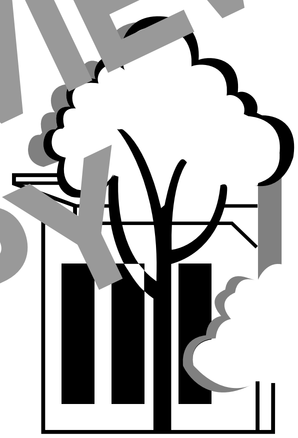
Table of Contents

STRUCTURAL PAINTING

Lesson One

Paint Selection for Normal Conditions



TPC Training Systems

36401

Lesson

1 Paint Selection for Normal Conditions

TOPICS

Why Paint?
Ingredients of Paint
General Types of Paint
Coating Selection
Substrate
Ferrous Metals
Nonferrous Metals
Concrete
Wood
Environment
Other Factors

OBJECTIVES

After studying this Lesson, you should be able to…

- Explain the three basic reasons for using paint.
- Identify the ingredients of paint and explain the importance of each.
- Name several generic paint types and describe their uses in normal industrial applications.
- Compare the characteristics of ferrous and non-ferrous metals, concrete, and wood as substrates.
- Discuss environmental factors that influence paint choices.

KEY TECHNICAL TERMS

Corrosion 1.02 the breaking down of a substance due to reaction with its environment
Substrate 1.03 the surface to be painted
Pigment 1.09 tiny solid particles that give paint its color and other qualities
Thinner (solvent) 1.10 a liquid that lightens the texture of paint and evaporates after application
Vehicle 1.10 the combination of thinner and binder
Volatile 1.10 evaporating easily
Binder 1.11 the ingredient that forms the final, dry paint film
Adhesion 1.23 sticking to the substrate
Laitance 1.53 a dusty, milky white surface layer on concrete

This Unit will cover the elements of structural painting that you need to know in order to become a competent maintenance painter in today's industrial workplaces.

In this Lesson, you will read about the basic ingredients of paint, as well as several general types of paint and their chief uses. The Lesson also discusses the most important factors that must be considered in deciding which paint or other coating should be used for a given job. These factors include the essential purpose of the coating, the kind of surface to which it will be applied, and the harmful environmental elements it must withstand.

Why Paint?

1.01 There are three main reasons for using paint and other coatings in today's industrial environment:

- for protection of materials
- to comply with industry or government regulations
- for appearance.

1.02 **For protection of materials**. Coatings are essential for extending the usefulness of buildings and equipment. They prevent, or at least slow down, the destructive forces in the surrounding atmosphere. They delay the effects of corrosion on metal. *Corrosion* is the breaking down of a substance due to a chemical reaction with its environment. Rust that forms on iron or steel is an example. Coatings also delay the rotting of wood and the spalling (surface chipping) of concrete.

1.03 When coatings are applied correctly, they provide a barrier between the *substrate* (the surface to be painted) and the environment. This barrier helps resist the damaging effects of the sun's ultraviolet rays, of moisture, chemicals, air pollution, mildew, rot, and traffic wear.

1.04 **To comply with industry or government regulations**. Common examples of coatings used to comply with regulations are those needed for cleanliness in food-handling or food-processing areas, and for tank linings in the plastics, water-treatment, and chemical industries. In addition, paints are essential to the safety color code required by government and industry standards for industrial piping systems. The color code identifies the hazardous or harmless fluids flowing through the pipes.

1.05 **For appearance**. The fact that coatings are applied for the sake of appearance today is obvious. What is not so obvious, however, is their psychological effect. In a building which is pleasing to the eye (and well maintained), the employees are better able to work efficiently. Attractive surroundings not only boost morale but also create a safer environment. Choice of the right colors can improve visibility while reducing eyestrain and glare.

1.06 Furthermore, the image presented by a company's building helps determine what the public thinks of that company. If people see a building with peeling or blistering paint, they may well wonder what else is being overlooked *inside* the building.

Ingredients of Paint

1.07 Paint is the most familiar and perhaps the most widely used structural coating. There are many different kinds of paint, with different advantages and disadvantages. There are also coatings other than paint—linseed oil and shellac, for example. In addition, there are heavier coatings, such as asphalt and cement plaster, that serve special purposes.

1.08 A coating can be defined as any liquid or pasty substance applied in one or more thin layers to form a continuous film bonded to a given surface. Paint is a coating made up of three major ingredients: pigment, thinner, and binder.

1.09 **Pigment.** A solid material ground into tiny particles, *pigment* is thoroughly mixed with the liquid elements of paint—that is, with the thinner and binder. The primary purposes of pigment are to give color to the paint film and to make it *opaque* (so that it hides the surface underneath). Other kinds of pigments are used to dull the gloss of the paint film and to give it greater corrosion resistance.

1.10 **Thinner.** Also called *solvent*, *thinner* lightens the texture of the binder so that the paint can be brushed, rolled, or sprayed easily. There are many different kinds of solvents, such as mineral spirits, naphtha, alcohol, or water. Which one is used in a given paint depends on the kind of binder. Water, for instance, is the thinner for latex paints. The combination of thinner and binder is called the paint *vehicle*. The thinner, or solvent, is *volatile*—that is, it evaporates as the paint dries.

