U. S. DEPARTMENT OF COMMERCE
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PAINT MANUAL

WITH PARTICULAR REFERENCE TO FEDERAL SPECIFICATIONS

BUILDING MATERIALS AND STRUCTURES REPORT BMS105

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By Percy H. Walker *and* Eugene F. Hickson

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REPORT BMS105

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U. S. DEPARTMENT OF COMMERCE
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Foreword

The need for information on protective coating materials in addition to that given in National Bureau of Standards Technologic Paper T274, published in 1925, has been expressed from time to time by various governmental agencies. Many changes in such materials have occurred since that publication, now out of print, was issued. Thus, this manual has been compiled to aid in the procurement of materials that would be suitable and adequate for most kinds of painting and that would assure successful application. This manual is based in large part on Federal Specifications and supplements but does not replace them.

Methods are described for the preparation of surfaces and the application of coatings that are known from experience to give satisfactory results. The information contained herein cannot supplant the skill of the experienced painter but should assist the procurement officer in specifying and obtaining the proper paint materials. It should also assist the planner and technical supervisor of work in obtaining and maintaining durable finishes at reasonable cost.

LYMAN J. BRIGGS, *Director.*

CONTENTS

Contents

Contents

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ABSTRACT

This manual presents recommendations by the National Bureau of Standards and cooperating organizations for the most effective use of painting materials meeting Federal Specifications. Chiefly nontechnical in nature, the manual provides practical information for the application of protective coatings. It also explains recent developments in the field of painting and includes pertinent references. Descriptions of approximately 60 paints and paint products are included to enable the painter to choose the most suitable materials for the surface to be covered. Emphasis is placed on methods of applying coatings and preparing surfaces for obtaining maximum protection with the materials used. Where paint failures have occurred, the causes are traced and remedies suggested.

I. INTRODUCTION

It is the purpose of this manual to help the various Federal Government agencies in the proper selection and use of paint (see glossary) and painting materials purchased under Federal Specifications.

Specifications for paint define for the purchaser the quality of materials to be procured. To the manufacturer they provide a fair basis on which to bid competitively. Adequate specifications for paint contain two essential provisions: requirements for composition and requirements for results, or performance, although one type of requirement may receive more emphasis than the other.

Federal Specifications are approved and promulgated by the Director of Procurement, Treasury Department, for the use of all Government agencies in the purchase of materials and equipment. They should not be confused with specifications issued by the various Federal departments and agencies for materials and construction to meet their own special requirements. Federal Specifications may be purchased from the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C., who will

send without charge a price list of Federal Specifications, on request.

A Federal Specification sets a standard that is considered adequate and economical for the service expected. If the purchase order requires that material conform to a particular Federal Specification, the seller may commit a fraudulent act if he knows that the material being furnished does not conform. Most manufacturers know how Federal Specifications apply to their products.

A specification sets forth in detail the minimum requirements and makes no allowance for material of superior grade. The purpose of the specification is to procure material that will give good performance. However, the difference in cost between material meeting the specification and that for material giving somewhat better performance may not be justified.

Federal Specifications for paint are set at a sufficiently high level of quality to give good service. They define materials fully adequate for the purpose intended at a reasonable price without expensive and unnecessary frills and cover paints obtainable from the widest practicable sources of supply.

It is the buyer's responsibility to see that deliveries of paints actually do conform to specifications, and that material purporting to meet a particular Federal Specification for paint is not accepted without test. Otherwise, material inferior to that called for in the specification will be accepted and used. The inevitable result will be unsatisfactory service and complaint that the specification is inadequate, whereas, the fault would lie with the purchaser who has not taken the necessary steps to be certain that the quality purchased and paid for was actually delivered.

The fact that a Federal Specification paint is less expensive than a proprietary brand of paint of the same type is not an indication that its quality is inferior to that of the higher-priced paint, which may include promotion and selling costs, but that it meets the prescribed quality requirements for this type of paint. The technical committee charged with preparing Federal Specifications for paints is constantly on the alert to revise or amend specifications to improve quality. Therefore, Government purchasing agents can be assured that paints they buy under Federal Specifications are of good and adequate quality.

II. GENERAL COMMENTS

Federal Specifications are prepared by committees comprised of representatives from the Government agencies having use for the materials or articles, specialists from the National Bureau of Standards who deal with the article in research or in acceptance tests, and representatives of manufacturers producing paint materials. Before promulgation, they are circulated to manufacturers for criticism. Federal Specifications are not prepared to cover all commercial products of a type but only those suitable for the services of the Government agencies interested. They establish minimum requirements for the service required. Some agencies buy materials and articles in quantity, requiring conformance to a designated Federal Specification. Other agencies, which contract for the construction of buildings or the manufacture of articles, require the contractor to use designated materials conforming to the appropriate Federal Specification. Inspection and sampling of material may be done at the place of manufacture, at point of use, or both. Frequently, an agency adds requirements to the specification in order to meet some specific condition or for some other reason.

After the specification has been in use for some time, slight changes based on experience with the specification, or improvements in the material covered by it, result in an amendment to the original specification, which includes any previous amendments. More comprehensive changes are covered by a complete revision, which is designated by addition of the lower-case letters a, b, c, etc. to the symbol of the original issue. Thus Federal Specification TT–P–781a, Putty indicates the first revision of this specification for putty.

Government and other large organizations buy quantities of equipment that is surface finished in factories under special conditions for rapid and careful work, often using coating material not covered by Federal Specifications. In general, the specifications for the completed object should contain directions for inspecting and testing the finish after it is completed rather than detailed specifications for the materials used in the various coats. Workmanship on such finishes is more important than the material used in most cases. Several of the Government agencies have had, at one time or another, specifications for coated surfaces. Among

such specifications are those covering the finish on steel bedsteads (Panama Canal), laboratory furniture (Department of Agriculture), school desks and tables (Office of Indian Affairs), and school furniture (District of Columbia).

Federal Specifications usually follow the same outline of form and are arranged in nine sections:

Section A—Applicable Specifications.
Section B—Types, Grades, etc. (as applicable).
Section C—Material and Workmanship, etc. (as applicable).
Section D—General Requirements.
Section E—Detail Requirements.
Section F—Methods of Sampling, Inspection, and Tests.
Section G—Packaging, Packing, and Marking for Shipment.
Section H—Requirements Applicable to Individual Departments.
Section I—Notes.

Details of this arrangement and explanation of each section may be found in "Outline of Form for Federal Specifications," for sale by the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C., price 5 cents.

Emergency Alternate Federal Specifications were set up during the war emergency to conserve supplies of strategic or critical materials or to provide substitutes for materials not available. Symbols for these specifications are the same as for the basic Federal Specifications except for the letter "E–" that precedes the symbol, as E–TT–P–115 for TT–P–115. However, for paint and paint materials, these "E–" specifications have been canceled, superseded by revised Federal Specifications, or incorporated in conservation amendments, indicated by asterisk (*). These conservation amendments will be considered for revision as required.

"Willing-to-Certify" lists are compiled by the National Bureau of Standards and distributed to governmental purchasing agencies and to others upon request. They include the names of firms that have stated to the National Bureau of Standards they are willing to certify to purchasers that they can supply commodities guaranteed to conform to Federal Specifications.

Simplified Practice Recommendations are proposed by manufacturers, dealers, or users, and may be defined as lists

of sizes, varieties, and types of products that have been approved for regular stock purposes. The National Bureau of Standards cooperates with these groups and promulgates the recommended lists of items after they have been approved by producers, distributors, and users. Paints are covered by a Simplified Practice Recommendation that establishes standards for the number of colors and container sizes.

