CHAPTER 6. PAINT MATERIALS

Section 1. GENERAL

A knowledge of the types of materials used for painting is useful in determining their capabilities and limitations. There are sound reasons for the existence of each coating specification, and these become more apparent with some insight into~the composition of the various types specified. This information is presented in this chapter to aid the reader in determining which product should be used for the job and to explain why the product is best suited for the particular combination of conditions present, i.e., the substrate, painting conditions, finish desired, and the environment to be withstood by the applied finish.

Section 2. PAINT BINDERS

6.2.1 GENERAL. Most paints are based on a film former or binder which is either dissolved in a solvent or emulsified in water. Upon application of the product in a relatively thin film, it will dry or cure to form a dry, tough coating. Solutions of such binders in solvent may be called by various names, e.g., clear finishes, varnishes if they dry by oxidation, or lacquers if they dry by evaporation. If opaque pigments or colors are dispersed in the binder, the product, which will produce an opaque white or colored film, is called a paint. Pigment concentration can also be varied to produce a high gloss, a semigloss, or lustreless (flat) finish. Special pigments, e.g., red lead and zinc chromate can be used to provide corrosion resistance in primers. Metallic pigments can be added to varnishes to produce metallic coatings, such as aluminum paints. The major performance characteristics of the coating depend generally on the type of binder used. The principal binders used in the paint materials covered in this manual are described in this section. These descriptions are concerned only with the reasons for their use, their superior characteristics, and their deficiencies. No attempt has been made to discuss their analytical composition in any detail since this would be of little value in this manual. The paint binders discussed are listed in alphabetical order for ease of reference.

6.2.2 ALKYD. Alkyd binders are oil modified phthalate resins which dry by reacting with oxygen from the surrounding air. Alkyd finishes are usually of the general purpose type, are economical, and are available as clear or pigmented coatings. The latter are available in flat, semigloss, and high gloss finishes and in a wide range of colors. They are easy to apply and, with the exception of fresh (alkaline) concrete, masonry, and plaster, may be used on most surfaces which have been moderately cleaned. Alkyd finishes have good color and gloss and retain these characteristics well in normal interior and exterior environments. Their durability is excellent in rural environments, but only fair in mildly corrosive environments. (See Table 6-2.) Alkyd finishes are also available in odorless formulations for use in hospitals, kitchens, sleeping quarters, and other areas where odor during painting might be objectionable.

6.2.3 CEMENT. Portland cement mixed with several ingredients acts as a paint binder when reacted with water. The paint is supplied as a powder to which the water is added before use. Cement paints are used on rough surfaces such as concrete, masonry, and stucco. They dry to form hard, flat, porous films which permit water vapor to pass through readily. Since cement paints are powders, they can also be mixed with masonry sand and less water to form filler coats to smooth rough masonry before applying other paints. Cement paints can be used on fresh masonry and are economical. The surface must be damp when they are applied, and must be kept damp for a few days to obtain proper curing. They should not be used in arid areas. When properly cured, cement paints of good quality are quite durable; when improperly cured, they chalk excessively on exposure, and then may present problems in repainting.

6.2.4 EPOXY. Epoxy binders are made up of two components which are premixed before use: an epoxy resin and a polyamide hardener. When mixed, the two ingredients react to form the final coating. These paints have a limited working or pot life, usually a working day. Anything left at the end of the day must be discarded. Epoxy paints can be used on any surface and can be applied at high solids, thus producing high film build per coat applied. The cured film has outstanding hardness, adhesion, flexibility, and resistance to abrasion, alkali, and solvents, as well as being highly corrosion-resistant. Their major uses are as tile-like glaze coatings for concrete and masonry and for the protection of structural steel incorrosive environments. Their cost per gallon is high, but this is offset by the reduced number of coats required to get adequate film thickness. Epoxy paints tend to chalk on exterior exposure so that low gloss levels and fading can be anticipated; otherwise, their durability is excellent.

6.2.5 EPOXY--COAT TAR. Coal tar is often added as an ingredient of epoxy paints, resulting in a significant decrease in cost with relatively minor effect on corrosion resistance. Color choice is limited because of the black color of the coal tar. It is used primarily for interior and submerged surfaces.

6.2.6 INORGANIC. The major inorganic binders used in paints are sodium, potassium, lithium, and ethyl silicates. These binders are used in zinc dust pigmented primers in which they react with the fine zinc metal to form very hard films. These films are extremely resistant to corrosion in humid or marine environments. Many of these primers also contain substantial concentrations of lead oxides which react with the silicates in conjunction with the zinc to form an even more corrosion resistant coating.

6.2.7 LATEX. Latex paints are based on aqueous emulsions of three basic types of polymers: polyvinyl acetate, polyacrylic and polystyrene-butadiene. They dry by evaporation of the water, followed by coalescence of the polymer particles to form tough, insoluble films. They have little odor, are easy to apply, and dry very rapidly. Interior latex paints are generally used either as a primer or finish coat on interior walls and ceilings whether made of plaster or wallboard. Exterior latex paints are used directly on exterior (including alkaline) masonry or on primed wood. They are nonflammable, economical and have excellent color and color retention. Latex paint films are somewhat porous so that blistering due to moisture vapor is less of a problem than with solvent thinned paints. They do not adhere readily to chalked, dirty, or glossy surfaces, such as those under eaves. Therefore, careful surface preparation is required for their use. Latex paints are very durable in normal environments, at least as durable as oil paints.

