heavier and less fragile items than those shipped in corrugated fiberboard boxes. If the weight of the box and contents does not exceed 40 pounds, the fiberboard will not be less than two-ply. If the weight exceeds 40 pounds, the fiberboard will be not less than three-ply.

Tapes

Among the tapes most commonly used for closing and sealing fiberboard boxes are--

- ASTM D 5486, a pressure-sensitive water-resistant, paper-backed tape, normally used to close interior containers. ASTM D 5486 is also a pressure-sensitive waterproof tape, used to close and waterproof interior and exterior fiberboard boxes.
- A-A-1492, A-A-1671, a reinforced, paper-gummed tape, used for sealing fiberboard containers for domestic shipment and storage.

Adhesive

Adhesive used for closing fiberboard boxes will conform to MMM-A-250.

Metal fastenings

Metal fastening for securing the manufacturer's joint and closing class weather-resistant and WWVR fiberboard boxes, will be commercially preformed staples or staples from commercial steel stitching wire. The staples will be treated with a commercially applied coating of zinc or copper wash to resist corrosion. ASTM D 5118 and ASTM D 1974 specifies the sizes of staples to use.

Reinforcing materials

Flat steel strapping ASTM D 3953; nonmetallic strapping, ASTM D 3950; or pressure-sensitive, filament-reinforced tape ASTM D 5530 are used to reinforce packed and closed fiberboard boxes. Another document to reference is ASTM D 4675, Standard Guide for Selection and Use of Flat Strapping Materials.

Fabrication of the Boxes

Cutting, scoring, and slotting. Special machines are used to cut, score, and slot the fiberboard material so that it can be made into a box.

Body joint (manufacture's joint)

Domestic boxes, types CF and SF. The body joint (manufacture's joint) of domestic, corrugated fiberboard boxes will be either overlapped or butted, as specified (fig 2-5). The type SF joint shall be overlapped.

Overlapped Joint (Joint Tab)

The joint shall be made with fiberboard joint tab overlap not less than 1 1/4 in. (32 mm) wide with the length of the overlap equal to the inside depth of the box. The joint tab may be an extension of either the end or side panel of the box. When specified the joint tab may extend into the flap area and be secured. The joint tab shall be fastened either inside or outside the adjoining panel and the top and bottom edges of the front tab shall be no more than 3/16 in. (5 mm) below the top or above the bottom scoreline of this panel. The overlapped joint of type CF boxes shall be fastened with adhesive. The toxicity requirement may be waived when packing items other than food. When adhesive is used it shall be applied so as to cover the full area between the joint tab and the adjoining panel. The adhesive shall substantially extend to all edges of the overlap. The overlapped joint of type SF boxes shall be fastened with metal fasteners. Metal fasteners for the type CF and type SF boxes having a depth dimension of 18 in. (457 mm) or less shall be spaced not more than 3 in. (76 mm) apart center to center.

