Chapter 3

Preservatives and Their Application

BASIC PRINCIPLES OF PRESERVATIVES PROTECTION

DETERIORATION OF MATERIALS (FIGURE 3-1)

The fact that items have been cleaned and dried does not insure that they will remain free from future contamination. In fact, cleaning may increase the possibility of damage to an item by leaving its surfaces exposed to the direct attack of destructive forces. Attacks by air, water, sunlight, living organisms, temperature changes, and aging occur everywhere. It is known that iron and steel rust; copper, zinc, and similar metals corrode; wood rots and decays; leather cracks and mildews; cork becomes brittle; paper and textiles fade and mildew; food molds and spoils; and other materials change in many ways to reduce their usefulness. This reduction in the usefulness of a material is deterioration. In most cases, deterioration is a chemical change, but it can also be a physical change such as the cold flow or plastic deformation of rubber. The deterioration of a material varies with its composition. Organic materials such as wood, leather, fabrics, rubber, and plastics are affected by micro-organisms, insects, heat, sunlight, and extremes of humidity. Inorganic materials such as metal, glass, quartz, graphite, and the like are attacked by chemical actions of gases, water, and sunlight.

Corrosion of Metals

The most prevalent form of deterioration to which metal items are subjected is corrosion. In the presence of gases found in industrial areas, unprotected metal is attacked. With water absent, the rate of attack is extremely slow because the film forming on an exposed metal surface by an initial attack acts as a protective layer and inhibits further corrosion on the base metal. For example, oxygen is a protective agent for most metals, despite its attack on all metals at various rates. The action of oxygen on metal usually produces a thin, uniform oxide film that impedes further attack. Pure aluminum, for example, will last indefinitely when exposed to air, because it is protected by an adherent and continuous oxide coating that forms immediately on exposure. In the presence of free water and corrosive gases, these protective oxide films change into other less stable oxides, hydroxides, chlorides, and sulfates, which are soluble in water and are thus removed by rain, snow, and sleet, with the result that some of the metal is destroyed. The rate of destruction depends upon such factors as temperature, humidity, evaporation, and sunlight.

Electrochemical Corrosion

Electrochemical corrosion takes place when two different metallic components are brought into contact with each other in the presence of water or another nonmetallic conductor (an electrolyte). The two metallic components plus the electrolyte make up the elements of an electrochemical cell (a battery) and an electrical current will flow accompanied by chemical action. This chemical action is corrosion. That is, one of the metals will dissolve while the other metal will be coated with reaction products. This is due to each metal possessing a different electromotive potential. Where two different metals such as aluminum and steel are coupled together, in the presence of an electrolyte, the potential difference is great enough to cause a flow of current. There is even sufficient potential difference between adjacent crystals of a single piece of impure metal for corrosion to occur when all the conditions are favorable.

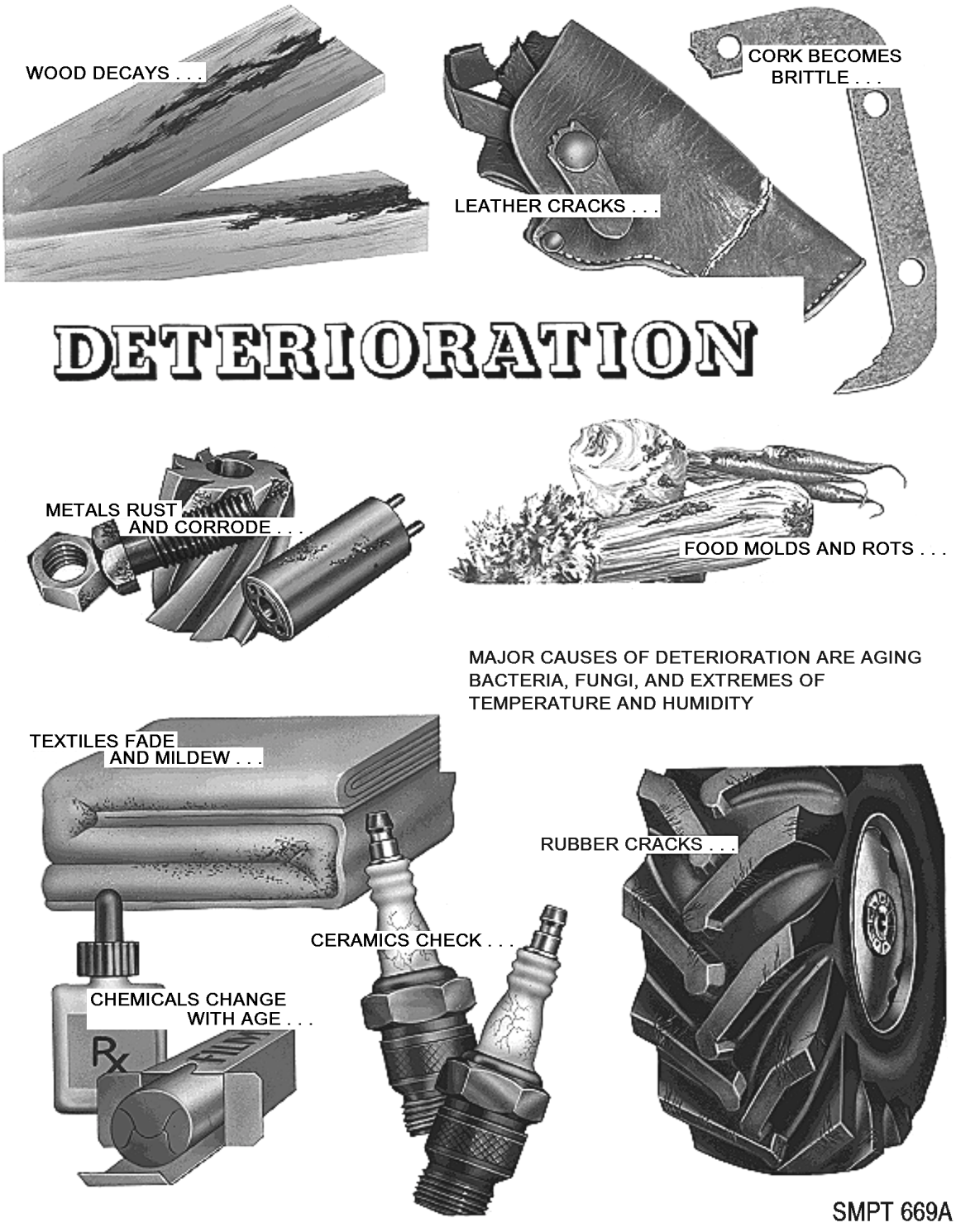


Figure 3-1. The causes and effects of deterioration.

Galvanic Corrosion

Galvanic corrosion occurs when electrical current flows between dissimilar metals that are in contact with each other or from one part of the surface of a piece of metal to another part of the surface. For this kind of corrosion to take place, an electrolyte such as water must be present. Table 3-1 lists an electrochemical series of metals ranging from the anodic or positive end to the cathodic or negative end of the series. Galvanic corrosion action is stronger when the metals are further apart in the series, such as when aluminum and copper are placed together. Metals closer to one another in the series, such as tin and steel (or iron) would have a lesser corrosion effect. The further apart any two metals are, the stronger the corroding effect on the higher one, toward the anodic end in the electrochemical series. So, for galvanic corrosion to occur in metals, there must be an electrolyte to allow current to flow between a metallic area or region with a negative charge in relation to a second area, and a second area positive in opposition to the first. The susceptibility to corrosion of iron and steel is of great concern because annual U.S. losses have been estimated at nearly $70 billion.

Table 3-1. Electrochemical Series.

Anodic (Positive) End	+
Lithium	
Rubidium	
Potassium	
Calcium	
Sodium	
Strontium	
Barium	
Magnesium	
Beryllium	
Aluminum	
Manganese	
Zinc	
Chromium	
Gadolinium	
Iron (Fe++)	
Cadmium	
Indium	
Tellurium	
Cobalt	
Nickel	
Tin	
Lead	
Iron (Fe...)	(neutral)
Hydrogen	
Antimony	
Bismuth	
Arsenic	
Copper	
Iodine	
Silver	
Palladium	
Mercury	
Platinum	
Gold	
	-
Cathodic (negative) End	

Preservatives Defined

Preservatives are materials that are applied to, or come in contact with, items to protect them from deterioration resulting from exposure to environmental conditions during shipment and storage. Some preservatives protect items by providing a barrier against moisture, air and other agents of corrosion. These are contact preservatives. Other preservatives protect items by releasing vapors which deposit an invisible protective film on the items. These materials are called volatile corrosion inhibitors (VCI).

PRESERVATIVE APPLICATION CRITERIA

Preservatives should be applied whenever items require protection against deterioration. The composition of some items render them immune to corrosion under ordinary conditions. For example, the more resistant metals such as gold, platinum, palladium, and beryllium seldom require a preservative application. Items fabricated from graphite, clay, stone, glass, or ceramics require no preservative coating. Many items susceptible to corrosion can be made less subject to deterioration by the application, at the time of manufacture, of a protective coating which remains an integral part of the item during its useful life. Such coatings are permanent preservatives. Many items, however, because of close tolerances, operating characteristics such as rolling, sliding, or bearing surfaces, or other limiting factors cannot be protected with a permanent coating but must be protected during shipment and storage by temporary preservatives. These materials are applied after the item has been manufactured and must be removed before the item can be used.

CLASSIFICATION OF PRESERVATIVES

Permanent and temporary preservatives are classified on the basis of the material to be preserved. There are preservatives for metals and for nonmetals. They are usually applied on the item at the time of manufacturer, however, they are also applied in the field. This is especially true of cordage, leather goods, and canvas materials. Preservatives for nonmetals are intended to protect items against deterioration by hardening, drying, aging, decaying, rotting, or decomposing.

PERMANENT PRESERVATIVES FOR METALS

CORROSION-RESISTANT METALS

The most effective means of giving permanent protection to items is to make them from metals which are highly resistant to corrosion. There are several metals and alloys available such as steel, copper, nickel, chromium, brass, bronze, and beryllium. Under normal conditions of usage, these metals are highly resistant to corrosion. However, the most resistant metals or alloys may be unacceptable because of technical or economic factors. The design engineer may be forced to compromise because of workability, mechanical properties, fabrication problems, availability, or cost. If corrosion resistance is the major design requirement, metals and alloys with superior corrosion resistance should be selected despite high cost and poor fabrication qualities. While the selection of the fabrication materials is not a direct responsibility of preservation personnel, a knowledge of the corrosion-resistant characteristics of items will assist in the choice of preservatives. For example, corrosion resistant steels quite often require added protection, especially when exposed to salt atmospheres.

METAL COATINGS

When a corrosion-resistant metal cannot be employed in the fabrication of an item, the next best alternative is to provide a protective metal coating for the corrodible metal used. There are two types of metal coatings that can increase the corrosion resistance of the base metal. They are -

Resistant (Cathodic) Coating

This coating furnishes complete protection of the base metal only if it is impervious to water. If any pores exist in the coating, corrosion of the base metal is accelerated. To increase protection and reduce porosity, the thickness of the coating must be increased. Nearly all the electroplated metals, except zinc and cadmium, are in this category. Of the more resistant metal coatings, nickel plating is the most used to protect steel and iron. A preliminary copper coating is frequently applied, partly because the copper is more cheaply polished than the underlying steel or the superimposed nickel. Copper also produces better adhesion. Other frequently used coatings are chromium, gold, silver, and tin.

Sacrificial (Anodic) Coating

Corrosion will attack this coating first. The coating is destroyed before the base metal is affected. Generally, the corrosion product of the coating provides further protection to the base metal. Some metals like zinc, aluminum, nickel, and copper, when exposed to the atmosphere, form a protective coating which retards further corrosion. Iron, however, continues to rust progressively after every exposure to water. The two sacrificial coatings most commonly used are zinc and cadmium.

CHEMICAL CONVERSION COATINGS

Metals are frequently given corrosion protection by applying chemicals that react with the base metal to form a thin coating which prevents further attack on the metal. These chemicals provide oxide, phosphate, and chromate coatings.

OXIDE COATINGS

There are several processes used to form oxide films on metals at a more rapid rate than would occur in nature. For ferrous metals, these films are produced by heating the metals in various atmospheres, depending on the color or character of the coating desired. In many applications, oxide coatings are more useful for their decorative value than for their corrosion resistance. Browning, bluing, and blackening (MIL-C-13924) are processes of this type. They color the metal more than they protect it and are seldom used without an oil or wax coating. For aluminum, the aluminum is rapidly oxidized in sulfuric or chromic acid to form permanent oxide coatings. This treatment is referred to as anodizing (MIL-A-8625).

PHOSPHATE COATINGS

Where "heavy" coatings are required, MIL-P-16232 should be used. This specification covers two types of heavy phosphate coating for ferrous metals, applied by immersion. The coatings consist of a manganese phosphate or zinc phosphate base. Light phosphate coatings used as a paint base are covered by other specifications, such as TT-C-490. However, heavy coatings may be used as a paint where required. In addition, TT-C-490 covers suitable cleaning processes for nonferrous surfaces.

CHROMATE COATINGS

Chromate conversion coatings are applied to items plated with zinc, cadmium, aluminum, magnesium, and other metals. Several procedures are available by which a protective film of chromium salts is produced on the metal platings. The film is formed by simple immersion of the plated item in a chromate or chromic acid solution and sulfuric acid. These chromate coatings applied to zinc and cadmium plated items extend the useful life of such items considerably.

VITREOUS COATINGS

Vitreous porcelain or glass enamel coatings consist of a thin layer of glass fused into the surface of the metal, generally iron. Obviously, these coatings have the properties of glass, and variations in their properties are due to the differences in the compositions and physical conditions of the glasses selected. These coatings have been long used for durable and sanitary finishes for iron cooking utensils, refrigerators, and plumbing fixtures.

ORGANIC COATINGS

Organic coatings are widely used to protect surfaces from deterioration. Such coatings are applied as liquids but become solid after application. Included in this group are varnishes, paints, lacquers, and enamels. Organic coatings are essentially barriers and unless care in their application and maintenance is exercised, cracks, pinholes, or other breaks will render the barrier ineffective as a protective coating.

VARNISHES

A varnish is a combination of drying oil and a fortifying resin, either natural or synthetic. The mixture is thinned with suitable solvents to brushing or spraying viscosity and employed as a clear composition. It dries by oxidation of the oil component.

PAINTS

Originally, this term applied to mixtures of pigments (usually oxides of metals) with a drying oil such as linseed oil. Oil base paints are the oldest type of protective coatings in general use. The term "paint" has now come to mean any combination of pigmented-and-liquid-vehicle, such as rubber-base and water emulsions, that are adaptable to brushing, rolling, or spraying, and that dry to a tough, adherent coating.

Enamels

An enamel is a pigmented varnish in its strictest sense. Actually, the wide use of fortifying resins in oilbase paints has resulted in the disappearance of any distinction, other than an arbitrary one, between paints and enamels. There is currently a tendency to term alkyd-resin-base finishes "quick-dry" enamels to differentiate them from the older, natural resin paints.

LAQUERS

Originally, a lacquer consisted of one or more selected natural resin dissolved in a rapidly volatile solvent. These compositions were either clear or pigmented. They set to very hard, glossy, nontacky films by solvent evaporation only. Presently, the term is expanded to mean any air drying or ovenbaking type composition, usually, but not necessarily based on nitrocellulose or similar cellulose resins.

PLASTIC COATINGS

Plastic protective coatings consist of solutions or dispersions of film-forming plastics in organic solvents. These coatings are satisfactory for continuous contact with mild corrosives such as fresh and salt water, some solvents, and some alkalies. Generally, they should be used only for exposure to splash and fumes in the presence of corrosive liquids. There are two basic types of plastic material employed for protective coatings.

THERMOPLASTIC COATINGS

A number of thermoplastic coatings have proved useful in protecting metal surfaces in mildly corrosive atmospheres. Of these, polyethylene, styrene copolymers, vinyl resins, and polyvinylidene chloride (saran) are especially valuable.

Vinyl Resins

Vinyl resins have been compounded to be highly resistant to alkalies, corrosive salts, certain solvents, and acids. They are used in the protection of metal against splash and fumes of corrosive chemicals, and for coating objects which are to be continuously immersed in fresh or salt water.

THERMOSETTING COATINGS

Several of the thermosetting types of plastics are being used as corrosion-resistant coatings.

Polyesters

Protective coatings consisting of polyesters blended with styrene can be compounded to yield good chemical resistance. Polyester coatings may be colored and may be applied by brushing, roller coating, or spraying.

Urea-melamine Resins

These resins are used primarily as baked coatings. When applied as organic solutions and baked at temperatures between 200º and 350ºF., hard, light colored, brittle films are produced.

Phenolic Coatings

Phenolic coatings have been used for many years for preventing iron contamination to liquids stored in drums and tanks. They are applied as liquid resins dissolved in alcohol and dried and baked at temperatures near 300ºF.

Epoxy Coatings

Epoxy coatings are resistant to acids, alkalies, and some solvents. They adhere well to a wide variety of surfaces, and their impact resistance can be made superior to that of phenolic coatings by the addition of flexibilizers.

Rubber-Type Coatings

A number of rubber-type coatings are employed as protective coatings.

Chlorinated Rubber

Natural rubber treated with chlorine forms a plastic material which has excellent adhesion to many surfaces and is resistant to many corrosives. It has low resistance to heat and light. By blending it with other resins and plasticizers, its brittleness is overcome to a great extent.

Chlorosulfonated Polyethylene

Exposure of polyethylene to chlorine and sulfur dioxide produces this material. This increases the solubility of polyethylene in several solvents. The dissolved polyethylene gives excellent adhesion characteristics. It has an excellent chemical resistance and can be pigmented to produce a wide choice of colors.

Chloroprene

Also know as neoprene, this material can be dispersed in organic solvents and can then be applied by brush or spray. It has excellent resistance to oils, sunlight, heat and ozone and has high retention of resilience upon aging. This combination of properties makes it ideal for use as a heavy-duty protective coating. Chloroprene

coatings with high solid content yield heavy films which adhere well to chlorinated-rubber primed surfaces.

FUSION-BONDED PLASTIC COATINGS (FIGURE 3-2)

The fusion-bonding of powdered plastics to the surfaces of objects that can be heated to the melting point of the plastic is a technique for applying protective and decorative plastic coatings. Many plastics which have not been used previously because of their insolubility as protective coating materials can now be used to provide excellent protection against acids, alkalies, and corrosive liquids. Plastics such as polyethylenes, polyesters, epoxies, vinyls, nylons, and saran can now be obtained in finely divided-powdered form in many colors. The powdered plastic is placed in a fluidizer consisting of a tank having an upper and lower section divided by a porous plate. Air or gas forced up through the porous plate causes the powder to vibrate as if it were a boiling liquid. The coating process consists of dipping a preheated item for a few seconds in the fluidized powdered plastic. Upon coming in contact with the heated item, the powder is melted and forms a smooth plastic film over the surface of the item. The coated item is then placed in an oven for curing to set the film.

PRESERVATIVES FOR NONMETALS

Since the preservatives for nonmetals include a wide variety of materials, in most instances intended for specific applications, their use is limited to the instruction contained in contracts, specifications, or special processing directives and manuals. Examples of some of the common nonmetal preservatives are electrical circuit preservatives, leather preservatives, and textile preservatives.

ELECTRICAL CIRCUIT PRESERVATIVES

These compounds are used to protect electrical and electronic equipment against the effects of fungus and moisture. It is generally desirable to design equipment so that the use of the products is not necessary; however, when equipment is not so designed, these materials are suitable for providing the necessary protection.

MOISTURE AND FUNGUS RESISTANT VARNISH (MIL-V-173)

Varnish conforming to this specification is used for the overall protection of communication and electronic equipment against the effect of moisture and fungus attack on the performance of the equipment. It may be applied by spraying, dipping, or brushing and must be used in conjunction with supplementary specifications stating the method of application of the varnish and the treatment of the equipment to receive it.

WATERPROOFING, ELECTRICAL IGNITION VARNISH (MIL-V-13811)

This material is a clear (unpigmented) compound intended primarily for use in protecting electrical circuits and engine parts of internal combustion engines used on military motor vehicles and other automotive equipment. This compound can be applied by spraying, dipping, or brushing. The resulting coating dries to a hard, flexible film in about 8 hours. The solvents used in this material have a low flashpoint (75ºF), and safety precautions against fire must be taken. It must not be applied to heated surfaces. This compound should be stored in tightly sealed containers.