A price list for all effective Simplified Practice Recommendations may be obtained free of charge from the National Bureau of Standards.

Commercial Standards promulgated by the National Bureau of Standards are voluntary recorded standards approved by producers, distributors, and consumers, covering terminology, types, classifications, grades, sizes, and use characteristics of manufactured products as a basis for better understanding between buyer and seller. They include standards, methods of test, rating, certification, and labeling, and provide a uniform basis for fair competition. They are made effective by means of voluntary guarantees on invoices and labels or by grade marks on the goods themselves.

A price list for all effective Commercial Standards may be obtained free of charge from the National Bureau of Standards.

III. COMMENTS ON INDIVIDUAL MATERIALS

1. GENERAL CONSIDERATIONS

As a matter of convenience, the composition of paints and paint-making materials is sometimes stated in proportions by weight, sometimes in proportions by volume, and sometimes in terms of the weight of one constituent added to the volume of another. For example, when a paint is analyzed in the laboratory, the various constituents are usually weighed as they are separated, and the convenient method of indicating the result is in percentage by weight; but when paint is mixed on the job, facilities for weighing may not be available, and it is usually more convenient to proportion the liquids in quarts and gallons. Pigments (see glossary) are usually purchased and packaged by the pound. For example, it is frequently convenient to use the term "100 lb of white lead to 3 gal of linseed oil."

The density of paint is usually stated in pounds per gallon. It may be stated as specific gravity, which is the ratio of the weight of paint to that of an equal volume of water. Pounds per gallon times 0.12 equals specific gravity. The reciprocal of pounds per gallon is a fraction of a gallon per pound and is given the special name "bulking value" (see glossary). It may also be said that the material bulks 0.1 gal/lb, meaning that it has a bulking value of that amount or that it weighs 10 lb/gal. The bulking value of a pigment refers to the volume of liquid displaced by 1 lb when wet with the liquid and not to the apparent volume of the material when dry, which includes a large percentage of air-filled voids. The "pigment volume," abbreviated PV, (see glossary) is the ratio of the percentage by volume of the pigment in a paint to the percentage by volume of pigment plus nonvolatile vehicle (see glossary).

(a) COMPOSITION BY WEIGHT AND BY VOLUME

To describe a method of converting weight to volume or volume to weight assume:

A = percentage by weight of volatile vehicle
a = bulking value of volatile vehicle
B = percentage by weight of nonvolatile vehicle
b = bulking value of nonvolatile vehicle
C = percentage by weight of pigment
c = bulking value of pigment
D = weight in pounds of 1 gal of total mixture
$1/D$ = bulking value of total mixture.

One hundred pounds of the mixture has a total volume of $Aa + Bb + Cc$ gallons; the bulking value of the mixture is $(Aa + Bb + Cc)/100 = 1/D$ and the percentages by volume of the constituents are

$\frac{100\,Aa}{D}$ or $\frac{100\,Aa}{Aa+Bb+Cc}$ = E percent by volume of volatile vehicle

$\frac{100\,Bb}{Aa+Bb+Cc}$ or $\frac{100\,Bb}{D}$ = F percent by volume of nonvolatile vehicle

$\frac{100\,Cc}{Aa+Bb+Cc}$ or $\frac{100\,Cc}{D}$ = G percent by volume of pigment.

If the percentage by weight or by volume of any two of the three components is known, the percentage of the third

is the sum of the two known percentages subtracted from 100. Thus:

$$100-(A+B)=C \qquad 100-(E+F)=G$$
$$100-(B+C)=A \qquad 100-(F+G)=E$$
$$100-(A+C)=B \qquad 100-(E+G)=F$$

(b) BASIC SPECIFICATIONS

Basic specifications are prepared for use where the normal supply of raw materials is available. It will be noted that some basic specifications stress detailed requirements for chemical composition (exterior house paints, for example), whereas others emphasize requirements based on physical and performance tests (interior paints and varnishes, for example).

(c) AMENDMENTS TO BASIC SPECIFICATIONS

Amendments to basic specifications are for the purpose of incorporating slight changes due to experience, or improvements in material covered by the specifications; war emergency amendments, indicated by an asterisk (*) on the first page of the specification, were intended to conserve strategic or critical war materials and replace those that were not available because of the war emergency. The use of an asterisk for the same purpose is also indicated in this manual.

2. LIQUIDS NOT GENERALLY USED ALONE

Liquids form the vehicle (see glossary) portion of paints. In general, liquids should be purchased by volume, the unit being 1 U. S. gal, 231 cu in. at 60° F. For large deliveries, it is suggested that the weight in pounds per gallon at 60° F and the net weight of the delivery be determined. The volume can then be obtained by dividing the net weight by the weight per gallon.

(a) Oil; Linseed, Raw
JJJ–O–336, Apr. 28, 1931
Amendment 2, May 28, 1943

Oil; Linseed, Boiled
JJJ–O–331, May 26, 1931
Amendment 2, May 28, 1943

Linseed oil is the most important of the drying oils (see glossary); a drying oil being one that changes to a relatively

hard, tough, elastic substance when exposed in a thin film to the air.

Raw linseed oil is the material from which boiled and refined linseed oils are made and is the most important of the liquids used for mixing paint on the job. The quality of raw linseed oil is probably more influenced by the presence of "foots" (the mucilaginous matter that settles to the bottom of a container) than by other deviations from the specifications. Paint made with oil containing considerable foots, but otherwise of high quality, is liable to dry very slowly and may easily be washed off long after it appears to be dry. As foots gradually settle, clear oil from the upper portion of the container may be drawn off.

It is necessary to use a drier with raw linseed oil; the amount varies, but usually for white or very light-tinted paint, 1 part of drier to 19 parts of oil is satisfactory. Dark-colored or black paint may require more drier than lighter colors.

Raw linseed oil dries too slowly for most purposes. Thus, as has just been stated, driers are added to the oil to accelerate the rate of drying. Instead of adding driers to raw linseed oil at room temperature, another method is to heat the oil in combination with compounds of lead, manganese, and cobalt. By using heat, these compounds dissolve in the hot oil, and the oil thickens slightly and becomes somewhat darker in color. This results in a product known as boiled linseed oil. The term "boiled" is a misnomer, as, in heating the oil, it is not actually boiled. Boiled linseed oil is frequently recommended for priming coats of paint intended for use on plaster, cement, and brick. A mixture of raw and boiled oils is often used in priming paints for structural steel. A blend of good raw oil and drier may be substituted for boiled oil.

(b) Soybean Oil; Refined
JJJ–O–348, June 25, 1942

Soybean oil is used largely in edible products rather than in paint. It is slower drying than linseed oil and generally is used in combination with faster drying oils, such as tung, perilla, or linseed oils. Its main uses are in varnish vehicles for interior paints and enamels, because paints made with soybean oil do not yellow as much as many other oils. Likewise, it is used in some of the best interior, architectural,

white enamels (see glossary) based on synthetic resins (see glossary) of the alkyd type. The type of oil known to the trade as "mechanically refined nonbreak" should comply with Federal Specification JJJ–O–348.

(c) Tung, China Wood Oil; Raw
JJJ–O–353, Dec. 10, 1943

Tung oil is one of the chief oils used in the manufacture of fast-drying, waterproof oil varnishes (see glossary). The most important characteristics for identification of tung oil are its high specific gravity and high refractive index. Raw tung oil dries rapidly but not to a smooth film, and is not used as such in exterior house paints where linseed oil is almost universally used. Some tung oil prepared by heat-treating the raw oil so as to overcome its defects, is used in house paints. However, the great use of this oil is in the manufacture of oil varnishes used as such, and in varnishes and liquids for the manufacture of interior paints, floor and deck enamels, water-resisting enamels, and in other specialized finishes.

