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THE PAINTING OF EXTERIOR METAL SURFACES

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Contents

INTRODUCTION

This letter circular is designed to answer average letters of inquiry on the subject of painting exterior metal surfaces. Although a full discussion of such a comprehensive subject is beyond the scope of this paper, it is the purpose of the authors to outline the more important considerations which should be borne in mind by engineers, maintenance superintendents and painters confronted by metal painting problems. Suggestions are made regarding the cleaning and pretreatment of metal surfaces in addition to a discussion of the various priming and finish coat paints that may be employed. For more detailed information, the references given in Letter Circular LC795[1], "Publications on Paint, Varnish and Bituminous Materials", should be consulted. Letter Circular LC795 also gives information as to how Federal Specifications for paint and other materials may be obtained. The reader is also referred to Building Materials and Structures Report BMS105[1], Paint Manual, price $1.00. This manual is nontechnical in nature and provides practical information for the application of protective coatings. A section on paint failures on exterior surfaces with the causes traced and remedies suggested is included. Additional information on the preparation of steel surfaces prior to painting and on the painting of the surface may be found in Building Materials and Structures Reports BMS44, Surface Treatment of Steel Prior to Painting, price 10 cents, and BMS102, Painting Steel, price 10 cents (stamps not accepted).

The subject of painting exterior metal surfaces has been studied at the National Bureau of Standards for over a quarter of a century. Most of the work has included the exposure to outdoor weather of paints of known composition, that is, paints made in the laboratory. The emphasis in these investigations, in fact, has been on the performance of various formulations rather than on proprietary products since the latter are, naturally, subject to change. This letter circular does not give information on brands of paint.

It is the purpose of this letter circular to describe paint systems intended for the protection of metal (steel, galvanized iron, terne plate, copper and aluminum) exposed to ordinary outdoor weather. Such paint systems must be resistant to sunlight, rain, heat and cold, wind, hail, snow, fog, industrial gases, etc. This letter circular does not cover paint systems intended for marine use (either partly or wholly submerged in water), or systems designed for a particular condition, for example, highly corrosive atmospheres.

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[1] Letter Circulars referred to may be obtained free from the National Bureau of Standards. Building Materials and Structures Reports and Federal Specifications are for sale at the price indicated by the Superintendent of Documents, Government Printing Office, Washington 25, D. C.

The chief reason for applying paint to metalwork, particularly iron and steel, is to control and prevent corrosion. The statement has been made that the estimated indirect annual cost throughout the world due to losses resulting from corrosion exceeds 2 1/4 billion dollars. Paint is an effective and economical material for preventing the corrosion of metals, particularly iron and steel. For best results, where long-time durability is expected (for example, bridges, trestles, and large tanks), two coats of priming paint followed by two coats of top or finishing paint are recommended on new work. For repainting, a spot coat followed by a full priming coat, and then one or two finish coats are recommended. Since the cost of the paint is only about 20 percent of the total cost of painting structural iron and steel, it pays not to stint on the quality and quantity of paint used. The usual recommended spreading rate of each coat of paint is about 600 square feet per gallon. With a four-coat paint job on new work, this should result in a total dry film thickness of about 0.005 inch. If the paints are properly formulated and skillfully applied to surfaces fit to receive them, the results should be satisfactory. In the suggestions to follow, it will be stressed repeatedly that the preparation of the surface, particularly structural steel surfaces, prior to painting is most important. Unless the surface is properly cleaned so that the priming paint comes in direct contact with the metal, early failure of the paint film will undoubtedly occur regardless of the quality of the paint and the care used in applying it.

GENERAL CONSIDERATIONS

The fundamental requisite of a priming-coat paint for any metal surface is that it adhere tenaciously to the surface. In preparing the surface and selecting the primer, this important fact should be kept constantly in mind. All paint should be applied in bright, warm weather to metal surfaces which are clean and dry. Painting should not be done early in the morning when the structure is damp from dew. Ample time should be allowed for each coat of paint to dry before applying another coat.