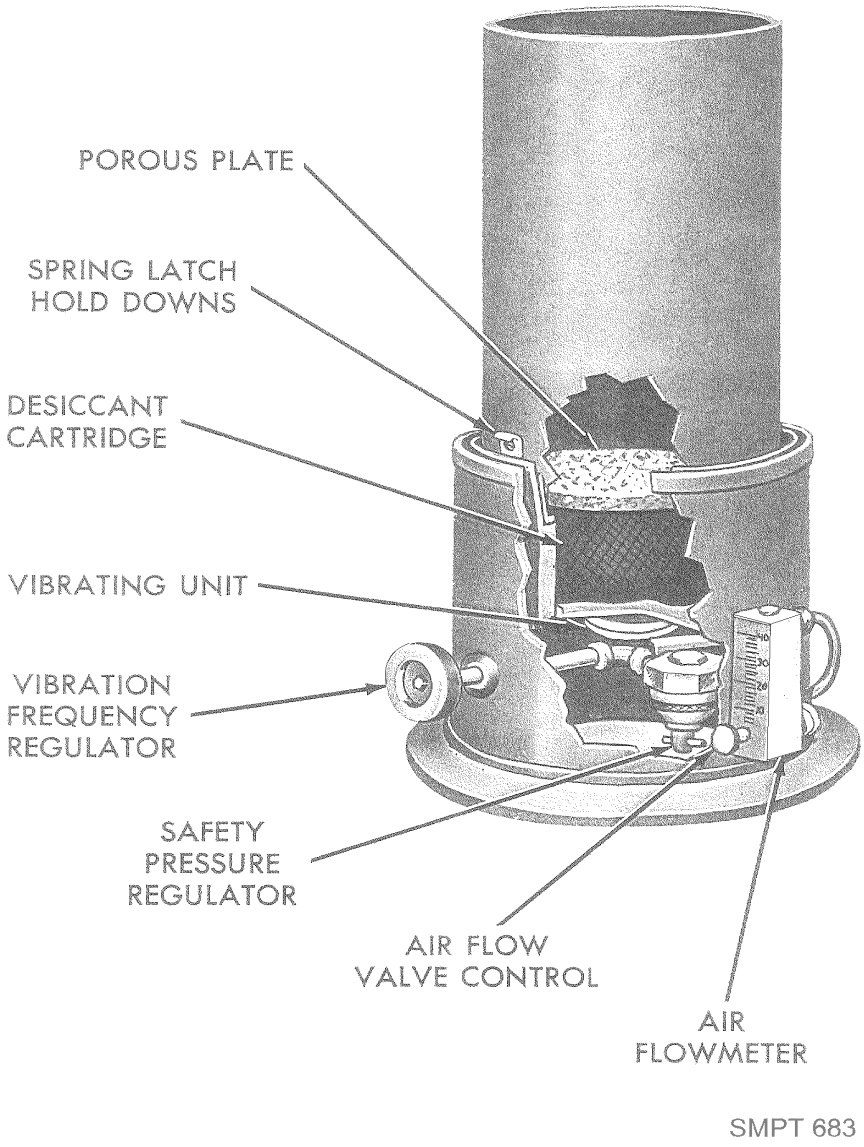


Figure 3-2. Fusion-bonding fluidizer.

LEATHER PRESERVATIVES

These compounds are used on leather items to give them resistance to cracking, mildew growth, and water penetration. They are expected to preserve the original qualities of leather and improve the qualities of leather items that have been in use.

SOLVENT TYPE MILDEW PREVENTATIVE (O-L-164)

This type of compound is used as received with no dilution necessary. Items must be cleaned in warm (not over 100°F) soapy water, rinsed and drained for about 5 minutes. The items are then immersed in the compound for about 2 minutes. The treated leather must be allowed to dry thoroughly in the open air before wearing.

Handling

These compounds must be handled with due regard to health. Application of these materials must be made in a well ventilated area. Skin contact and the breathing of the fumes should be avoided. The hands must be washed thoroughly in cool water and soap after application. Treated materials must be thoroughly aired and dried before allowing them to come in close contact with the skin. These compounds should not be used on leather products which will come in prolonged contact with the skin. When boots and shoes are treated, socks must be worn.

TEXTILE PRESERVATIVES

These consist of several complex chemical treatments which are intended to give a high degree of mildew resistance to fabrics, wool felt, rope, thread, twine, and other natural fibers. The chemical agents used in these treatments are capable of limiting the growth of mildew and fungus. Most of these processes should not be applied to materials which will come in frequent and close contact with a person's skin during use. They should not be used on materials which will be coated with, or come in contact with natural rubber. They will cause an undesirable reaction with the rubber. In preparing colored materials, allowance must be made for the effects the process may have on the colors. Many textiles are also protected by the use of vapor type preservatives such as naphthalene or paradichlorobenzene (A-A-52287) which repel insect attack, principally by the cloths moth.

LINSEED OIL (ASTM D 234 OR ASTM D 260)

Linseed oil can be obtained raw (ASTM D 234) or kettle boiled (ASTM D 260). Aside from its use in the manufacture of and thinning of paints and varnishes, linseed oil is used to preserve wooden gun stocks and similar wooden items and to treat the inner surfaces of chests and lockers in hot, humid, or dry areas. For gun stocks, it is prepared by mixing 1 gallon of volatile mineral spirits paint thinner with 6 gallons of raw linseed oil (kettle boiled if faster drying is desired) and 2 percent of fungicide. Any wiping cloths used while applying linseed oil should be disposed of immediately after use to avoid fire by spontaneous combustion.

CASTER OIL, TECHNICAL (ASTM D 960)

Caster oil is used as a preservative on hydraulic brake systems and as a leather dressing.

CONTACT PRESERVATIVES FOR METALS

Many finished metal items require a preservative coating that is easily removed and yet will not rub off or abrade. Attempts were made to use lubricating oils for this purpose, since oil and water do not normally mix. It was found that lubricating oils, being lighter than water, and with less attraction to the metal surface, were soon displaced by water. A number of protective, removable petroleum base compounds have been developed with characteristics for specific preservation needs. By adding ingredients with water displacing compounds and inhibiting qualities to lubricating oils, greases, and hydraulic fluids, several temporary preservatives have been developed. These compounds have different consistencies and require different methods of application.

CONTACT PRESERVATIVE GROUPS (TABLE 3-2)

For convenience, the preservatives listed in MIL-STD-2073-1C, Appendix A, Table A.III, Contact Preservative Category Code Determination, may be placed into four groups, according to their composition and application requirements, as follows:

X thin film, solvent cutback, cold application;
X petrolatum base, hot application;
X rust inhibiting oils, cold application; and
X special purpose, cold application.

Group 1

The contact preservatives in Group 1 are as follows:

X Code 01, MIL-PRF-16173, Grade 1, corrosion preventative, solvent cutback, cold application, hard film;
X Code 02, MIL-PRF-16173, Grade 2, corrosion preventive, solvent cutback, cold application, soft film;
X Code 03, MIL-PRF-16173, Grade 3, corrosion preventive, solvent cutback, cold application, water displacing soft film;
X Code 19, MIL-PRF-16173, Grade 4, corrosion preventive, solvent cutback, cold application, transparent, not-tacky; and
X Code 21, MIL-PRF-16173, Grade 5, corrosion preventive, solvent cutback, water displacing soft film, low pressure steam removable.

The thin film solvent cutback, cold application preservatives contain 40 to 60 percent petroleum solvent, which evaporates, leaving a thin protective film. Code 01 is black in color. Asphaltic preservative Codes 02 and 03 are amber in color and are intended for short-term outdoor and long-term indoor exposures. Code 02 is oil miscible and Code 03 is water displacing. Code 19 is a transparent nontacky film. Code 21 is the same as Code 03 but with the additional requirement that it is removable with hot water or low pressure steam.

Table 3-2. Contact Preservatives for Metal Items*

GROUP 1	GROUP 2	GROUP 3	GROUP 4
THIN FILM, SOLVENT CUT-BACK, COLD APPLICATION	PETROLATUM BASE, HOT APPLICATION	OILS, RUST-INHIBITING, COLD APPLICATION	SPECIAL PURPOSE, COLD APPLICATION
Code 01 02 03 19 21	Code 06	Code 07, 09 10, 15 17	Code 11 20

*Contact preservative material codes are found in Table J.III, Appendix J, MIL-STD-2073-1C.

Group 2

The contact preservative in Group 2 is Code 06, MIL-C-11796, Class 3, light preservative compound, soft film, hot application. Only one petrolatum base, hot application preservative is currently in use by the military. Code 06 consists of petroleum plus inhibitors. It is made by adding oils of high viscosity to the petrolatum base. As the consistency decreases, the ease of application increases, but the degree of protection decreases. It is applied by brushing or swabbing at room temperature or by dipping in the molten state. It is used for preservation of antifriction bearings and for use on machined surfaces for which a protective material that is brushable and easily removable at room temperature is required.

Group 3

The contact preservatives in Group 3 are as follows:

- X Code 07, MIL-PRF-3150, medium preservative oil, cold application;
- X Code 09, VV-L-800, very light preservative oil, water displacing, cold application;
- X Code 10, MIL-L-21260, preservative and break-in lubrication oil, internal combustion engine, Grade 10, 30, or 50.
- X Code 15, MIL-H-46170, hydraulic fluid, synthetic, rust inhibited, fire resistant; and
- X Code 17, MIL-PRF-6085, lubricating oil, instrument, aircraft, low volatility.

Rust inhibiting oils, cold application, consist of petroleum oils to which rust inhibitors have been added. These oils are used where the petrolatum base types are unsuitable or difficult to apply, for example, in oil lubricated bearings, hydraulic systems, turbines, and gearcases. These oils drain off or are removed by wick action; thus greaseproof wraps must be used to keep the oils within the package. Examples of these oils are Code 07, Code 09, Code 10, Code 15, and Code 17. Code 09 is also water displacing.

Group 4

The contact preservatives in Group 4 are Code 11, MIL-G-23827, grease, aircraft and instrument, gear and actuator screw, and Code 20, MIL-P-46002, preservative oil, contact and volatile corrosion inhibited. Special purpose, cold application compounds are made for specific use and should be applied to those items for which they are intended.

CONTACT METAL PRESERVATIVES AND THEIR USE

The description, characteristics, physical properties, uses, application, and removal of the contact preservatives are presented in table 3-3 at the end of this chapter. The flashpoints are included to indicate possible fire hazards, and the pour point indicates possible climatic problems.

LUBRICANTS AND TEMPORARY PRESERVATIVES OTHER THAN CONTACT PRESERVATIVES

There are a number of preservatives for temporary use not listed in MIL-STD-2073-1C, some of which have been developed for specific uses. These preservative or corrosion preventing materials are listed in table 3-4 located at the end of this chapter. The flashpoint and flow point values, where available, have been listed to indicate possible fire hazards and usage in cold climate situations.

APPLICATION PRINCIPLE

Most temporary preservatives are oily or greasy in nature and vary greatly in chemical composition and consistency. Therefore, they cannot be used indiscriminately on all kinds of materials. They may even destroy the usefulness of an item due to the difficulty of removal. An example is the application of a hard-drying contact preservative to a typewriter. A preservative may penetrate into unwanted areas and cause swelling or decomposition of the material, or it may reduce its electrical conductivity. The criteria for preservative application have been established with some exception for specific situations.

BASIC APPLICATION REQUIREMENTS

Petroleum or contact preservatives are applied to those metal surfaces on which corrosion in any form, such as oxides, sulfides, and verdigris, would impair the usefulness of the item or assembly, except under the conditions discussed below. The type of preservative is usually specified in procurement documents or processing

specifications. In the absence of specific instructions, the choice of preservatives is made from those listed in MIL-STD-2073-1C as shown in table 3-3 at the end of this chapter. Care must be taken that the preservative selected will not damage the mechanism, structure, or function of the item, either when applied, in use, or during removal.

EXCEPTIONS TO BASIC APPLICATION REQUIREMENTS

Contact preservatives are not applied to surfaces which are protected with solid film lubricants, vitreous, plastic, prime, or paint coatings. They are not normally used on noncritical metal surfaces that are inherently resistant to corrosion, brass, bronze, or other corrosion resistant metals and alloys. Contact preservatives are not applied to noncritical items that have been chromium, silver, nickel, cadmium, zinc, or tin plated or coated. Cadmium plated or coated items packaged in nonventilated containers together with organic coated items or insulated electrical items require application of a preservative. Oily type preservatives are not applied to items that are vulnerable to damage by the petroleum ingredients, such as those fabricated from textiles, cordage, plastics, mica, rubber, paper, felts, leather and leather products, or prelubricated bushings. These preservatives are not applied to certain types of electrical and electronic components, distributor rotors, circuit breakers, switches, resistors, and rectifiers. Finally, contact preservatives are not applied to any items which would suffer damage to the mechanism or structure, or where malfunction or unsafe operational conditions would result from the application or removal of the preservative.

PRESERVATIVE SELECTION CRITERIA (FIGURE 3-3)

To choose the type of preservative to be applied to a specific item, a number of factors must be considered. First is the characteristics of the item. The composition, surface finish, complexity of construction, size, and shape must all be evaluated before a preservative is applied. Second is the characteristics of the preservative. Some preservatives are hard-drying and difficult to remove. Some are thin and drain off too rapidly under high temperatures. Some require heating for application, while others can be applied cold. Third is the extent of protection desired. If the item is to be used within a relatively short period of time, only a light, temporary preservative is necessary, but, if the item is to be shipped overseas or must remain in storage for several years, then a more persistent protective coating is demanded. Finally, the requirements of the user must be considered. If it is necessary to spend hours in the field attempting to remove hard-drying and hard-setting preservatives, without adequate cleaning equipment, the outcome of a military engagement may be influenced by such delay. A light preservative in combination with a waterproof or watervaporproof pack may be preferred for certain items, rather than using a hard film preservative such as Code 01 or Code 19.

Item Composition

The composition of an item determines whether it can be preserved and, if so, what kind of preservative is used. Generally, metal items are preserved with any of the contact preservative compounds. The exceptions are when there is a possibility of chemical reaction between the metal and certain additives in the preservative. For instance, some highly finished copper or brass, or cadmium or zinc plated items, have been stained by preservatives containing sulfur or phosphorous ingredients. Usually, contact preservatives are not applied to nonmetal items made of glass, rubber, leather, cork, paper, fabrics, or plastics, unless they are combined in an assemble with corrodible metals. In this event, the preservative must be applied in such a manner to ensure the coating will not come into contact with the nonmetal portion or component of the item.

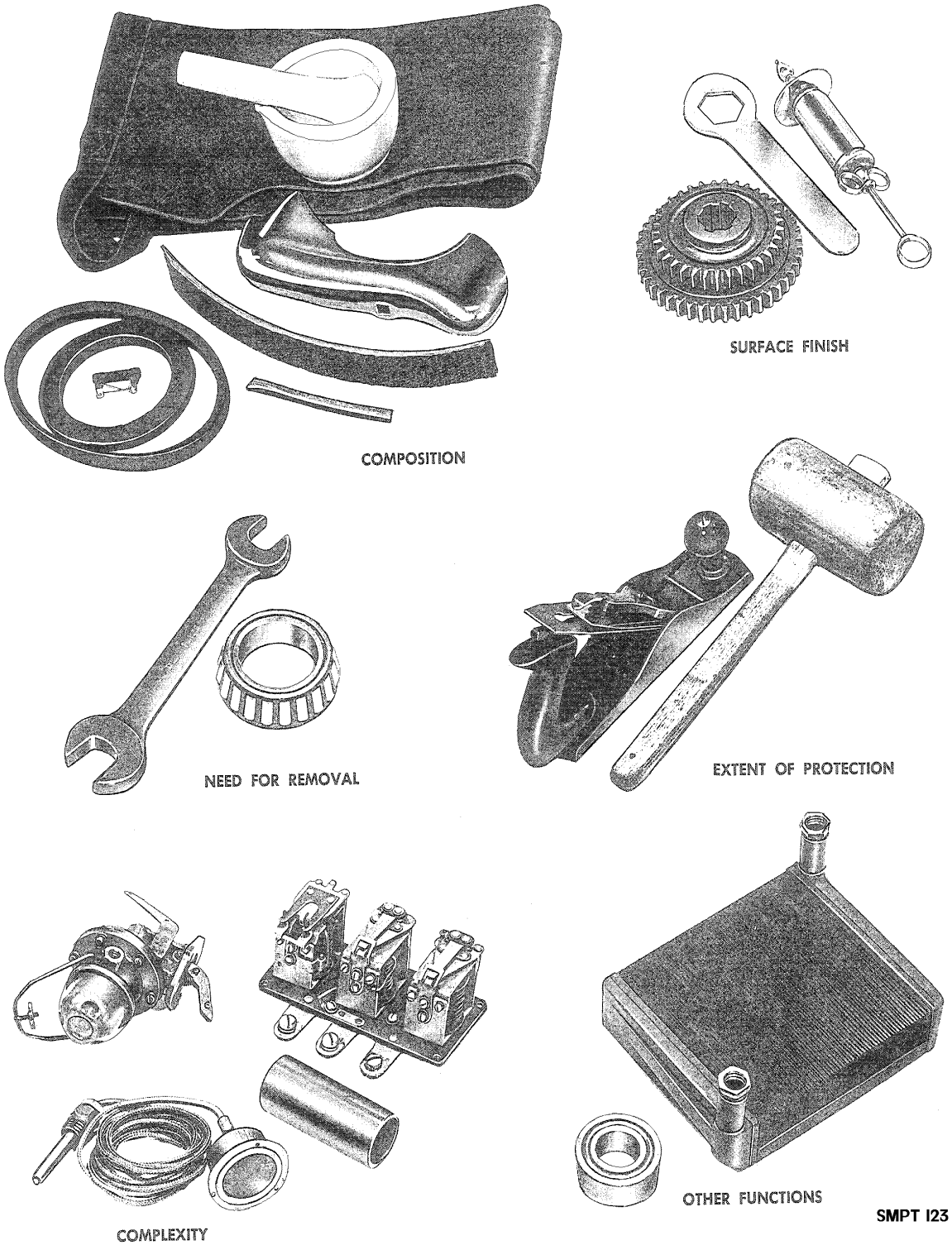


Figure 3-3. Preservative selection criteria.

Surface Finish

If the item is forged, stamped, rough cast, rough ground, or rough machined, and has nonprecision uses, it may be protected by almost any of the petroleum type preservatives. On the other hand, items of precision use with surfaces held to close tolerances require an easily removed preservative, or one which may be left in place without interfering with the functioning of the item. Oil and light grease-type preservatives are preferred for these items. Small fragile items require light oil-type preservatives. Heavier preservatives are unsuitable because they may interfere with future operation or their removal may result in damage to the item.

Complexity of Construction

Items should be cleaned, dried, and preserved in as simple unit state as possible. Disassembled items with close tolerances should not be coated with heavy greases or hard-drying types of preservatives which may interfere with or prevent later reassembly. If disassembly is not practical or the item is highly irregular with blind holes, crevices, and the like, heavy preservatives may be difficult to apply and impossible to remove. Molten grease types, carelessly applied, may result in some portions of complex items receiving no coating. This is true where air may be trapped in small, blind holes or crevices.

Extent of Protection Required

The hazards to which the item may be subjected and the atmospheric conditions and time limits expected for the items must be considered. In most instances where time limits and severity of hazards are unknown, the best possible type of preservative should be used. If these time limits are short and the weather conditions to be encountered are mild, then work and expense may be saved by using light, temporary oil-type preservatives.

Ease or Need for Removal

The user of the item must be kept in mind when choosing a preservative. The time required for removal, equipment available in the field, and whether removal is necessary should all be considered before applying a preservative. Items shipped to a battle area which require time-consuming and elaborate removal equipment, might make a major difference in the outcome of a campaign. If complete or partial removal of the preservative is necessary in order for the item to function properly, a light, readily removable, oil-type preservative should be employed.

OTHER FUNCTIONS OF PRESERVATIVES

In some instances, the characteristics of the item or assembly require that the preservative act also as a lubricating oil or hydraulic fluid. For example, engines require Code 10 and hydraulic systems require Code 15. In such cases, lubricating oil requirements for engines and hydraulic system requirements must be met first; the preservative properties are secondary. Dual purpose preservatives, therefore, should be used only where their dual function is required and where it is known that the degree of preservation they offer will be sufficient. Generally, dual purpose types do not give the extent of protection given by those types which are primarily corrosion preventatives. Whenever sever corrosion conditions will be encountered and the degree of protection offered by the dual material becomes insufficient, a material should be chosen definitely for its preservative qualities. The proper lubricant, hydraulic fluid, and the like should be introduced at the place of use.

PACKING APPLIED OVER PRESERVATIVES

It is necessary to know if and how the items coated with the preservatives are to be packed before a particular type of corrosion preventive is selected. Unless both the preservative and the method of preservation are considered, full protection cannot be expected. For example, if the preservative compound has no impact or abrasion

resistance, then the packing and wrapping must be selected which will protect the preservative. If the characteristics and size of the item are such that physical limitations are encountered when designing the pack it may be necessary to select a preservative with good impact and abrasion resistance to prevent mechanical damage to the preservative coating. If the packed items may be exposed to rain, salt water, high temperatures, and other hazardous situations, it is necessary to correlate the type of preservative with the method preservation in order to offset the shortcomings of one or the other.

AVAILABILITY OF MATERIAL

If the proper and necessary preservative material is unavailable, then the best possible substitute should be used rather than omit using any preservative at all. However, when proper preservatives do exist, inconvenience or difficulty in obtaining them should not influence the choice. Damage through corrosion will far outweigh any special effort and expense necessary to obtain the most satisfactory material.

DIFFICULTIES OF APPLICATION

Corrosion preventive materials should not be chosen merely because they are easy to apply. This should be a governing factor only when all other previous requirements have been met. It is possible to find a suitable means of applying all approved materials.

METHODS OF APPLYING PRESERVATIVES TO METAL ITEMS

DIPPING (FIGURE 3-4)

This is done by the complete submersion of the item in a bath of the preservatives. This procedure is preferred whenever the size, shape, and nature of the item will permit its being used.

Loading Items for Dipping

Cleaned and dried items must be held on hooks, in baskets, by metal tongs, on wax-coated cord, or by gloved hands, in such a way that a complete coating and thorough drainage of excess material will result. Wire baskets, used for many small items in large quantity, should be loaded only one item deep to permit the formation of a continuous, even coating around each item. Groups of fine, small items can be tied together with moisture free, wax-coated cord.