(d) Turpentine; Gum Spirits and Wood (Steam-Distilled and Sulfate), (for) Paint
LLL–T–791b, July 12, 1941

Turpentine; Wood (Destructively-Distilled) (for) Paint
LLL–T–792a, July 12, 1941

The basis of purchase of turpentine (section E–9a in the Federal Specifications) provides for purchase by: (a) volume, 231 cu in. to the gallon at 70° F, or (b) weight, 7.12 to 7.25 lb/gal. When purchases are made by weight, quotations should be by the pound or by the hundred pounds, and the request for bids should state whether quotations are by the gallon, pound, or hundred pounds. Section I–3 in the specifications states that nothing contained therein should be construed to exempt the seller from compliance with the Federal Naval Stores Act or any other law applicable to the selling of turpentine.

Turpentine is one of the oldest and most widely used volatile thinners for oil paints and for oleoresinous varnishes. However, in prepared paints, volatile thinners derived from petroleum and having the general characteristics

of turpentine are used to a considerable extent. Destructively distilled wood turpentine, used in the manufacture of paint and varnish, is a good solvent, and, in general, can be used in place of gum spirits or wood turpentine with good results. A sample for odor should be specified before making purchases under Federal Specification LLL–T–792a. At present, the amount of turpentine available is inadequate to meet the demands of the paint and varnish industry. It is preferred by the painter because it is not likely to cause varnishes or paints to thicken or gel when diluted with it. The characteristic odor makes turpentine easily identified.

(e) Thinner; Paint, Volatile Mineral Spirits
TT–T–291a, July 26, 1945

Volatile mineral spirits should be purchased by volume, 231 cu in. to the gallon. The basis of purchase for mineral spirits is given in detail in paragraph F–4a of the Federal Specification.

Federal Specification TT–T–291 covers a petroleum distillate known as mineral spirits or petroleum spirits; it evaporates at about the same rate as turpentine and is frequently used in its stead for thinning oil paints. It distills between kerosine and V.M. & P. (Varnish Makers and Painters) naphtha. Chemically, it is a mixture of aliphatic, naphthenic, and aromatic (see glossary) hydrocarbons. It should evaporate completely from the film during the drying period; otherwise, heavy ends, which do not evaporate, may hinder drying or prevent drying of the paint to a satisfactory film. Its weight per gallon varies considerably, but an average figure is about 6½ lb. Some varnishes may not be entirely miscible with mineral spirits. Because of the present limited production of turpentine, it is advisable to use other thinners whenever possible; in many cases, mineral spirits are entirely satisfactory as a substitute for turpentine, and in almost all cases can replace at least a part of the turpentine.

(f) Drier; Paint, Liquid
TT–D–651a, Aug 28, 1942

Two types of liquid drier are covered in Federal Specification TT–D–651a. Driers consist of metallic soaps or salts of organic acids dispersed in suitable media thinned to a liquid with petroleum spirits, turpentine, or a mixture

thereof, and are for use in paints or similar finishing materials. Resinates, linoleates, and naphthenates are permitted. Type I driers call for both lead and manganese and may also contain cobalt or any other drying metal; type I driers are intended for general use, the minimum percentages of lead and manganese representing the normal amounts required for use with raw linseed oil in the ratio of 1 volume of liquid drier (see glossary) to 19 volumes of oil. Type II driers should be free from lead, contain not less than 0.6 percent of cobalt, and be used where lead-free driers are necessary. Both driers are much like short-oil thin varnishes, except for their larger content of drying metals. The specification limits the total nonvolatile matter to not more than 30 percent by weight. The addition of insufficient drier to a paint results in the paint drying too slowly; the addition of too much drier may also cause the paint to dry too slowly or may produce other undesirable results, such as wrinkling of the film. A good rule is to use the minimum amount of drier consistent with the drying rate required of the paint.

(g) Thinner; Lacquer TT–T–266, Apr. 20, 1942

Federal Specification TT–T–266 covers a volatile thinner intended for use in connection with spraying lacquer conforming to Federal Specification TT–L–58. Material meeting this specification will weigh from 6.83 to 7.16 lb/gal at 15.5° C (60° F) and should be purchased by volume, 231 cu in. to the gallon. A typical formula for a lacquer thinner is as follows:

	Weight *Percent*
Butyl acetate	20
Butyl alcohol	10
Ethyl acetate	10
Petroleum naphtha	15
Toluene	45
Total	100

(h) Oil; Flatting and Mixing (for Thinning White-Lead-Paste and Similar Paste Paints) TT–O–356a, Aug. 30, 1943

Class 1, Flatting Oil.—This is a complete vehicle for thinning white-lead paste and similar paste paints and is

composed of processed drying oils and drier, thinned with turpentine, mineral spirits, or a mixture thereof; when added to white-lead paste and similar paste paints, it produces flat, washable, interior finishes for use on plaster, wood, wallboard, and fabric surfaces. A flat finish may be obtained by adding 2 or 3 gal of flatting oil to 100 lb of white-lead paste. New plaster and wood should be primed in the usual manner before applying the flat-finished coat. Flatting oil is also used as a vehicle for glaze colors on plaster by mixing some of the oil with colors-in-oil, such as umber, sienna, and Van Dyke brown.

Flatting oils weigh about 7 lb/gal at 60° F.

CLASS 2, MIXING OIL.—This is also a complete vehicle for thinning white-lead paste and similar paste paints, and is composed of processed drying oils with or without resins, driers, turpentine, and mineral spirits. It is used for finish-coat paint for exterior surfaces where low-gloss or eggshell finishes are desired and for interior decoration where finishes having a gloss higher than those obtainable with class 1, flatting oil, are desired. Mixing oil may be used in the proportion of 3 gal of mixing oil to each 100 lb of white-lead paste.

The average weight of mixing oil is 7 lb/gal.

(i) Oil; Linseed-Replacement (for Thinning Paints and Pastes-in-Oil)
TT–O–371, May 1, 1943
Amendment 2, March 17, 1944

Linseed-replacement oil should be purchased by volume, 231 cu in. to the gallon. The weight of 1 U. S. gal of this material at 60° F varies slightly, but generally it will fall within the range of 7.3 to 7.5 lb/gal.

Linseed-replacement oil is a mixing or thinning oil blended before packaging and is used widely in thinning paste white lead on the job and ready-prepared paints. The material is a replacement for either raw linseed oil, thinner, and drier or for boiled linseed oil and thinner. Although linseed-replacement oil was prepared during the war period and was designed to aid in the conservation of linseed oil, it should not be considered as a mere substitute for linseed oil. The replacement oil contains heat-bodied

linseed oil, and some paint experts consider that the presence of this oil makes the replacement oil actually superior to ordinary raw or boiled linseed oil, both in toughness and water resistance.

In many war emergency amendments to Federal Specifications for oil paints, the vehicle specified is intended to conserve linseed oil. For example, the amendment to Federal Specification TT–P–40 provides a vehicle specified in Federal Specification TT–O–371 for Linseed-Replacement Oil, except that the requirements for appearance, color, and viscosity (see glossary) are waived. This can be accomplished by using a vehicle that may consist of 35 percent by weight of thinner and drier and 65 percent by weight of oil composed of 3 parts of raw or alkali-refined (see glossary) linseed oil and 2 parts of Z-2 pale heat-bodied linseed oil. The amendment requires that some heat-bodied oil be present but does not limit the amount or kind. Heat-bodied oil used in replacement oil should be bodied at low temperatures and should have an acid number (see glossary) of not more than 8, based on total solids. In all exterior paints except black and graphite, the pounds of oil per gallon must be not more than 3.75 (to meet War Production Board Order M–332* as amended April 12, 1944, the purpose of which is to conserve the supply of domestic linseed oil). Normally these paints contain about 5 lb of oil per gallon.