1.11 **Binder.** The *binder* is the nonvolatile element that forms the final paint film after the thinner has evaporated. The binder holds the pigment and adheres, or sticks, to the substrate. Since the binder forms the actual coating, it determines the character and qualities of the paint film. It also gives its name to the paints in which it is used. Paints made with latex binders, for example, are known as latex paints.

General Types of Paint

1.12 **Oil-base.** Oil-base paints are the oldest type. Although they are classified more as general-purpose paints than the newer high-performance coatings, they do have limited uses *(or applications)* in a normal industrial environment.

1.13 The greatest advantage of oil-base paints is that they wet the surface better than most other coatings. In other words, they flow into the pores and crevices of the surface rather than bridging over them. Therefore, they are an excellent choice where surface preparation is poor (assuming that other factors do not dictate a special type of coating).

1.14 Oil-base paints are slow-drying and easily damaged by alkalies, but they are easy to apply. Because of their flexibility, they are particularly good at expanding and contracting with wood grains. However, they are not suitable for coating concrete. They become brittle with age, and probably should not be used in *marine* applications—where they would be exposed to salty sea mists.

1.15 **Alkyd**. Considered the workhorses of the coating industry, alkyds are made by a reaction of alcohol and acids that produce a resin with better chemical and weather resistance than the oil-base paints. They are useful in many situations and are economical as well. They are also faster-drying. These characteristics, coupled with the fact that they are easy to apply by brush, roller, or spray, make alkyds the volume leader in the coatings industry.

1.16 Alkyds usually are classified by oil length, which means the ratio of oil to the total nonvolatile elements in the paint. These coatings are referred to as short-oil, medium-oil, long-oil, and very-long-oil alkyds. Oil length is the main factor in determining the flexibility and hardness of alkyds.

1.17 The medium-oil alkyds are the most important for corrosion protection and are commonly used as enamels for exterior equipment. Long-oil alkyds, which are easier to apply, have limited exterior industrial use except for wood structures and trims. Short-oil alkyds, which have only fair corrosion resistance, are most often used as product finishes. Modified alkyds rather than pure alkyds are used in most industrial applications. Table 1-1 compares the strengths and weaknesses of the more common alkyds.

1.18 **Latex.** Latex coatings, like the oil-base and alkyd paints, are economical and easy to apply. Latex paints have a further advantage in ease of cleanup: since they have a water base, all that is needed is soap and water. They are very fast-drying and are more flexible than oil-base paints. Because latex coatings are relatively porous, and because of their water base, they can be used on damp surfaces.

1.19 Latex paints are also nonflammable and meet air-pollution regulations. They cannot be used if the temperature is below 50°F (10°C) or if the relative humidity is very low or very high. So far, latex paints are not suitable for any severe industrial environment. With current research and development, however, they may well have more uses as maintenance coatings in the near future.

1.20 **Epoxy.** There are several types of epoxy coatings. Those of one type, the epoxy esters, are much like alkyds. They are more expensive, though, and produce a harder film that is more alkali-resistant. Epoxy coatings of another type, the two-component epoxies, are much more widely used. They form a film by chemical reaction, rather than by evaporation of the thinner. In this second type, epoxy resin is combined with a hardener, usually either polyamine or polyamide.

1.21 The epoxy-polyamine combination produces a hard coating which is extremely resistant to sol-

Table 1-1. Properties of alkyds

Property	Medium-oil alkyd	Vinyl alkyd	Silicone alkyd	Uralkyd	Epoxy ester
Surface character	Flexible	Tough	Tough	Hard, abrasion-resistant	Hard
Water resistance	Fair	Good	Good	Fair	Good
Acid resistance	Fair	Best of group	Fair	Fair	Fair-good
Alkali resistance	Poor	Poor	Poor	Poor	Fair
Salt resistance	Fair	Good	Good	Fair	Good
Solvent resistance	Poor-fair	Fair	Fair	Fair-good	Fair-good
Weather resistance	Good	Very good	Very good, excellent gloss retention	Fair	Poor
Temperature resistance	Good	Fair-good	Excellent	Fair-good	Good
Age resistance	Good	Very good	Very good	Good	Good
Recoatability	Excellent	Difficult	Fair	Difficult	Fair
Best characteristic	Application	Weather resistance	Weather, heat resistance	Abrasion resistance	Alkali resistance
Poorest characteristic	Chemical resistance	Alkali resistance	Alkali resistance	Chemical resistance	Weathering
Primary coating use	Weather-resistant coating	Corrosion-resistant coating	Corrosion-resistant coating	Abrasion-resistant coating	Machinery, enamel

vents, alkalies, salt, and water. Epoxy-polyamine paints often are used for coating tanks. But they have poor weather resistance, and tend to chalk (develop a powdery surface film) when used outdoors.