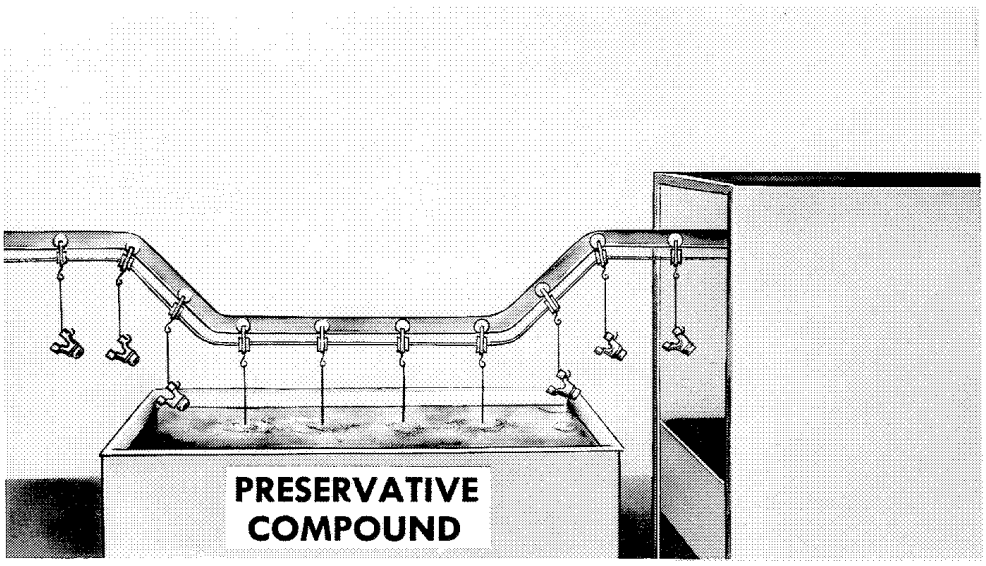
Dipping Items Into Preservatives

When items are dipped into the tank by hand or by conveyor, care must be taken that air bubbles are not caught on any of the surfaces of the item. Completely immerse items below the preservative level. Move them slowly beneath the surface to eliminate any air which may have been trapped inside. Keep them at the proper angle for coverage and draining. Trials should be conducted to determine the best temperature and length of time necessary for a suitable coating.

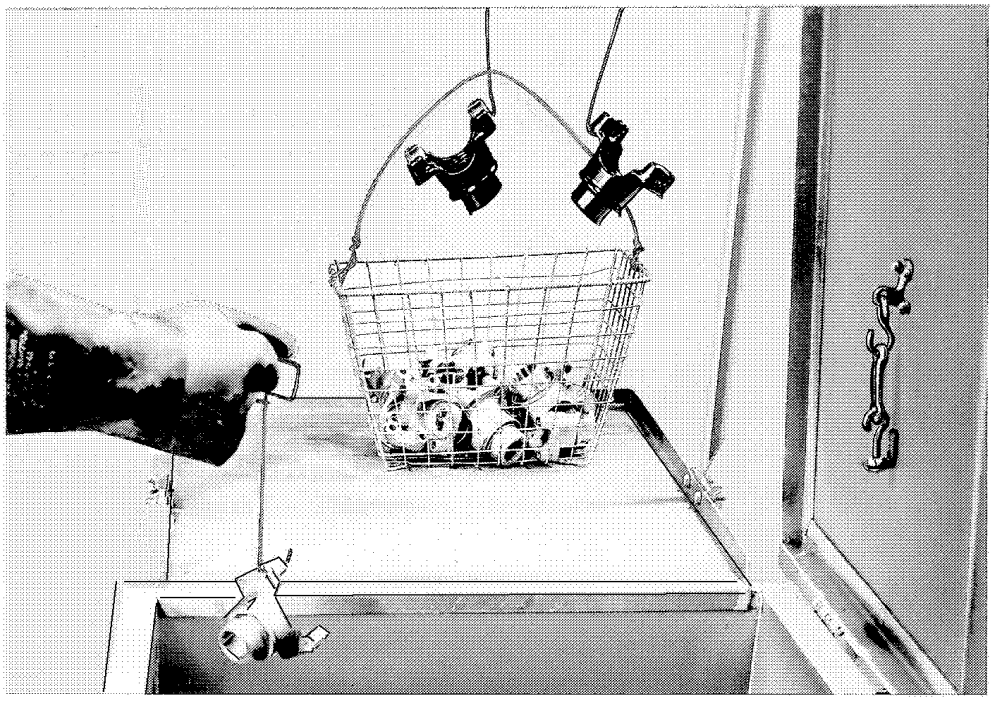
Removing Items From Tank

When removing items from the tank, allow excess compound to drain from all surfaces so that pools of material do not collect in corners and pockets. Items individually handled should be hung on hoods, rings, rods, or racks until preservative has set or dried. Items dipped in baskets are left in the baskets until the preservative film sets. Just before wrapping, any marks left by hook or hanger should be touched up by applying more preservative with a brush. Bare spots can be avoided somewhat by predipping hooks or baskets before dipping the item. After the preservative has dried or set, the item should be placed on a precut piece of

greaseproof barrier material. This should be the initial wrap for the packing operation. If items cannot be wrapped or packed immediately, they should be placed in baskets or trays and protected from dust and dirt with a suitable cover. Cleaned items left overnight should be carefully inspected for signs of corrosion before continuing with the application of preservatives.



CONVEYORIZED DIPPING



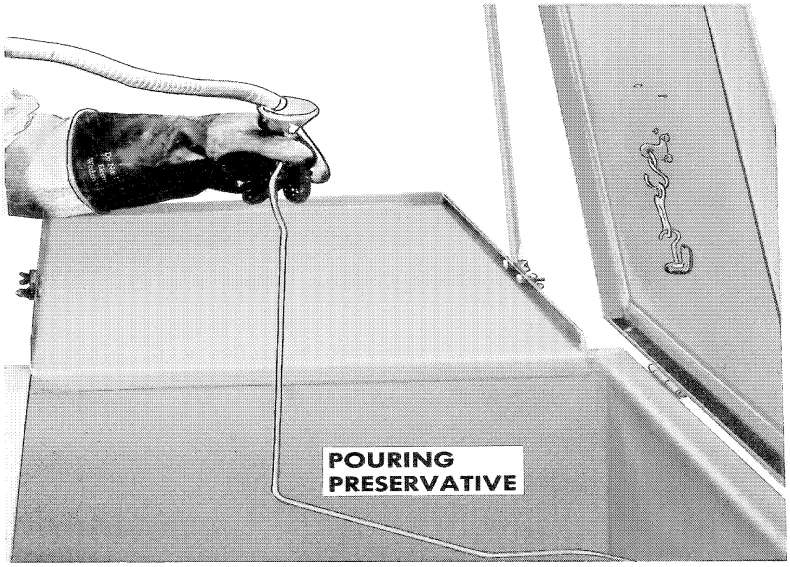
HAND DIPPING

SMPT 718A

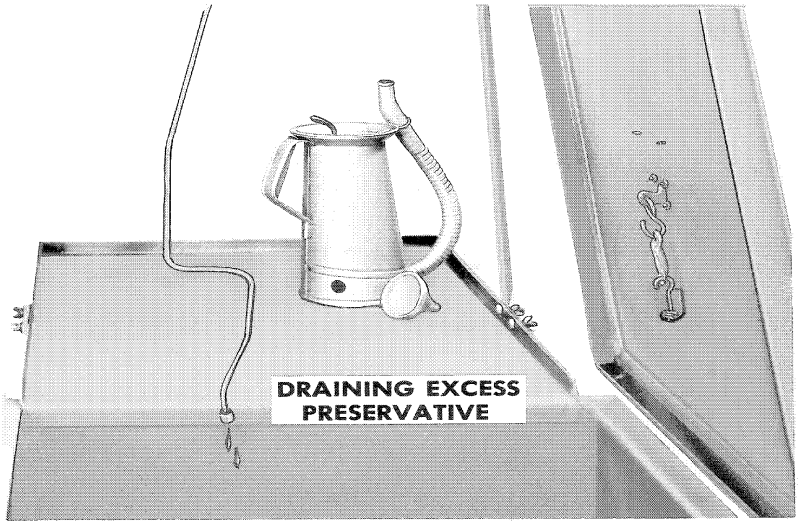
Figure 3-4. Application of preservative by dipping.

FLOW-COATING (FIGURE 3-5)

This procedure is accomplished by coating the surfaces of the item by pouring the preservatives on the item or portions of the item. This procedure is generally used for items too large to dip or on limited areas of items of a complex nature which cannot be completely covered without injury to some of the materials of which they are made.



NOTE. POUR PRESERVATIVE INTO TUBE ALLOWING IT TO FLOW THROUGH TUBE AND COVER INTERIOR SURFACES.



NOTE. DRAIN EXCESS PRESERVATIVE FROM TUBE BY HOLDING TUBE OVER PRESERVATIVE TANK ALLOWING PRESERVATIVE TO DRAIN INTO TANK.

SMPT 719A

Figure 3-5. Application of preservative by flow-coating.

Positioning Items for Flow-Coating

Items are to be placed in such a manner, before coating, as to prevent pocketing of the preservative in blind holes or cavities. Tilt them to an angle that will permit free flow of the preservative and drainage by gravity.

Pouring Preservative on Items

Use oil type preservatives and pour slowly over surfaces to be coated. Flow on sufficient preservative to completely cover the desired areas and permit the excess to drain off by gravity. Avoid any unnecessary handling until after preservative has set. Do not handle items with bare hands or dirty gloves while applying the preservative.

SLUSHING (FIGURE 3-6)

This procedure is performed by pouring the preservative into the item to be preserved and rotating, agitating, or slanting the item to insure complete coverage of all internal surfaces. The item is then drained of excess preservative. This procedure is most often used to coat inside surfaces of chambers, tubing, oil coolers, metal tanks, and their cavities not accessible by other procedures of application. For this reason, oils and soft thin film preservatives should be used. If properly selected, the preservatives do not normally require removal from the item before using. If removal should be required, they are easily flushed out.

Inserting the Preservative

Pour a sufficient quantity of the preservative into the interior of the item to cover all surfaces when the item is rotated. If available, a small pump with a flexible outlet hose may be used to pump the preservative inside the item.

Slushing the Item

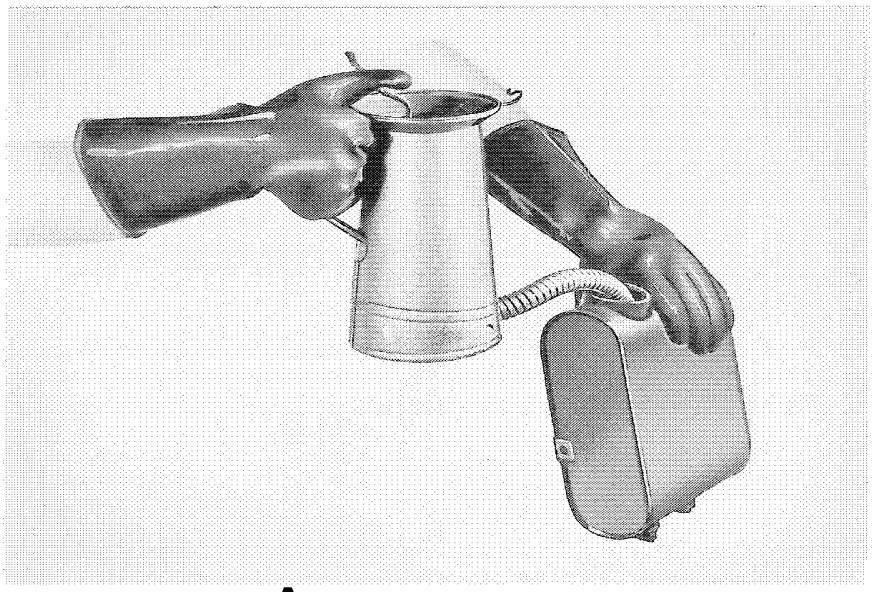
Shake, rotate, agitate, or slant the item in all directions to insure complete coverage of all interior surfaces. Never mix two different compounds for slushing, as this may cause a lumping of the ingredients.

Draining Off the Preservative

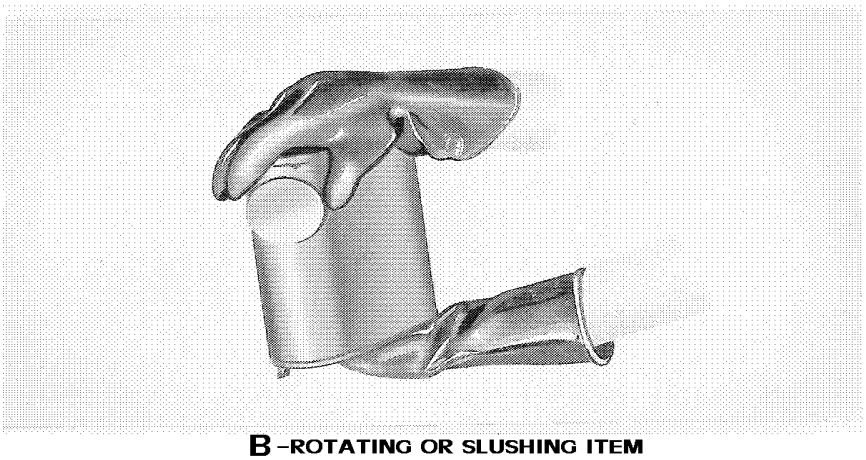
Drain off excess compound by rotating the item, if necessary, to prevent the collection of preservative in blind holes and crevices. It is always desirable that care be taken to prevent spilling the preservative thus avoiding safety or fire hazard. Equipment and methods of operation should insure economy through the reuse of slushing oils.

Closing the Item

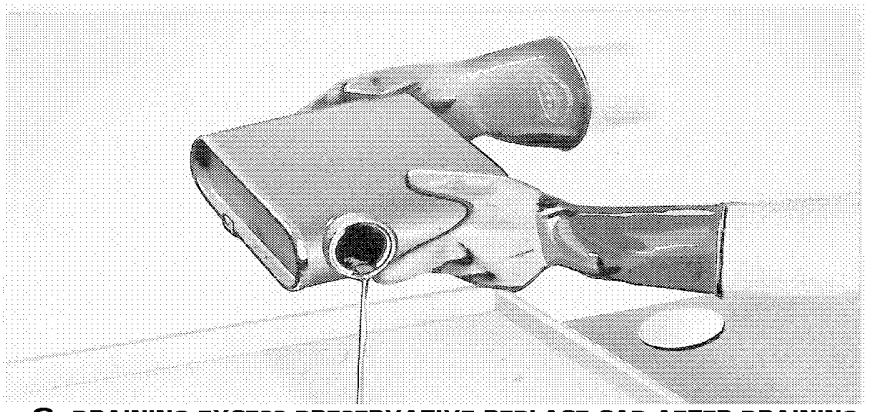
After draining, close all openings of the item to keep out dirt and other foreign matter. Plastic plugs are most satisfactory for sealing openings. Male and female types are available for various kinds of openings. Never use wooden plugs as closures, since splinters from the wood are difficult to remove and may clog fuel or oil lines and cause serious damage.



A –INSERTING PRESERVATIVE



B –ROTATING OR SLUSHING ITEM



C –DRAINING EXCESS PRESERVATIVE REPLACE CAP AFTER DRAINING

SMPT 717

Figure 3-6. Application of preservative by slushing.

Brushing (figure 3-7)

Brushing is performed by using a brush to coat the item or limited surfaces of the item with a preservative. This procedure is used when no other procedure is available or suitable. Brushing is used extensively where only one part of an assembly requires the coating, such as against hinge fittings, inside surfaces of bushings, or bare metal surfaces next to fabric or rubber materials that must not be coated with preservative compounds.

Applying the Coating

Make sure the item is clean and dry before brushing. Use only clean brushes for applying the coating. Apply an even and continuous coating. Do not handle items with bare hands or dirty gloves.

Checking the Coating

Inspect item to be sure that areas not readily visible are not left uncoated. It may be necessary for more than one brush application to provide an unbroken, continuous coating.

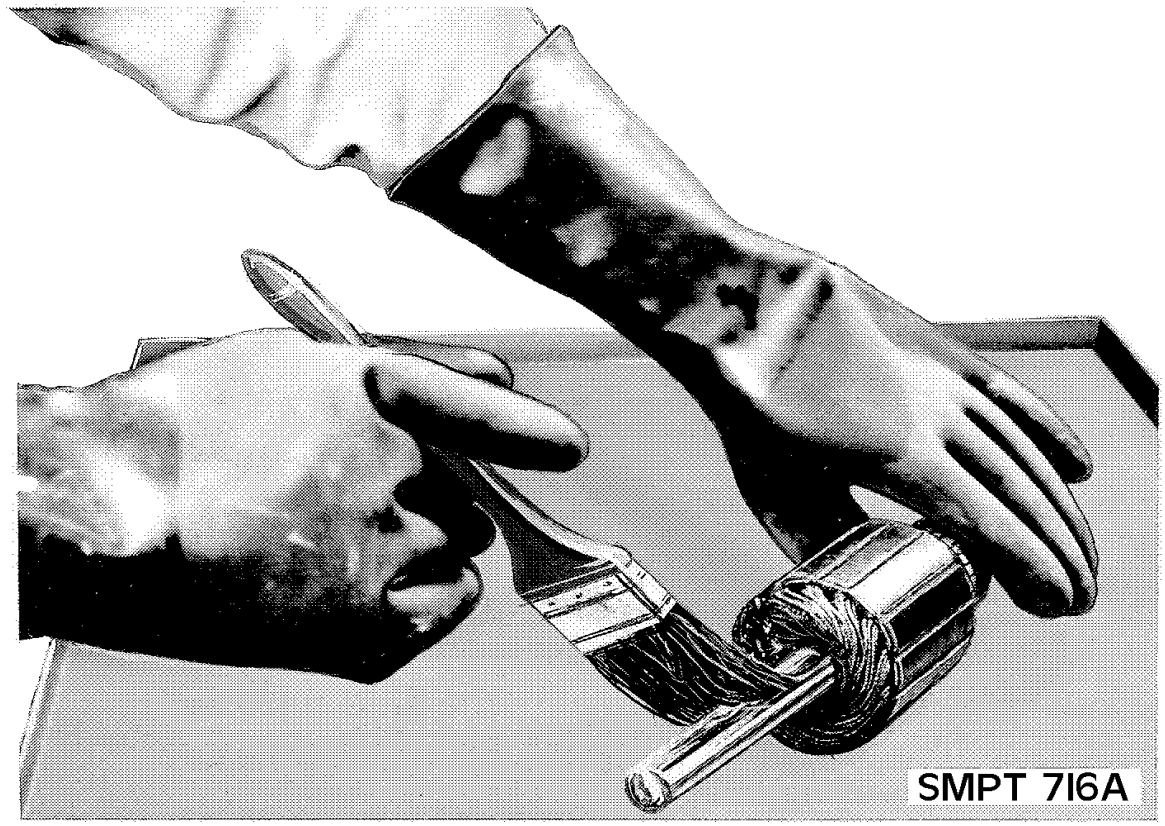


Figure 3-7. Application of preservative by brushing.

FILLING OR FLUSHING (FIGURE 3-8)

This procedure is accomplished by completely filling the items with preservative until all interior surfaces are satisfactorily coated.

Filling Item

Insure coverage of all interior surfaces by completely filling the item with preservative. Care should be taken so that entrapped air will not prevent complete coverage of the interior surface. Oils or easily removed thin film preservatives are to be used for filling.

Draining Preservative

Drain off the preservative oil and close up the openings. If oil is not to be drained, space must be allowed for thermal expansion. Close all openings and make sure they are sealed to prevent any leakage. Wipe up any spilled oil to avoid possible fire hazards.

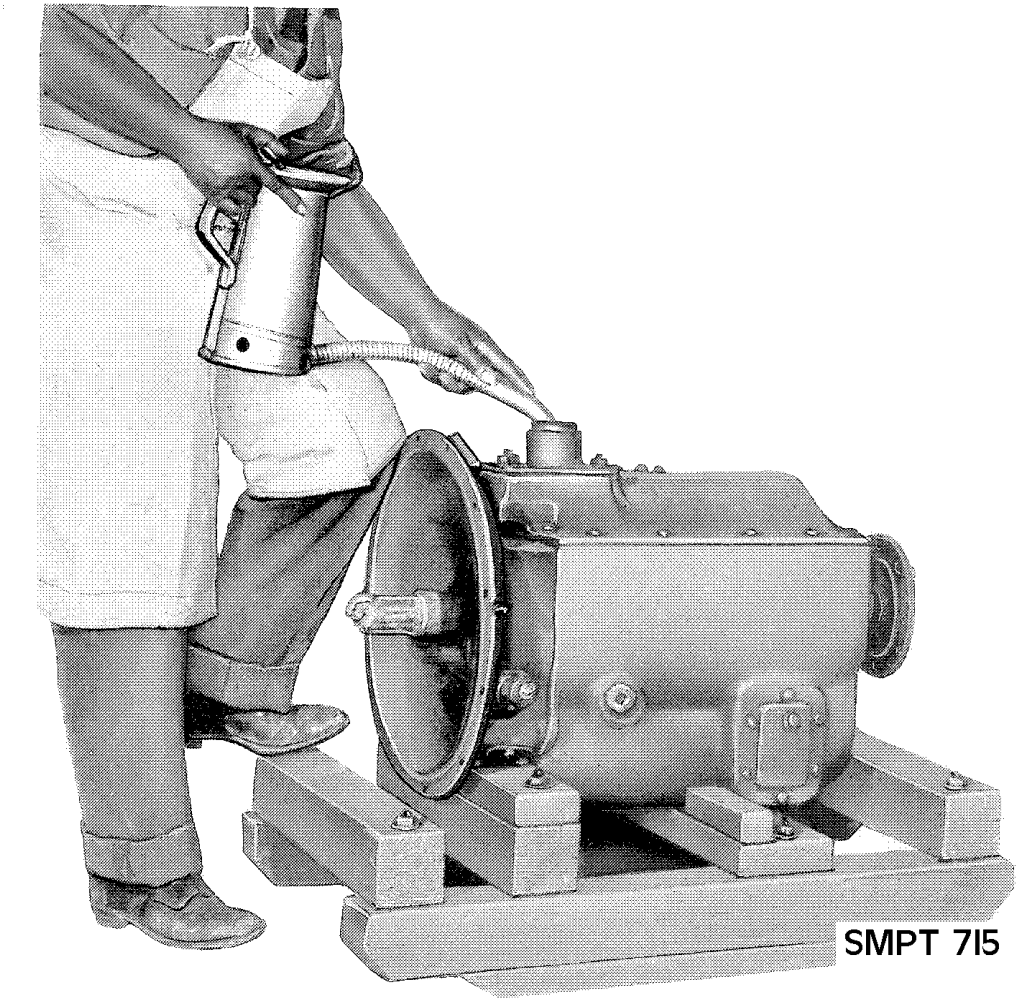


Figure 3-8. Application of preservative by filling or flushing.