It is generally believed by most paint technologists that good linseed oil paints made with heavy or medium weight pigments (sp. gr. 2.5) should contain more than 28 percent by volume of pigment in the dry film. This expression is often referred to as "Pigment Volume" or simply "PV". The paint formulas given in this paper are based upon experience with average pigments of good quality and raw or boiled linseed oil and synthetic resin varnishes. If a given lot of pigment is coarser than the average good grade, it may be necessary to increase the proportion of pigment to get a paint of good working properties. On the other hand, if a given lot of pigment is much finer than the average good grade, it may be necessary to decrease the proportion of pigment to keep the paint from being too thick for proper brushing.

The advent of synthetic resins and their formulation for use in paint vehicles has given impetus to the production of a variety of priming paints of high quality. Glyceryl phthalate and phenolic resins are the most commonly used in protective coatings and usually are modified with oil or some other resin to give properties to the paint desirable or essential for the specific application contemplated. Good adhesion, color and gloss retention, durability and flexibility are some of the characteristics imparted to paints containing properly formulated glyceryl phthalate resin vehicles. Phenolic resin vehicles have good water, acid and alkali resistance.

The federal specifications referred to are believed to represent satisfactory materials for the purposes indicated. "Federal Standard Stock Catalog, Section IV. Federal Specifications, Part I, Index", lists all federal specifications with information as to how they may be obtained. This index can be purchased for 30 cents (stamps not accepted) from the Superintendent of Documents, Washington 25, D. C.

STRUCTURAL STEEL

Cleaning can well be considered the most important step in preparing metalwork for painting. It can be divided into two phases; the removal of oil and grease, and the removal of rust, dirt, scale, old paint and moisture. All oil and grease should be removed before mechanical methods of cleaning are started. The usual method is to wipe the surface with clean cloths and mineral spirits or carbon tetrachloride. The liquid and the cloths should be kept clean by frequent renewals so as to avoid leaving a thin, greasy film on the surface. The steel should then be thoroughly cleaned by sandblasting, scraping, chipping, wire brushing, flame cleaning or other approved methods, so as to remove all rust, dirt, scale and moisture. The problem of whether to remove scale from structural steel is an old one. If the scale is continuous and adheres tightly and remains so, it would offer considerable protection. On the other hand, the partial removal of scale is generally worse than no removal. It is generally agreed that the best practice on structural steel is to remove all scale as well as rust. When the steel is at the mill, the removal of scale can be done by sandblasting or pickling. However, after the structure is erected the removal of scale becomes a real problem. The best method is to remove all the scale with controlled sandblasting or steel grit blasting. The more common practice however is to use a wire brush (either manually or mechanically operated) and scrapers, removing the rust and as much of the scale as is possible. Frequently a rust-inhibitive wash of the phosphoric acid type follows, and then after this is dry, the priming coat paint is applied.

The best coating will fail in performance if the metal is not cleaned properly. In addition to having a clean surface, it has also been found beneficial, particularly for industrial finishing under controlled conditions, to treat the metal with certain chemical solutions. This should be done as soon after cleaning as practicable and before any corrosion takes place. These processes involve chemical and electro-chemical treatments of the surface of the steel so as to produce a rust inhibited surface that will bond well with the priming paint. There are many proprietary brands of pre-treating solutions available. One inhibitive wash specified in U. S. Army Specification No. 3-205 has the following composition:

Orthophosphoric acid (75 percent H_3PO_4) . . .	12 gallons (one carboy)
Chromium sulfate (water soluble)	25 pounds
Monobutyl phenyl phenol sodium sulfonate (detergent)	1 1/2 gallons
Ethylene glycol monoethyl ether (cellosolve)	6 gallons
Water to make	160 gallons

These quantities are not mandatory, but the above proportions of ingredients should be adhered to. The rust inhibitor should be applied either by brush or by dipping. Not less than one hour after application of the inhibitor, residue on the surface should be removed by thorough wiping with damp cloths or by flushing with hot water after which the surface should be thoroughly dried, and the priming paint applied before corrosion occurs.