6.2.8 OIL. Linseed oil is the major binder in oil house paints. These paints are the oldest type of coatings in use and have the longest history of performance. They are used primarily on exterior wood and metal since they dry too slowly for interior use and are sensitive to alkaline masonry. Oil paints are easy to use and give high film build per coat. They also wet the surface very well so that surface preparation is less critical than with other types of paints for metal. They are recommended for hand cleaned iron and steel. Oil paints are not particularly hard or resistant to abrasion, chemicals, or strong solvents, and they are durable in normal environments.

6.2.9 OIL-ALKYD. Linseed oil binders are often modified with alkyd resins in order to reduce drying time, to improve leveling, hardness, gloss, and gloss retention, and to reduce fading and yet maintain the brushability, adhesion, and flexibility of the oil. One end use is in trim paints which are applied to exterior windows and doors. Since these areas are relatively small and painted in solid colors rather than tints, they require better leveling, gloss retention, and fade resistance than the rest of the exterior walls. Also, these areas are subject to some handling and, therefore, require faster drying and harder finishes. Oil-alkyd paints are also used on structural steel when faster drying finishes are desired. However, somewhat better surface preparation is required than with oil paints.

6.2.10 OLEORESINOUS. These binders are made by processing drying oils with hard resins. They generally are used either as spar varnishes or as mixing vehicles to be added to aluminum paste to produce aluminum paints (see 6.2.11). Alkyd finishes are often called oleoresinous because a drying oil is combined with the alkyd (phthalate) resin. Alkyd finishes usually are preferred where better color retention is desired.

6.2.11 PHENOLIC. Phenolic binders are made by processing a drying oil with a phenolic resin and are thus a class of oleoresinous binders. They may be used as clear finishes or pigmented in a range of colors in flat (lustreless) and high gloss finishes. The clear finishes may be used on exterior wood and as mixing vehicles for producing aluminum paints. The durability of the clears is very good for this class of finishes (1 to 2 years); the durability of the aluminum paints is excellent. Phenolic paints are used as topcoats on metal for extremely humid environments and as primers for fresh water immersion. These paints require the same degree of surface preparation as alkyds but are slightly higher in cost than alkyds. Phenolic coatings have excellent resistance to abrasion, water, and mild chemical environments. They are not available in white or light tints because of the relatively dark color of the binder. Furthermore, phenolics tend to darken during exposure.

6.2.12 PHENOLIC-ALKYD. Phenolic and alkyd binders are often blended to corn-combine the hardness and resistance properties of the phenolics with the color and color retention of the alkyds. This may be done either by blending phenolic varnish with the alkyd vehicle or by addition of phenolic resin during processing of the alkyd resin.

6.2.13 RUBBER-BASE. So-called rubber-base binders are solvent thinned and should not be confused with latex binders which are often called rubber-base emulsions. Four types are available: chlorinated rubber, styrene-butadiene, vinyl toluene-butadiene and styrene-acrylate. They are lacquer type products (see 6.3.2) and dry rapidly to form finishes which are highly resistant to water and mild chemicals. Recoating must be done with care to avoid lifting by the strong solvents used. Rubber-base paints are available in a wide range of colors and levels of gloss. They are used for exterior masonry, also for areas which are wet, humid, or subject to frequent washing, e.g., swimming pools, wash and shower rooms, kitchens, and laundry rooms. Styrene-butadiene, when combined with chlorinated plasticizers and silicone resins, is used to produce high heat-resisting ready-mixed aluminum paints.

6.2.14 SILICONE. Silicone binders are used in two ways: for water repellents and for heat resistant finishes.

6.2.14.1 Water Repellents. Dilute solutions (5 percent solids) of silicone resin are of temporary help in reducing water absorption when applied to unpainted concrete or masonry such as brick or stone. They usually do not affect the color or appearance of the treated surface. Cracks and open joints must be repaired before water repellents are applied.

6.2.14.2 Heat-Resistant Finishes. Heat-resistant organic finishes containing a high concentration of silicone resins, when pigmented with aluminum, have the ability to withstand temperatures up to 1200° F.

6.2.15 SILICONE ALKYD. The combination of silicone and alkyd resins results in an expensive but extremely durable coating for use on smooth metal.

6.2.16 URETHANE. Two types of URETHANE finishes are covered in this manual: oil-modified urethanes and oil-free, moisture-curing urethanes. Both are used as clears but the oil free type is also available pigmented.

6.2.16.1 Oil-Modified Urethanes. These are similar to phenolic varnishes, although more expensive, but have better initial color and color retention, dry more rapidly, are harder, and have better abrasion resistance. They can be used as exterior spar varnishes or as tough floor finishes. Oil modified urethanes can be used on all surfaces. In common with all clear finishes, they have limited exterior durability.

6.2.16.2 Moisture Curing Urethanes. These are the only organic products presently available which cure by reacting with moisture from the air. They also are unique in having the performance and resistance properties of two-component finishes yet are packaged in single containers. Moisture-curing urethanes are used in a manner similar to other one package coatings except that all containers must be kept full to exclude moisture during storage. If moisture is present in the container, they will gel.

6.2.17 VINYL. Lacquers based on modified polyvinyl chloride resins are used on steel where the ultimate in durability under abnormal environments is desired. They are moderate in cost but have low solids and require the most extensive degree of surface preparation to secure a firm bond. Because of their low solids, vinyl finishes require numerous coats to achieve adequate dry film thickness so that the total cost of painting is higher than with most other paints. Since vinyl coatings are lacquers, they are best applied by spray and dry quickly, even at low temperatures. Recoating must be done with care to avoid lifting by the strong solvents which are present. In addition, these solvents present an odor problem. Vinyls can be used on metal or masonry but are not recommended for use on wood. They have exceptional resistance to water, chemicals and corrosive environments but are not resistant to strong solvents.