1.22 Polyamide makes the epoxy film longer-lasting and more flexible. It also gives the mixture a longer *pot life.* That is, once the two components are combined, they remain liquid and usable longer. Epoxy-polyamide paints are not as resistant to acids or solvents as the polyamines, but they have superior weather resistance. They are frequently the choice for coating structural steel.

1.23 *Adhesion* (sticking to the substrate) is excellent in the epoxies. They also show good resistance to impact and to *abrasion* (wearing away by friction). However, the pot life, even in the epoxy-polyamides, is short—usually four to eight hours. Polyaminecured epoxy is a skin irritant, and its fumes are toxic.

1.24 **Urethane/polyurethane.** The outstanding characteristic of urethane and polyurethane coatings is their resistance to abrasion. These coatings, because of the very wide variety of materials with which they can react, range from very hard to soft and rubbery. Moisture-cured urethanes, which come in one package, produce extremely hard, tough coatings, used mostly as clear finishes.

1.25 Two-component polyurethanes are durable enough to be used as topcoats for steel in marine and corrosive atmospheres. Some polyurethanes, known as *aliphatic* polyurethanes, have excellent color and gloss retention. Others, (*aromatic* polyurethanes) do poorly in sunlight.

1.26 Urethanes cure better than epoxies at low temperatures. They are very commonly used in heavy traffic areas and on walls subject to chemical abuse. They are, however, more difficult to mix and apply properly than most other coatings.

1.27 **Vinyl.** Vinyl coatings are known for performing well in acid environments. Although they probably have greater chemical resistance than any other coating, they are dissolved by some solvents. Some vinyls dry so fast they must be sprayed instead of being brushed. Vinyl coatings perform well in underwater (*immersion*) applications, usually lasting 15 years or more without maintenance. They have good abrasion resistance but do require very careful surface preparation.

1.28 **Silicone.** Silicone coatings are used mainly for high-temperature applications. Silicones with aluminum or carbon-black pigments can withstand temperatures of up to 1184°F (640°C). Some ceramic silicones can reach 1400°F (760°C) without damage.

1.29 Since silicone resins are transparent to ultraviolet light and have excellent water resistance, they are extremely weather-resistant. They are also sufficiently corrosion-resistant to be used on smokestack exteriors. They do not do well in abrasive applications, however, or where they are subject to solvents. They are also expensive.

1.30 **Phenolic.** Phenolics, the first synthetic resins, are highly corrosion-resistant and often are used for tank linings. They are less affected by solvents than any other organic coating. Since they are odorless, tasteless, and nontoxic when cured, they have many uses in the food and beverage industries. They are also resistant to boiling water and many acids, but are unsuitable for applications that would expose them to any alkali.

1.31 Epoxy-phenolic coatings, however, are alkaliresistant, and they maintain the other phenolic qualities to a slightly lesser degree. Most phenolics are sprayed on and must be heat-cured. The recommended procedures for surface preparation and for application and curing of phenolics must be followed precisely.

1.32 **Zinc-rich.** Zinc-rich inorganic paints are the worldwide standard for a long-term, corrosion-resistant coating for steel in such difficult applications as ships and offshore structures. Since they are inorganic, they are not affected by any weather factors or by any organic solvents. They have excellent resistance to radiation, abrasion, and fire.

1.33 Inorganic zinc-rich paints are used mainly as first coats (*primers*). They can be topcoated with a wide range of paints, including epoxies, vinyls, and polyurethanes. They also have high temperature resistance—up to 750°F (398°C).

1.34 Of great importance is the ability of these coatings to bond chemically with steel, preventing corrosion under the coating. Inorganic zinc-rich coatings require excellent surface preparation and none of them can be applied over old paint.

Coating Selection

1.35 The selection of the coating to be used in a project may not be up to you. Sometimes the choices are detailed in a job specification. Such a specification often is prepared by a corrosion engineer or other specialist. It spells out requirements for surface preparation, coating application, and inspection, in addition to specifying the paint or other coating. Even if selection is not your responsibility, however, you should know something about the factors involved in making correct choices.

1.36 The first point to consider is the reason for the job. No one coating can be used for all situations, nor is it likely that one coating will be perfect for all the conditions of a given situation. There almost always will be some element of compromise.

1.37 Therefore, you must be very sure of the coating's essential purpose. Is it mostly for decoration, or is it primarily for corrosion resistance? Is rust a problem? Is there danger of mildew or fire? Once you have determined exactly what this particular coating job is supposed to accomplish, then you can start limiting the choices.

1.38 Since there are literally thousands of products on the market, as well as many other variables that must be considered, coating selection is not an easy task. A good generic coating chart, such as the one shown in Table 1-2, is a great help. Use of the chart will at least allow you to narrow down the field to two or three coating types.

Substrate

1.39 A basic consideration in the choice of a coating is the type of substrate to which you will apply it. Even if you are dealing with a previously coated surface, the chances are that at least part of the substrate is showing through. You must make sure that the new coating and the substrate are *compatible*—that is, that there will be no undesirable chemical effects between the two.