The steel must be protected by the paint in contact with it, and since it is difficult to be sure that every part of the structure is covered by the priming coat, it is best to have the second coat like the priming coat except for a slight difference in color. The succeeding coats should protect the underlying paint and furnish the desired color. White and slightly tinted paints are less durable and more expensive than dark-colored paints. However, white and tinted finish coats are used where appearance and visibility or light (heat) reflection demand a light color.

PRIMING PAINT

Since the primary function of a priming-coat is to protect the metal from corrosion, it should contain rust-inhibitive pigments. It can be applied by either brush or spray but particular care should be taken to cover the surface completely with the proper thickness of paint. Two coats are recommended for new work. The second coat may be tinted to a slightly different color to facilitate inspection. Ample time should be allowed for drying before application of succeeding coats.

Where the surface is rough, for example structural steel, and where it may not have been cleaned thoroughtly, one of the best types of priming paint is an unbodied linseed oil paint. Raw linseed oil tends to wet the metal and penetrate depressions, spongy metal, cracks and crevices. Varnish vehicle paints may tend to bridge over small cracks and depressions rather than penetrate and fill them. Thus they should be modified with some raw linseed oil for use on rough steel, or used preferably on smooth steel or steel that has been thoroughly cleaned of scale, rust, etc.

A widely used priming paint for structural steel exposed to the weather is red lead paint meeting Federal Specification TT-P-86. Red lead can also be used for other intermediate coats, preferably by darkening each coat with the addition of small amounts of lamp-black-in-oil, but it is unsuited for the final coat. Blue lead paint (Fed. Spec. TT-P-20) and basic lead chromate paint are also used for priming and body coats. Iron oxide paint (Fed. Spec. TT-P-31a) can be used for all coats but is better suited for use as a topcoat. Iron oxide-zinc chromate pigment in synthetic resin vehicles make very good priming paints for steel. The following priming paints are listed in most cases according to the type of pigment. However, it should be emphasized that the value of a priming paint depends upon the entire paint, both vehicle and pigment. This is all the more true with the advent of synthetic resin vehicles.

BASIC LEAD CHROMATE PRIMERS

Basic lead chromate paints are considered very good priming paints for steel. In fact tests at the Bureau show that it is among the best pigments in priming paints for steel. The paint should be made by grinding the basic lead chromate to a paste with part of the oil, and then thoroughly mixing this with the remaining vehicle by running again through the mill. While our tests have generally been made with basic lead chromate paints containing about 75 percent by weight of pigment and 25 percent by weight of linseed oil without volatile thinner of any kind, it is believed that the addition of some volatile thinner would make the paint flow more readily into cracks, porous iron, and the irregularities of a steel structure. The paints should therefore be made to approximate the following composition:

Dry basic lead chromate	15 1/2 pounds
Raw linseed oil	5 pints
Turpentine	2 gills
Liquid drier	2 gills
	1.02 gallon

or

Dry basic lead chromate	15 1/2 pounds
Boiled linseed oil	5 pints
Turpentine	1 pint
	1.02 gallon

These paints weigh about 21 pounds per gallon and the nonvolatile portion contains about 30 percent by volume of pigment.

BLUE LEAD PRIMERS

For first and intermediate coats, a good mixing formula using blue lead as paste in oil, is:

	Priming Coat	Body Coat
Blue lead paste, lb	100	100
Boiled linseed oil[1], gal	2 3/4	2 3/4
Turpentine or mineral spirits, pt	2	2
Liquid drier, pt	1	1
Lampblack-in-oil, pt	...	3/4
Quantity of paint produced, gal	6 1/4	6 3/8

[1] If raw linseed oil is employed, use 1 quart of drier.