6.2.18 VINYL-ALKYD. The combination of vinyl and alkyd resins offers a corn-promise between the excellent durability and resistance of the vinyls with the lower cost, higher film build, ease of handling, and adhesion of the alkyds. They can be applied by brush or spray and are widely used on structural steel in marine and moderately severe corrosive environments.

6.2.19 COMPARISON OF PAINT BINDERS. Tables 6-1 through 6-3 list the relative properties of the major and more common binders as follows:

Table 6-1, Application Properties
Table 6-2, Use and Service
Table 6-3, Film Properties

Table 6-4 summarizes the outstanding properties from these tables. Properties of the following binders are not included but can be estimated to be similar to those listed as follows:

Oil-alkyd = Oil + alkyd
Oleoresinous = Similar to alkyds but with less color retention
Phenolic-alkyd = Phenolic + alkyd
Oil-modified urethane = Phenolic + alkyd
Vinyl-alkyd = Vinyl + alkyd

TABLE 6-1
Comparison of Paint Binders
Application Properties

	Alkyd	Cement	Epoxy	Latex	Oil	Phenolic	Rubber	Moisture-Curing Urethane	Vinyl
Solvents	MS*	Water	Lacquer	Water	MS	MS + Ar	MS + Ar	Lacquer	Lacquer
Brushability	G	G	F	EX	EX	G	F	F	Spray
Odor	[1]Mild	None	Strong	V. Mild	Mild	Mod	Mod	Strong	Strong
Method of cure . . .	Oxygen	Chem	Chem	Coates	Oxygen	Oxygen	Evap	Moisture	Evap
Speed of dry:									
50° F to 90° F . . .	G	G	G	EX	F	G	EX	EX	EX
Below 50° F	F	F	P	P	P	F	G	G	G
Film build/coat . . .	G	EX	EX	G	EX	G	G	EX	F
Safety (personnel) .	G	EX	F	EX	G	G	G	F	F

*See footnote at end of Table 6-3.
[1]Very mild for odorless type.

TABLE 6-2
Comparison of Paint Binders
Use and Service

	Alkyd	Cement	Epoxy	Latex	Oil	Phenolic	Rubber	Moisture-Curing Urethane	Vinyl
Use on wood	EX*	NR	EX	EX	EX	EX	NR	EX	NR
Use on fresh concrete	NR	EX	EX	EX	NR	NR	EX	G	EX
Use on metal	EX	NR	EX	NR	EX	EX	G	G	EX
Minimum surface preparation for metal [1] . .	Class 3	X	Class 3	X	Class 1	Class 3	Class 3	Class 4	Class 4
Use as clear	EX	NR	NR	NR	NR	EX	NR	EX	NR
Use in aluminum paint	G	NR	G	NR	NR	EX	[2]	NR	G
Choice of gloss . . .	Any	FIat	Any	Flat	Mod	Any	Any	High	Low
Service:									
Interior	EX	EX	EX	EX	NR	EX	EX	EX	NR
Normal exposure .	EX	G	EX	EX	EX	EX	EX	EX	EX
Marine exposure .	F	F	EX	F	F	G	EX	EX	EX
Corrosive exposure	F	NR	EX	NR	NR	G	G	G	EX

*See footnote at end of Table 6-3.
[1]See 4.4.2.7.
[2]See 6.2.13.

TABLE 6-3
Comparison of Paint Binders
Film Properties

	Alkyd	Cement	Epoxy	Latex	Oil	Phenolic	Rubber	Moisture-curing Urethane	Vinyl
Gloss Retention (Paint)	EX*	[1]	P	[1]	P	EX	G	F	EX
Color, Initial . . .	EX	G	G	EX	G	P	EX	EX	EX
Yellowing (Clear) . .	Slight	X	X	X	X	Cons	X	Mod	X
Fade Resistance (Paint)	EX	F	F	EX	G	G	G	F	EX
Hardness	G	EX	EX	G	P	EX	EX	EX	G
Adhesion	G	F	EX	G	EX	G	G	EX	F
Flexibility	G	P	EX	EX	EX	G	G	EX	EX
Resistance to:									
Abrasion	G	G	EX	G	P	EX	G	EX	EX
Water	F	F	G	F	F	EX	EX	EX	EX
Detergents	F	F	EX	G	F	EX	EX	EX	EX
Acids	F	P	G	G	P	EXt	EX	EX	EX
Alkali	F	EX	EX	G	P	G	EX	EX	EX
Strong Solvents . .	P	EX	EX	G	P	G	P	EX	F
Heat	G	G	G	G	F	G	[2]	G	P
Moisture Permeability	Mod	V. High	Low	High	Mod	Low	Low	Low	Low

[1]Available as flat finish only.
[2]See 6.2.13.

Legend Used in Tables 6-1 through 6-3
Comparison of Paint Binders

MS--Mineral spirits
Ar--Aromatic hydrocarbon solvents, e.g., xylene
Mod--Moderate
Cons--Considerable
Oxygen--Dries by reaction with oxygen from the air
Chem--Cures by chemical reaction
Coales--Dries by coalescence of latex particles
Evap--Dries by solvent evaporation
Moisture--Cures by reaction with moisture from the air

Min. Surf. Prep.--Minimum surface preparation
EX--Excellent
G--Good
F--Fair
P--Poor
V--Very
NR--Not recommended
X--Not applicable