1.40 The coating must also be compatible with any substrate corrosion, as well as with the existing coating, if it is not going to be removed completely. Table 1-3 on page 10 lists some of the more common pairings of substrates and coatings.

1.41 In the very rare instances in which you are applying the coating over a continuous, unbroken film that is still

Table 1-2. Evaluation of coating systems

Intermediate chemical resistance (chiefly splash and spillage)	Outstanding advantages	Chief limitations	Typical applications
Latex	1. Chemical resistance 2. Ext. color retention 3. Ext. gloss retention 4. Ease of application 5. Water cleanup 6. Nonflammable 7. Surface preparation	1. Abrasion resistance 2. Application temperature 3. Heat resistance	1. Storage tanks 2. Chemical plant equipment 3. Oil refineries 4. Marine superstructures
Chlorinated rubber	1. Chemical resistance 2. Water resistance (immersion) 3. Abrasion resistance	1. Solvent resistance 2. Heat resistance	1. Chemical plants 2. Water immersion 3. Machinery 4. Floor finish
Epoxy ester	1. Chemical resistance 2. Abrasion resistance 3. Surface preparation 4. Ease of application 5. Water resistance	1. Ext. gloss retention 2. Ext. color retention 3. Film build	1. General interior plant use 2. Floor finish 3. Primers
Phenolics (oil-modified)	1. Water resistance 2. Acid resistance 3. Abrasion resistance 4. Hardness 5. Ease of application	1. Yellowing 2. Recoatability (intercoat adhesion) 3. Exterior fading 4. Exterior chalking	1. Marine applications 2. Floor finishes 3. Water/sewage plants 4. Machinery
Tar epoxy	1. Water resistance 2. Chemical resistance 3. High film build	1. Bleeding 2. Ext. color retention 3. Ext. gloss retention 4. Two package 5. Brittle 6. Dark colors	1. Crude oil tank lining 2. Sewage disposal plants 3. Pipe lining or exterior coating

Low chemical resistance (general-purpose products)	Outstanding advantages	Chief limitations	Typical applications
Oil, linseed	1. Ease of application 2. Minimum surface preparation 3. Flexibility 4. Excellent adhesion	1. Slow dry 2. Soft film 3. Low chemical resistance 4. Poor solvent resistance 5. Water resistance 6. Abrasion resistance	1. Wooden buildings (exterior) 2. Metal surfaces (exterior)
Alkyd	1. Ease of application 2. Surface preparation 3. Low cost 4. Good one-coat hiding 5. Durability 6. Gloss retention	1. Chemical resistance 2. Water resistance	1. Tank exteriors 2. Structural metal 3. Machinery 4. Plant equipment 5. Interior/exterior wood or metal
Exterior latex products	1. Water reducible 2. Nonflammable 3. Ease of application 4. Blister resistance	1. Freeze-thaw limitations 2. Heat resistance	1. Exterior wood 2. Exterior concrete, stucco, masonry 3. Exterior metal
Silicone (masonry water-repellent)	1. Colorless 2. Invisible 3. Effective for 10 years 4. Prevents staining	1. Not for use on limestone 2. Use only on new masonry	1. New brick, mortar, sandstone, poured concrete

Table 1-3. Coating types and common substrates

Substrate	Paint	Comments
Interior wood	Oil	Generally slow drying and relatively soft.
	Alkyd	May be hard or soft.
	Latex (vinyl or acrylic)	Can be applied over oil, alkyd, or latex primer.
Exterior wood	Oil	Good wetting of weathered wood and paint chalk, slow drying, soft.
	Alkyd	Good wetting, variations give variety of properties.
	Silicone alkyd	Good wetting, good gloss.
	Latex (vinyl or acrylic)	Poor wetting of weathered wood and paint chalk, easily applied.
Interior masonry, plaster, and wallboard	Acrylic latex	Easily applied, brushing is good on coarse surfaces, must remove all loose chalk.
	Vinyl latex	Same as acrylic latex.
	Chlorinated rubber	Good for waterproofing.
Exterior concrete and masonry	Latex (vinyl or acrylic)	Fill coats of these materials will reduce water penetration.
	Chlorinated rubber	Good for waterproofing.
	Vinyl	For concrete in very corrosive environments.
Interior iron and steel	Alkyd	Never in continuously damp or immersed environments.
	Vinyl	Good resistance to water, poor resistance to strong solvents.
	Epoxy	Good durability and chemical resistance.
	Urethane	Good durability and chemical resistance.
Exterior iron and steel	Oil	For mild environments only.
	Alkyd	For mild environments only.
	Silicone alkyd	For mild environments only, good gloss
	Inorganic zinc	Very abrasion resistant, limited life in seawater without topcoat.
	Vinyl	Good durability, easily touched up.
	Epoxy	Good durability and chemical resistance, but chalks in sunlight.
	Urethane	Aliphatic type has good weathering over epoxy primer.

firmly bonded to the substrate, the nature of the substrate is not particularly important. In such a case, you must be sure that the new coat is compatible with the previous coat.