Amendment 2 of Federal Specification TT–O–371 provides for two types of linseed-replacement oil: type I, with driers added, and type II, without driers.

Type I is for thinning paints or pastes, mixed on the job, which require a drying type of thinning liquid; type II is for thinning ready-mixed paints or pastes that already contain sufficient drier. Neither type is intended to produce flat paints.

The attention of paint users is directed to National Bureau of Standards Letter Circular LC717, Conservation of Linseed Oil in Paint, a copy of which may be obtained free of charge from the National Bureau of Standards, Washington 25, D. C.

The formulas given in table 1 involve the mixing of paste white lead with linseed-replacement oil [1].[1]

* This order was revoked on Aug. 31, 1945.

[1] Figures in brackets indicate the literature references at the end of this paper.

TABLE 1.—*Linseed-replacement oil formulas for reducing paste white lead to paint*

Type of work	Coat	Soft-paste white lead	Linseed-replacement oil	Pure turpentine	Flatting oil	Yield	Coverage (spreading rate) per gallon
		lb	*gal*	*gal*	*gal*	*gal*	*ft²*
New exterior wood (three coats)	Priming coat	100	4	2	.....	9¼	600
	Second coat	100	1½	1½	.....	6¼	700
	Gloss finish	100	3¼	.....	.....	6½	700
New exterior wood (two coats)	Priming coat[1]	100	2¾	.....	.....	6	500
	Gloss finish	100	3¼	.....	.....	6½	700
Repainting wood exterior	First coat	100	2	2	.....	7¼	700
	Gloss finish	100	3¼	.....	.....	6½	700
Exterior concrete, stucco, and asbestos cement shingles	Priming coat	100	5	.....	.....	8¼	200
	Second coat	100	2	1	.....	6¼	400
	Gloss finish	100	3¼	.....	.....	6½	500
	Semigloss finish.	100	1	.....	2	6¼	500
Exterior brick common	Priming coat	100	5	¾	.....	9	200
	Second coat	100	3	1	.....	7¼	400
	Gloss finish	100	3¼	.....	.....	6½	500
	Semigloss finish.	100	1	.....	2	6¼	500
Repainting brick, stucco, concrete and asbestos shingles	First coat	100	2	1	.....	6¼	400
	Gloss finish	100	3¼	.....	.....	6½	500
	Semigloss finish.	100	1	.....	2	6¼	500
Unpainted interior, plaster and wallboard	Priming coat	100	5	.....	.....	8¼	600
	Second coat	100	2	.....	1	6¼	800
	Flat finish	100	.....	.....	2	5¼	800
Unpainted interior, plaster and wallboard (2 coats)	Priming coat						
	Flat finish	100	4	.....	.....	7¼	600
		100	.....	.....	2	5¼	800
Repainting interior, plaster and wallboard	First coat	100	2	.....	1	6¼	800
	Flat finish	100	.....	.....	2	5¼	800

[1] Add ⅛ pint of raw umber in oil to this formula.

3. PIGMENTS

Pigments form the solid portion of paint and are practically insoluble in the vehicle or liquid portion. The following section describes the various pigments, including white, black, colored, and metallic aluminum, covered by Federal Specifications:

(a) White Lead; Basic-Carbonate, Dry, Paste-in-Oil, and Semipaste containing Volatile Thinner
TT–W–251b, May 30, 1945

White Lead; Basic-Sulfate, Dry and Paste-in-Oil
TT–W–261a, Oct. 25, 1937
Amendment 2, Sept. 6, 1943

White lead, a component of almost all white and light-colored paints, is one of the most important white paint pigments. Both kinds, basic-carbonate and basic-sulfate, are frequently used in ready-mixed paints. For paint mixed on the job, paste-in-oil is used, whereas the dry pigment is used by the paint manufacturer. The term "white lead" paste is used to designate the usual paste white lead composed of about 91 percent of basic-carbonate white lead and 9 percent of linseed oil, or 89 percent of basic-carbonate white lead, 2 percent of turpentine, and 9 percent of linseed oil. When referring to white lead in ready-mixed paint, the term may mean either basic-carbonate white lead or basic-sulfate white lead; this latter material is used to a large extent in commercially prepared, exterior, ready-mixed paints.

There are two types of commercial white-lead paste—heavy paste and soft paste. Type B, paste-in-oil, is a heavy-paste white lead. Type C is a soft, or semipaste, of recent development and is similar to the heavy paste, except for the addition of a small amount (about 2 percent) of turpentine. It is more easily removed from the container and mixed with vehicle than type B and thus is preferred to type B by most users.

One hundred pounds of either type of paste approximates 3¼ gal. One gallon weighs about 30 lb. As there has been some tendency in the past to add too much linseed oil to white-lead paste, it is suggested that tables 2, 3, and 4 be consulted for the correct proportions. National Bureau of

Standards Letter Circular LC717, mentioned in connection with linseed-replacement oil, gives additional details on this point.

Instead of mixing white-lead paint on the job with a combination of several materials such as liquid drier, turpentine, and linseed oil, it may be easier to use a single liquid, such as: Oil: Linseed-Replacement (Fed. Spec. TT–O–371), or Oil: Flatting and Mixing, (Fed. Spec. TT–O–356a). This is illustrated in tables 1 and 5.

TABLE 2.—*Painting exterior new wood (3 coats), using ordinary linseed oil and white-lead paste*

[Mixed-on-the-job formulas]

Materials	Formulas		
	Priming coat	Body coat	Finish coat
White lead, semipaste (TT-W-251b, type C)..... *lb*	100	100	100[1]
Raw linseed oil (JJJ–0–336)..... *gal*	4	1½	3¼[2]
Turpentine (LLL–T–791b)[3] or mineral spirits (TT–T–291a)..... *gal*	2	1½	----------
Liquid drier (TT–D–651a)..... *pt*	1	1	1
Quantity of paint produced..... *gal*	9⅜	6⅜	6⅝

[1] For the finish coat, some users may want a lead-zinc paint. In this case, use 75 lb of the white-lead paste and 25 lb of zinc-oxide paste (TT–Z–301).

[2] For a harder film, the linseed oil may be reduced to as low as 2¼ gal. In this case, 2 to 3 pt of turpentine should be added.

[3] For priming wood, turpentine is preferred by some painters.

TABLE 3.—*Painting exterior new wood (2 coats), using ordinary linseed oil and white-lead paste*

[Mixed-on-the-job formulas]

Materials	Formulas		
	Priming coat	Finish coat (1)	Finish coat (2)[1]
White lead semipaste (TT–W–251b, type C)..... *lb*	100	100	100
Raw linseed oil (JJJ–0–336)..... *gal*	1½	3¼	2⅜
Turpentine (LLL–T–791b)[2] or mineral spirits (TT–T–291a)..... *gal*	½	----------	⅜
Liquid drier (TT–D–651a)..... *pt*	1	1	1
Raw umber-in-oil (TT–P–381)..... *pt*	¼	----------	----------
Spar varnish (TT–V–121b)..... *gal*	¾	----------	----------
Quantity of paint produced..... *gal*	6⅛	6⅜	6⅜

[1] Alternate finish-coat formula (2) meets Federal Housing Authority requirements and gives a harder film than formula (1).

[2] For priming wood, turpentine is preferred by some painters.