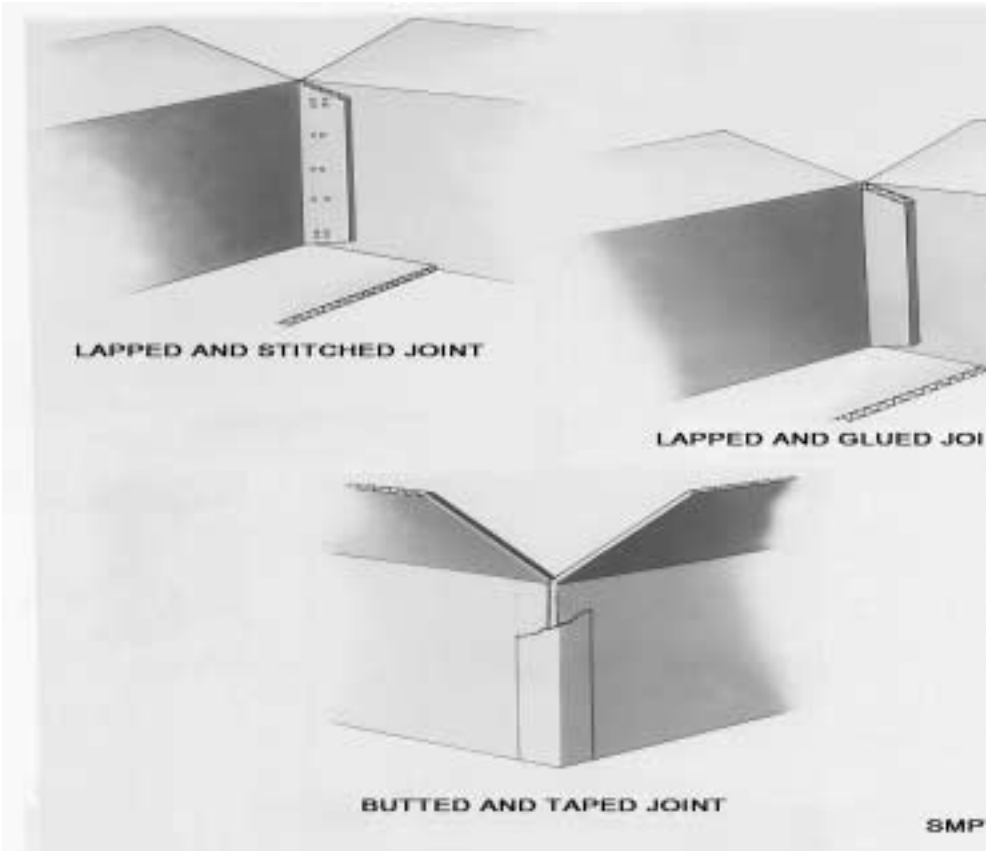

Figure 2-5. Body joints for fiberboard boxes.

Metal fasteners for the type SF box having a depth dimension greater than 18 in. (457 mm) shall be spaced not more than 2 2 in. (64 mm) apart center to center. The distance between the ends of the joint and the nearer end of the nearest fastener shall not exceed 1 in. (25 mm). Metal fasteners may be applied diagonally, vertically or horizontally at the option of the supplier.

Weather-resistant and WWVR Boxes, Type CF and SF

The lap joint shall be used on weather-resistant and WWVR grade boxes (fig 2-5). The lap joint will overlap either inside or outside the box not less than 1 1/2 inches, and will be secured with steel staple or steel stitching wire. The staples or stitches will be spaces not more than 2 inches apart, and the distance between the outer stitches and the end of the joint will not exceed 1 inch. An additional tie-stitch will be used about 1/4 to 3/4 inch from each end of the joint.

In lieu of a tie-stitch joint, boxes may be stapled or stitched with the same number of fasteners (including tie-stitches) equally spaced in a single row. When specified, the body joints of grades W5c, W6c, and V3c fiberboard boxes may be secured by the use of adhesive conforming to MMM-A-250.

Butted Joint (Type CF Only)

The butted joint shall be made by fitting the edges of the panels to be joined closely together and securing them with gummed tape. Tape used to secure the body joint of boxes having gross weight, of 40 lb (18 kg) or less (grade 125 to 175) shall be that normally used by the industry for this purpose.

Tape used to secure the joints of boxes having a gross weight of more than 40 lb (18 kg). (Grades over 175) shall be reinforced with sisal, cloth, glass, rayon or double strand nylon fibers. The tape shall be not less than 2 in. (51 mm) in width for boxes having a gross weight of 65 lb (30 kg) or less (grade 200 and below) and not less than 3 in (76 mm) in width for boxes having a gross weight over 65 lb (30 kg) (grade above 200). The tape shall be centered on the joint and extend its full length, or within 3/8 in (10 mm) or full length be centered on the joint and shall adhere over not less than 90% to the entire area of contact with the fiberboard.

Styles of Fiberboard Boxes

The styles covered in figures 2-6, 2-7, and 2-8 are the basic styles of domestic, weather-resistant, and WWVR fiberboard boxes.

RSC, Regular Slotted Box (figure 2-6)

In this design, all the flaps (inner and outer) are of equal length. The outer flaps meet in the center when closed. This style is the most commonly used.

SFF, Special Full Flap Slotted Box (figure 2-6)

In this design the inner flaps meet in the center of the box. A one-fourth inch gap is permitted.

FOL, Full Overlap Slotted Box (figure 2-6)

In this design, the length of the outer flaps shall be not less than the inside width of the box minus 1 inch. This design results in a container with at least two thicknesses of fiberboard covering the entire top and bottom surfaces.

OSC, Overlap Slotted Box (figure 2-6)

In this box, when closed, the inner flaps must not overlap, and the outer flaps will overlap the distance specified in the order or invitation for bids. The inner flaps will be of the same length as the outer flaps, except when the relation of width to length would cause the inner flaps to overlap. In such a case, the inner flaps will be cut to meet in the center of the box.

CSSC, Center Special Slotted Box (figure 2-7)

This box is designed so that the inner and outer flaps meet in the center giving a double thickness for top and bottom.

CSOSC, Center Special Overlap Slotted Box (figure 2-7)

This box is designed the same as the CSSC except the outer flaps are the same length as the inner flaps and may overlap. No flap cutting is required.

HSCC, Half Slotted Box With Cover (figure 2-7)

This box consists of a box body and a cover. The body is formed from fiberboard, scored, slotted, and stitched to form a tube having four flaps of equal length, approximately half the width of the box, on the bottom only. Unless otherwise specified the cover shall be a Type I. When specified the cover shall be a Type II. The depth of the cover is 3 in. unless otherwise specified.