1.42 If you cannot positively identify the existing coating, you have three choices. One is to use a commercial field test kit, such as the one developed by the Naval Civil Engineering Laboratory. You also can send a sample of the paint to a laboratory for analysis.

1.43 A third method is to run your own test by applying the coating you plan to use over a small, well-cleaned area of the surface you plan to paint. After allowing it to dry overnight, you may be able to tell if the new coat is compatible. If it is possible, however, it is safer to wait two weeks or more to ensure that any incompatibility has a chance to show up. You should watch for any peeling, blistering, lifting, or softening of the new coating.

1.44 There are four main groups of substrates:

- ferrous metals (those containing iron)
- nonferrous metals
- concrete
- wood.

The Programmed Exercises on the next page will tell you how well you understand the material you have just read. Before starting the exercises, remove the REVEAL KEY from the back of your Book. Read the instructions printed on the Reveal Key. Follow these instructions as you work through the Programmed Exercises.

1-1. The three main reasons for using paint are for protection, to comply with regulations, and for __________.	1-1. APPEARANCE Ref: 1/01
1-2. Which ingredient lightens the texture of the paint so that it can be applied easily?	1-2. THINNER or SOLVENT Ref: 1.10
1-3. The paint vehicle is the combination of __________ and __________.	1-3. THINNER; BINDER Ref: 1.10
1-4. The paints that are considered the workhorses and the volume leaders in the coating industry are the	1-4. ALKYD Ref: 1.15
__________ paints. 1-5. Two-component __________ form a dry film by chemical reaction.	1-5. EPOXIES Ref: 1.20
1-6. The outstanding advantage of urethane/polyurethane coatings is their resistance to __________.	1-6. ABRASION Ref: 1.24
1-7. Inorganic zinc-rich paints are used mainly as __________ on steel.	1-7. FIRST COATS or PRIMERS Ref: 1.32, 1.33
1-8. The first point to consider in choosing a coating is the __________ for the job.	1-8. REASON Ref: 1.36

Ferrous Metals

1.45 **Steel**. In industry, steel is the most common surface to be coated. New steel provides a smooth, uniform surface which takes coatings well. It is also dense and nonporous, allowing good adhesion. However, steel reacts readily with acids and other chemicals and must be thoroughly protected from these materials. Since some grades of alloy steel resist atmospheric corrosion four to six times better than carbon steels, you need to find out from your supervisor the type of steel being coated.

1.46 **Cast iron.** Cast iron surfaces are more porous than steel and can present adhesion problems because of their ability to trap and hold certain gases. Cast iron is more granular than steel. Its surface is less dense and is composed of more varied substances, including *graphite* (a form of carbon). It can suffer from what is known as *graphite corrosion*. This occurs when the iron actually dissolves from around the carbon particles. With correct surface preparation, however, cast iron provides a good substrate.

Nonferrous Metals

1.47 Because of their physical composition, aluminum, copper, and zinc usually provide their own corrosion protection. In a normal industrial environment, they do not require coating. For some applications, however, they must be protected and are, therefore, worth discussing here.

1.48 **Aluminum**. Surface preparation of aluminum is very important because of the metal's smoothness, which results from its protective aluminum oxide film. Chemical surface treatments are sometimes necessary for good adhesion. Imperfections in coatings on aluminum readily lead to corrosion in alkaline atmospheres.

1.49 **Copper.** Like aluminum, copper can present adhesion problems because of an oxide film. Copper reacts with sulfide atmospheres and will turn black. Copper is also very reactive in an acid atmosphere, although it does make a good substrate for coatings such as vinyls and epoxies.

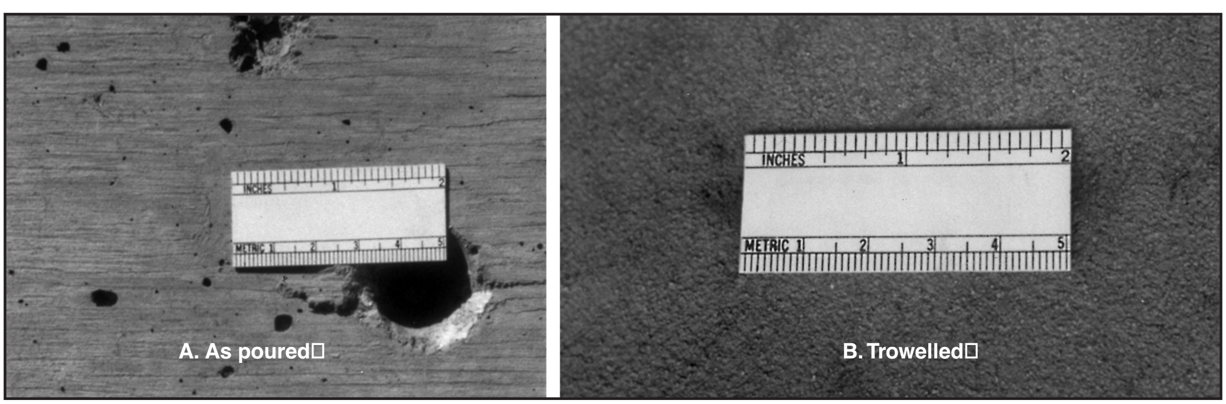
1.50 **Zinc.** Zinc also reacts readily with most acids, so that galvanizing (coating iron or steel with zinc) is not very effective where acids are prevalent. Zinc, however, makes a good substrate for high-performance nonreactive coatings. Oil-base and alkyd coatings are *not* good choices for zinc substrates, because they form zinc soaps, which shorten the adhesion life of the coating.