TABLE 4.—*Repainting exterior wood (2 coats), using ordinary linseed oil and white-lead paste*

[Mixed-on-the-job formulas]

Materials	Formulas	
	Priming coat	Finish coat
White-lead, semipaste (TT-W-251b, type C) *lb.*	100	100
Raw linseed oil (JJJ-0-336) *gal.*	2	3¼
Turpentine (LLL-T-791b) or mineral spirits (TT-T-291a) *gal.*	2	
Liquid drier (TT-D-651a) *pt.*	1	1
Quantity of paint produced *gal.*	7⅜	6⅝

TABLE 5.—*Painting interior plaster, wallboard, and wood (3 coats), using white-lead paste*

[Mixed-on-the-job formulas]

Materials	Priming coat	Body coat	Finish coat	Finish coat, semigloss
FORMULAS				
White lead, semipaste (TT-W-251b, type C) *lb.*	100	100	100	50
Mixing oil (TT-0-356a, class 2) *gal.*	4 to 5	3 to 4	3 to 4	1½
Wall primer (TT-P-56) *gal.*				3
Quantity of paint produced *gal.*	7¼ to 8¼	6¼ to 7¼	6¼ to 7¼	6
ALTERNATE FORMULAS				
White-lead, semipaste (TT-W-251b, type C) *lb.*	100	100	100	100
Raw linseed oil (JJJ-0-336) *gal.*	3			
Turpentine (LLL-T-791b) or mineral spirits (TT-T-291a) *gal.*	1¼	1½	1¾	1½
Varnish (TT-V-71a) *gal.*	2	¾	⅛	1½
Liquid drier (TT-D-651a) *pt.*	1	½	½	¼
Quantity of paint produced *gal.*	9⅝	5½	5⅛	6¼

An easy way to mix white-lead paint, when scales and weights are not available, is to measure the materials by volume. This plan is illustrated in figure 1 [2].

(b) Zinc-Oxide; Dry and Paste-in-Oil
TT–Z–301, Mar 31, 1931
Zinc-Oxide; Leaded, Dry and Paste-in-Oil
TT–Z–321, June 23, 1931

Zinc oxide (see glossary) with varying properties is made from ore (American process) or from spelter (French

FIGURE 1.—*Volume-mixing directions for soft-paste white lead TT–W–251b.*

process). Made by either process, it may differ in color and oil absorption. Hence, a purchaser should have an agreed-upon sample for color, color strength, and oil absorption. Zinc oxide alone with linseed oil gives a paint that chalks less readily than most other linseed-oil paints (see glossary) but dries to a hard film that tends to check and crack. It is added to the chalking type of pigments to harden the film, to help retain the color of light tints, and to retard the formation of mildew. Paints mixed-on-the-job may contain either zinc-oxide or low-leaded zinc-oxide (see glossary) pastes-in-oil. In general, not more than 1 lb of either type of zinc-oxide paste-in-oil should be used with 3 lb of white-lead paste or semipaste.

By weight, an average zinc-oxide paste-in-oil meeting the specification contains 83 percent of pigment and 17 percent of oil; by volume, 44 percent of pigment and 56 percent of oil; and 1 gal weighs about 25 lb.

(c) Red Lead; Dry and Paste-in-Oil
TT–R–191a, July 5, 1938
Amendment 2, May 28, 1943

Red lead is used in paint for priming iron and steel surfaces. Federal Specification TT–R–191a covers two types and three grades as follows:

TYPE I, DRY	TYPE II, PASTE-IN-OIL
Grade A.....85 percent.	Grade B.....95 percent.
Grade B.....95 percent.	Grade C.....97 percent.
Grade C.....97 percent.	

Type I, dry red lead, may vary somewhat in specific gravity, becoming slightly lighter as the true red lead increases. Grades A, B, and C have a specific gravity of about 8.9, and 1 gal of dry red lead weighs about 74 lb with a bulking value of about 0.0135 gal/lb.

Type II, paste-in-oil, has an average specific gravity of 5.37 and shows an average weight per gallon of about 45 lb. Formulas for mixing red-lead paints on the job are given in tables 6 and 8. The priming paint in table 6 weighs 25 lb/gal and has a PV of 30. The formulas given in table 8 produce paints that have a PV of 36 and dry somewhat harder and with less gloss, and allow recoating earlier than paints whose vehicle is high in oil (as in table 6).

TABLE 6.—*Painting iron and steel (exposed to the weather), using red lead and ordinary linseed oil*

Materials	Formulas (mixed-on-the-job)		For the finish coat, any of the following Federal Specification ready-mixed paints may be used—
	Priming coat	Body coat	
Red lead paste (TT-R-191, types B or C)---------- *lb*--	100	100	TT-P-31a (red or brown).
Raw linseed oil[1] (JJJ-0-336)---------*gal*--	1⅞	1⅞	TT-P-40 (white, gray, etc.).
Turpentine (LLL-T-791b) or mineral spirits (TT-T-291a)---------- *pt*--	1½	1½	TT-P-6la (black). TT-P-7la (green).
Liquid drier (TT-D-651a)---------- *pt*--	1½	1½	
Lampblack-in-oil (TT-P-381)-------- *pt*--	----------	¾	
Quantity of paint produced---------*gal*--	4½	4⅝	

[1] If boiled linseed oil (JJJ-0-331) is used, omit drier, and the oil may be increased to 2 gal.

TABLE 7.—*Painting iron and steel (exposed to the weather), using blue lead and ordinary linseed oil*

Materials	Formulas (mixed-on-the-job)		For the finish coat, any of the following Federal Specification ready-mixed paints may be used—
	Priming coat	Body coat	
Blue lead paste (TT-B-486, type B). *lb*--	100	100	TT-P-31a (red or brown).
Boiled linseed oil[1] (JJJ-0-331)-------*gal*--	2¾	2¾	TT-P-40 (white, gray, etc.).
Turpentine (LLL-T-791b) or mineral spirits (TT-T-291a)---------- *pt*--	2	2	TT-P-61a (black). TT-P-71a (green).
Liquid drier (TT-D-651a)---------- *pt*--	1	1	
Lampblack-in-oil (TT-P-381)-------- *pt*--	----------	¾	
Quantity of paint produced---------*gal*--	6¼	6⅜	

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

(d) Blue-Lead; Basic Sulfate, Dry and Paste-in-Oil
TT–B–486, Oct. 2, 1934
Amendment 1, May 28, 1943

Blue lead is a slate-gray sublimed pigment that contains approximately 75 percent of basic-lead sulfate and generally more than 20 percent of other lead compounds. Blue-lead oil paints brush easily and are durable for priming structural steel. Blue lead is also used in special vehicles designed for marine use.

Type A, dry pigment, is a blue basic-lead sulfate useful in the manufacture of type B, paste-in-oil, or ready-mixed

TABLE 8.—*Painting iron or steel (exposed to the weather), using red or blue lead and linseed-replacement oil*

Materials	Formulas (mixed-on-the-job)		For the finish coat, any of the following Federal Specification ready-mixed paints may be used—
	Priming coat	Body coat	
RED LEAD			
Red lead paste (TT–R–191a, types B or C)—*lb*	100	100	TT–P–31a (red or brown).
Turpentine (LLL–T–791b) or mineral spirits (TT–T–291a)—*gal*	½	½	TT–P–40 (white, gray, etc.).
Linseed-replacement oil (TT–O–371)—*gal*	2	2	TT–P–61a (black).
Lampblack paste (TT–P–381)—*pt*		¾	TT–P–71a (green).
Quantity of paint produced—*gal*	4¾	4⅞	
BLUE LEAD			
Blue lead paste (TT–B–486, type B). *lb*	100	100	TT–P–31a (red or brown).
Turpentine (LLL–T–791b) or mineral spirits (TT–T–291a)—*gal*	½	½	TT–P–40 (white, gray, etc.).
Linseed-replacement oil (TT–O–371). *gal*	2¾	2¾	TT–P–61a (black).
Lampblack paste (TT–P–381)—*pt*		¾	TT–P–71a (green).
Quantity of paint produced—*gal*	6⅞	6½	

paint, as described in Federal Specification TT–P–20. One gallon of dry blue lead weighs about 57 lb.