Weight per gallon of paint . . . . about 20 lb
Volume percent of pigment in dry film . . . about 29.

Federal Specification TT-P-20 covers a ready-mixed blue-lead-base paint intended for priming and body coats on iron and steel. This paint weighs about 20 pounds per gallon and has a PV of 29; one gallon contains 0.27 gallon of blue lead pigment and 0.92 gallon of film-forming solids (pigment plus nonvolatile vehicle).

IRON OXIDE PRIMERS

Dull red and brown iron oxide paints meeting Federal Specification TT-P-31a are typical of many low-priced paints that have been used for years for painting structural metal and particularly terne-plate roofs. It is a durable and economical paint, and is frequently referred to as roof and barn paint, red metallic paint, metallic brown paint, mineral red paint, or freight-car red. The paint may be used both as a priming and finish coat. A ready-mixed paint, conforming to this specification, contains a small amount (about 12 percent in the pigment) of zinc oxide, thus increasing rust-inhibitive properties and color retention, and decreasing the susceptibility of the paint to mildew. Roof exposure tests at the Bureau show a definite advantage in durability in having about 12 to 15 percent zinc oxide along with the iron oxide, as is required in the Federal Specification. The paint weighs about 14 lbs. per gallon and has PV of 28; one gallon contains 0.24 gal of pigment and 0.84 gal of film-forming solids.

RED LEAD PRIMERS

For many years, unadulterated red lead-linseed oil paints have been considered among the best paints for priming structural steel. In any carefully conducted tests, red lead has consistently ranked very high. This opinion is held by a large number of experienced engineers, as well as by other competent observers, and has prevailed ever since structural steel came into use. Formerly, such paints were made without any liquid drier or volatile thinner, but now it is generally agreed that some liquid drier and volatile thinner improves the quality of the red lead-linseed oil mixtures.

Exposure tests made at the Bureau on red lead paints indicate that a high proportion of pigment gives the best results. This may be due in part to the fact that under these conditions the pigment, because of its alkaline nature, has a better opportunity to take care of decomposition products from the vehicle, and to render the metal surface more passive. The exact upper limit of pigment has not been determined, but a safe guide is to use the maximum amount of well-dispersed red lead consistent with good brushing properties. We believe that red lead paints properly mixed and made according to either of the following formulas (Fed. Spec. TT-R-191a) can be considered "standard" red lead priming paints for structural steel:

Dry red lead	20 pounds
Raw linseed oil	5 pints
Turpentine	2 gills
Liquid drier	2 gills
Yield about	1.02 gallon

Red lead paste in oil	20 pounds
Raw linseed oil	3 pints
Turpentine	2 gills
Liquid drier	2 gills
Yield about	0.94 gallon

These paints weigh about 25 pounds per gallon, and the nonvolatile portion contains about 30 percent by volume of pigment. For second coats with either basic lead chromate or red lead paints it is advisable to add about 1/2 gill (2 ounces) of lampblack in oil to the above formulas. This will change the color so as to facilitate inspection.

Federal Specification TT-P-86 covers a ready-mixed red lead paint weighing not less than 25 lbs. per gallon. One gallon of this paint contains about 0.26 gallon of red lead and 0.95 gallon of red lead plus linseed oil. The percentage by volume of pigment on the total nonvolatile solids ("PV") amounts to 28 percent. The pigment consists entirely of red lead, containing not less than 97 percent true red lead (Pb_3O_4), and meets the applicable requirements of Federal Specification TT-R-191a, Type I, Grade C. The ready-mixed paint is designed to give good body and is particularly intended for the priming and body coats on iron and steel. If thinning is necessary, turpentine or mineral spirits should be added instead of linseed oil. This ready-mixed paint keeps well in storage and in this respect is superior to paints mixed on the job.