Concrete

1.51 In many ways, the characteristics of concrete are just the opposite of steel characteristics. Concrete is porous and always has air pockets and pinholes. Some of the epoxy coatings work well on concrete, because they penetrate the pores. Vinyl coatings can do the same if they are applied as a diluted solution.

1.52 The most even concrete surface is a hard troweled one. In heavy corrosion applications, cement plaster or resinous surfacers are used to provide a more satisfactory base for top coatings. Figure 1-1A shows an untroweled concrete surface as originally poured; Fig. 1-1 B shows a troweled concrete surface.

Fig. 1-1. Untroweled and troweled concrete



1.53 Laitance often creates coating problems on a concrete substrate. *Laitance* is a weak, dusty, milky white surface layer that tends to separate the concrete surface and the coating. It should be removed by acid etching or light blasting.

1.54 The greatest problems in coating concrete are usually due to moisture. Changes in humidity make significant differences in how much water vapor is transmitted by the concrete. If there is no waterproofing, water or water vapor will push against the back of the coating, particularly if the relative humidity is 80% or more. Therefore, the coating must have excellent adhesion.

1.55 Because of its brittleness and low tensile strength, concrete is very susceptible to cracking. This undesirable feature obviously creates problems, since the coating also cracks and is no longer protective at that point. Coatings that are 20 to 40 mils thick, and are more *extensible* (capable of being stretched), provide reduced surface stress. A mil is one thousandth of an inch.

1.56 The high alkalinity of concrete also presents a problem: it is readily attacked by any acid. Strong acids create a chemical and/or physical reaction that dissolves the binder around the aggregate. These reactions also may create a new material which grows enough to push the coating up off the surface. Even water can corrode concrete if the water is the least bit acidic.

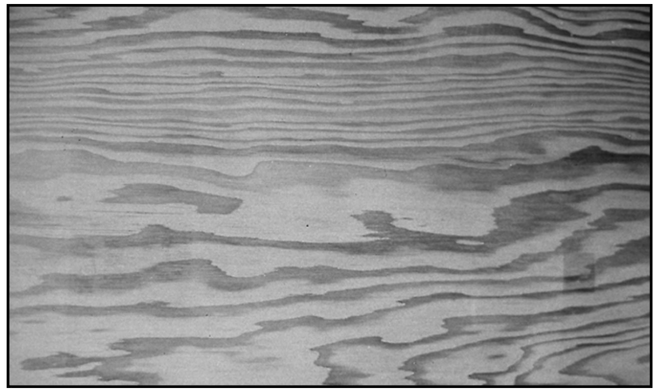
1.57 Vinyl and epoxy coatings are particularly alkali-resistant. Vinyl is less chemically reactive, and epoxy offers maximum adhesion because of its excellent penetration and wetting characteristics.

Wood

1.58 Wood surfaces, although smooth, are made up of two grains that differ in density. The darker grain is winter wood; the lighter is summer wood (see Fig. 1-2). Responding to atmospheric moisture, the two grains expand and contract at different rates.

1.59 Any coating used on a wood substrate, therefore, must be flexible enough to accommodate these different rates of expansion and contraction. Soft woods, such as pine, need a more flexible coating than hard woods (oak or maple, for example).

Fig. 1-2. Summer and winter wood grains



1.60 On the plus side, wood is fairly nonreactive with many chemicals, especially acids. This fact makes it possible for coatings (even some of the alkyds) to hold up well on wood substrates in atmospheres where these chemicals are present.

Environment

1.61 The final major factor in choosing the right coating for a given job is the environmental elements the coating must withstand. Some of the most common problems are:

- heat
- moisture
- abrasion
- solar ultraviolet radiation
- chemical atmospheres.

1.62 You might easily find all of these factors at work in a typical industrial environment. As you examine the conditions affecting the task at hand, determine which factors are most important. Remember that no one coating will be perfect in all respects—try to find the one that comes closest.

1.63 **Heat.** All coatings are subjected to temperature changes, usually both by day and by season. High temperatures are an important factor in the South, while extreme seasonal changes must be considered in the North. A coating for a normal temperature range, if subjected to temperatures over 200°F

(93°C), will most likely discolor, blister, and burn off. In some cases, high temperatures can cause eventual coating breakdown.

1.64 Some polymers seem to evaporate from the surface in high temperatures. Epoxies may become brittle and less adhesive. Some silicone polymers, however, work well even in temperatures above 1000°F (537°C). Table 1-4 compares the general temperature resistance of typical coatings. A specific coating within a listed type, however, may vary from the figures given.