Type B, paste-in-oil, is used for blue-lead paint to be mixed on the job. One gallon of the paste-in-oil weighs about 30 lb. Formulas for mixing blue-lead paint on the job are given in tables 7 and 8. The formulas for priming coats in table 7 produce paint weighing about 20 lb/gal and having a PV of 29. The formula for priming coat in table 8 produces a paint weighing about 19 lb/gal and having a PV of 34. This formula gives a paint that dries harder and with less gloss and allows recoating earlier than a paint whose vehicle is high in oil (as in table 7).

(e) Aluminum Pigment Powder and Paste (for) Paint TT–A–468, Mar. 6, 1942

Aluminum pigment is largely pure metallic aluminum and contains appreciable amounts of "polishing lubricant," a mixture of stearic and other fatty acids. The total amount

of the combined and uncombined fatty matter varies from less than 1 percent by weight to not more than 4 percent. This specification covers two types and two classes of aluminum pigment:

Type I.—Aluminum-pigment powder.
Class A.—For general paint use.
Class B.—For special finishes.

Type II.—Aluminum-pigment paste.
Class A.—For general paint use.
Class B.—For special finishes.

Aluminum-pigment paste weighs about 12.4 lb/gal.

Class A aluminum-pigment powder is known commercially as Standard Varnish Grade. Class B aluminum-pigment powder is finer than class A and is known in the trade as Extra Fine Lining Grade.

Formulas for mixing aluminum paint on the job are given in table 9.

TABLE 9.—*Aluminum paint*
[Mixed-on-the-job formulas]

Purpose	Mixing formulas			
	Aluminum		Varnish	
		lb		*gal*
Priming coat on exterior wood.	TT-A-468, class A, paste	2	TT-V-81a, type I, class B	1
Do	TT-A-468, class A, powder	1½	TT-V-81a, type I, class A	1
Body coat on exterior steel[1]	TT-A-468, class A, paste	[2]1¾	TT-V-81a, type II, class B	1
Finish coat on exterior steel	TT-A-468, class A, paste	2	TT-V-81a, type II, class B	1
Do	TT-A-468, class A, powder	2	TT-V-81a, type II, class A	1
Finish coat on interior steel	TT-A-468, class A, paste	2	TT-V-71a	1
Do	TT-A-468, class A, powder	2	TT-V-71a	1
Special finishes having maximum smoothness.	TT-A-468, class B, paste	1¼	TT-V-81a, class B	1
Do	TT-A-468, class B, powder	¾	TT-V-81a, class A	1
Sealing coat to prevent bleeding of stains.	TT-A-468, class A, paste	2½	TT-V-71a[3]	1

[1] Aluminum is not recommended as a priming coat for steel.
[2] The addition of ¼ lb of iron-blue paste (TT-P-381) is recommended.
[3] The addition of ½ pt of mineral spirits (TT-T-291a) is recommended.

In purchasing aluminum paste or powder, it is advisable that the material should match a mutually-agreed-upon sample for smoothness, luster, and appearance. Both

powder and paste mix easily with long-oil (see glossary) varnish, such as described in Federal Specification TT–V–81a. In general, the amount of aluminum pigment in the completed paints is less than 20 percent by weight and 8¾ percent by volume. The PV is less than 18. An average mixing formula is 2 lb of class A aluminum powder or paste to 1 gal of mixing varnish.

(f) Pigments; Colors-in-Oil (for) Paint TT–P–381, July 27, 1944

The colors-in-oil listed in Federal Specification TT–P–381 are pigments ground in a vehicle of about 80 percent linseed oil and 20 percent volatile solvent, with a small amount of wetting or dispersing agent to form paste of a consistency that will flow from the containers.

TABLE 10.—*Characteristics of colors-in-oil for paint*

Colors	Federal specification for pigment content	Weight per U.S. gallon (pounds)	Pigment (percentage by weight) minimum
Blacks:			
Color 1A—bone black	TT–B–600	10.8	51
Color 1B—carbon black, high-color	TT–C–120, class A	7.9	10
Color 1C—carbon black, standard all-purpose	TT–C–120, class B	7.9	10
Color 1D—lampblack	TT–L–70	8.7	28
Blues:			
Color 2A—iron-blue	TT–I–677	9.9	48
Color 2B—ultramarine-blue	TT–U–450	13.2	70
Browns:			
Color 3A—metallic brown	TT–M–251	17.9	75
Color 3B—sienna, burnt	TT–S–346	12.7	55
Color 3C—umber, burnt	TT–U–481	12.8	55
Color 3D—umber, raw	TT–U–481	12.4	55
Greens:			
Color 4A—chrome green	TT–C–235	16.4	70
Color 4B—chromium-oxide-green	TT–C–306	19.6	75
Oranges:			
Color 5A—chrome orange, dark	TT–C–290, type V	23.9	79
Color 5B—chrome orange, light	TT–C–290, type IV	23.9	79
Reds:			
Color 6A—iron-oxide, bright-red	TT–I–511, type II	21.9	80
Color 6B—indian-red	TT–I–511, type I	21.9	80
Color 6C—mineral red	TT–M–381	18.1	75
Color 6D—toluidine	TT–T–562	9.1	47
Color 6E—venetian	TT–V–226	16.5	76
Yellows:			
Color 7A—chrome-yellow, lemon	TT–C–290, type II	20.6	75
Color 7B—chrome-yellow, medium	TT–C–290, type III	20.6	75
Color 7C—chrome-yellow, primrose	TT–C–290, type I	20.6	75
Color 7D—ocher	TT–O–121	14.7	70
Color 7E—sienna, raw	TT–S–346	12.3	55
Color 7F—yellow-iron-oxide	TT–Y–216	13.9	60

Table 10, column 1, gives the names of these colors. Column 2 refers to Federal Specifications for content of dry pigment. Column 3 gives approximate weight in pounds per United States gallon of the soft paste conforming to the specification, and column 4 gives the minimum percentage by weight of pigment in the soft paste.

Following are the intended uses of the various pigments-in-oil described in table 10:

BLACKS.—This group covers four black pigments used for tinting and solid colors:—boneblack; high-color carbon black, all-purpose carbon black, and lampblack. Carbon black and lampblack are stronger than boneblack in tinting strength, and lampblack is most frequently used. Boneblack and carbon black are blacker than lampblack. All these color pastes produce paints suitable for "trim colors" (see glossary) by thinning the paste to brushing consistency with a vehicle composed of 3 parts of linseed oil, 1 part of spar varnish (see glossary), and ½ part of liquid drier, by volume.

Synthetic black iron oxide (not included as a color-in-oil in the above list) is a black pigment covered by Federal Specification TT–I–698. This pigment consists of oxides of iron, and has a specific gravity of about 4.7. It is used in black metal protective paints, and for tinting and blending purposes.