Fogging (figure 3-9)

This procedure is accomplished by coating interior surfaces of items, such as tanks and chambers, with preservatives injected as a cloud or mist from an air atomizing gun until the inclosed atmosphere is saturated.

Preparing Fogging Gun

Fill the gun container with a light preservative oil and attach the flow of preservative fluid by turning the base of the handle grip. Press thumb valve or finger trigger, allowing fluid to run. Adjust the flow of preservative fluid by turning the nozzle to the left to increase and to the right to decrease the flow of preservative. Tighten the locknut on the nozzle after the flow has been adjusted and keep the air vent located on the left side of the container open. Be sure the air is dry.

Fogging Interior of the Item

Insert the nozzle through the opening of the item and fog until atomized mist begins to come out around the nozzle. If more than one opening is available on the item, repeat the process at these openings to insure complete fogging of the interior. For extra large tanks or chambers, extensions are available to attach to the nozzle to reach into otherwise inaccessible corners and pockets.

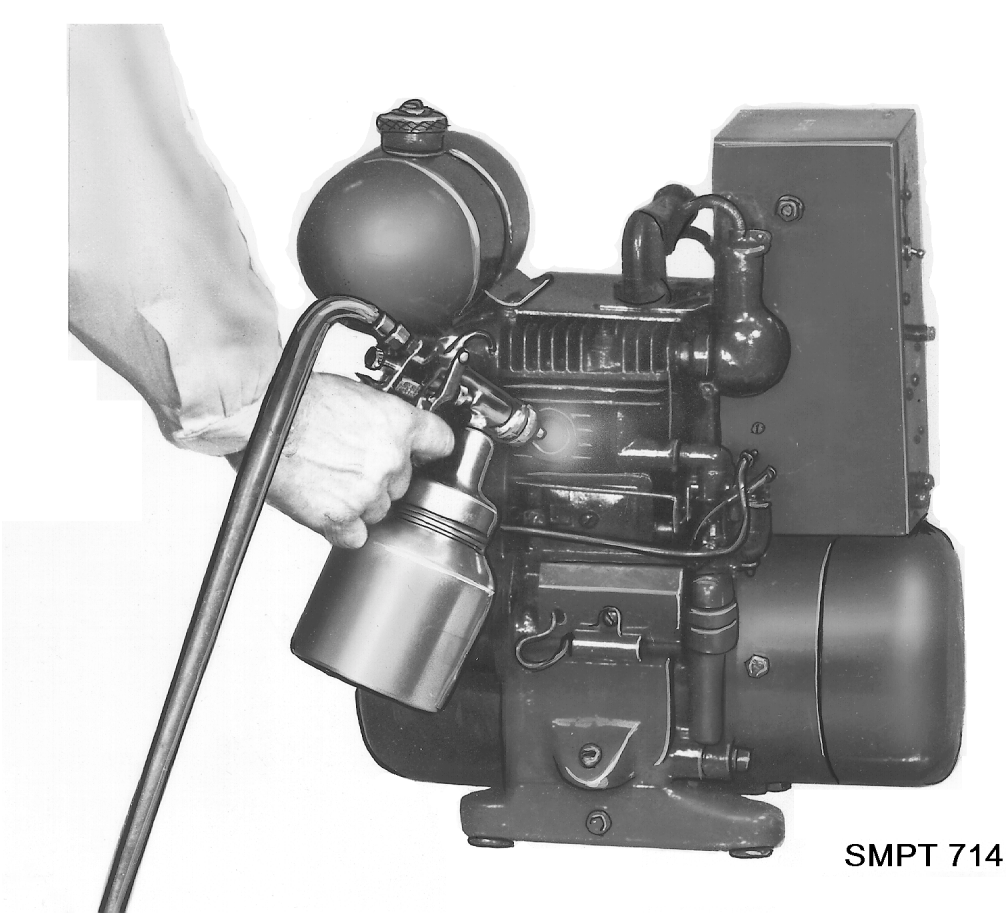


Figure 3-9. Application of preservative by fogging.

Spraying (figure 3-10)

This application is done by coating surfaces (interior or exterior, as applicable) of the items with preservative applied as a spray. Spraying is especially useful for preservation of large and heavy items that cannot be dipped or assemblies requiring a preservative only on certain portions of their surfaces. Thin film or oil-type preservatives usually are used in spraying.

Preparing Item for Spraying

Mask all surfaces that are not to be coated, including such parts as fiber looms, electrical wiring, receptacles, rubber and fabric components. Suitable materials for masking are kraft paper and pressure-sensitive tape. Code 01 preservatives and oils will not damage paints or primers on metal surfaces and are not usually marked as such.

Spraying the Item

Spraying must be done in a well ventilated area. Wear protective clothing, masks, gloves, etc. Fill spray gun with the selected oil or thin film preservative. If contact preservative is to be used, it may be necessary to dilute it with petroleum solvent until it will spray effectively. Adjust spray gun and apply an even, continuous, and unbroken film around each item surface. Use normal spray painting technique for applying the coating. Allow preservative coating to thoroughly dry or set before further handling.

Figure 3-10. Application of preservative by spraying.

VOLATILE CORROSION INHIBITORS (VCI)

CONCEPT OF VCI

Development of VCI

Chemists have known for some time that chemicals such as camphor and moth balls give off vapors. Some of these chemicals are known to inhibit corrosion and neutralize the effects of moisture laden air within a package. These chemicals are called Volatile Corrosion Inhibitors or VCI. They are available for packaging applications in several forms.

Description of VCI

VCI compounds are white crystalline powders similar in appearance to a fine talc. While the crystals are used in some instances, for preserving interiors of engines and other applications, the most widely used forms of the material are coated and impregnated papers. As a coating, the chemical is mixed with casein which acts as a bond or adhesive to stick the crystals to the paper surface. In impregnated papers, the process consists of soaking the paper in a solution containing a concentration of the inhibitor. The solution evaporates and leaves the crystals impregnated in the fibers and the surface of the paper.

How VCI Prevents Corrosion (figure 3-11)

When used as a wrap around an item, the crystals in the paper slowly vaporize. This vapor moves from the paper and fills the entire volume within the pack. When the vapor concentration reaches a certain level, an equilibrium is established, provided the pack is airtight, so that crystals will condense on the surface of the item as rapidly as they vaporize from the paper. The vapor forms on all surfaces of the item, including all cracks and crevices, and forms an invisible, adhering, protective film which resists the corrosive action of water vapor. Corrosion is prevented as long as the chemical remains active and this will depend on the effectiveness of the pack in keeping the vapors concentrated inside.

USE AND LIMITATIONS OF VCI

Use

VCI offers effective protection to iron and steel. This protection is equal to or better than that provided by the more commonly used contact preservative compounds. VCI provides good protection to areas of an item where it would be impossible or impractical to apply a grease or oil type preservative. Such areas as small holes, blind holes, cups, cavities, or threads are also protected by the vapors of VCI. VCI offers a choice in the degree of protection given to military supplies and equipment. This may vary from temporary protection given to items during processing operations, through protection for shipment and immediate use, to complete protection for long-term storage or overseas shipment. VCI provides for savings through the simplicity and ease of its application. It reduces labor and time in the complicated preserving and cleaning operations normally associated with the use of grease and oil type preservatives. VCI offers a strategic advantage by allowing many essential stored items to be ready for immediate use. Weapons need little or no disassembly or cleaning and reassembly prior to use. Production equipment and machine tools may be stored in convenient areas where little time would be required to put them into use.

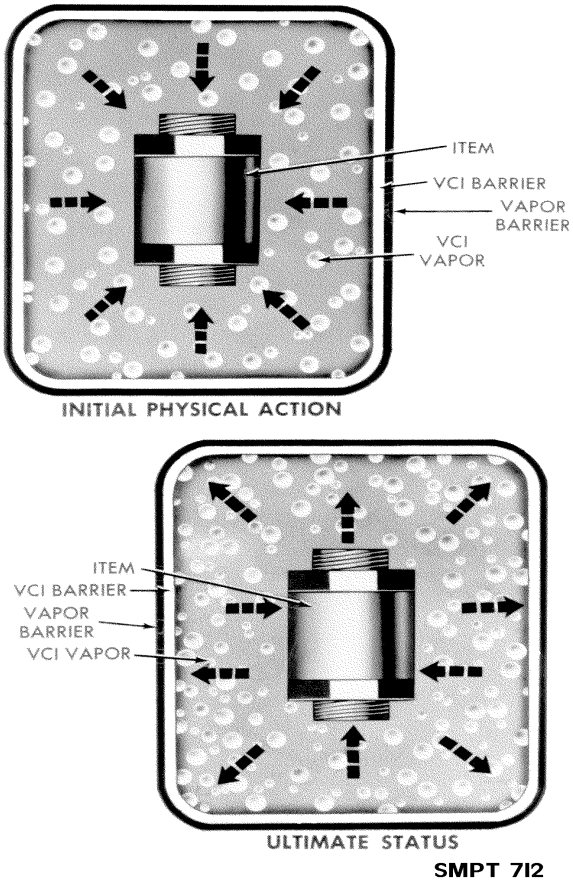


Figure 3-11. Action of VCI.

Limitations

VCI materials will not protect all metals from corrosion. In fact, they appear to increase the rate of corrosion in certain metals. VCI materials must not be used to protect any assemblies containing optical systems or precision moving parts which have been coated with a preservative or lubricant, unless otherwise specified. Items protected with bonded films, such as molybdenum (a dry lubricant), are not included in this category. VCI materials are affected by heat and light. They lose their effectiveness as the temperature increases and they decompose if exposed to direct sunlight for extended periods. They also decompose in the presence of acids or strong alkalies. Precautions must be taken when VCI is used with items, assemblies and subassemblies containing zinc plate, cadmium, zinc-base alloys, magnesium-base alloys, lead-base alloys, and alloys of other metals including solders and brazing alloys. If such items contain more than 30 percent of zinc or 9 percent of lead, they must not be preserved with VCI. In all cases, direct contact of VCI with nonferrous metals except aluminum and aluminum-base alloys should be avoided unless specific permission had been granted. Care should also be taken with assemblies containing plastics, painted parts, or components of natural or synthetic rubber. Assemblies containing parts made of these materials should not be packed with VCI until proof is established that they have passed the compatibility test required by MIL-I-8574.

FORMS OF VCI

These materials are covered in several specifications and are available in the forms of treated kraft paper, barriers, paperboard wrapping, cushioning, oils, crystalline powder, and others.

Packaging Materials (Wraps, Barriers and Bags)

MIL-PRF-3420, Packaging Materials, Volatile Corrosion Inhibitor Treated, Opaque

This specification establishes the requirements for materials (kraft paper, barriers, or paperboard wrapping and cushioning) which are treated with a corrosion inhibitor. The treated materials come in two forms, three classes, and seven styles. Form "a" and Form "b" represent a carrier's material which has been coated or impregnated respectively with corrosion inhibitors. The three classes relate to the strength of the material and the seven styles to the composition of the material. Styles A and B consist of kraft paper; styles C and G are constructed using waterproof-greaseproof barriers; style H may be either single ply or laminated kraft with a cohesive coating; and styles J and K are made from paperboard conforming to PPP-P-291, type III, style 1. Styles J and K are alike except that style J has a cohesive coating on one side. Refer to table 3-3 for information on the use of these VCI materials. Table 3-3 is located at the end of this chapter.

MIL-PRF-22019, Barrier Materials, Transparent, Flexible, Sealable, Volatile Corrosion Inhibitor Treated

This VCI material is available in two types. Type I material is intended for use where a heat-sealable, VCI treated barrier material is required. Type II material is for use where either production processing or custom hand processing requires a cold-sealable, VCI treated barrier material. Refer to table 3-3 for information on the intended use and other characteristics of this material.

MIL-B-22020, Bags, Transparent, Flexible, Sealable, Volatile Corrosion Inhibitor Treated

The bags are intended for use in the packaging of items requiring protection by volatile corrosion inhibitors. The bags come in two classes. Class 1 bags are intended for use where heat-sealable, transparent, VCI-treated bags are required. Class 1 bags are made from barrier material qualified under Type I material of MIL-PRF-22019. Class 2 bags are intended for use where pressure cold-sealable, transparent, VCI-treated bags are required and are fabricated from Type II material of MIL-PRF-22019. These bags are available in eleven sizes from as small as 2-1/2 X 3 inches to as large as 10 x 13 inches (length x width).

Powders and Oils

MIL-I-22110, Inhibitors, Corrosion, Volatile, Crystalline Powder

The VCI crystals provide corrosion protection for most metals under specific conditions. Table 3-3 at the end of this chapter provides information on the use and limitations of this crystalline powder form.

MIL-P-46002, Preservative Oil, Contact And Volatile Corrosion Inhibited

This VCI lubricating oil is intended for use in the preservation of enclosed systems where the volatile components will provide protection above the preservative. This material is not to be used in the preservation of any engine fuel tank or fuel storage tank. Refer to table 3-3 for information on how to apply this VCI. Table 3-3 is located at the end of this chapter.

Other Forms of VCI

Although specifications have not yet been issued covering items, there are other forms of VCI available to industry which may be used if permitted by the military activity concerned. Volatile corrosion inhibitors are now available in tablet form. The tablets can be used in automated packaging of small items such as bolts, pins, dowels, screws, drills, taps and dies, etc., where a hopper feed machine can form a bag, drop in the item and a pellet in the bag, and seal the bag in a single operation. Also available are VCI crystals compounded with a noncaking agent and supplied in 2-ounce cotton bags; VCI-treated papers fabricated into bore tubes for small arms preservation; envelopes of VCI-treated kraft; spirally-wound fiber cans (MIL-C-3955) and fiberboard boxes coated with VCI; and aerosol containers with VCI dissolved in alcohol.

HANDLING AND APPLICATION OF VCI MATERIALS

Application and use criteria of volatile corrosion inhibitors will be in accordance with the procedures given in MIL-I-8574.

Storage Requirements

Sheets and Rolls

VCI materials must be stored in a cool, dry location. Original packages must not be opened until shortly (not more than 24 hours) before use. During use operations, the material must be protected from excessive heat, direct sunlight, moisture, strong drafts, and excessive dust. At the close of each working day, VCI-treated materials should be replaced in their original containers or completely wrapped or covered with aluminum foil, QQ-A-1876, greaseproof barrier material MIL-B-121, (Grade C), or water-vaporproof barrier material MIL-PRF-131. Should any material be subjected to damaging or adverse conditions, its effectiveness can be determined by the appropriate test found in the applicable material specification.

Lined Barrier Bags

Barrier bags lined with VCI-treated materials are self-protected, except for the unsealed ends which can be folded over to retain the vapors. Punctured or otherwise damaged bags should be discarded. When feasible, the lines should be stored separately from the bags until ready for use.

Bore Tubes

VCI-treated bore tubes must be kept in a closed, barrier-type container. The container should be opened only for withdrawal of tubes for immediate use.

Safety Precautions

VCI materials may include ingredients irritating to the eyes and skin of some people. Do not rub or wipe eyes while handling VCI-treated materials. After handling, wash hands thoroughly with soap and water.

HOW TO APPLY VCI

Cleaning and Drying

Metal items to be protected with VCI must be cleaned and dried in accordance with requirements of MIL-STD-2073-1C. If a vapor degreaser is used, operation and control instructions furnished by the manufacture of the degreaser must be strictly followed to prevent the possibility of acid residues being left on the item which would render the VCI ineffective and promote corrosion.

Use of VCI With Operational Lubricants

When VCI materials are used on assemblies containing operational lubricants, it is necessary to establish the fact that the specific VCI and the lubricants being used are compatible. Prior to the application of the VCI to the assemblies, the excess oil must be drained off. This is not required in the case of items protected with bonded films.

Application of packaging materials (wraps, barriers, and bags)

VCI-treated materials must completely enclose the item, or the item may be wrapped with strips of material without any other material between the item and the wrapping. Complete wrapping, where feasible, is preferred. The treated face of the material must be placed toward the item being wrapped. The wraps should be applied in such a manner that any air entering the pack will pass through or over the surface of the VCI before reaching the item. The VCI-treated materials should not be more than 12 inches away from any surfaces to be protected (see figure 3-12). Whenever possible, the opening of the VCI-treated, transparent bags, MIL-B-22020, should be heat sealed.

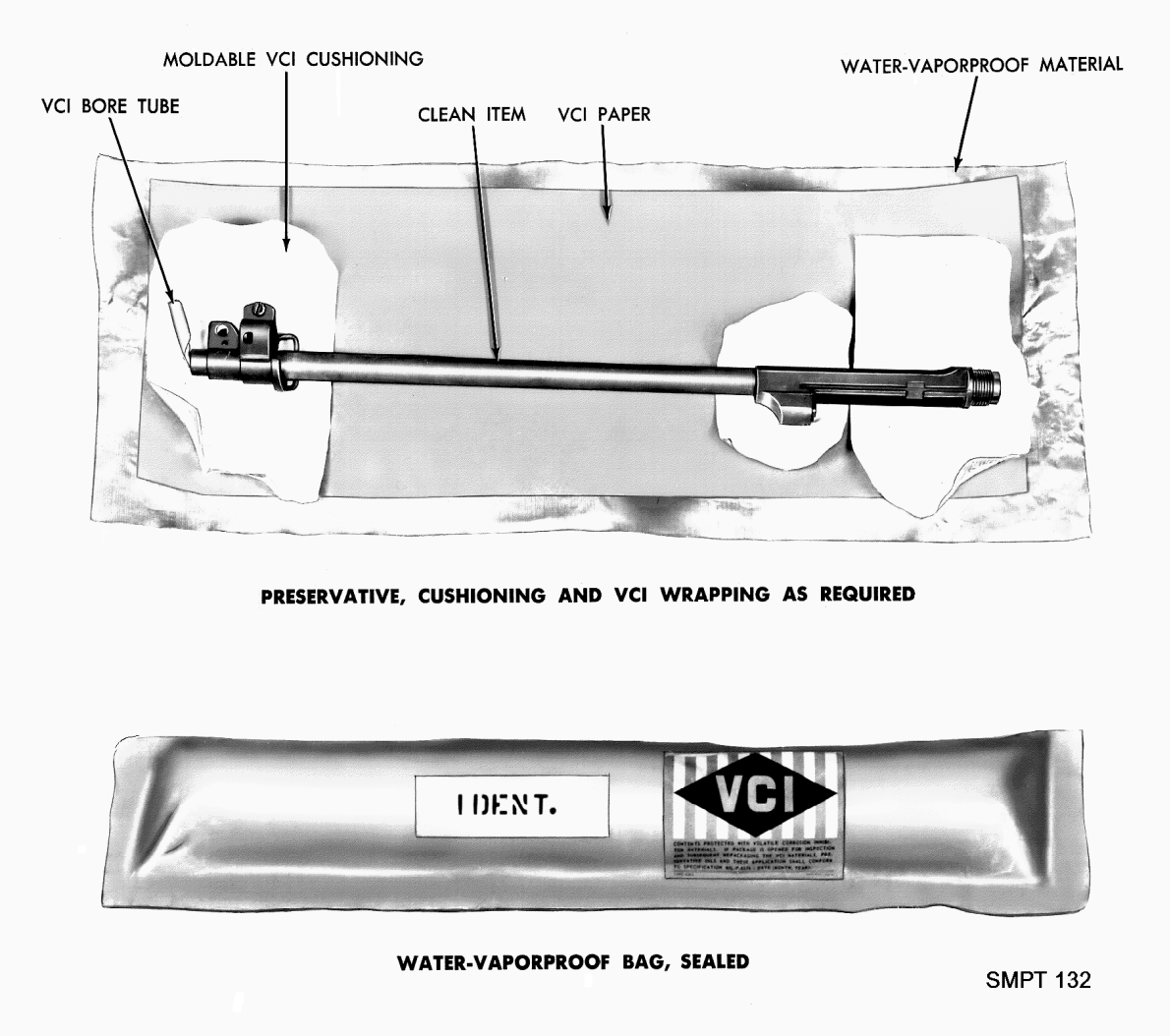


Figure 3-12. Application of packaging with VCI-treated materials.

Application of Crystalline Powder, MIL-I-22110.

These materials are sprayed, atomized, or dusted over the entire surface of the item. If feasible, the VCI should also be sprayed, dusted, or atomized into the container immediately before sealing.

Material in tiers or layers

When items are packaged in tiers or layers, the VCI should be placed between the tiers. Where VCI-treated materials are used in a box containing separators, all faces of the separators must be lined with VCI-treated material, in addition to lining the inside of the box.

Amount of VCI Required

When used as a complete overwrap, the amount of VCI-treated barrier, MIL-PRF-3420, and barrier, MIL-PRF-22019, should at least equal 3/8 of the surface area of the container. When not used as an overwrap, the amount of VCI-treated material must be at least equal to the surface area of the container. VCI crystalline, MIL-I-22110, should equal 1 gram per cubic foot of volume of the enclosing container.