Consideration is being given to the desirability of revising Federal Specification TT-P-86 to include three types of red lead paint as follows:

Type I - Red Lead-Linseed Oil (Slow-Drying)

This type of paint has been used for years for priming structural steel and is particularly recommended for rough surfaces, where the full advantage of raw linseed oil is wanted. It is the type of paint being specified at present.

Type II - Semi-Quick-Drying Red Lead Paint

The vehicle in this paint is contemplated to be a blend of 50 percent long oil alkyd resin (meeting U. S. Navy Specification 52R13) and 50 percent raw linseed oil with thinners and driers. This paint can be used in place of Type I for priming structural steel when a somewhat quicker drying primer is desired.

Type III - Quick-Drying Red Lead Paint (Synthetic)

The vehicle in this paint is intended to be an alkyd resin (oil type) varnish which dries to a hard and smooth finish within 8 hours. This primer is intended for use in shop painting of articles made of smooth steel and could be used for touch-up work where rapid drying is desired. However, for rough surfaces such as bridges and similar structural steel, Types I or II paint would be recommended.

ZINC CHROMATE YELLOW PRIMERS

Zinc chromate yellow was used in metal primers in tremendous quantities by the armed forces during the war period, and it is expected that this trend will continue in peacetime. The good performance of zinc yellow primers is brought out in the National Bureau of Standards BMS Report 102, "Painting Steel", October 16, 1944, a copy of which can be purchased from the Superintendent of Documents, Washington 25, D. C., for 10 cents. Because of its slight solubility, zinc chromate is capable of furnishing chromate ion for corrosion inhibition. It is not used in a straight linseed oil vehicle, but is used in synthetic resin vehicles of the phenolic resin or alkyd resin types. For priming structural steel (atmospheric exposure) the addition of some raw linseed oil to the synthetic resin vehicles is advantageous. For structural steel painting, where a primer is wanted that must be easy brushing on rough steel, have good penetration rather than bridge over depressions, not flow away from sharp edges, such as bolt heads, etc., and be durable, the following zinc chromate primer is showing good results in some of our preliminary testing work (all percentages by weight):

Pigment	Vehicle
40% Zinc yellow	48% Long oil alkyd resin (70% solide)*
30% Iron oxide (85% Fe_2O_3)	34% Raw (not bodied) linseed oil
30% Flake talc	18% Thinner and drier

Paint	
57% Pigment	Weight per gallon = 13.1 lb
43% Vehicle	PV = 35

Ratio of alkyd resin solids to raw linseed oil is 1 to 1.

*Meeting U. S. Navy Specification 52R13.

ZINC DUST PRIMERS

Zinc dust (metallic zinc powder) has good rust-inhibitive properties and in combination with zinc oxide is used in industrial and maintenance paints for painting steel, but particularly for galvanized iron and sheet zinc. This subject will be discussed in detail later on under the heading of galvanized metal. The usual combination of pigment is 80 percent zinc dust and 20 percent zinc oxide and the vehicle may be of the usual linseed oil type. The paint has a "battleship gray" color and may be used either as a primer or as a priming and finish coat. The gray color is retained over long periods of exposure. The paint may be tinted with colors-in-oil, for example, Indian red, C. P. chrome green, chrome oxide green, C. P. chrome yellow, burnt umber and zinc chromate yellow. Lampblack should not be used, at least in the first coat next to the metal, because the protective value of the paint is lowered. One of the most durable combinations is the addition of chromium oxide green to the paint. For priming steel, iron oxide is generally added to the zinc dust-zinc oxide mixture (about 50% zinc dust, 30% iron oxide and 20% zinc oxide).