1.65 Coatings subjected to very low temperatures are likely to suffer from brittleness, shrinkage, and lack of adhesion. Coatings that retain some flexibility are not as likely to shrink on the substrate, because they expand and contract with it.

1.66 **Moisture.** Moisture problems vary widely from one workplace to another, and often from area to area within a given workplace. Moisture, however, is probably the greatest source of coating failure everywhere.

1.67 Water molecules can readily penetrate almost all organic compounds, including coatings. Water can also cause ammonia, carbon dioxide, and hydrochloric acid to become even more penetrating than normal, thus adding significantly to the corrosion factor.

1.68 The *moisture vapor transmission rate (MVT)* indicates how rapidly moisture vapor passes through a coating if there is a higher vapor pressure on one side than there is on the other. Each specific coating has its own MVT.

Table 1-4. Temperature resistance of some coating types

Coating	Immersion	Nonimmersion
Vinyl copolymer	100°F (38°C)	150°F (65°C)
Chlorinated rubber	100°F (38°C)	140°F (60°C)
Coal tar	122°F (50°C)	150°F (65°C)
Coal tar epoxy	122°F (50°C)	203°F (95°C)
Epoxy	122°F (50°C)	203°F (95°C)
Urethane	100°F (38°C)	250°F (120°C)
Epoxy phenolic	180°F (82°C)	250°F (120°C)
Baked phenolic	180°F (82°C)	250°F (120°C)
Inorganic zinc	—	698°F (370°C)
Silicone	—	698°F (370°C)

1.69 In a coating with excellent adhesion, no problem arises. But in a coating with poor adhesion, vapor pressure in the surrounding atmosphere can force moisture through the coating into the imperfect bond between the coating and the substrate, where the vapor pressure is lower. The result is blistering.

1.70 **Abrasion.** Some coatings must be extremely tough, adhesive, and shock-resistant to withstand the three main types of abrasion and impact:

- heavy foot, wheel, or equipment traffic
- damage from tools or equipment
- sand scouring.

1.71 Organic coatings vary greatly in their resistance to abrasion, with the polyurethane coatings usually being the most resistant. Inorganic zinc coatings make a good abrasion-resistant primer, particularly in marine applications. Because of their extreme hardness, coal tar epoxies are often good choices for abrasion resistance on a concrete substrate.

1.72 **Solar ultraviolet radiation.** Color durability is important in a coating subjected to the sun's rays. Most tans, browns, and grays last well under ultraviolet radiation. Bright reds and blues tend to fade rapidly and suffer from chalking. Solar radiation is a particular problem in the South.

1.73 **Chemical atmospheres.** The chemical atmosphere due to vapors or fumes in a normal industrial environment is only moderately acid or alkaline. In a typical general manufacturing plant, about 80% of the area is subjected to this sort of atmosphere. The chemicals in the atmosphere can first eat through the coating, exposing the substrate. Then they begin corroding the substrate itself.

1.74 The most important factor in preventing corrosion in such an atmosphere is identifying exactly which chemicals must be dealt with. This task is often far harder than it sounds. Acidity and alkalinity can change as the humidity, temperature, and wind direction change. Thus, what starts out as one chemical composition can eventually turn into another.

1.75 Determining which specific coating offers the best protection against which specific type of chemical corrosion is a study in itself. Generally speaking, though, chlorinated rubber and vinyl perform well against acids and alkalies. Phenolic and urethane coatings work well against acids.

1.76 Each case must, however, be considered individually, since there are innumerable factors that determine the correct selection. Because a coating might contain up to 20 ingredients, each of which can react chemically, protection against chemical corrosion is complex indeed.

Other Factors

1.77 Coating selection varies not only with the substrate and environmental factors, but with other related factors as well. Whether the building is new or old, whether it is unrusted or heavily rusted, makes a definite difference.

1.78 Coating selection is comparatively simple when the structure is new. That is the ideal time for a correctly applied, economically designed paint system. A *paint system* is a number of coats of paint of one or more types, each coat being allowed to dry or cure before the next coat is applied.

1.79 If the wrong system is applied to save money or time, the results probably will add to the maintenance costs for the life of the structure. Since the cost of materials averages out to only about 20% of all painting costs, it makes little sense to try to save money in that area. It is also uneconomical to rush work start-up before all coats have been applied, especially if a plant's process activities add to the corrosive atmosphere.

1.80 If the structure is not new and rust is prevalent, that condition must be dealt with. Even after sandblasting, rust may show up again prior to coating. The Steel Structures Painting Council (SSPC) has approved several pretreatment methods and materials that are effective in specific circumstances. Rust inhibitors used as additives are also effective in many cases. You should be very wary of nonapproved pretreatments that claim they can substitute for proper surface preparation.