Packaging Components With Closed Spaces and Blind End Cavities

Assemblies with enclosed portions, such as gear boxes, must be protected with strips of VCI material placed inside and the opening sealed. Open end voids, where the opening is small in relation to the void, should be treated likewise. Open end voids of a depth greater than 6 inches, such as gun barrels or bolt holes in castings, should have an inserted strip or tube of VCI-treated material slightly longer than the depth involved. The protruding portion of the bore tube or strip should be bent over and held in place with tape or other material to aid in its removal whenever an enclosed area of an assembly is not used prior to the application of the proper lubricant.

Use of Cushioning and Dunnage

Projections or sharp corners and edges of the item shall be cushioned with moldable VCI-treated materials to prevent damage either to the item or the barrier. Where dunnage is required next to, or around the item, a facing of VCI-treated material must be placed between the item and the dunnage. When the dunnage or other nonmetallic materials used in the package are hygroscopic or may give off corrosive vapors, the item and the VCI must be isolated by the use of aluminum foil or other suitable barrier material.

Use of Greaseproof Barriers

When VCI-treated items, coated with operational oils, are packed with outer packing materials that are not greaseproof, a greaseproof barrier must be used to separate the packed items from the outer materials. Styles C and G of MIL-PRF-3420 VCI-treated barrier materials may be used for this purpose since both styles incorporate a greaseproof barrier in their composition.

Marking of VCI Packs

Unit and intermediate packs shall be marked for identification in accordance with MIL-STD-129. An example of these unit pack markings are shown in figure 4-46 at the end of chapter 4.

Chapter 4

Methods of Preservation (Unit Protection)

GENERAL PRINCIPLES AND REQUIREMENTS

Preservation is the application or use of adequate protective measures to prevent deterioration resulting from exposure to atmospheric conditions during shipment and storage. Such protective measures, applied to military supplies and equipment, include, as applicable, the use of appropriate -

- X Cleaning processes.
- X Drying procedures.
- X Preservative application.
- X Wraps, barrier materials, and containers when necessary.

Methods of preservation (unit protection) are therefore those protective measures which have been developed, grouped together, tested, and are presently approved for the prevention of deterioration of military supplies and equipment. The methods of preservation are established by MIL-STD-2073-1C, and consist of the five following basic methods:

- X Method 10 - Physical protection.
- X Method 20 - Preservative coating only (with greaseproof wrap, as required).
- X Method 30 - Waterproof or waterproof-greaseproof protection (with preservative, as required).
- X Method 40 - Watervaporproof protection (with preservative, as required).
- X Method 50 - Watervaporproof protection with desiccant.

This chapter contains information that will enable you to construct unit packs using standard methods of preservation. However, there are several areas that you need to become familiar with before actually getting into the steps and techniques of unit pack construction. These areas include sources of packaging requirements; information on packaging materials such as adhesives, bags, sacks, tubing, envelopes, barriers, wraps, cushioning, tapes, and labels; information on the use of desiccants, desiccant formulas, humidity indicators, inspection windows; and the use of heat sealing machines. Finally, information is provided on the construction of all methods of preservation. The chapter ends with information concerning quality assurance provisions which will help you to determine if your unit packs will pass the tests and inspections required by MIL-STD-2073-1C.

The basic concept of military preservation hinges upon the ability of a particular method to provide the following protective measures, as needed:

- X Mechanical and physical protection.
- X Greaseproof protection.
- X Waterproof protection.
- X Watervaporproof protection.

Figure 4-1 depicts the five basic methods of military preservation which are applied to military items or materiel.

SOURCES OF PACKAGING REQUIREMENTS

MIL-STD-2073-1C provides the standards for military packaging when items are expected to enter the military packaging distribution system. It, also, provides a system for codification of packaging materials and processes used in military packaging. Packaging codes are particularly useful for procurement and contract administration purposes.

MIL-STD-2073-1C recommends the use of commercial packaging to the maximum extent possible. It provides a "decision chart" and lists several non-Government specifications, including ASTMs, to advance the DOD's policy for the use of commercial packaging.

Packaging simplification has been achieved in MIL-STD-2073-1C because it has incorporated the following documents and eliminated the need for them as separate documents:

- X MIL-P-116
- X MIL-STD-2073-2
- X MIL-STD-1510

Some military/Federal specifications and standards were replaced with non-Government standards. Over 400 seldom or unused packaging codes were eliminated.

MIL-STD-2073-1C provides criteria for control and development of all military packaging requirements based upon the item's physical-chemical characteristics, fragility, dimensions and weight. It establishes and defines codes used in describing materials and techniques for these requirements.

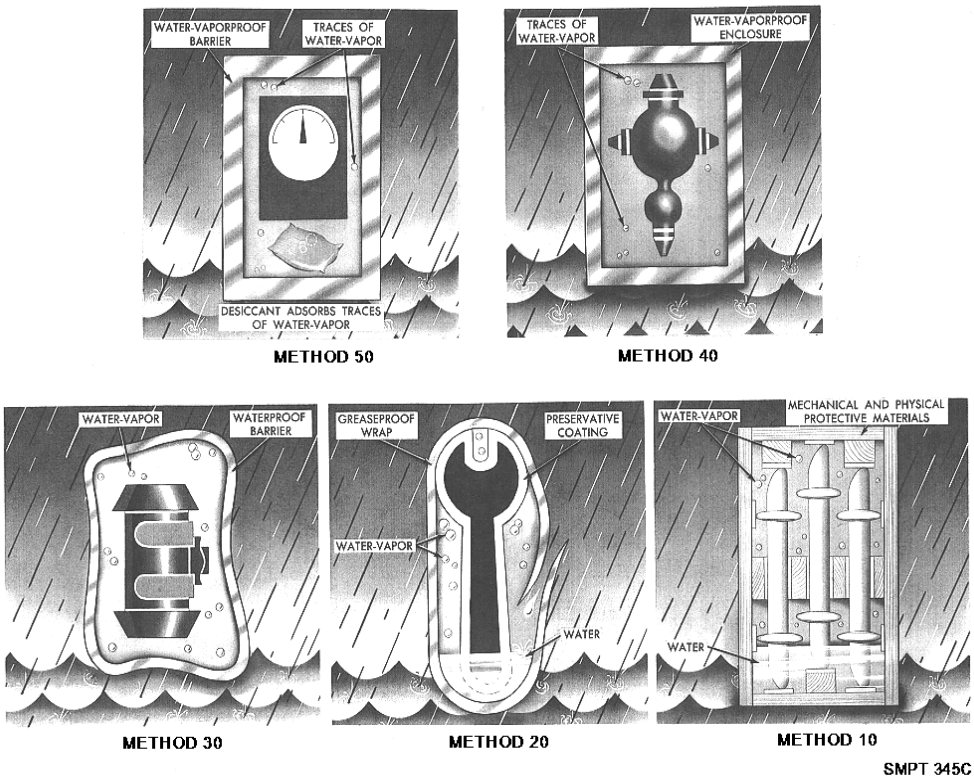


Figure 4-1. Concepts of the basic methods of military preservation.

TYPES OF ITEMS OR CLASSIFICATION IN ACCORDANCE WITH MIL-STD-2073-1C

All material to be packaged can be classified into one of three groups of items:

- X common,
- X selective, and
- X special.

Common Items

Items for which complete packaging details can be specified by predetermined coding are classified as common items. First, a four digit category code must be determined by chemical, physical, and other characteristics of the item using tables from MIL-STD-2073-1C. These tables are also used to reveal the packaging information such as cleaning procedure, wraps, cushioning thickness and the like. Table 4-1, which is identical to figure A.1 in MIL-STD-2073-1C, shows a packaging code of 42100EALCCED. In this example, the table shows that digit position 10 (which corresponds to a "C" in the coded packaging data) indicates a cushioning thickness of 3/4 inch.

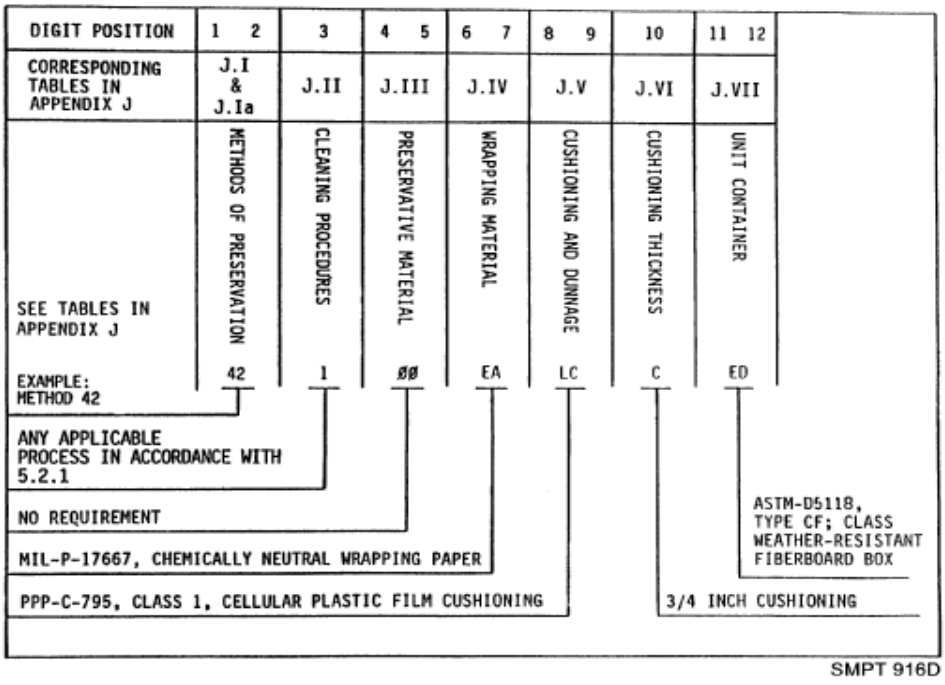
Selective Items

Items are called selective if they cannot appropriately use predetermined packaging data and yet do not require a drawing, sketch, illustration or narrative type instruction to specify packaging details. However these packaging details can be found in tables A.I, A.II, A.III, and A.IV of MIL-STD-2073-1C.

Special Items

Items assigned to this special group have peculiar characteristics such as mass (weight), configuration, complexity, fragility, or other considerations that preclude their being grouped as common or selective. An item is considered special if drawings, sketches, illustrations, or narrative type instructions or a reusable container are required to specify packaging details.

Table 4-1. Format for interpretation of packaging code sequence



Other Packaging Information

In addition, MIL-STD-2073-1C provides formulas for packaging material weight and size calculations; exterior shipping containers - weight of contents (lbs., max.) and levels of protection; quantity per unit pack determination formula; guidance for establishing number of unit packs per intermediate container; fiberboard container size list (including NSNs); and other packaging information.

PACKAGING MATERIALS

Among the most commonly used packaging materials are adhesives, bags, sacks, and envelopes, barrier and wrapping materials (opaque and transparent), cushioning materials, desiccant, humidity indicators, inspection windows, labels, and tapes. A general knowledge of the composition, characteristics, intended uses, and methods of application of these materials is very important from both an engineering standpoint and the performance standards required of military packs. Unauthorized use of these materials should be discouraged at all times. Their procurement and distribution should be based on requirements contained in Government and/or DoD adopted non-government specifications and on the needs emanating from official mission assignments. A brief discussion of the materials listed above is contained in the following paragraphs and tables. Unit containers such as fiberboard, setup, folding and metal-stayed boxes and cartons, cans, drums, etc., are described in chapters 6 and 7.

ADHESIVES

Adhesives include such materials as cement, glue, mucilage, paste, thermoplastic adhesives, etc. These are generally fluid or semifluid materials used to bond two surfaces together by forming a solid or semisolid interface between the two contacting surfaces. The term *adhesive* may be modified by adjectives which describe its physical state, e.g., *liquid adhesive, tape adhesives***;** its chemical type, e.g., *silicate adhesive, resin adhesive***;** the materials bonded together, e.g., *paper adhesive, can-label adhesive***;** or the condition of use, e.g., *hot-setting adhesive, thermoplastic adhesive*. Adhesives may be procured through the General Services Administration. Adhesives must be stored indoors at temperatures ranging from 45ºF. to 75ºF. Exposure to freezing temperatures reduces their adhesive properties. Length of storage should not exceed the manufacturer's recommendations and/or length of storage criteria provided in the material specification. Information concerning specification symbols, nomenclature, uses, and methods of application of the most commonly used adhesives is provided in table 4-2.

BAGS, SACKS, AND ENVELOPES

The containers are especially adaptable for the packing of small, lightweight items. The fact that they can be manufactured from transparent stock; can be made waterproof, watervaporproof, and greaseproof; can be lined or treated with corrosion inhibiting materials; and can be provided with cushioning effects broadens their application to a large number of items of various types and characteristics. Bags, sacks, and envelopes are generally procured prefabricated and can be stored in a minimum of space. For specific sizes and properties required, the pertinent specifications should be consulted. Basic information concerning the most commonly used bags, sacks, and envelopes can be found in table 4-3.

Bags, Sleeves and Tubing (MIL-B-117)

Bags used for interior packs, when required by a method of preservation, must be made in accordance with MIL-B-117. Types, classes, and styles of MIL-B-117 bags are shown in table 4-4 and also in the left three columns of table 4-5.

Table 4-2. Adhesives Used in Military Packaging.

Specification	Title	Uses	Method
MMM-A-250	Adhesives, water-resistant (for closure of fiberboard boxes).	For closure of fiberboard boxes, cartons, and cases. Type I - For application by automatic box closing equipment. Type II - For hand application by brushing. Type III - For hand application, form pressurized container.	Type I - Machine. Type II - Brush. Type III - Aerosol.
MMM-A-260	Adhesive, water-resistant (for sealing waterproofed paper).	For application to seams in the manufacture and closure of waterproof bags, wraps and case liners. Type I - For application by machine. Type II - For hand application. Class 1 - Solvent-base adhesive. Class 2 - Water-emulsion adhesive. Class 3 - Hot-melt adhesive.	Type I - Machine. Type II - Brush.
MMM-A-105	Adhesive, paper label, water resistant.	Type I - For attaching printed paper labels to shipping containers, also coating the top of labels to make them water resistant. Type II - For repairing and mending articles of glass, metals, leather, china, etc.	Brushing. Brushing.
MMM-A-178	Adhesive, paper label, water resistant.	One type, all purpose for application of paper labels to soft wood, fiberboard, black iron, galvanized iron, glass, tin, enamel painted metal, and rubber surfaces.	Brush application. Room temperature.

Table 4-3. Bags, Sacks, Envelopes Used in Military Packaging

Specification	Title	Type, grade, or class	Uses
MIL-B-22020	Bags, transparent, flexible, sealable, volatile corrosion inhibitor treated.	Class 1- Heat sealable Class 2 - Pressure (cold) sealable Note: Class 1 bags are made from type I material of MIL-B-22019. Class 2 bags are made from type II material of MIL-B-22019	For use in packaging of items that are adaptable to protection by volatile corrosion inhibitor treated materials. Bags shall be used in accordance with Specification MIL-I-8574.
A-A-302	Sack, shipping, paper (cushioned).	None	For shipment of publications and small parts where a light cushioning effect and water resistance are required. The maximum weight limit is 10 lbs.
A-A-1588	Sack, shipping, paper (cushioned with closed cell plastic film).	None	For interior packaging of fragile items such as bottled liquids, testing and laboratory equipment. The maximum weight limit is 10 lbs.
MIL-E-6060	Envelopes, packaging, watervaporproof, flexible.	One type only	Generally - For packaging of items required maximum watervaporproofing protection under Methods 40 & 50. Specifically - For floating bag application (methods 43 & 53); for containers having two dimensions over 36"; or for packages containing inspection windows.
MIL-B-81997	Pouches, cushioned, flexible, electrostatic-free reclosable, transparent.	Type I - Three-Ply Wall; Two Outerplies - Barrier Electrostatic-Free transparent; Inner Ply-Cushioning, Electrostatic-Free Transparent; Type II - Single Ply; Cushioning-Electrostatic-Free Transparent.	For packaging and storing static-sensitive electronic devices.

Table 4-4. MIL-B-117 types, classes and styles.

TYPES CLASSES STYLES	DESCRIPTION
Type I	Heavy duty
Type II	Medium duty
Type III	Light duty
Class A	Waterproof, electrostatic protective, static dissipative
Class B	Waterproof
Class C	Waterproof, greaseproof
Class E	Watervaporproof, greaseproof
Class F	Watervaporproof, electrostatic protective, electrostatic and electomagnetic shielding
Class G	
Class H	Watervpaporproof, greaseproof, flame resistant Waterproof, electrostatic protective, electrostatic shielding
Style 1	Opaque
Style 2	Transparent
Style 3	One side opaque, other side transparent

Materials (table 4-5)

Materials shall conform to the specification numbers shown in the center column of table 4-5. The material's type, grade, and class are shown in the three right columns of the table. For example, a bag conforming to MIL-B-117, Type I, Class C, Style 2, would be constructed from material conforming to MIL-PRF-22191, Type II.

Intended use of bags

Bags are used as containers to provide various degrees of protection to the contents. Transparent bags are used where transparency is desired to facilitate visual inspection of the enclosed product. Common stock sizes are listed in table 4-6. According to the class designations shown in table 4-4, the bags are used as follows:

- X Class A bags are designed for critical items that require protection against the buildup or retention of electrostatic potential in addition to protection against water penetration and are equivalent to the protection offered by Method 31.
- X Class B bags are designed as unit packages for items requiring waterproof protection and are equivalent to the protection offered by Method 31.
- X Class C bags are designed as unit packages for items that require greaseproof protection in addition to waterproof protection and are equivalent to the protection offered by Method 33.
- X Class E bags are designed as unit packages for critical items that require general protection against watervapor penetration in addition to waterproof and greaseproof protection and are equivalent to the protection offered by Methods 41 and 51.
- X Class F bags are designed for critical items that require protection against the buildup or retention of electrostatic potential in addition to protection against water and water vapor and are equivalent to the protection offered by Method 41.

X Class G bags are designed for critical items that require flame resistance in addition to protection against water, water vapor, and grease penetration and are equivalent to the protection offered by Methods 41 and 51.

Table 4-5. Classification of Materials (MIL-B-117)

Classification (MIL-B-117)				Classification (material specification)		
Type	Class	Style	Specification	Type	Grade	Class
I	A	2	MIL-PRF-81705	II	-	1 or 2
I	B	1	MIL-B-121	I	A	1
II	B	1	MIL-B-121	II	A	1
III	B	1	MIL-B-121	II	A	1
I	B	2	MIL-PRF-22191 A-A-3174 1/	III I OR II	- A	- 1 2/
I	B	3	MIL-B-121 MIL-PRF-22191	I III	A -	1 -
I	C	1	MIL-B-121	I	A	1
II	C	1	MIL-B-121	II	A	1
I	C	2	MIL-PRF-22191	II	-	-
I	C	3	MIL-B-121 MIL-PRF-22191	I II	A -	1 -
I	E	1	MIL-PRF-131	I	-	1
I	E	2	MIL-PRF-22191	I	-	-
II	E	1	MIL-PRF-131	I	-	3
III	E	1	MIL-PRF-131	I	-	2
I	E	3	MIL-PRF-131 MIL-PRF-22191	I I	- -	1 -
I	E	3	MIL-PRF-131 MIL-PRF-22191	I I	- -	3 -
I	F	1	MIL-PRF-81705	I	-	1 or 2
I	G	1	MIL-PRF-131	II	-	-
I	H	1 or 2	MIL-PRF-81705	III	-	1 or 2

1/ Unless otherwise specified, nominal thickness shall be 0.004 inches.
2/ Finish shall be No. 2 (treated).

Table 4-6. Common Stock Sizes

Size Designation	Inside dimensions in inches
1	2-1/2 x 3
2	2-1/2 x 6
3	3 x 5
4	4 x 6
5	4 x 8
6	4 x 12
7	6 x 6
8	6 x 8
9	8 x 12
10	10 x 10
11	10 x 13
12	10 x 12
13	12 x 12

Dimensions are expressed in inches and fractions,
width first and length second, as follows:
4" x 6" is a bag that is 4"wide and 6" long.

Dimensions and Tolerances For Bags

The bag length and width tolerances and maximum heat seal width depend on the area of the bag. See table 4-7 for these values.

SIZE AND WEIGHT LIMITATIONS

Size Limitations

Size of bags is unrestricted with the following exceptions:

- X Type III, class E, style 1 - 450 square inches; maximum product of inside width times inside depth.
- X Type II, class C, style 1 - 50 square inches; maximum product of inside width times inside depth.

Weight Limitations

Net weight of contents shall not exceed 10 pounds when bag is used without additional packaging/packing. No weight restrictions are imposed if the filled bag is packed in a supporting container. There are no weight restrictions for bags shown in table 4-8.

Table 4-7. Heat Seal Width.

Area of bag (one side)	Heat seal width maximum	Tolerance - width and length of bag
25 sq. in, or less	3/8"	-1/16 + 1/8
26 thru 200 sq. in.	1/2"	-1/8 + 1/4
201 thru 500 sq. in.	5/8"	-1/4 + 3/8
501 sq. in. or over	5/8"	-1/4 + 1/2

Seams fabricated by the dielectric, impulse or ultrasonic process shall have a minimum 1/32 inch heat seal. Seams of bags fabricated from unsupported plastic sheet (i.e. polyethylene, polyolefin) shall be required to meet the seam strength test specified in para. 3.4 of MIL-B-117 with no minimum seam width required.

Table 4-8. No Weight Restrictions

Type	Class	Style
I	B	2*
I	C	2
I	E	1,2,3
I	F	1
I	G	1

*when using A-A-3174 the following applies:

Nominal Thickness	Weight Limitation
.004	up to 5 pounds
.006	over 5 pounds

Envelopes, Packaging, Watervaporproof, Flexible (MIL-E-6060)

For large sizes of watervaporproof bags, those conforming to MIL-E-6060, Envelopes, Packaging, Watervaporproof, Flexible, shall be used. The Air Force provides specification sheets for fabricating bags for Power Plants. These are shown in table 4-9.