MIXED PIGMENT PRIMERS

Various commercial linseed oil priming paints for structural steel contain basic lead chromate, zinc chromate, blue lead, red lead, or a mixture of these pigments, along with cheaper pigments or extenders of lighter weight. One such mixture of pigments, that has given good service, is the following blue lead base primer for atmospheric exposure:

Pigment - 54%		Vehicle - 46%	
Blue lead	60%	Raw linseed oil	97%
Zinc chromate	20%	Drier	3%
Magnesium silicate	15%		100%
Diatomaceous silica	5%		
	100%		

A properly formulated linseed oil paint made with this pigment has a color which makes inspection easier than is the case with a straight blue lead paint. It is doubtful whether it is any better as a rust preventive coat than straight blue lead paint.

Another multiple pigment primer that has given good results on structural steel is the previously-mentioned combination of 50-20-30 zinc dust-zinc oxide-iron oxide in a linseed oil vehicle.

The addition of opacifying agents such as a good grade of iron oxide or titanium dioxide and carefully selected extending pigments such as magnesium silicate to the rust-inhibitive pigments such as red lead, zinc chromate, basic lead chromate, blue lead, zinc dust, etc., is a common practice today. A good primer can be obtained with the above mixtures of opacifying and extending pigments provided there is a sufficient amount of the rust-inhibitive pigments present. The following are some examples of mixed-pigment red lead paints that have been found practical in field use:

No. 1		No. 2	
Red lead	75%	Red lead	75%
Diatomaceous silica	10%	Iron oxide (80% Fe_2O_3)	25%
Magnesium silicate	15%		

No. 3		No. 4	
Red lead	60%	Red lead	70%
Iron oxide	20%	Zinc oxide	10%
Magnesium silicate	20%	Iron oxide	10%
		Magnesium silicate	7%
		Diatomaceous silica	3%

QUICK-DRYING PRIMERS

Quick-drying metal primers for automobiles (for example Federal Specification TT-P-636) and machinery are generally highly pigmented iron oxide primers in which the vehicle is a thin varnish (long-oil spar or the new synthetic resin type). They dry to smooth (self-leveling) velvety flat to eggshell finishes, which give excellent foundations for the decorative coats. Some dry overnight while others dry within one or two hours. Some of the pigment combinations are, by weight, 1/3 zinc chromate or basic lead chromate and 2/3 iron oxide; others are equal parts of these pigments. One quick-drying primer consists of pure red lead and synthetic resin varnish. Where it is possible to bake such primers, the synthetic-resin, alkyd type primers appear among the best, with the phenol-aldehyde type of synthetic resin primers best for under water or moist conditions. For intermediate conditions there are now many combinations of these types that deserve consideration. However, in structural metal (maintenance) painting, it should be pointed out that varnish-vehicle paints with enamel-like consistency and flowing properties, tend to show surface tension effects at sharp corners or edges which may result in thinner coats at such points.

FINAL COATS

The function of the final coat on structural steel is to protect the underlying coats, which in turn protect the steel from rust, and to give the desired color. Since black and dark-colored paints are more durable than light-colored paints, dark colors are commonly used. Red lead paint should not be used as a final coat. It is not only too expensive, but it does not retain its color, and on long exposure to sun and weather develops small checks to a greater extent than many of the much cheaper dark paints. Blue lead does not hold its color on exposure. Chrome orange (basic lead chromate) is suitable for both priming and finish coats. The "international orange" paint used on airway signal towers contains chrome orange pigment. One good formula for this paint, which of course should be mill-ground and not just hand-mixed, is (all percentages by weight):

Pigment	
C. P. chrome orange of approved color	90 percent
Magnesium silicate	10 percent
Vehicle	
Raw linseed oil	80 percent
Spar varnish (TT-V-121b)	10 percent
Liquid paint drier	10 percent
Paint	
Above pigment	70 percent
Above vehicle	30 percent

For finish coats of other colors, paints meeting the following Federal Specifications may be used: black, Fed. Spec. TT-P-61a; dull red or brown, Fed. Spec. TT-P-31a; olive drab, Fed. Spec. TT-P-81a; gray and various tints, Fed. Spec. TT-P-40; green, Fed. Spec. TT-P-71a; and graphite paint, Fed. Spec. TT-P-27.