TABLE 6-4
Comparison of Paint Binders
Principal Properties

	Alkyd	Cement	Epoxy	Latex	Oil	Phenolic	Rubber	Moisture-curing Urethane	Vinyl
Ready for use	Yes	No	No[3]	Yes	Yes	Yes	Yes	Yes	Yes
Brushability	A	A	A	+	+	A	A	A	-
Odor	+[1]	+	-	+	A	A	A	-	-
Cure--normal temp . .	A	A	A	+	-	A	+	+	+
--low temp . . .	A	A	-	-	-	A	+	+	+
Film build/coat . . .	A	+	+	A	+	A	A	+	-
Safety	A	+	-	+	A	A	A	-	-
Use on wood	A	-	A	A	A	A	-	A	-
Use on fresh concrete	-	+	+	+	-	-	+	A	+
Use on metal	+	-	+	-	+	+	A	A	+
Corrosive service . .	A	-	+	-	-	A	A	A	+
Gloss--choice	+	-	+	-	A	+	+	A	A
--retention . .	+	X	-	X	-	+	A	A	+
Color--initial . . .	+	A	A	+	A	-	+	+	+
--retention . .	+	-	A	+	A	-	A	-	+
Hardness	A	+	+	A		+	+	+	A
Adhesion	A	-	+	A	+	A	A	+	-
Flexibility	A	-	+	+	+	A	A	+	+
Resistance to:									
Abrasion	A	A	+	A	-	+	A	+	+
Water	A	A	A	A	A	+	+	+	+
Acid	A	-	A	A	-	+	+	+	+
Alkali	A	+	+	A	-	A	+	+	+
Strong Solvent . .	-	+	+	A	-	A	-	+	A
Heat	A	A	A	A	A	A	+[2]	A	-
Moisture permeability	Mod	V. High	Low	High	Mod	Low	Low	Low	Low

+ = Among the best for this property
- = Among the poorest for this property
[1]Odorless type
[2]See 6.2.13
[3]Two component type
A = Average
X = Not applicable

Section 3. TYPES OF PAINTS

6.3.1 GENERAL. This section covers the various common types of paints used. Special types such as fire-retardant paints and traffic paints are discussed in Chapters 10 and 11.

6.3.2 LACQUER. Strictly speaking, all coatings which dry solely by evaporation of the solvents may be described as lacquers. Thus, the rubber-base coatings and vinyl solution coatings covered in this manual can be considered to be lacquers. The term is more commonly used to describe finishes based on nitrocellulose or acrylic resins which are used on furniture or automobiles. Such finishes are outside the scope of this manual. Lacquers dry rapidly even at low temperatures, and brushing may be difficult. Their solids content usually is relatively low so that numerous coats are often necessary in order to obtain adequate film thickness. Recoating, especially by brush, must be done with care to avoid lifting by the strong solvents used.

6.3.3 VARNISH. Varnishes are solutions of oil-modified alkyds or oil-modified resins (oleoresinous) in solvents, with driers added so that they will dry by oxidation. The film produced is clear so that the term "clear finishes" is often used to not only classify varnishes but other nonpigmented finishes as well, e.g., lacquers and moisture-curing urethanes. Varnishes are available in a variety of types as follows:

6.3.3.1 Spar Varnish. The term "spar" refers to the spars on a ship, hence spar varnishes are intended for exterior use in normal or marine environments. However, this material has limited exterior durability.

6.3.3.2 Aluminum Mixing Varnish. Aluminum paint is often made by mixing aluminum paste with a varnish before use. The varnish used is specially formulated to produce optimum leafing of the aluminum, i.e., metallic brilliance and to retain this leafing for at least a few days after mixing.

6.3.3.3 Sealer. Clear sealers are varnishes to which additional solvent has been added to make them quite thin in viscosity. Thus, when used, they penetrate and seal the substrate rather than form a relatively thick film on its surface. Sealers are used to prevent grain raising and to fill the pores of porous substrates, such as plywood, to avoid excessive loss of binder when topcoats are applied. Another use is to seal wood floors without leaving any significant glossy film on the surface which could be marred by subsequent abrasion under use.

6.3.3.4 Flat Varnish. Varnishes normally dry with a high gloss. Often, a lower gloss or even flat finish is desired for reasons of appearance or to reduce glare. The varnish finish, if hard enough, can be dulled by hand rubbing with a very mild abrasive such as rottenstone. A much simpler method is to use a varnish whose gloss has been reduced by the addition of transparent but highly efficient flatting pigments such as certain synthetic silicas. These pigments are dispersed in the varnish to produce a clear finish, which when applied, will dry to a low gloss, but will still be transparent so that the surface underneath, for example, the grain of the wood, will not be obscured.

6.3.4 PAINT AND ENAMEL. White and colored pigments are dispersed in paint binders to produce paints and enamels. If the pigmented product is relatively easy to brush and is used on large areas such as walls or structural steel, it is called a paint. If it is relatively fast drying, levels out to a smooth, hard finish and is used on relatively small areas or smooth substrates such as woodwork, it is called an enamel. Paints can be rolled whereas enamels rarely are. The term "paint" is also used in the broad sense to cover all types of pigmented opaque finishes and also their application, i.e., "to paint".

6.3.4.1 Gloss. The extent of pigmentation of the paint or enamel determines its gloss. Generally, gloss is reduced by adding nonopaque, lower cost pigments called extenders. Typical extenders are calcium carbonate (whiting), magnesium silicate (talc), aluminum silicate (clay), and silica. The level of gloss is achieved by varying the ratio of pigment to binder. (See Figure 6-1.)

a. High Gloss: The maximum gloss in paints and enamels is obtained by omitting all extenders. This characteristic produces maximum washability and durability.

b. Low Gloss: This may be called flat, dull, or lustreless. Pigmentation is highest to reduce gloss to a minimum. Low gloss minimizes surface imperfections on interior walls. In using low gloss finishes, washability, and durability are sacrificed to some degree.

c. Semigloss: This is a compromise between the appearance of the flat finish and the performance of the high gloss finish.