BARRIER AND WRAPPING MATERIALS

A barrier material is a paper like or film material designed to withstand, to a given degree, the penetration of water, water vapor, grease, or certain gases. Barrier materials may serve to exclude or retain such elements within or outside the pack. A wrap is simply a sheet of flexible material, usually fed from roll stock, and formed around the item or pack to exclude dirt and facilitate handling, marking, or labeling. Barrier and wrapping materials may be divided into two general categories: opaque (nontransparent) and transparent. Opaque barrier materials are especially manufactured made to resist puncture or tear in shipping and handling. They must be flexible, waterproof, watervaporproof, greaseproof, or gasproof, or be resistant to flame, tarnish, or mold, if so specified. Some must prevent corrosion, provide protection against penetration by insects, or be nontoxic, odorless, and tasteless. Practically all must be capable of accepting markings for identification and some must be heat sealable. Transparent films are unsupported, nonfibrous, thin, flexible, organic plastic materials that are highly desirable in preservation-packaging operations due to their clear and protective characteristics. Examples of these materials are polyethylene, cellulose acetate, polyester, polystyrene,

rubber hydrochloride, vinyl chloride, and chlorotrifluoroethylene. Correct handling of barrier and wrapping materials is a great factor in avoiding inefficient wrapping operations. It is extremely important to receive, store, and handle barrier and wrapping roll stock according to recommended practices. Rolls should be stored on end, and flat cuts should be stored on their flat surfaces. Temperatures of 45º to 75ºF., and a relative humidity of 40 percent to 50 percent are recommended for the storage of most barrier and wrapping materials. The use of dispenser units and automatic splicing equipment will contribute greatly to economy in the use of barrier and wrapping materials. It will also help to maintain a uniform and constant flow of work through the packaging line. Specification symbols, nomenclature, available types, grades, and classes, and intended uses of the most common barrier and wrapping materials are given in table 4-10.

Table 4-9. Specification Sheets.

MIL-E-6060/1A(USAF)	Envelope, Packaging, Watervaporproof, Flexible (R-986 and R-1340 Engines)
MIL-E-6060/2A(USAF)	Envelope, Packaging, Watervaporproof, Flexible (R-1820, R-1830 and R-2000 Engines)
MIL-E-6060/3A(USAF)	Envelope, Packaging, Watervaporproof, Flexible (R-2800 Engine)
MIL-E-6060/4A(USAF)	Envelope, Packaging, Watervaporproof, Flexible (5 KW Aircraft Power Plant)
MIL-E-6060/5A(USAF)	Envelope, Packaging, Watervaporproof, Flexible (J-33 Engine)
MIL-E-6060/6A(USAF)	Envelope, Packaging, Watervaporproof, Flexible (O-435 Engine)
MIL-E-6060/7A(USAF)	Envelope, Packaging, Watervaporproof, Flexible (R-4360 Engine)

Table 4-10. Barrier and Wrapping and Materials Used in Military Packaging

Specification	Title	Type, grade, or class	Uses
MIL-B-121	Barrier Material, Grease-Proofed, Waterproofed, Flexible.	*Type I - Heavy Duty* Grade A - Greaseproofed, waterproofed, and non-corrosive. Class 1 - Heat sealable, nonstretchable. Class 2 - Nonheat sealable, stretchable. Grade C - Greaseproofed, waterproofed noncorrosive moldable and self-adhering. Class 1 - Self-adhering coating applied on nongreaseproof side only. Class 2 - Self-adhering coating applied on both sides. *Type II - Medium Duty* Grade A -Greaseproofed, waterproofed, and noncorrosive. Class 1 - Heat sealable, nonstretchable. Class 2 - Nonheat sealable stretchable.	*General* - This material is used for protection of military supplies and equipment during transportation and storage under all types of climatic conditions. *Grade A material* - Grade A, class 1 material is primarily used in the fabrication of grease-proofed, water-proofed packaging bags and also as an intimate wrap instead of Grade A, Class 2 material. Grade A, class 2 material is essentially used as an intimate wrap to maintain and protect coatings of oily or soft preservatives in contact with metal surfaces to which applied. It is also used where it necessary to insulate the metal surface of packaged items form hygroscopic or corrosive elements of the pack where contact of required outer wraps of other barrier materials would contaminate the metal surfaces of the packaged item; or where other more protective barrier materials are not required. *Grade C material* - Grade C material is used primarily as an outer wrap of boxed or unboxed preserved material and usually sealed by a waxdip coating over the closed wrap. Grade C, class 1 material only may be used as an intimate wrap for critical items preserved with oily or soft preservatives since the surface of the wrap in contact with critical surfaces is noncorrosive and free of transferrable. material.
MIL-P-130	Paper, Wrapping, Laminated And Creped.	Type - Heavy. Type II - Medium duty. Type III - Light duty.	As a protective cover or wrap over Grades A and C, MIL-B-121, barrier material; as an intimate wrap on nonprecision parts where greaseproofness is not required; a wrap on parts or articles where a carton would waste shipping space; as a protective band around the outer surface of cylinders on completed radial-type engines; and as a complete cover for in-line-type engines. Not intended for use as a substitute for waterproof barrier materials.
MIL-PRF-131	Barrier Materials; Watervaporproof, Greaseproof, Flexible, Heat Sealable.	Class 1 - Plastic and non-woven backing. Class 2 - Kraft backing (limited use)	*Class 1* - For use in packaging operations where heat-sealable, flexible, water-vaporproof barrier materials are required. *Class 2* - Suitable for use in packages where the combined weights inside the barrier does not exceed 10 pounds. For all practical purposes, class 2 materials should be limited to use in bags whose inside length plus width does not exceed 42 inches. Class 2 materials should not be used in floating bag applications, in packaging operations under low temperature conditions (below 32EF) where fabrication or manipulation of the material is required, or where a double seam junction is fabricated.
MIL-P-17667	Paper, Wrapping, Chemically Neutral (Noncorrosive).	Type 1 - Flat. Type II - Creped (furnished in the following classes); Class 1 - Creped in one direction. Class 2 - Creped in two directions, or creped in one direction and corrugated in the other.	Intended for use as an initial wrap on items requiring a noncorrosive, dust protective wrap applied prior to, or as a part of unit packaging, where a greaseproof wrap is not required. *Note.* Not intended as an antitarnish paper for silver and magnesium.
MIL-PRF-22019	Barrier Materials, Transparent, Flexible, Sealable, Volatile Corrosion Inhibitor	Type I - Heat sealable. Type II - Pressure (cold) sealable.	The VCI treated materials are mainly for interior packs where transparency is desired. The Type II material lends itself to custom hand processing in bag sealing operations.

Table 4-10. Barrier and Wrapping and Materials Used in Military Packaging (continued)

Specification	Title	Type, grade, or class	Uses
MIL-PRF-22191	Barrier Material, Transparent, Flexible, Heat Sealable.	Type I - Waterproof, greaseproof, watervaporproof. Type II -Waterproof, greaseproof. Type III - Waterproof Note. All three types come in Class 1 (unlimited use) and Class 2 (automated bag making machines only).	Type I - Used in packaging applications requiring watervaporproof and greaseproof barriers. Type II – Used in packaging applications required waterproof and greaseproof barriers. Type III - Used in packaging applications requiring waterproof barriers.
MIL-PRF-81705	Barrier Materials, Flexible, Electrostatic Protective, Heat Sealable.	Type I - Watervaporproof, electrostatic protective, electrostatic and electromagnetic shielding. Type II - Transparent, waterproof, electrostatic protective, static dissipative. Type III - Transparent, waterproof, Note. All three types come in Class 1 for unlimited use and Class 2 for automated bag making machines only.	Type I - Used for the watervaporproof, electrostatic and electromagnetic protection of electrostatic discharge sensitive items. Type II - Used where transparency and static dissipation is required. Type III - Used where a transparent, waterproof, electrostatic field protective barrier is required. Note. Type II or III must be used in conjunction with Type I material to provide level A protection.
A-A-3174	Plastic Sheet And Strip, Thin Gauge, Polyolefin.	Type I - Normal impact strength polyethylene. Type II - High impact strength polyethylene. Type III - Polyproplene. Type IV - Heat shrinkable polyethylene. Class 1 - For nonfood contact application. Class 2 - For use in contact with food. Class 3 - Biaxially oriented. Class 4 - Preferentially oriented.	Intended for use in general purpose packaging applications where high degree of water resistance, moderate moisture vapor resistance, and dust protection are desired. It is not intended for use in special packaging applications where special grease or oil resistance properties may be required.
QQ -A-1876	Aluminum Foil.	Type I -Rolls. Type II - Interfold flat sheets. Class 1 - Flat sheets 12 x 10-3/4 inches. Class 2 - Flat sheets, 9 x 10-3/4 inches. Type III - Single-ply flat cuts (size to be specified in the contract or order). Grade A - For food handling and processing application. Grade B - For application other than food handling or processing.	As a noncorrosive barrier between surfaces which have been coated with preservative compounds and wood or dunnage, or between treated surfaces which would cause action. *Caution.* Direct contact with metals other than cadmium, aluminum, magnesium, or zinc should be avoided in application which may be exposed to water, to prevent galvanic action.
A-A-203 A-A-1894 (Formerly UU-P-268)	Paper, Kraft, Untreated Paper, Kraft, Treated (Fire Resistant)	Type I - Untreated. Grade A - No. 1 commercial designation. Grade B - No. 2 commercial designation. Type II - Fire resistant treated. Grade C - Heavy duty. Grade D - Light duty.	For general use in the overwrapping of packages where a chemically neutral or greaseproof, waterproof, or vaporproof barrier is not required. Types I and II are not intended for use as a wrapping material for food items.
A-A-1249 (Formerly UU-P-553)	Paper, Wrapping, Tissue	Type I - Regular. Class 1 - Bleached. Class 2 - Unbleached. Type 2 - Neutral (antitarnish). Class 1 - Bleached. Class 2 - Unbleached.	Type I is used as an initial wrap to protect items from breaking, scratching, and dusting during shipment and storage. Type II, in addition to the use requirements of type I, is used to prevent tarnishing.
PPP-B-1055	Barrier Material, Waterproofed, Flexible.	Classes: B-1 - Baling and interior wraps. B-2 - Baling and interior wraps. B-3 - Baling and interior wraps. C-1 - Interior wraps. C-2(a) - Crate liners and interior wraps. E-1 - Interior wraps and crate liners. E-2 - Interior wraps, crate liners, shrouds, and baling. H-2 - Case liners. H-3 (a) - Case liners. H-4 - Case liners. H-5 - Case liners, shrouds, and crate liners. L-2(b) - Case liners and crate liners. L-4 - Temporary tarpaulins. M-1 - Case liners, shrouds, and crate liners.	Baling - Classes B-1, B-2, -3 and E-2. Interior wraps - Classes C-1, C-2(a), E-1, and E-2. Case liners - Classes H-1, H-2, H-3(a), H-4, H-5, L-2(b), and M-1 Crate liners - Classes C-2(a), E-1, E-2, H-5, L-2(b), and M-1. Shrouds - Classes E-2, H-1, H-5, and M-1. Ammunition containers - Class P-1.

Desiccants (Activated)

Desiccants are used in connection with Method 50 preservation and must conform to the requirements of specification MIL-D-3464. Desiccants are available in three types - type I-General Purpose, type II - Nondusting, type III-for specific conditions (8 and 16 units only). The type II is intended for use in critical packing application where dusting cannot be tolerated. The Type II is intended for use where a danger exists of accidental flooding by water. The durability of the bag material and seams should be sufficient to prevent contamination of a system by accidental dispersal of desiccant material. Desiccants are furnished in bags of unit size 1, fractional sizes of 1/6, 1/3, and 1/2 of a unit, and multiple sizes of 2, 4, 8, and 16 units. A unit size is that quantity of desiccant which will adsorb at equilibrium with the air and at 77ºF. temperature at least the following quantity of water vapor: 3.00 grams at 20 percent relative humidity and 6.00 grams at 40 percent relative humidity. Desiccant bags shall be secured to prevent movement, possible rupture of bags or barriers, or damage to the item. Securing may be accomplished by tying, storage in specially provided baskets, taping, or other approved means. Desiccant bags should be located uniformly throughout the pack and in such a manner that all voids are exposed to the dehydrating action of the material. It is recommended that the total amount of desiccant be in as small unit bag sizes as possible without increasing the cube of the pack. Desiccant bags will not be placed on or permitted to come in contact with critical surfaces of the packed item. If it becomes necessary to place bagged desiccant in contact with a preservative coated part, the bags shall be isolated by wrapping the coated part with MIL-B-121, Grade A barrier material. The minimum quantity of desiccant for use per pack is determined in accordance with Formula I or Formula II of table 4-11, as applicable. Removal of the desiccant from its storage container and its insertion into the unit pack shall be the last action prior to sealing the bag or container.

HUMIDITY INDICATORS (FIGURE 4-2)

Humidity indicators shall be used in Method 50 packs, unless otherwise specified. As applicable, the indicator shall be located behind inspection windows or immediately within the closing edge, face or cover of the barrier and as far as practicable from the nearest unit of desiccant. Humidity indicators used within sealed packs shall conform to military standard MIL-I-8835 (formerly MS 20003-2), Indicator, Humidity, Card, Three-Spot Impregnated Areas (figure 4-2). This indicator is a three-spot paper card type, 2x4 inches in size. The spots indicate relative humidities of 50 percent, 40 percent, and 30 percent, top to bottom, by changing color from blue to pink. The indicator is accurate within 5 percent of the aforementioned relative humidities. Desiccant type humidity indicators will be subject to approval of the procuring agency. Externally mounted indicating elements or devices such as the plug type, when specified, shall be installed in place of, or when required, in addition to, the humidity indicators conforming to military standard MIL-I-8835 (formerly MS 20003-2). Externally mounted color change indicators, unless otherwise specified, will conform to MIL-I-26860 (Indicator, Humidity, Plug, Color Change). This is a metal plug type indicator which is permanently calibrated, reacts quickly to humidity changes, and is used for determining relative humidity within rigid containers and flexible watervaporproof barriers. Plug type indicators change from blue to pink at 40 percent relative humidity. When used with pressure or vacuum containers, they will hold up to 20 pounds per square inch differential air pressure. Advancements in plug type indicators have produced one that provides positive and permanent indication of early moisture entry before corrosion takes place. These "Irreversible Relative Humidity Indicators" trip (stain) at a set relative humidity (usually 55%) and are not reset by temperature or sunlight.

Table 4-11. Minimum Quantity of Desiccant per Unit Pack.

Formula I - To find units of desiccant for use within barrier other then sealed rigid metal barrier:
$U = CA + X_{(1)} D + X_{(2)} D + X_{(3)} D + X_{(4)} D$
Formula II - To find units of desiccant for use within sealed rigid metal barrier: $U = KV + X_{(1)} D + X_{(2)} D + X_{(3)} D + X_{(4)} D$
In the above formulas:
U = Number of units of desiccant to be used.
C = 0.011 when area of barrier is given in square inches.
C = 1.6 when area of barrier is given in square feet.
A = Area of barrier in square inches or square feet.
K = 0.0007 when volume is given in cubic inches.
K= 1.2 when volume is given in cubic feet.
V = Volume within barrier in cubic inches or cubic feet.
D = Pounds of dunnage (other than metal) within barrier.
$X_{(1)}$ = 8 for hair felt, cellulosic material (including wood) and other material not categorized below.
$X_{(2)}$ = 3.6 for bond fibers (animal hair, synthetic fiber and vegetable fiber bound with rubber).
$X_{(3)}$ = 2 for glass fiber.
$X_{(4)}$ = 0.5 for synthetic foams and rubber.
Note - Use only the X factors for material used in fabrication of the unit pack being considered.

Formula II may be used to determine units of desiccant required for sealed rigid containers (other than all-metal) when the sealed barrier provides a MVTR not exceeding 0.001 grams per 24 hours per 100 square inches, as established by Government specification or when tested in accordance with ASTM D1008.
Area (A) = L x W
L = Length of barrier material to be used to fabricate pack.
W = Width of barrier material to be used to fabricate pack.
Volume (V) = $\pi r^2 h$
$\pi = 3.1416$
r = Radius of can (2 distance across top)
h - Height or length of can

INSPECTION WINDOW

When specified in the contract or order, a window of material conforming to MIL-PRF-22191, Type I shall be provided in the bag in accordance with MIL-E-6060 procedures for Method 53 packs 15 cubic feet or larger. See figure 4-2 for “humidity indicators” and figure 4-3 for “inspection window”.

Window Dimensions

Unless otherwise specified, the window will be 4 inches by 8 inches.

Method of Mounting Window

The inspection window shall normally be mounted by means of heat sealing. If heat sealing cannot be accomplished, the window may be secured to the inside of the bag by means of a suitable water-resistant adhesive, and cloth-backed tape conforming to ASTM D 5486. After adhesively mounting the window to the inside of the bag, the edges of the window shall be completely taped from the inside, using 2-inch strips (minimum width) of ASTM D 5486 tape.

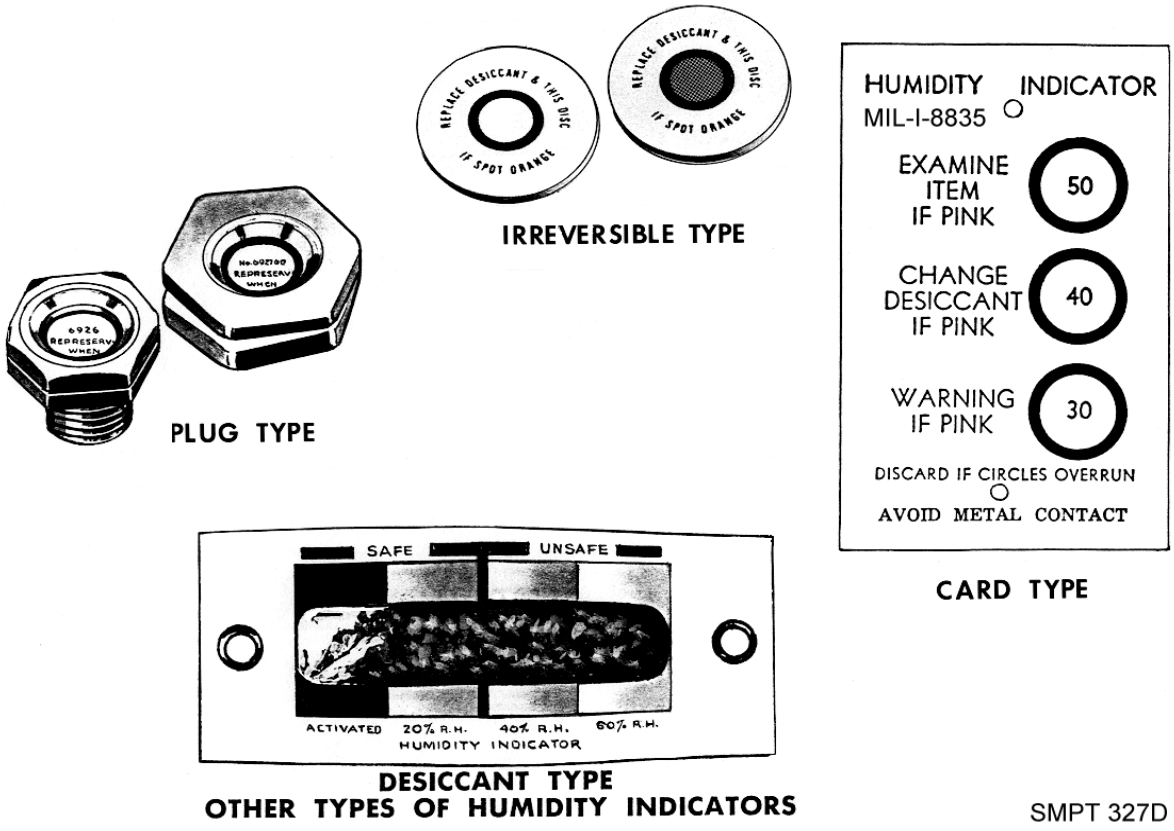


Figure 4-2. Humidity Indicators.

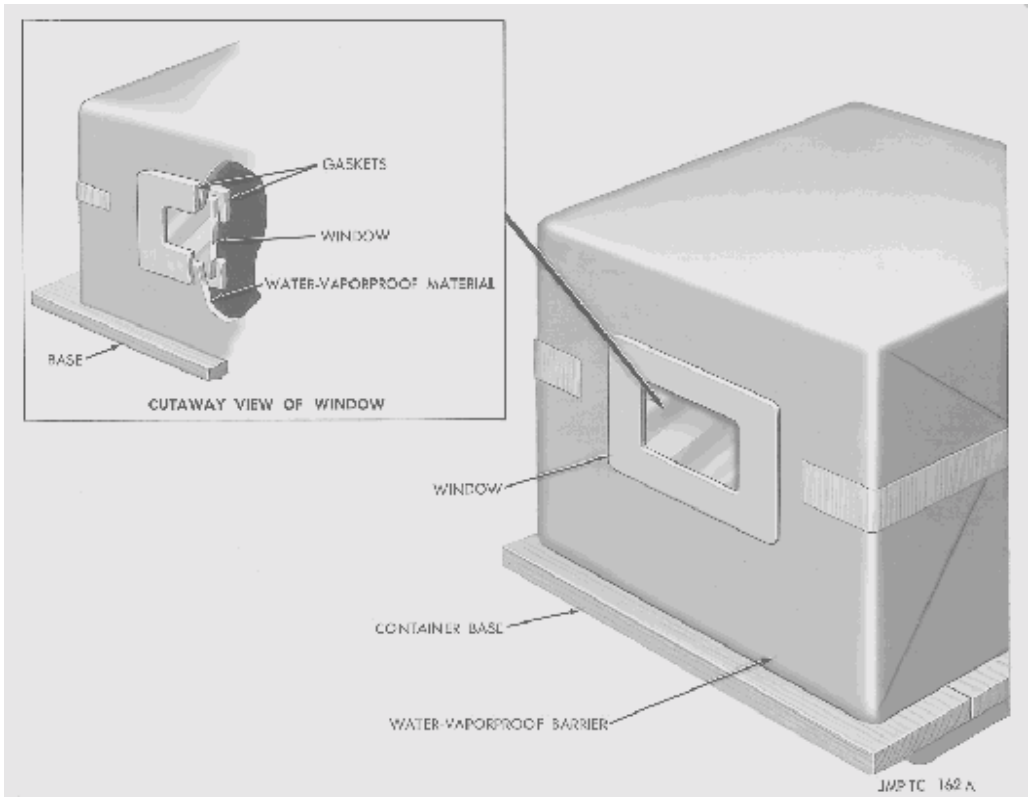


Figure4-3. MIL-E-6060 inspection window.