The retention of color and gloss and general appearance of all dark-colored, linseed oil paints, such as those just mentioned, can be improved by adding a small amount of spar varnish to the paint. The amount of varnish (Fed. Spec. TT-V-81a or TT-V-121b) added should be quite small - from one-half pint to a pint per gallon of paint, and care should be taken to select a varnish which will mix properly with the particular paint.

One of the best finish coats is an aluminum paint made by mixing about 2 lbs. of aluminum powder or paste, Fed. Spec. TT-A-468, with one gallon of varnish, Fed. Spec. TT-V-81a.

Another good method of painting structural steel is to apply one or preferably two coats of a rust-inhibitive primer, such as red lead, blue lead or zinc chromate-iron oxide paints previously mentioned, and follow with one coat of natural (untinted) dark-gray graphite paint and a finish coat of black graphite paint meeting Federal Specification TT-P-27.

Still another good system of painting structural steel is to apply priming coats of red lead, blue lead, zinc chromate-iron oxide, etc., followed by finish coats of iron oxide paint (Fed. Spec. TT-P-31a).

GALVANIZED METAL AND SHEET ZINC

Since the zinc coating on galvanized metal offers a better protection from rusting than any paint coating, it is not necessary or advisable to apply as many or as thick coats of paint to galvanized metal as to ordinary iron and steel. However, it is advisable to paint before rusting occurs. It is well known that it is difficult to get paint to adhere to galvanized metal. Many explanations have been advanced for this lack of adhesion. For example, zinc salts may be left on the surface during the galvanizing process, certain chemical reactions may take place in the paint film itself, and reactive decomposition products in the presence of moisture may react with the metal at the interface. Zinc formate has been isolated at the interface between the paint and the metal zinc surface. This formation of zinc formate has been suggested as one of the possible causes for the poor adherence of paints to galvanized metal. Exposing the galvanized metal to the weather for at least six months will dull the smooth, spangled structure to some degree and many chemical solutions, which etch the surface, have been used for treating the metal before painting. The best treatments do more than merely roughen the surface - they change the surface chemically, depositing a nonmetallic film that increases the adherence of the applied paint and retards corrosion under the paint film. Solutions of the zinc phosphate and phosphate-chromate types sold under proprietary brands, apparently accomplish these functions to a great extent. Phosphate-treated galvanized metal sheets are available commercially. Dirt or greasy material should be removed by cleaning with a solvent, such as turpentine or mineral spirits, before pretreating or painting.

A zinc dust-zinc oxide priming paint, conforming to Federal Specification TT-P-641, is especially intended for use on galvanized metal. This specification covers the requirements for a zinc dust-zinc oxide paint for priming new or old galvanized surfaces. Type I is a linseed oil paint, Type II contains a glyceryl phthalate resin vehicle; and Type III contains a phenolic resin vehicle. Types II and III paints may be either air-dried or baked at temperatures up to 380° F. For ordinary atmospheric exposure, Type I (linseed oil) and Type II (glyceryl phthalate) are recommended. Where severe moisture conditions prevail, Type III is preferred. Each type may be obtained in either Class A, ready-to-mix paint, or

Class B, ready-mixed paint. Class A is a semiprepared paint, with the zinc oxide mill-ground in the entire vehicle in one separate compartment. For mixing, a small portion of the zinc oxide vehicle is added to the zinc dust and mixed to a smooth paste, after which the balance is added and thoroughly mixed to uniform consistency. Class B is a ready-prepared paint with all of the ingredients mixed together in one container.

While the primary function of these paints is to provide adequate adherence on galvanized metal, they are also satifactory as finish coats and may be used in one or more coats. If desired, any of the final coats mentioned under painting of structural steel may be used as topcoats over the zinc dust-zinc oxide primer. Since paint fails on galvanized metal by flaking off, it is advisable to use as few and as thin coats as will give the desired appearance. The building up of thick layers of paint should be avoided.