1.81 Selecting a coating for the interior of an industrial building is significantly different from selecting one for the exterior. While the outside coating will be subjected to solar radiation and weather, the inside coating may have to withstand dampness, condensation, fumes, and severe abrasion. An oilbase paint, for instance, would be a good choice for exterior wood but not for interior wooden floors, because it does not stand up well under abrasion and impact.

1.82 Coatings for surfaces that will be immersed in liquid also require special consideration. The qualities needed in the lining of a water tank, for instance, are quite different from those required in its exterior paint. Similarly, different coatings are needed on the immersed and nonimmersed sections of a bridge.

1-9. In industry, the most common substrate to be coated is __________.	1-9. STEEL Ref: 1.45
1-10. Cast iron provides a good substrate if it is given correct ___________.	1-10. SURFACE PREPARATION Ref: 1.46
1-11. The nonferrous metals that do require coating in some applications are aluminum, zinc, and __________.	1-11. COPPER Ref: 1.47
1-12. Epoxy paints work well on a concrete substrate because they penetrate the __________.	1-12. PORES Ref: 1.51
1-13. A difficulty in painting wood is that it has two kinds of grain with different rates of __________ and __________.	1-13. EXPANSION; CONTRACTION Ref: 1.58, 1.59
1-14. In very cold temperatures, a paint that retains some ___________ is not as likely to shrink on the substrate.	1-14. FLEXIBILITY Ref. 1.65
1-15. Probably the greatest source of coating failure everywhere is ___________.	1-15. MOISTURE Ref: 1.66
1-16. A number of coats of paint, each one being allowed to dry before the next is applied, is called a paint __________.	1-16. SYSTEM Ref: 1.78

Answer the following questions by marking an "X" in the box next to the best answer.

1-1. Rust on iron or steel is an example of

- ☐ a. spalling
- ☐ b. protection
- ☐ c. corrosion
- ☐ d. adhesion

1-2. The paint ingredient that forms the final dry film is the

- ☐ a. binder
- ☐ b. thinner
- ☐ c. pigment
- ☐ d. solvent

1-3. A great advantage of oil-base paints is that they

- ☐ a. are fast-drying
- ☐ b. wet the surface well
- ☐ c. are an excellent coating for concrete
- ☐ d. are highly resistant to alkalies

1-4. Which of the following is a disadvantage of two-component epoxy paints?

- ☐ a. Poor adhesion
- ☐ b. Short pot life
- ☐ c. Poor resistance to abrasion
- ☐ d. Slow solvent evaporation

1-5. The first step in coating selection is determining the

- ☐ a. substrate
- ☐ b. color
- ☐ c. required thickness
- ☐ d. reason for the coating

1-6. The most common industrial substrate is

- ☐ a. steel
- ☐ b. wood
- ☐ c. concrete
- ☐ d. zinc

1-7. One of the characteristics of a concrete substrate is that

- ☐ a. laitance improves paint adhesion
- ☐ b. it is resistant to cracking
- ☐ c. it does not transmit water vapor
- ☐ d. it has air pockets and pinholes

1-8. Which paint type best withstands extreme heat?

- ☐ a. Latex
- ☐ b. Oil-base
- ☐ c. Silicone polymers
- ☐ d. Epoxy-polyarnine

1-9. An important factor in a paint's ability to withstand moisture in the atmosphere is its

- ☐ a. adhesion
- ☐ b. pigment
- ☐ c. oil length
- ☐ d. solvent

1-10. Which of these paint colors is most likely to fade under solar radiation?

- ☐ a. Tan
- ☐ b. Blue
- ☐ c. Gray
- ☐ d. Brown

SUMMARY

The three main reasons for painting today's industrial structures and equipment are: for the protection of materials, to comply with industry or government regulations, and for the sake of an attractive appearance.

Paint is perhaps the most frequently used structural coating. It is made up of pigment, thinner (or solvent), and binder. The binder holds the pigment in the paint film that adheres to the surface after the solvent has evaporated.

Oil-base paint, the oldest type, is still useful in some industrial applications. However, newer paints and other coatings are much more widely used for their versatility and special high-performance qualities. Outstanding among these newer coatings are alkyd, latex, epoxy, urethane, vinyl, silicone, phenolic, and zinc-rich paints.

Which paint to use depends primarily on the precise reason for the job. Other important factors in paint choice are the substrate and the environmental elements it must be protected from. Metal (with steel heading the list), concrete, and wood are the most common industrial substrates. Harmful environmental forces include heat, moisture, abrasion, solar radiation, and chemical atmospheres.

Answers to Self-Check Quiz

1-1. c. Corrosion. Ref: 1.02

1-2. a. Binder. Ref: 1.11

1-3. b. Wet the surface well. Ref: 1.13, 1.14

1-4. b. Short pot life. Ref: 1.20, 1.23

1-5. d. Reason for the coating. Ref: 1.36

1-6. a. Steel. Ref: 1.45

1-7. d. It has air pockets and pinholes. Ref: 1.51 to 1.55

1-8. c. Silicone polymers. Ref: 1.64

1-9. a. Adhesion. Ref: 1.69

1-10. b. Blue. Ref: 1.72

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