6.3.4.2 Primer. Generally two types of paints are required. The coat of paint next to the substrate, called the primer, is formulated to perform the functions indicated below; the top coat is used to produce the desired finished appearance or to protect the primer and, consequently, the substrate beneath it. Various types of primers are used, depending on the substrate and, in some cases, the top coat as well.

a. Primer-Sealer: This is used to seal a porous or alkaline substrate so that the topcoat is unaffected by loss of or damage to the binder. Some paints, such as interior latex wall paints, are self-priming and usually do not require a special primer.

b. Enamel Undercoater: This is a coating which dries to a smooth hard finish that can be sanded. when sanded, the perfectly smooth surface is ideal for obtaining the best leveling and appearance of the subsequently applied enamel top coat.

c. Anticorrosive Primer: Primers based on anti-corrosive pigments, such as red lead, zinc chromate, lead silico chromate and zinc dust, are applied to iron and steel wherever corrosion is a problem. They retard corrosion of the metal but must usually be protected by other types of coatings.

The combination of primer, intermediate coats, if any, and top-coat is called the paint system.

6.3.5 ALUMINUM PAINT. Metallic paints such as aluminum paints are available in two forms: ready mixed and ready-to-mix.

6.3.5.1 Ready-Mixed Aluminum Paints. These paints are supplied in one package and are ready for use after normal mixing. They are made with vehicles which will retain leafing qualities or metallic brilliance after moderate periods of storage. They are more convenient to use and allow for less error in mixing than the ready-to-mix form.

6.3.5.2 Ready-to-Mix Aluminum Paints. These paints are supplied in two packages: one containing the clear varnish and the other the required amount of aluminum paste (usually 2/3 aluminum flake and 1/3 solvent). They are mixed just before use by slowly adding the varnish to the aluminum paste while stirring. The mixed paint will usually retain its leafing for a few days. Since leaf retention during storage is no problem, ready-to-mix aluminum paints allow a wider choice of vehicles and present less of a problem with storage stability. Leafing also is generally better when this paint is freshly mixed.