BLUES.—This group covers two blue pigments—iron blue (also called Prussian blue) and ultramarine blue. Iron blue has a relatively low specific gravity and high bulk and is stronger than ultramarine blue. For tints, iron blue is very susceptible to the action of alkalies, however weak, whereas ultramarine blue is not affected by alkalies but is affected even by weak acids. Although both colors, in either tints or solid colors, have fair permanency when exposed to the weather, a newer blue pigment known as copper-phthalocyanine blue is more durable, in light or "shutter blue" tints. Federal Specification TT–C–610 covers this newer pigment.

BROWNS.—This group covers four brown pigments: metallic brown, burnt sienna, burnt umber, and raw umber. Metallic brown is adaptable as a trim color, but is used more as a solid paint and is durable for painting barns, tin roofs, and freight cars. The other brown pigments are suitable for tinting purposes and for stains. They are among the most durable when exposed to the weather.

Another brown pigment (not included as a color-in-oil in the above list) is synthetic brown iron oxide covered by Federal Specification TT–I–702. This pigment consists of oxides of iron and has a specific gravity of about 4.5. It is used in various types of paints and enamels.

GREENS.—This group covers two green pigments: chrome green and chromium-oxide green. Chrome green consists of a mixture of two pigments, chrome yellow and iron blue; it covers a variety of light, medium, and dark chrome greens used both for tinting purposes and for solid trim colors. Chrome greens are brighter and stronger than chromium-oxide greens, but they are not as permanent and are sensitive to alkalies. Chromium-oxide green consists of a single pigment, chromium oxide, and is used with white for tinting purposes to give soft, gray-green tints; for trim purposes as a durable, solid color; and for tinted bridge paints. It is somewhat weaker in tinting strength and lower in hiding power than chrome green, but is more permanent; it will withstand high temperatures and is unaffected by alkalies and acids.

ORANGES.—This group covers two shades of chrome orange that may be used for tinting and for solid or trim colors. They are relatively permanent when exposed to the weather. The pigment is a basic lead chromate obtainable in shades designated as light and dark, the latter shade known as International Orange.

REDS.—This group covers five red pigments: bright-red iron oxide, Indian red, mineral red, toluidine red, and Venetian red. With the exception of toluidine, these red pigments may be used for tinting purposes. Bright-red iron oxide and Indian red are used in all types of paints, enamels, and stains, and are quite permanent; mineral red and Venetian red are widely used for exterior barn and roof paints; toluidine red, a bright, organic red, is permanent when exposed to the weather but is not permanent in a light tint, such as pink, when used outdoors.

YELLOWS.—This group includes a variety of yellow pigments:—lemon chrome yellow, medium chrome yellow, primrose chrome yellow, yellow ocher, raw sienna, and yellow iron oxide. For tinting purposes, the chrome yellows are suitable for outside use. One pound of medium chrome yellow added to 50 lb of white-lead paste gives a "yellow-ivory" shade. This color may also be used as a solid or trim color paint, following the thinning suggestion in paragraph

I-4a, Federal Specification TT–P–381. For tinting purposes, yellow ocher is a durable outdoor shade; one pound of the paste added to 50 lb of white-lead paste gives a "chamois" tint. Raw sienna is used more widely for tinting and staining purposes than for solid or trim color. When mixed with whites, it gives tints classed as ivory and light buff. These tints prove durable when exposed to the weather. Yellow iron oxides are used for both tinting and solid colors, particularly in floor enamels. They cover a variety of shades and on reduction with whites give cream, ivory, and buff tints. They are much stronger than the yellow ochers. Another yellow pigment, zinc yellow, is used to some extent as a color pigment, but its main use is a rust-

TABLE 11.—*Identification of widely used tints made by tinting 100 pounds of paste white lead with Federal Specification TT-P-381, Pigments-in-Oil; Paint Colors*

[This information is merely as a guide.]

Color	Pigment	Maerz and Paul number[1]	Munsell number[2]	Name ISCC–NBS[3]	Formula (based on 100 pounds of white lead)
Blacks	Lampblack	37–A–2	9.0Y5.6/0.2	Medium gray	¼ pt.
Blues	Iron blue	37–K–5	1.6B3.8/4.2	Moderate greenish blue.	½ pt.
	Ultramarine blue	35–G–2	9.5BG6.7/2.0	Pale blue	1 pt.
	Sienna, burnt	5–B–11	3.0YR4.4/5.2	Moderate brown	1 pt.
Browns	Umber, burnt	14–D–6	0.5Y4.8/3.0	Pale brown to medium yellowish brown.	1 pt.
	Umber, raw	12–C–2	5.8Y6.6/2.8	Weak yellow	1 pt.
Greens	Chrome green (medium)	20–A–8	2.5G5.0/3.9	Weak yellowish green to medium green.	1 pt.
	Chromium oxide	21–A–4	7.0GY5.6/1.6	Weak yellow-green.	¾ pt.
Oranges	Chrome orange (dark)	9–C–6	6.2YR7.8/6.2	Pale orange	¼ pt.
Reds	Indian red	6–J–9	8.2R3.9/3.6	Weak red	1 pt.
	Toluidine red	3–J–8	4.0R5.3/6.0	Moderate red	¾ pt.
	Venetian red	5–E–11	1.8YR4.1/5.2	Moderate brown	1 pt.
	Chrome yellow (medium)	9–K–5	1.8Y7.7/8.2	Moderate yellowish orange.	¾ pt.
Yellows	Ocher	11–C–4	0.8Y6.6/4.0	Weak yellowish orange.	1 pt.
	Sienna (raw)	11–G–5	0.5Y6.6/4.9	Weak yellowish orange.	1 qt.
	Yellow iron oxide	10–I–6	9.2YR7.4/7.0	Weak to moderate yellowish-orange.	1 pt.

[1] A Dictionary of Color, by Maerz and Paul, McGraw-Hill Book Co., Inc., New York, N. Y.

[2] Munsell Book of Color (1929). Munsell Color Co., Baltimore, Md.

[3] Inter-Society Color Council Proposed Color Nomenclature for Drugs. Developed and recommended by the National Bureau of Standards.

inhibitive pigment in metal primers (see glossary). This pigment is covered by Federal Specification TT–Z–415.

As indicated, several of the colors just described may be mixed with white-lead paste or other white pastes or paints to form light tints. For example, 100 pounds of white-lead paste mixed with a definite volume of the various colors-in-oil of a particular brand produces the colors listed in table 11 and referred to by number in "Dictionary of Color" by Maerz and Paul [3], and the "Munsell Color System" by Munsell [4]. However, this information is intended to serve only as an approximate guide.

4. READY-MIXED OIL AND VARNISH VEHICLE PAINTS

All ready-mixed paints should be purchased by volume. The purchaser should specify the type, class, and in the case of tints or body colors, the exact color required and whether it should match a sample agreed upon by buyer and seller (preferably a wet sample of paint).

(a) Paint; Oil, Exterior, Ready-Mixed Light Tints, and White TT–P–40, May 19, 1943 Amendment 1, June 26, 1943*

Federal Specification TT–P–40 covers two types of exterior oil-gloss paint intended as finish coats. These paints are for use over a primer as second or third coats for outside wood, metal, and concrete. The primer should be suitable for the particular material on which it is to be used. Type I is a multiple-pigment paint available in class A white, general-purpose paint; class B, a special white lead-free paint to be used where sulfide fumes are encountered; and class C, a tint base. If a particular tint is desired, tinting material may be added to the class C white paint. Class A white should not be tinted. Type II is a white-lead paint obtainable in both white and tints.

The type of titanium dioxide used in classes A and B should be used only for white as it chalks heavily.

Class C contains the proper type of titanium dioxide to be mixed with colors because it chalks relatively little.