Unit and Intermediate Pack Labels

When labels are used for marking identification and contract data, the following applies:

- X Labels shall be machine printed, typed, stamped, or reproduced.
- X The label used to mark a unit pack shall be no larger than any side of the unit pack.
- X Paper labels that are other than pressure-sensitive shall be securely affixed with a water-resistant label adhesive that is applied on the complete underside of the label. An alternate method is to place ASTM D 5486 transparent tape over the entire surface of the label.
- X Pressure sensitive labels shall be of a water-resistant grade of paper, film, fabric, or plastic and shall be coated on one side with a pressure-sensitive, permanent adhesive. The adhesive shall adhere to metal, plastic, or fiberboard surfaces under high or low temperatures.

TAPES

A tape is an adhering strip or band of paper, textile, plastic, etc., which has several applications in military packaging, among them the closing and sealing of containers. On the basis of the nature of the adhesive applied to the backing material of tapes, those used predominantly by the military fall into two major categories: pressure-sensitive tapes and water-activated tapes (gummed tapes). Pressure-sensitive tapes are those which in the dry (solvent-free) form are highly and permanently tacky at room temperature and firmly adhere to the surface upon mere contact and without the need of more than slight finger or hand pressure. Water-activated tapes are those which require activation of the adhesive holding power. Tapes should be stored in clean, dry places. Storage temperatures of 70º to 75ºF. are recommended. Tapes should be stored in their original containers, and purchases should be adjusted to avoid storage for more than 6 months. All tapes, especially pressure-sensitive tapes, should be stored so that the pressure is exerted against the edge of the tape. Tapes which have been stored for over 1 year should be examined carefully before use, and, if there is any evidence of deterioration such as separation of layers within the roll, tape adherence to its own backing, or stringy appearing adhesive when the tape is unrolled, the tape should be replaced. Specification symbols, nomenclature, available types, grades, and classes, and intended uses of the most common tapes are given in table 4-12.

CUSHIONING MATERIALS AND THEIR APPLICATION

CONCEPT AND FUNCTIONS OF CUSHIONING

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.

The following paragraphs provide engineering principles involved in the use of various cushioning materials. MIL-HDBK-304, “Package Cushioning Design,” is one of the best documents to understand the characteristics and functions of cushioning materials and how these factors may affect the protection of the item within the package.

Table 4-12. Tapes used in Military Packaging

Specification	Title	Type, grade, or class	Uses
L-T-99	Tape, Pressure-sensitive, Adhesive, Identification.	Type I - Interior labeling and identification. Type II - Edging. Type III - Exterior labeling and identification	Type I. For interior use as an identification medium. In the printed form it may be used for labeling application including files, containers of all types, charts, etc. Colored tape, with or without printing can be used for identifying the metal in metal shapes, color coding, etc. It is not recommended for edging purposes. Type II. For edging of documents; maps, charts, etc. to protect the edges from tearing or other damage during handling and storage. Type III. For both interior and exterior identification applications such as Air Mail Tape and other special markings required in packaging. Office use and similar applications. It is not recommended for edging purposes.
A-A-883	Tape, Pressure-sensitive, Adhesive, Masking.	Type I - Creped. Type II - Flat.	For light duty bundling, holding, and packaging applications such as bundling small parts to be overpacked, holding small parts to larger assemblies, and for temporary closing of chipboard and fiberboard boxes that are *not* to be shipped.
A-A-1492 A-A-1671 (Formerly PPP-T-45)	Tape Gummed, Paper, Reinforced and Plain, for Sealing and Securing.	A-A-1671 Type I - Asphalt lamination Type II - Nonasphalt laminated Class 1 – Strippable Class 2 – Nonstrippable Style A - 2 way reinforcement Style B - 3 way reinforcement A-A-1492 Grade A - Light duty Grade B - Medium duty Grade C - Heavy duty	A-A-1671 Intended for closure of fiberboard boxes. For domestic shipment and storage and securing wrapping of packages A-A-1492 Use for general sealing of cartons and fiberboard boxes, wrapping of packs, and banding of paper and paper products.
ASTM D 5486 (Formerly PPP-T-60 and PPP-T-76)	Pressure-sensitive Tape for Packaging, Box Closure, and Sealing.	Type I – Waterproof, weather-resistant; polyester-backed. Class 1 - Colored. Class 2 - Transparent. Type II Water-resistant, polyester backed. Class 1 – Tan. Class 2 – Transparent. Type III – Water-resistant, polypropylene. Type IV – Water-resistant, woven, cloth backed. Type V – Weather-resistant, paper backed.	These tapes are used when packaging and sealing performance against water penetration and low temperatures are desired. Type I is used for box closure and sealing where strength and resistance to sunlight, rain, and other deteriorating elements are required. Type I, Class 2 can also be used for label attachment and covering applications where weather resistance is needed. Type II is used for box closure where strength and water-resistance are required. Type II, Class 2 is also used for label attachment and covering application where water-resistance is desired. Type III is used for box closure where a general purpose water-resistant tape is desired. Type IV is used for less critical packaging applications where a cloth-backed tape is desired. Type V is used for box closure and sealing where weather-resistance and water-resistance are required.

Table 4-12. Continued.

Specification	Title	Type, grade, or class	Uses
A-A-1689 (Formerly PPP-T-66)	Tape, Packaging ,Vinyl Plastic Film.	Type I - General Purpose. Class 1 -Transparent. Class 2 - Colored. Type II - Printable.	Both Types I and II are intended for uses such as sealing out moisture and applications requiring the flexibility, toughness, and conformability normally possessed by a plasticized vinyl film.
ASTM D 5330 (Formerly PPP-T-97)	Pressure-sensitive Tape for Packaging, Filament-Reinforced.	Type I -Low tensile strength. Type II - Medium tensile strength. Class A - Opaque. Class B - Transparent. Type III - High tensile strength. Type IV - High tensile strength, weather resistant.	Type I – For strip reinforcement of Containers and anchoring moving parts. Type II – For closures. Type III – For bundling and other forms Type IV – Where weather resistance is required.
A-A-113	Tape, Pressure-sensitive Adhesive.	Type I - Glossy finish. Class A - Transparent, cello-phane, or other material. Class B - Colored, cellophane, or other material. Type II - Matte finish. Class A - Transparency, cellulose acetate backing. Class B - Cellulose acetate, transparent, glossy backed.	Type I, Class A tape is for temporary mending and attaching. Type I, Class B tape is for temporary identification, charting, and decorating. Type II, Class A tape is virtually invisible. Type II, Class A - For permanent mending of paper, documents, blueprints, maps, etc. Type II, Class B - For permanent applications such as light holding, covering, shielding, and sealing.
MIL-T-22085	Tape, Pressure-sensitive, Adhesive, (For Exterior Preservation and Sealing of Military Vehicles, Aircraft, and Related Equipment)	Type II - For use with or without overcoating. Type IV - For use without overcoating for extended time periods.	Type II - For use in the preservation and sealing of military vehicles, airplanes, missiles, and other related equipment where long term exterior exposure is anticipated. Overcoating is required when unprotected outdoor storage is anticipated. Type IV - For the same application as Type II. Type IV shall be used where extended periods of unprotected outdoor storage are expected. Type IV tape may be used without overcoating for the sealing of equipment that may have shed or indoor storage.
MIL-T-43036	Tape, Pressure-sensitive Adhesive, Plastic Film (For Sealing Fiber Containers and Cans).	Type I - Reinforced polyester film. Type II - Non-reinforced polyester film.	For sealing fiber containers and cans meeting MIL-C-2439 and MIL-C-3955 and for slip cover metal containers. It may be used in other applications where waterproof, watervaporproof, medium tensile strength tape possessing good low temperature removal properties is required.

Cushioning Vs Dunnage

According to MIL-HDBK-304 “Cushioning Design” there is a profound difference between cushioning material and dunnage. Cushioning an item is an engineering application of a specific material thickness and bearing area to protect against known forces. Usually this involves testing the bare item for fragility, designing the cushioning system and testing the resulting design for complete item protection from shock and vibration forces.

Dunnage is the application of unspecific material to fill voids, protect the finish from scratches or abrasions, or prevent load shifting during transport. Dunnage use does not apply the engineering design and test process to ensure specific shock and vibration protection. Until recently, military packagers used loose-fill dunnage materials extensively. Many problems surfaced with the use of this dunnage material. This material is forbidden for use by most of the military services and DLA. One problem with loose fill was the shifting of the item within the package so that no item protection was available. Also, foreign object debris (F.O.D.) on the flight line was a problem. For example, polystyrene peanuts may find their way into the aircraft engine causing costly damage upon engine start-up.

Many dunnage wrap materials such as polyethylene, polyurethane, and polypropylene foams, flexible cellular plastic films and thin-sheet cellulose material are all acceptable for void fill. Dunnage types include PPP-C-795, A-A-3129, PPP-C-1797, A-A-59135, A-A-1051, and A-A-1898. The packer simply wads up several sheets and forces them into the void.

Cushioning materials can be used as dunnage, but the cost is excessive. Unless the packer has excess or scrap cushioning materials available that can not be otherwise used for an engineering purpose, it is best to only use the cheaper dunnage materials for void fill.

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, as shown in figure 4-4, the most important functions are as follows:

- X Control item movement. Cushioning, when properly applied, controls the movement of the item within the barrier or container and mitigates the effects of shock and vibration.
- X Protect fragile or delicate components. When fragile or delicate components form a part of an otherwise rugged item, they may be disassembled and packed separately. If disassembly is not permitted and they must be left in place, cushioning is applied to give them protection.
- X Prevent rupture of barriers and containers. Many items have sharp corners or projections which could puncture the barriers or containers in which they are packed, resulting in the entry of moisture or water. Cushioning is applied to these projections or corners to insure that waterproof or watervaporproof barriers are not rendered useless by such damage.
- X Distribute forces. Cushioning materials reduce the effects of impact shock to an item by distributing the damaging forces over a large area, thus lowering the energy concentration at any one point on the surface of the item.
- X Prevent abrasion. Items with highly finished surfaces which may be marred by blocking, strapping, or contact with other items in the container must be protected against abrasion by cushioning. Usually, lesser amounts and

thicknesses of cushioning materials are employed to accomplish this cushioning function.

X Absorb shocks. Perhaps the most frequent and important use of cushioning is to absorb the energy resulting when a container is subjected to impact. This shock energy is absorbed as the cushioning material is compressed by the item.

MULTIPURPOSE CUSHIONING

Although the foregoing functions of cushioning are described separately, in practical application most materials used for cushioning serve more than one function. A material selected to protect an item from damage by impact shock may also prevent abrasion, protect barrier materials and cover sharp projections. Another material may serve to distribute shock forces as well as limit movement. Some materials serve as rigid blocking with limited shocks and as flexible cushioning with more severe shocks. Cushioning materials may also be required to absorb liquids, in case the inner container becomes damaged and leaks. This is particularly required for liquids which are corrosive or otherwise dangerous.

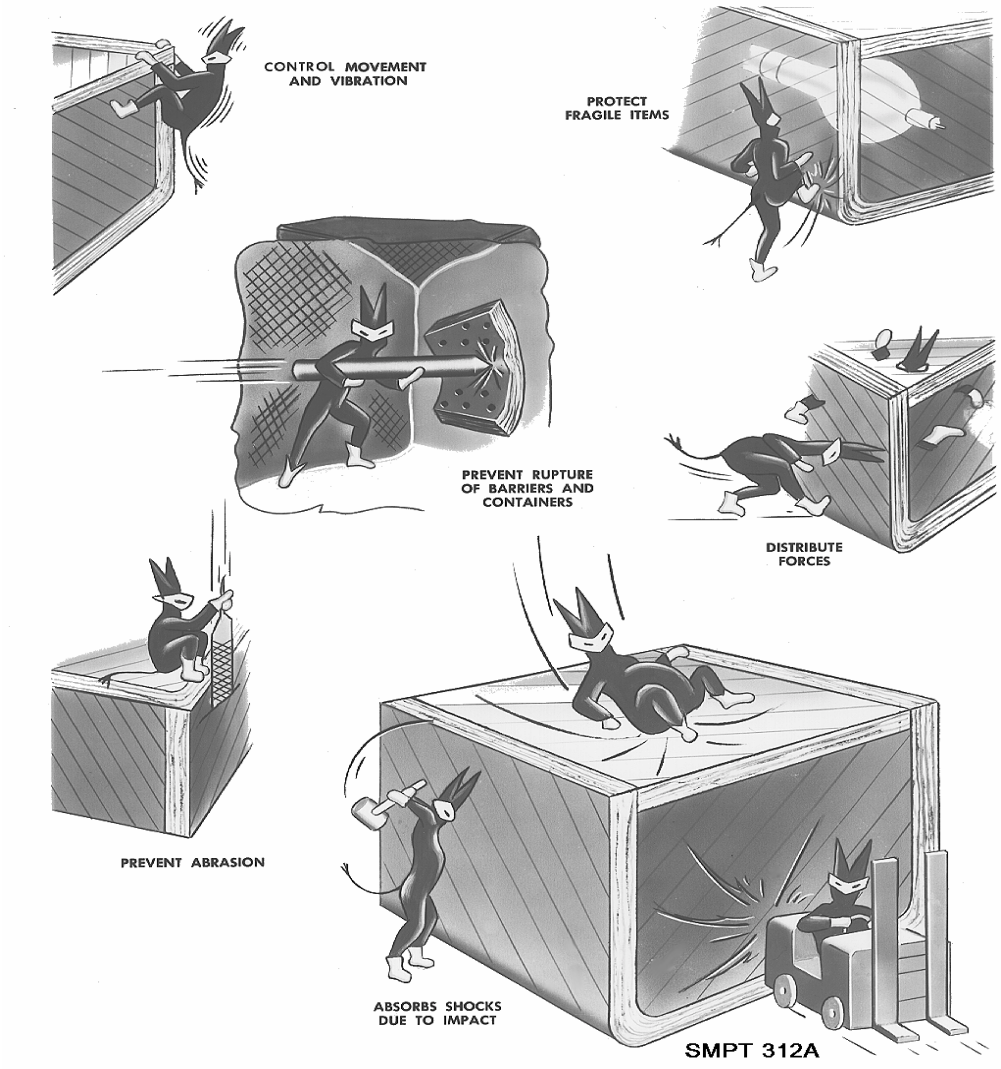


Figure 4-4. Functions of cushioning.

REQUIREMENTS FOR THE USE OF CUSHIONING MATERIALS

In addition to the requirements established in cushioning specifications which control material quality, construction, and performance, three important requirements must be met when cushioning materials are used within waterproof or watervaporproof barriers. MIL-STD-2073-1C requires the following:

- X Cushioning be as dry as practicable.
- X Cushioning must be noncorrosive.
- X If the item is coated with a preservative, the preserved item must first be wrapped in a greaseproof barrier conforming to Grade A or C of MIL-B-121, QQ-A-1876, or Type II of MIL-PRF-22191. In addition, material conforming to Type III of MIL-PRF-22191 may also be used as cushioning and dunnage when bags are made of material conforming to Grade A of MIL-B-121, MIL-PRF-131, or Type II of MIL-PRF-22191.

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 packs, and the means of transportation must all be taken into consideration before an item can be properly cushioned.

CHARACTERISTICS OF THE ITEM (FIGURE 4-5)

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. Design data such as specifications and/or drawings are excellent sources for this information.

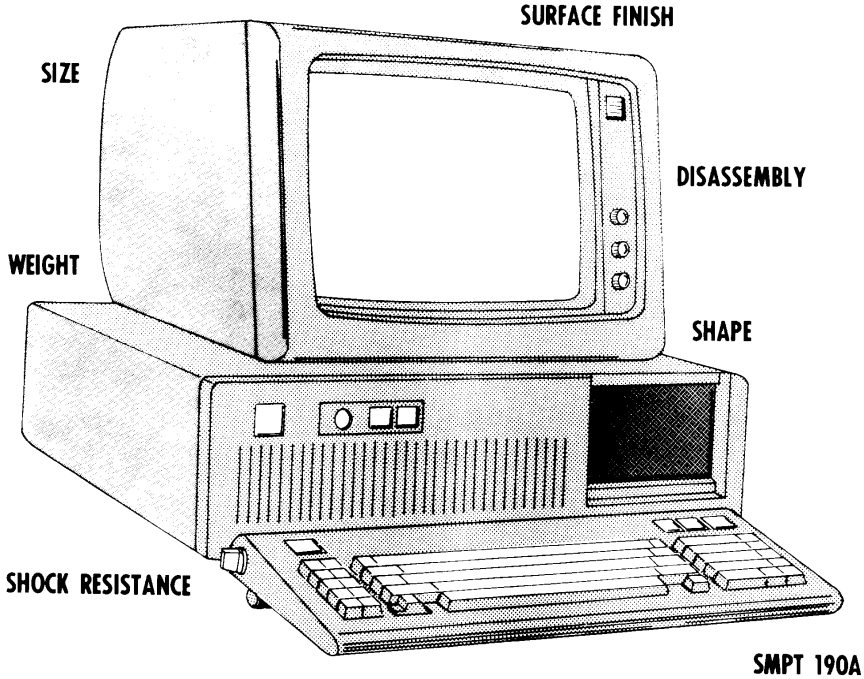


Figure 4-5. Item characteristics which determine the selection of cushioning material.

Shock Resistance or Fragility

Fragility cannot be determined by eye alone. The tendency is to over-cushion seemingly fragile items and to under-cushion seemingly sturdy items. Fragility, the greatest amount of energy 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 fragility testing in which as item is subjected to impact shocks of increasing severity. The minimum deceleration of the item at which damage or malfunction occurs divided by the acceleration due to gravity is called the "G-factor" for that item. This is expressed as:

$$\text{G-Factor} = \frac{\text{Acceleration}}{\text{Gravity}}$$

The G-factors of many military items are being determined. In the absence of known G-factor values, the determination of the right cushioning must be based on the history of previous shipments and, whenever practicable, on actual drop testing of the completed pack.

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 up 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 in conjunction with cushioning will have to be employed to protect such items.

Static Stress

Tables of cushioning performance factors usually present data based on static stress (the weight per unit area). This is determined by dividing the weight in pounds by the area of the weight bearing surface in contact with the cushioning.

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 surface may be corroded and pitted by chemical action due to the presence of moisture and acidic or basic elements in the cushioning material.

Disassembly

The disassembly of a highly irregular item may allow a reduction in its cube and permit simpler cushioning to give the necessary protection. Before disassembly,

however, competent advice should be obtained as to the feasibility of reassembly and calibration, if necessary, in the field.

CHARACTERISTICS OF CUSHIONING MATERIALS

The chemical and physical properties of cushioning materials are many and 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. The hygroscopic characteristic of some materials is to absorb water from the atmosphere. High moisture absorbency is required for packing liquids but is not desirable when packing corrodible metal items.

Compression Set (Figure 4-6)

This is the difference between the original thickness of a cushioning material and the thickness of the same material after having been released from compression. Compression set is undesirable as it creates free-moving space in the container.

Resilience (Figure 4-6)

Resilience 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 cold conditions, unless altered by additives.

Rate of Recovery (Figure 4-6)

This is the time it takes for a cushioning material to return to its original shape after compression. This is important because some materials have too rapid a rate of recovery and "spring back" so quickly that damage to the item may result.

Dustiness (Figure 4-7)

A 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.

Corrosiveness (Figure 4-7)

The corrosive effect of some cushioning materials is undesirable when packing 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 alkaline content must not be enclosed within waterproof or watervaporproof barriers.

Fungus Resistance (Figure 4-7)

Some cushioning materials have a low fungus resistance and will allow 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.

Abrasiveness (Figure 4-8)

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 materials are soft-textured and generally can be placed in contact with easily marred surfaces. Coarse-textured materials should not be used on such surfaces.