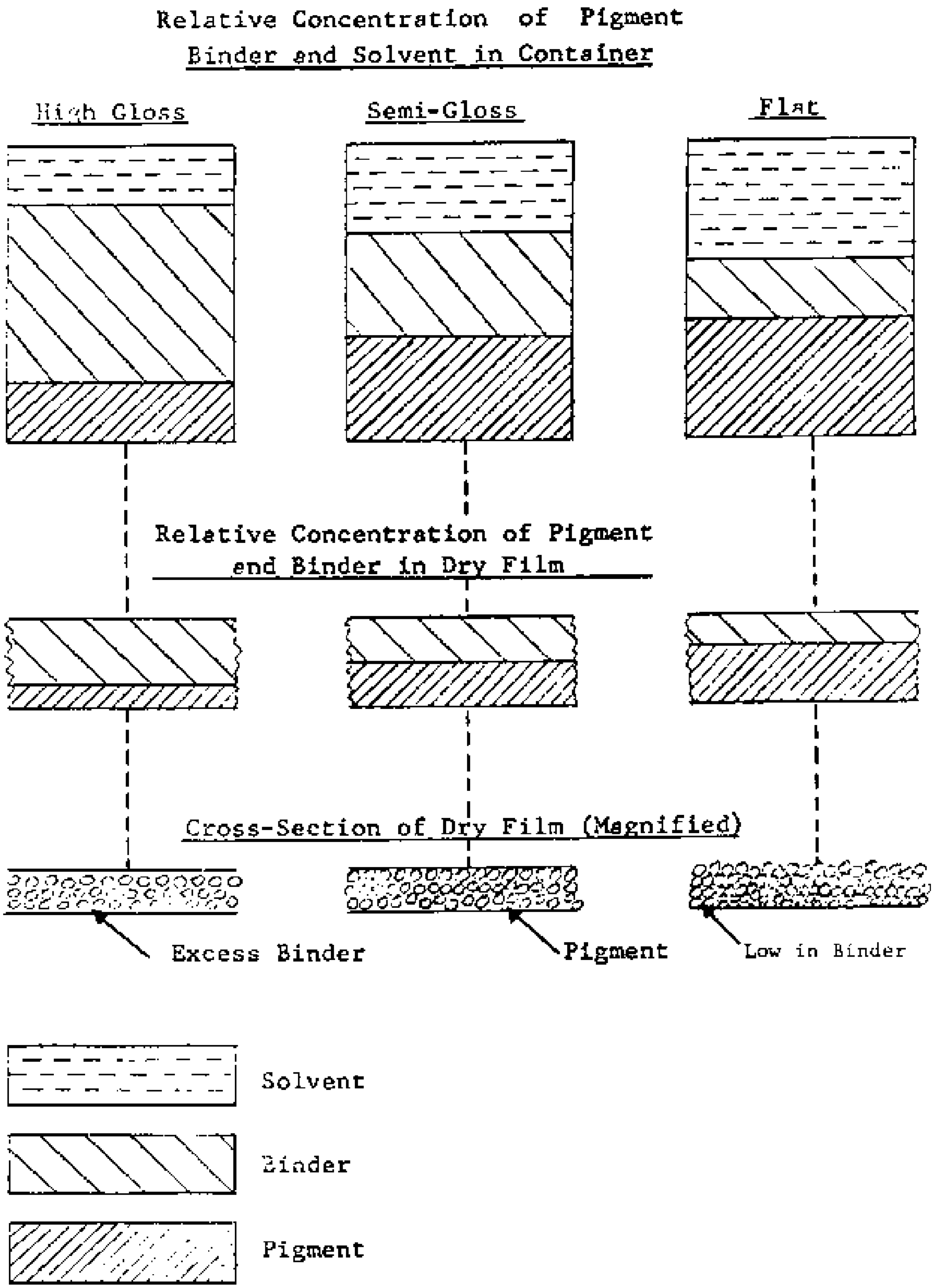

FIGURE 6-1
Effect of Pigment/Binder on Gloss

6.3.5.3 Moisture. Another potential problem with aluminum paints is moisture. If moisture is present in the container, it may react with the aluminum flake to form hydrogen gas and create pressure buildup in the closed container. This can cause bulging and even popping of the cover of the container. Check all ready mixed paints for bulging. If present, puncture the can cover carefully before opening. Be sure to use dry containers when mixing two package paints. Always brush out a test area before use to be sure that leafing is satisfactory.

6.3.6 OIL STAIN. Oil stains are based on a drying oil such as linseed oil in which color pigments are dispersed and which is then thinned to a very low consistency to obtain maximum penetration when applied to wood. Interior stains are applied generously to the sanded, dust free surface, allowed to dry for a short period of time, and the excess then wiped off so that only the stain which has penetrated the wood remains.

6.3.7 GLAZE COATING. Glaze coatings are based on high solids binders which do not penetrate porous substrates to any degree. When applied to concrete and masonry, the coating cures to a hard glass-like film on the surface of the relatively rough masonry. Glaze coatings are very easy to clean and are resistant to strong detergents or cleaners. They are ideal for areas which require extreme cleanliness, e.g., clean rooms.

6.3.8 WATER REPELLENT. Water repellents are water thin clear finishes based on silicone resins (see 6.2.14.1).

6.3.9 SPECIAL PURPOSE PAINT MATERIALS. See the following chapters for descriptions of paint materials not covered in this chapter:

Chapter 10--"Special Purpose Coatings"
Chapter 11--"Signs and Traffic Marking"

6.3.10 ACCESSORY PAINT MATERIALS. See the following sections in Chapter 4 for description of accessory paint materials:

Section 4--"Preparation of Surfaces"
Section 5--"Repair of Surfaces"

6.3.11 COATING COMPATIBILITY. Compatible coating systems are categorized in Appendix D-4 as follows: 1) for use on various substrates, e.g., wood, concrete, metal, 2) type of exposure, e.g., exterior, interior, and 3) use, e.g., general purpose, heavy duty, marine. The coating systems are designed for use in new construction or for maintenance painting where the old paint has been completely removed. These coating Systems would also be used for spot painting where only small areas of substrate are exposed. However, in most instances, the facilities maintenance engineer has the responsibility of painting over a paint or primer system which may be deteriorated but which cannot be removed conveniently. The existing paint system is the actual substrate, not the underlying wood, concrete, or metal. Therefore, it is important that the new paint system be compatible with the existing paint system. For a better understanding of coatings as substrates, their method of curing, generic type and some of their characteristics have been listed in Table 6-5. Table 6-6 is intended to provide guidance in selecting paints for use over an existing paint and is not intended to recommend usage of various combinations of generic types as primer-top coat coating Systems. The matrix may be used for guidance for coating existing paints with less than 6 months weathering and also to paints weathered beyond this time period. Beyond 6 months weathering, many coatings will have been more completely cured and will be less likely to be affected by solvents in the paints used for the top coating process. After this period of time, oil-based paints have undergone significant chemical changes, e.g., cross-linked polymerization that may permit their being overcoated. However, experience has shown that it is safer to use combinations where there are no compatibility restrictions. For guidance, exterior latex stains (TT-s-001992) and oil stains (TT-s-708) recommended for use on wood substrates should be considered equivalent to the corresponding latex or oleoresinous paint in using Table 6-6.

Paint compatibility is often dependent on the applied coating being the same or a similar generic type to the substrate (weathered paint), e.g., alkyd paint applied to an oleoresinous substrate. However, other factors, such as solvent effects, mechanical bonding, and chemical reactivity between the applied coating and substrate (weathered paint), also influence paint compatibility.

a. compatibility Problems: The potential sources of paint incompatibility due to solvents may be illustrated by Tables 6-5 and 6-6. For example, some high performance coatings, e.g., vinyl, chlorinated rubber, styrene--acrylate, epoxy, or urethane, contain active solvents such as ketones and aromatic hydrocarbons. The strong solvents in the top coat can penetrate a recently applied oil or alkyd paint and damage the system by causing wrinkling, peeling, or blistering, e.g., TT-P-95 over TT-P-645. The strong solvents in the top coat could damage the lacquer-type coating substrate. A potential example would include an epoxy top coat (TT-c-535) over the lacquer-type filler (TT-F-1098). The solvent problem may be exaggerated by excessive use of solvent as a diluent for the topcoat or even by excessive application of top coat. Another solvent problem is caused by asphalt from an asphaltic paint or pavement bleeding into a wet paint film. <u>Where there is concern for the effects of solvent on paint compatibility, a small test area should be applied to determine if any compatibility problems exist</u>. Premature coating failures result when a poor mechanical bond is formed between the top coat and weathered paint substrate. For example, a gloss alkyd enamel applied to a glossy alkyd enamel substrate may delaminate--even though the gloss alkyd enamels might be identical generically. Thus, it is considered good practice to sand the surface of gloss or semigloss enamels prior to recoating. Also, epoxies, coal tar epoxies, and urethanes are extremely difficult to coat after complete curing, because they form a hard, smooth surface that provides no tooth for a top coat. Thus, if two coats are to be applied, the second coat should be applied before the first coat has been completely cured. If this is not possible, either a thinned coat of the top coat should be applied as a tie coat or the substrate should be sanded prior to recoating. Loose material present on the substrate surface (weathered paint) also produces detrimental results on the mechanical bond formed between the applied top coat and substrate. These materials may be chalk, dirt, fungi, chemical reaction products of the older paint, etc. A disturbing number of paint failures occur when latex paints are applied to an old oil-based paint substrate which has chalked. While latex paints are compatible when coated over oil-based paint substrates