TERNE PLATE ("ROOFING TIN")

The usual red or brown iron oxide paint (TT-P-31a) is an economical as well as a good paint for terne plate ("roofing tin"), such as is used on roofs. Care should be taken to see that the new terne plate, before painting, is wiped with a cloth saturated with gasoline or turpentine to remove any oil or grease. The paint should be well brushed out. This is especially true on nearly flat "tin" roofs, as thick coats will crack later on. Repainting should not be done too frequently, or cracking of thick coats may result. On the other hand, terne-coated steel is rapidly destroyed once rusting starts. For this reason, it should not be allowed to rust before painting.

COPPER

Copper gutters and flashings, as well as copper or bronze screening, are apt to cause bad yellowish-green stains on light- or white-painted houses, owing to the washing off of corrosion products. Exposure tests at this Bureau indicate that one of the best ways to paint copper or bronze surfaces is to wash off any grease, using gasoline or turpentine. The surface may be roughened slightly with sandpaper, and a priming coat composed of 1 1/2 to 2 pounds of aluminum powder to 1 gallon of aluminum mixing varnish (TT-V-81a) applied, followed by the desired color coat. Weathered copper or bronze fly screening should be thoroughly dusted, and then given two coats of a thin black paint (1 gallon of TT-P-61a ready-mixed paint thinned with 1 quart of turpentine), or a thin black enamel (1 gallon TT-E-521 enamel thinned with 1 pint to 1 quart of turpentine). Some of the best grades of black auto top dressings, which are essentially thin, water-resistant, carbon black enamels, make good screen enamel. Good results have also been obtained with zinc dust-zinc oxide paints on copper and bronze screens. This gives a gray color.

ALUMINUM AND ALUMINUM ALLOYS

Aluminum and aluminum alloy structural parts will undoubtedly be used more than ever in the post-war period. Before painting such metals, the surface which should be free of grease, oil or other foreign material, should be given a chemical treatment, the object of which is to form a stable and nonreactive coating on the base metal, so as to inhibit corrosion and increase the adherence of the subsequent paint coating. One method consists of immersion of the aluminum in phosphoric or chromic acids after cleaning the metal in an inhibited alkali cleaner. Another treatment consists of an aqueous solution of phosphoric acid with organic grease solvents and emulsifiers (for example the formula given on page 5 and directions for its use). This mixture may be brushed on the surface. There are a number of satisfactory proprietary products of this type on the market. Another method consists of an electrochemical oxide coating formed by an anodic treatment using an electrolyte. Still another method consists in reacting the clean aluminum surface in a metal acid phosphate solution (hot), followed by a chromic acid or phosphoric-chromic acid rinse. Then preferably a zinc chromate primer in a relatively non-permeable vehicle should be applied. A good specification for such a primer is Army-Navy Specification AN-TT-P-656b. The composition of the pigment meeting this specification is 85 percent zinc chromate yellow and 15 percent magnesium silicate. If a zinc chromate primer is not available, an iron oxide primer, while not as effective as zinc chromate, should be satisfactory. The usual topcoat paints suitable for steel may then be applied.

In addition to the information given in this letter circular on painting exterior metal surfaces, information on painting exterior masonry surfaces, including concrete block, cinder block, concrete, brick, and cement-asbestos siding, may be found in the Bureau's Letter Circular LC747, "Painting Exterior Walls of Porous Masonry". Information on painting exterior wood surfaces is contained in the Bureau's Letter Circular LC810, "The Painting of Exterior Wood Surfaces". For those interested in the mechanism of corrosion and more detailed and basic information on the painting of metal, reference is made to the Bureau's Letter Circular LC671, "Sources of Information on Paint and Related Materials", which contains a classified list of reference books on "Metal Painting". Letter circulars are available free by writing the Bureau.