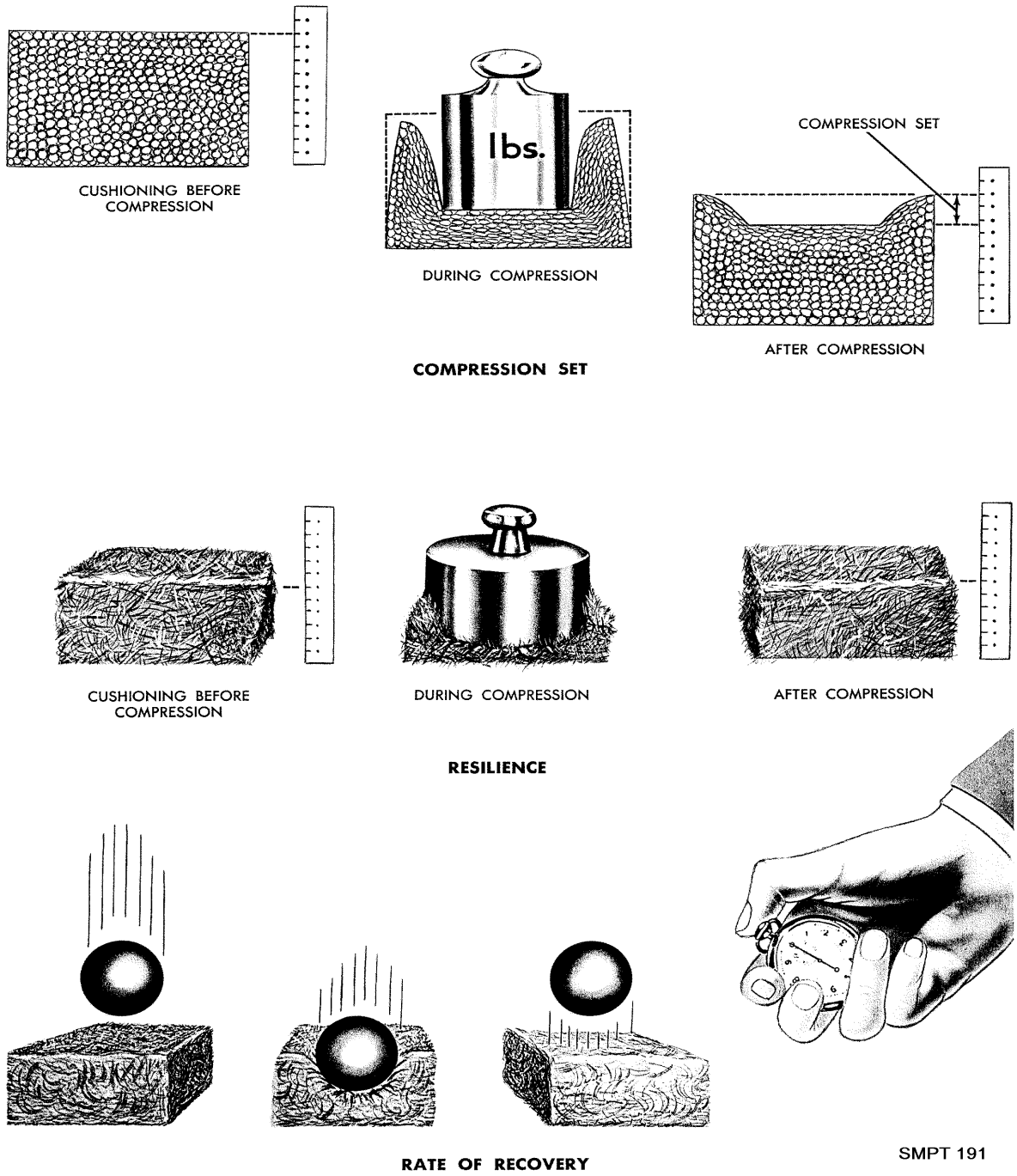


Figure 4-6. Characteristics of cushioning materials-compression set, resilience, and rate of recovery.

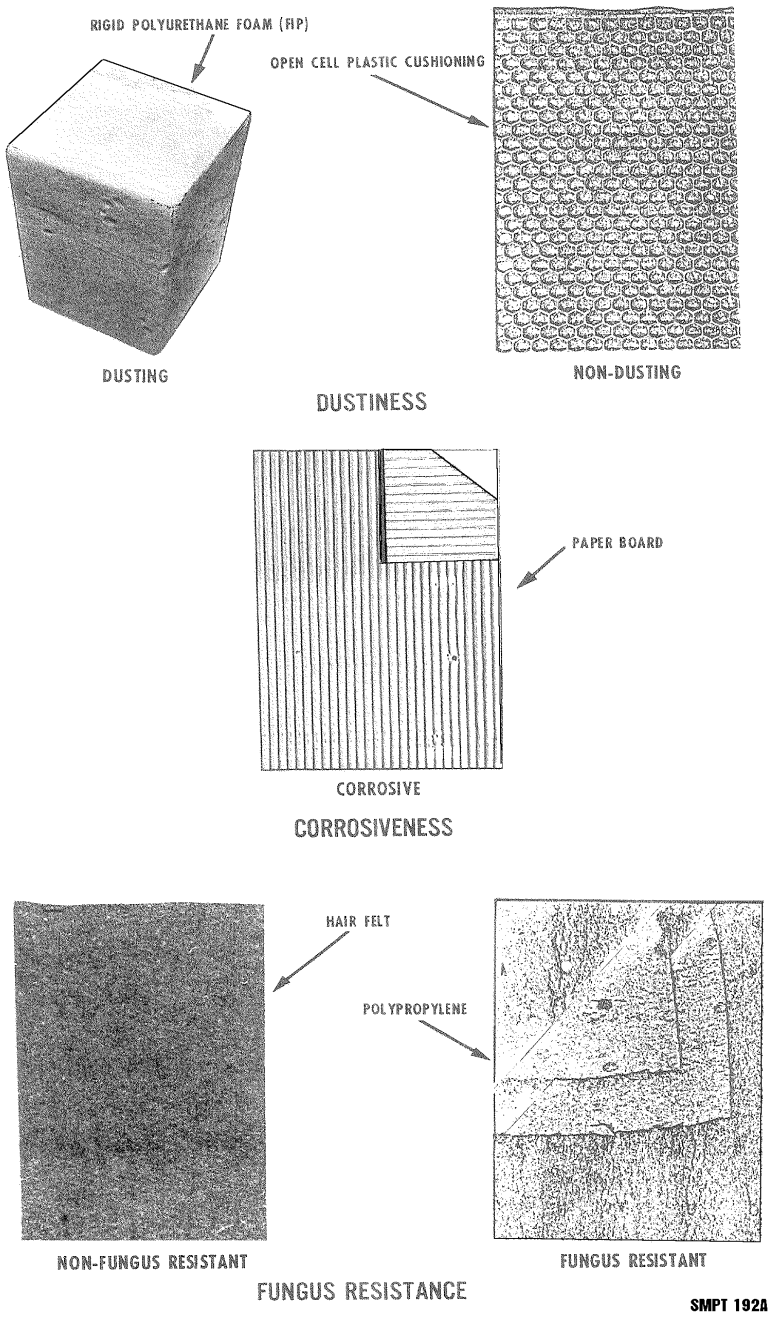


Figure 4-7. Characteristics of cushioning materials-dustiness, corrosiveness, and fungus resistance.

Temperature Performance (Figure 4-8)

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.

Other Characteristics

Fire resistance or flammability (see figure 4-8) should not be overlooked in choosing cushioning materials. Also, be aware that certain cushioning materials may cause skin irritation to personnel who come in contact with it.

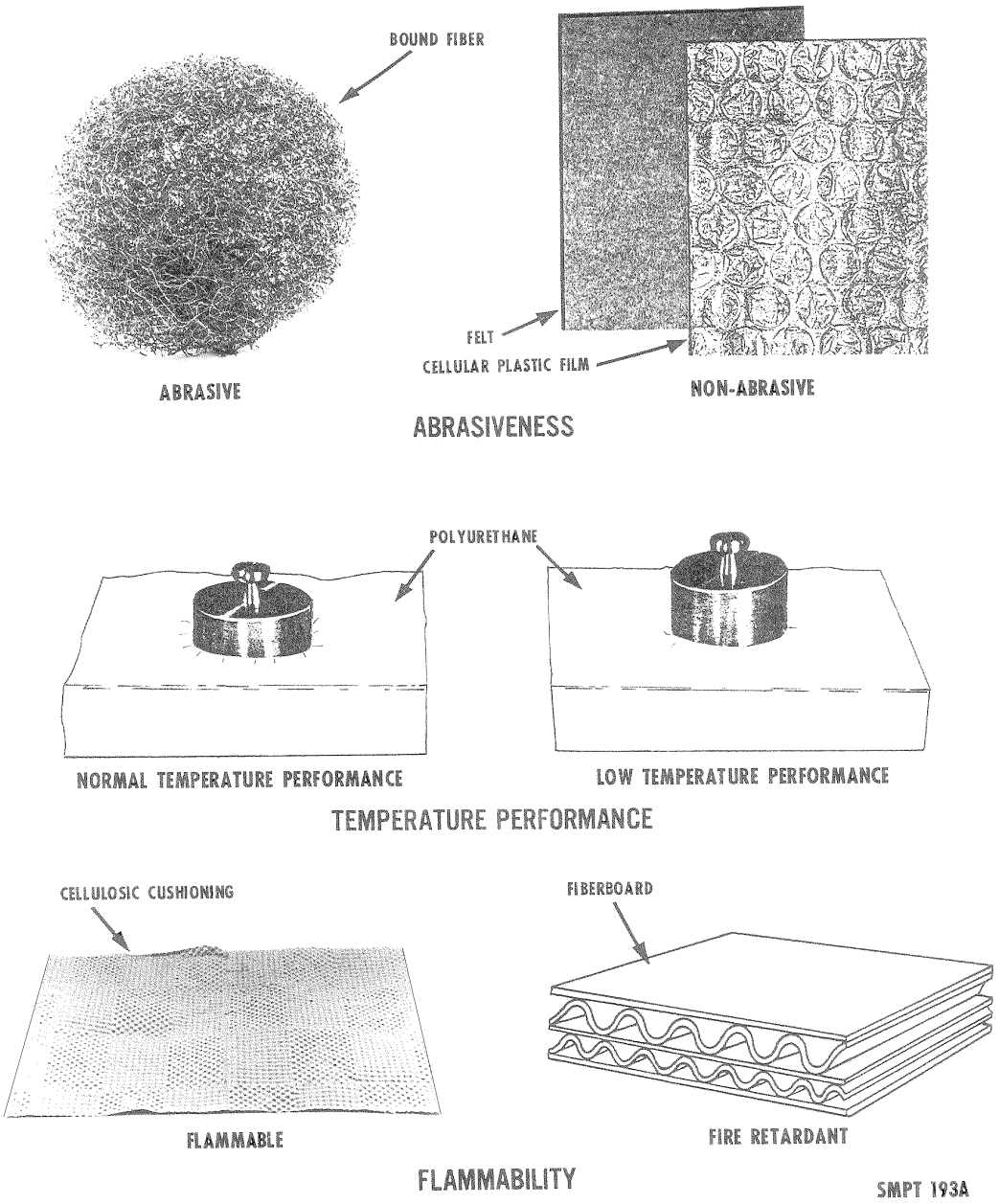


Figure 4-8. Characteristics of cushioning materials-abrasiveness, temperature performance, and flammability.

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 that they become 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 an item being transhipped from truck, to rail, to ship might receive than one 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

Bound Fiber (PPP-C-1120)

These materials 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 common examples. The materials are furnished in four types and two classes. Class A is water-resistant, natural hair. Class B, common class, is not necessarily water-resistant. The four types are classified according to firmness, from soft to firm (capable of supporting loads up to 0.5 pound per square inch). They may be supplied as noncompressed flat sheets for general cushioning applications, or in molded forms shaped 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 reduced at low temperature. They are intended to protect items against vibrational and impact shocks where resilient and water-resistant cushions are required.

Cellulosic (A-A-1898)

The General Services Administration has authorized the use of this Commercial Item Description (CID) in preference to PPP-C-843, which has been canceled.

This material may be made of any kind of cellulosic matter which will result in a product meeting the CID. The cellulosic matter used may be cotton, bonded fibers, natural fibers, or creped wadding. The material is furnished in three grades and three classes. They are -

- X Grade I - water absorbent.
- X Grade II - water resistant.
- X Grade III - fire retardant, water resistant.
- X Class A - low tensile strength
- X Class B - medium tensile strength
- X Class C - 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 packing lightweight, fragile items; as a protection against abrasion; and grade I, specifically, for absorbing liquids from containers broken in transit.

Low Density Polypropylene Foam Cushioning Material (PPP-C-1797)

This material, in rolls, tear-perforated rolls, or flat cuts, is a low density, resilient, unicellular (closed cell) polypropylene foam material for use in cushioning and packing applications. It is useful throughout a temperature range from -65ºF (-54ºC) to 160ºF (71ºC). Type I is used for general cushioning applications while Type II is used for electrostatic protective cushioning applications. For high density items, it can be used for protection of surfaces from abrasion. It is nondusting and nonlinting. Typical packaging applications would be surface protection for optical lenses, equipment with critical surfaces, electrical and electronic equipment, glassware, ceramics, and magnetic tape rolls.

Pad, Energy Dissipator (MIL-PRF-9884)

Kraft fibers are constructed into sheets of paper board that resemble honeycomb. This material is primarily used as an energy dissipating medium for landing shock to which air dropped objects are subjected. It may also be used for special packing requirements.

Felt Sheet Hair and Felt Roll Hair (ANSI/BHMA A156.17)

This specification covers cattle hair felt as manufactured by the felted and fulled process in sheet and roll form. The felt is used for cushioning, packing, padding, crating, and shock mounts for long-term operation. One variety of this material is designed for shielding where high strength and abrasion resistance are required.

Solid and Corrugated Fiberboard

MIL-B-3106, Board, Composition, Water-resistant, Solid (For Filler or Cushioning Pads), and ASTM D4727/D4727M, Standard Specification for Corrugated and Solid Fiberboard Sheet Stock (Container Grade).

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. See figure 4-9 for examples of these. 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 the 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 on 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 of irregular shape. Application of fiberboard cells, trays, and pads is illustrated in figure 4-10.

Solid Fiberboard (MIL-F-26862)

This fiberboard is made from cane, wood or other vegetable fiber by a felting or molding process which incorporates a sizing agent to form uniform solid sheets, blocks, or special fabricated shapes. The board is made in two types - single-ply and laminated multiple-ply. The single-ply is furnished in 1/2 inch and 3/4 inch thickness. The material is available in a density of between 14 and 19 pounds per cubic foot. It has an average resilience, low compression set, low damping quality, and performs fair in cold weather. Its dusting qualities are low. The fiberboard is intended for use in packaging where a non-corrosive, fungus resistant material is needed to afford protection against vibration and impact damage during shipment and handling.

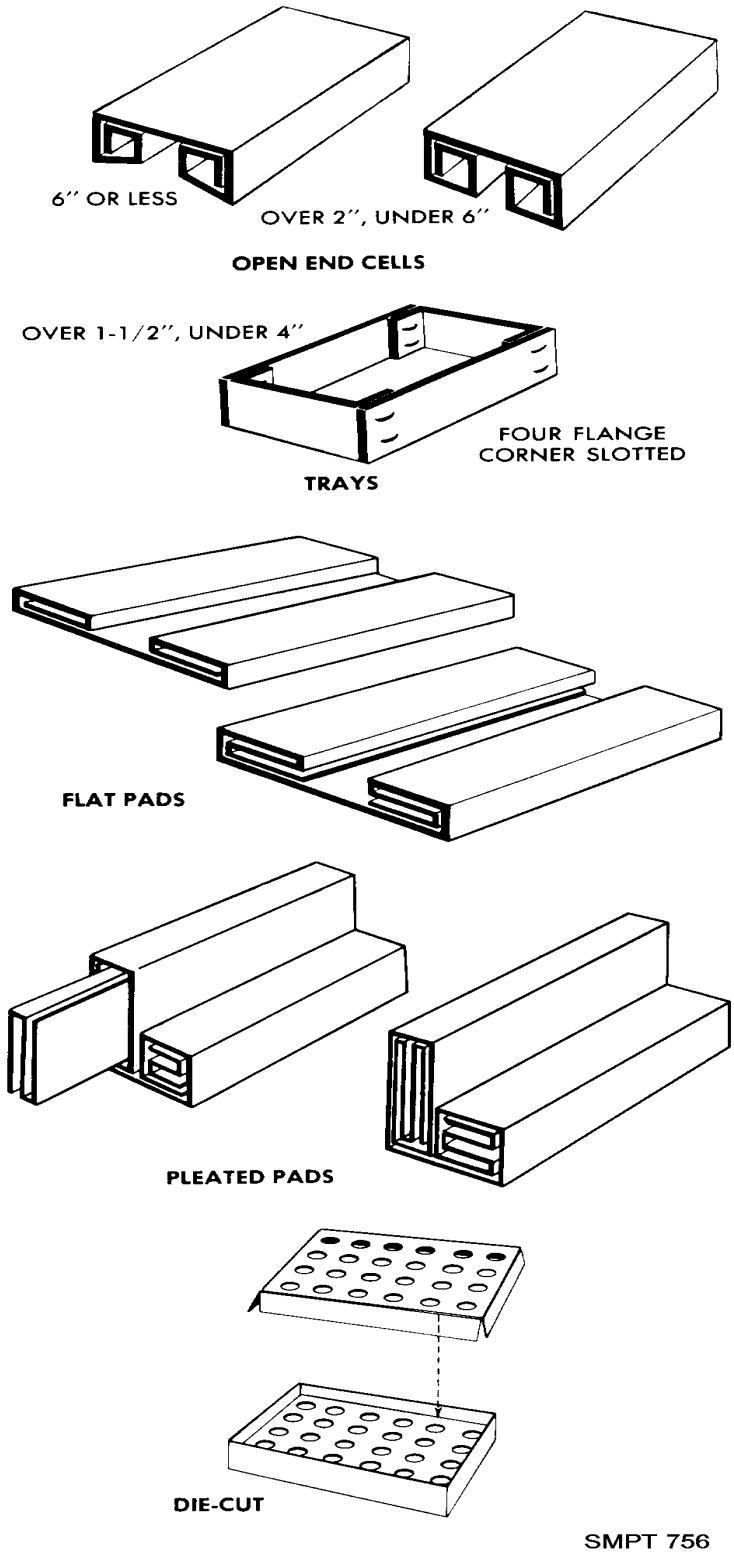


Figure 4-9. Examples of fiberboard die-cuts, open end cells, trays, and pads.

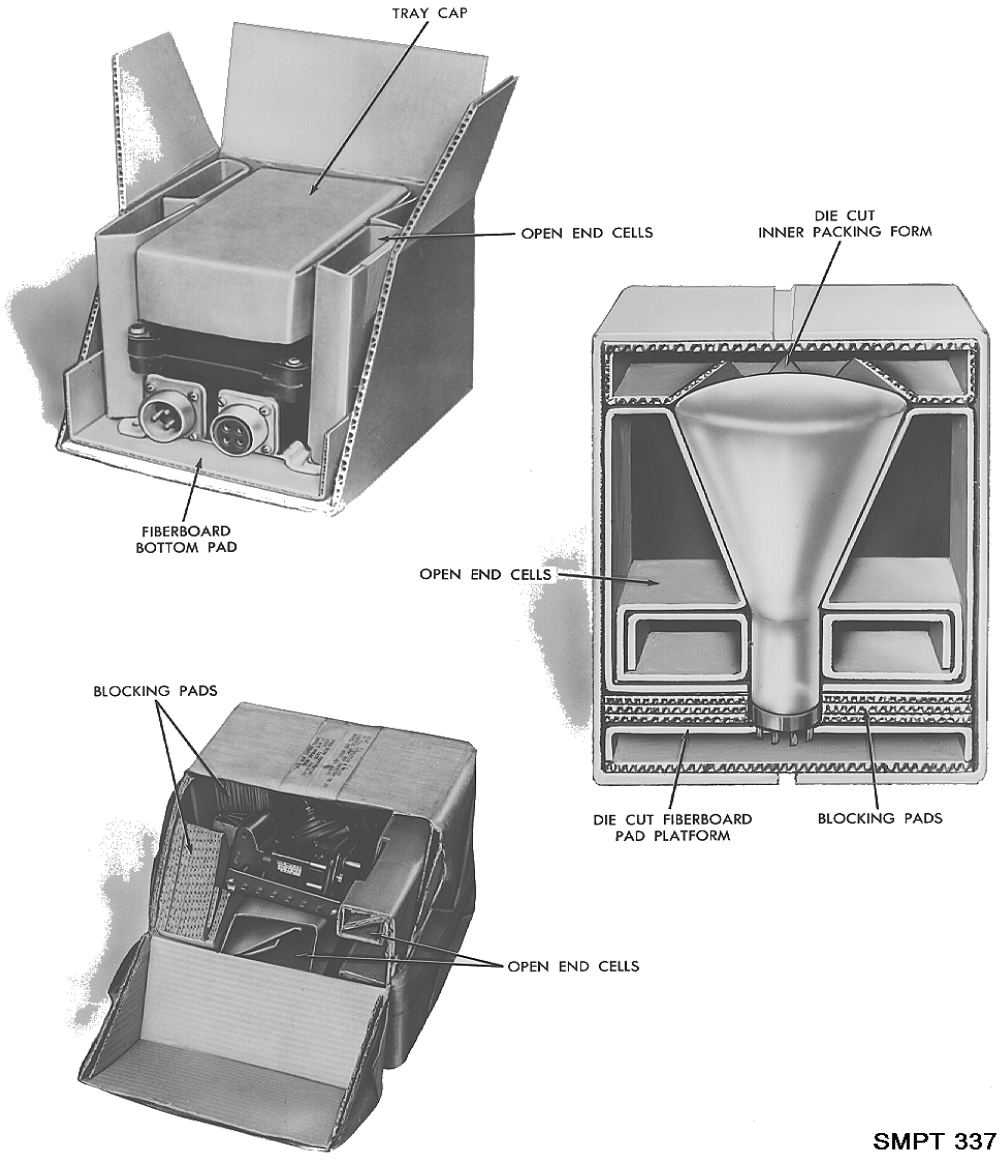


Figure 4-10. Application of fiberboard die-cuts, open end cells, trays, and pads.

Wrapping Paperboard (A-A-1051)

This is a paperboard composed of a corrugated sheet or a solid method 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 - backing sheet, mandatory, and style 2 - backing sheet, optional. It is furnished in sheets or rolls, as desired. This material has high compression, low resilience, excellent damping, and some dusting. The moisture content and moisture absorption are high. The material 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.