Table 6-5
Classification of Coatings According to Methods of Cure

Method of Curing	Generic types	Typical specification example	Comments
Air oxidation of drying oils (Solvent-thinned)	Oleoresinous	TT-V-85 TT-R-659	Good wetting slow curing, soft film recommended in normal environments only.
	Alkyd	TT-P-645 MIL-P-52324 TT-E-508 TT-P-30 TT-P-102	Good wetting and appearance, poor in alkaline or solvent environments.
	Silicone alkyd	TT-E-490 TT-P-1593	Improved durability, gloss and chemical resistance compared to alkyds, but still poor in alkaline or solvent environments.
	Phenolic Oleoresinous	TT-E-522 TT-P-1757 TT-V-119	Good resistance to abrasion and mild chemical environments; however, dark color of binder precluded their use in white or tight tints.
Solvent evaporation (lacquers)	Vinyl (polyvinyl chloride-acetate)	MIL-P-15929 MIL-P-15930 VR-3 VR-6 MIL-P-28641 MIL-P-28642	Good water resistance, limited solvent resistance, poor adhesion unless surface has been properly prepared (abrasive blast cleaning).
	Chlorinated rubber	TT-P-95 TT-C-800 TT-P-1046	Good water resistance, limited solvent resistance.
	Styrene-butadiene Styrene-acrylate	TT-P-1181 TT-F-1098 TT-P-95 TT-P-1411	Good water resistance, limited solvent resistance.
	Coal tar	NAVFAC-TS-09805.1	Soft, black only; of limited use, mostly on mechanically cleaned surfaces.
	Polyvinyl-butyral	TT-C-490 MIL-P-15328	Exclusively used in pretreatment (wash) primers.
Evaporation of water (latex, emulsion, water-thinned)	Acrylic Polyvinyl acetate (PVA)	TT-P-19 TT-P-1510 TT-P-1952 TT- P-55 TT-P-29	Recommended in normal environments only; used especially on concrete and masonry.
Chemical reaction	Epoxy	TT-C-535 MIL-P-24441 Formula E-303, O.C.E.	Good water, chemical, abrasion and solvent resistance, chalks freely on exterior exposure, difficult to top coat.
	Coal tar epoxy	SSPC No. 16 MIL-P-23236, Type I, Class 2	Improved water resistance and lower raw material costs compared to epoxies, black only difficult to top coat.
	Polyester	TT-C-1226	Frequently used with glass fibers to give abrasion and water resistant coating, but only fair alkali resistance.

Table 6-5 (Continued)
Classification of Coatings According to Methods of Cure

Method of Curing	Generic types	Typical specification example	Comments
	Zinc inorganic	MIL-P-38336 MIL-P-23236, Type I, Class 3	Requires adequate surface preparation (SSPC SP No. 10, Near White Blast Cleaning), adequate curing time required, excellent corrosion protection, good abrasion, solvent, and high temperature resistance, must be top coated in aggressive environments, reacts with alkali-sensitive top costs.
	Cementitious	TT-P-21 TT-P-35	Inexpensive, requires adequate curing for best performance, and tends to chalk with aging, poor corrosion resistance.
	Urethane	TT-C-542 TT-C-540	Good water, chemical abrasion, and solvent resistance, difficult to top coat.

TABLE 6-6
Compatibility of Commonly Used Paints

	Top Coat → / Primer or weathered paint ↓	Solvent-thinned: Oleoresinous	Solvent-thinned: Alkyd	Solvent-thinned: Silicone Alkyd	Solvent-thinned: Phenolic Oleoresinous	Lacquer: Vinyl	Lacquer: Chlorinated Rubber	Lacquer: Styrene-Butadiene Styrene-Acrylate	Water-thinned (latex): Acrylic	Water-thinned (latex): Polyvinyl Acetate	Chemically reactive: Epoxy	Chemically reactive: Coal Tar Epoxy	Chemically reactive: Polyester	Chemically reactive: Urethane
Solvent-thinned	Oleoresinous	C	C	C	C	NR	NR	NR	CT	CT	NR	NR	NR	NR
	Alkyd	C	C	C	C	NR	NR	NR	CT	CT	NR	NR	NR	NR
	Silicone alkyd	C	C	C	C	NR	NR	NR	CT	CT	NR	NR	NR	NR
	Phenolic Oleoresinous	C	C	C	C	NR	NR	NR	CT	CT	NR	NR	NR	NR
Lacquer	Vinyl	C	C	NR	NR	C	CT	CT	CT	CT	CT	CT	NR	NR
	Chlorinated rubber	C	C	C	C	CT	CT	NR	CT	CT	NR	NR	NR	NR
	Styrene-butadiene Styrene-acrylate	C	C	C	C	CT	NR	CT	CT	CT	NR	NR	NR	NR
	Bituminous	NR	NR	NR	NR	CT	CT	CT	CT	NR	NR	NR	NR	NR
Water-thinned (latex)	Acrylic	C	C	C	NR	CT	CT	CT	CT	CT	CT	NR	NR	NR
	Polyvinyl acetate	C	C	C	NR	CT	CT	CT	CT	CT	CT	NR	NR	NR
Chemically Reactive	Epoxy, catalyzed	NR	NR	NR	NR	CT	NR	NR	NR	NR	CT	CT	CT	CT
	Coal tar epoxy	NR	NR	NR	NR	NR	NR	NR	NR	NR	CT	CT	NR	NR
	Zinc rich epoxy	NR	NR	NR	NR	NR	CT	CT	NR	NR	CT	CT	NR	NR
	Polyester	NR	NR	NR	NR	NR	NR	NR	NR	NR	CT	NR	CT	CT
	Inorganic zinc	NR	NR	NR	NR	CT	CT	CT	CT	NR	CT	NR	NR	NR
	Cementitious	NR	NR	NR	NR	CT	CT	CT	CT	CT	C	C	C	C
	Urethane	NR	NR	NR	NR	NR	NR	NR	CT	NR	NR	NR	C	CT

C = Normally compatible.
CT = Compatible with special surface preparation of the weathered coating substrate and/or careful application of top coat containing active solvents.
NR = Not recommended because of known or suspected problems. It may be noted that certain combinations marked NR may be used provided a suitable tie coat is applied between the two coatings. Specifications and/or manufacturer's literature should be consulted for guidance.

and vice versa, latex paints applied to a substrate of chalked oilbase paint require either the use of a thin tie coat (conditioner) or complete chalk removal to prevent premature bond failure. On the other hand, the superior wetting properties of oil-based paints permits them to bond to moderately chalked surfaces (ASTM D 659 chalk rating greater than 8). However, no paint will adhere well to a heavily chalked surface (ASTM D 659 chalk rating less than 8). When a mildewed substrate is painted, not only is the bond weakened between top coat and substrate surface, but the top coat may be rapidly attacked by fungi resulting both in unsightly appearance and premature failure. The zinc in zinc rich inorganic and organic primers oxidize in certain environments. The surface oxidation products formed may well be a source of premature paint failure when the primer is top coated. It may be noted that many zinc rich coatings are not top coated even in aggressive environments.

Where cementitious paints (TT-P-21, TT-p-35) have been applied to concrete and masonry substrates, the weathered free chalking loose materials is often present in larger amounts than with other types of weathered paint. For this reason, the weathered cementitious paint should be cleaned thoroughly to remove loose material. Cleaning methods, such as wire brushing, power tools, or sandblasting, produce additional loose material on the surface, and all loose material should be dusted or rinsed off before repainting. In addition, a surface conditioner, TT-P-620, may be used to provide good intercoat adhesion. Sufficient surface conditioner should be applied to the surface to ensure good penetration. However, the surface conditioner is not intended to be a finish coat. The effects of chemical reactivity on the compatibility between the applied coating and substrate (weathered paint) are illustrated by the following examples. Latex paints are generally preferred on cementitious substrates because oil-based paints are not as stable in the alkaline environment. The zinc in exposed zinc rich coatings (as substrate) may react chemically with the ester groups in oil, alkyd, silicone alkyd, or ester-modified epoxy or urethane top coats resulting in premature failures.

b. Summary: The paint compatibility matrix Table 6-6 should be used as guidance in conjunction with the following recommended application practices:

1. When possible, the same or similar type of coating already on the structure should be specified for the new top coat, e.g., alkyd paint over oil-based paint. Paints of similar chemical type are almost always compatible.

2. When both primer and top coat are required, e.g., spot painting, it is good practice to use materials from one supplier.

3. Follow the specifications, manufacturer's labeling information, and Chapter 4 for guidance on surface preparation and application conditions. As examples, an oil paint should not be applied to a damp surface nor should a latex paint be applied over a heavily chalked surface or when temperatures are below freezing.

4. Follow specification or manufacturer Is guidance on the application rate. Too thick a layer of paint can be as damaging as too thin a layer because of possible solvent entrapment and resultant blistering.

5. When the substrate is an intact older paint, do not apply a primer coat over the entire surface. Apply a primer coat only to areas of exposed underlying substrate, e.g., wood, concrete, metal. Excessive paint film build contributes to premature paint failures.

6. Epoxies, coal tar epoxies, and urethanes are extremely difficult to coat after complete curing because they form a hard, smooth surface that provides little tooth for a top coat. A similar condition exists with gloss

and semigloss enamels. The surface should be sanded or a tie coat should be applied prior to top coat application.

7. Thin tie coats (conditioners) should be used over weathered paint substrates where chalk and other loose material has not been completely removed and also where the substrate is very smooth, hard, or glossy.

8. Special care must be taken when latex paints are to be applied over a chalked, weathered paint substrate. The chalk and other loose material must be completely removed before application of the top coat.

9. Chalk and other loose material should be removed from the weathered paint substrate prior to repainting. While oil-based paints have some tolerance for an incompletely cleaned surface, painting chalked surfaces with chalk ratings less than eight (ASTM D 659) will lead to premature paint failures.

10. Special care should be exercised when applying a paint containing strong solvents to a lacquer-type paint substrate. This care should also be extended to other weathered paint substrates.

11. If the identification of the existing paint surface is not certain because of incomplete or lost records, send samples to an analytical laboratory for positive identification of the samples, e.g., infrared spectrophotometry or gas chromatography. This will often be well worth the time and money spent.

12. If a question of compatibility between painting over a weathered paint substrate arises, use a test area to examine the compatibility of the paint system prior to full-scale application. Often, paint failures caused by compatibility problems will be clearly identified within a month's time.