Both types brush freely, have exceptionally good hiding power, and dry to an oil gloss. Before they are applied to unpainted wood, the wood should be treated with a primer that seals the surface and insures uniform texture and tint

in the succeeding coats. Such a prepared primer conforms to Federal Specification TT–P–25. A self-primer can be made by adding 1 pt of linseed oil to 1 gal of either type I or type II paint. For two-coat work the primer should be spread at the rate of 450 ft^2/gal and the topcoat or finish coat, should be spread at the rate of 550 ft^2/gal. For three-coat work the primer should be spread at the rate of 500 to 600 ft^2/gal and the second and third coats at from 600 to 700 ft^2/gal. If necessary, the paint can be slightly thinned by the addition of not more than 1 pt of turpentine or mineral spirits to 1 gal of paint.

Type I class A white paint (titanium-lead-zinc) weighs 16 lb/gal and has a PV of 30; one gallon of paint contains 0.27 gal of pigment and 0.90 gal of film-forming solids. The pigment is composed of 57 percent by volume of white lead plus zinc oxide in the ratio of 1.2 to 1. Type I class B (titanium-zinc) weighs 13 lb and has a PV of 29; one gallon of paint contains 0.26 gal of pigment and 0.88 gal of solids. Figures for type I class C tint-base paint are practically the same as for type I class A.

Type II white lead paint weighs 20 lb/gal and has a PV of 28; one gallon of paint contains 0.25 gal of pigment and 0.89 gal of solids. This is a heavy-bodied paint that can be thinned for finish-coat painting by the addition of not more than 1 pt of turpentine or mineral spirits to 1 gal of paint.

Under amendment 1 to TT–P–40, the amount of linseed oil in the paints just described is reduced from a range of 86 to 88 percent by weight of vehicle to not less than 65 percent, and the PV is increased from about 29 in the basic specification to about 36 in the amendment. Where reactive pigments such as zinc oxide (see glossary) are present, it is particularly important for the manufacturer to use the most nonreactive, heat-bodied oil available in order to avoid thickening of the paint and lowered durability.

As a result of this amendment, type I classes A and C paint weigh 16 lb/gal and contain 0.26 gal of pigment, 0.71 gal of film-forming solids, and not over 3.75 lb of linseed oil. The PV is 37, an increase from 29 in the basic paint.

Type II paint weighs 20 lb/gal and contains 0.25 gal of pigment and 0.71 gal of solids. The PV is 36, an increase from 28 in the basic paint.

(b) Paint; Exterior-Primer, Ready-Mixed, White (Undercoat for Wood)
TT–P–25, Dec. 9, 1942
Amendment 1, June 5, 1943

This is a specialized paint intended primarily as the undercoat, or primer, on outside unprimed wood for two-coat exterior painting. Its purpose is to overcome the nonuniform absorption by the wood of the ordinary priming paint. It should be applied without thinning (but ½ pt of turpentine or mineral spirits may be added to each gallon of paint) at a spreading rate of approximately 450 ft^2/gal and should be allowed to dry at least 48 hr, or until the film is hard, before the topcoat is applied. Based on exposure tests at this Bureau and elsewhere, this exterior primer for wood has given very good results.

When properly formulated and applied, two-coat paint systems offer equal durability and substantial saving of labor over the usual three-coat paint system. This assumes that the total thickness of the paint coat is equal in both cases. Two-coat systems are not intended to save on paint materials. The final film thickness should be the same as in three-coat jobs of conventional paint (about 0.005 in).

This paint (Fed. Spec. TT–P–25) may also be used for priming exterior wood in three-coat painting and as the first coat for repainting weathered exterior wood surfaces. It should not be used as a topcoat or finish coat.

Although the exact composition of this paint is not specified, the preferred formula is 66 percent of pigment and 34 percent of vehicle by weight as follows:

Pigment:	50 percent of white lead (one-half carbonate and one-half sulfate).
	35 percent of titanium-barium pigment (30 percent TiO_2).
	15 percent of magnesium silicate.
	100 percent.
Vehicle:	28 percent of Z–4 bodied linseed oil.
	28 percent of raw linseed oil.
	4 percent of coumarone resin or low acid number ester gum (cooked in the Z–4 bodied oil).
	40 percent of mineral spirits and drier.
	100 percent.

This paint weighs 16 lb/gal, and has a PV of 40; one gallon of paint contains 0.26 gal of pigment and 0.66 gal of

film-forming solids. The above formula is the preferred one to use in making paint to meet Federal Specification TT–P–25, and it is recommended that the formula be incorporated in purchase orders for this priming paint.

(c) Paint; Exterior, Ready-Mixed, and Semipaste, Black
TT–P–61a, Oct. 28, 1944

Federal Specification TT–P–61a covers an exterior black gloss paint (slow drying) for use on wood and structural steel. This paint is one of the most durable when exposed to the weather. When applied to structural steel primed with two coats of a rust-inhibitive paint (for example, red-lead paint), it gives very good service as a topcoat, or cover coat and retains its color well. The paint has good working properties and excellent hiding power. It can be made from a variety of inexpensive pigments, such as the various mineral blacks in which the amount of carbon varies from 20 to more than 70 percent.

An average paint weighs 10 lb/gal and has a PV of 18; one gallon contains 0.14 gal of pigment and 0.80 gal of film-forming solids.

(d) Paint; Graphite, Outside, Ready-Mixed, Black
TT–P–27, July 23, 1938
Amendment 2, Jan. 23, 1945

Black graphite paint covered by this specification is used for structural steel such as bridges and tanks. It is furnished in two types.

Type I, natural flake graphite pigment, is dark steel gray with a metallic luster; blackness is obtained by the addition of lampblack or carbon black. This graphite has, to a certain extent, the property of "leafing," a characteristic that probably accounts for its durability.

Type II, which is generally darker in color than type I, may include all four forms of graphite:—natural crystalline vein or lump, natural crystalline flake, artificial graphite, and natural "amorphous."

A good method of painting structural steel is to apply a coat of a rust-inhibitive primer, such as red lead or blue lead paints, and to follow with one coat of natural (untinted)

dark-gray graphite paint and a finish coat of black graphite paint meeting this Federal Specification.

Paint meeting Federal Specification TT–P–27 weighs 10 lb/gal and has a PV of 24; one gallon contains 0.21 gal of pigment and 0.87 gal of film-forming solids. One gallon of this paint contains about 5 lb of linseed oil.

(e) Paint, Red-Lead Base; Linseed Oil, Ready-Mixed
TT–P–86, Sept. 9, 1939
Amendment 1, Sept. 1, 1943*

The basic unamended specification covers a long-oil (see glossary), gloss (see glossary) paint used as priming and body coats on steel and iron. One or two coats may be applied but two are preferable. If thinning is necessary, turpentine or mineral spirits should be used instead of linseed oil. This ready-mixed paint keeps well in storage and in this respect is superior to paints mixed on the job.

Paint meeting Federal Specification TT–P–86 weighs at least 25 lb/gal and has a PV of 28; one gallon contains 0.26 gal of red lead and 0.95 gal of film-forming solids.

The amendment reduces the amount of linseed oil from 94 percent by weight to not less than 65 nor more than 70 percent. A conservation paint is thus produced which dries to a good surface for repainting in a shorter time than the original, although it has a lower consistency and less gloss. To keep the red-lead pigment in loose suspension, an addition of aluminum stearate by the manufacturer to form 0.3 percent by weight of the pigment is recommended.

It is estimated that 1 gal of paint meeting this amendment weighs 24 lb and contains 0.25 gal of pigment, 0.72 gal of solids, and not over 3.75 lb of linseed oil. The PV is 36, an increase from 28 in the basic paint.

(f) Paint; Blue-Lead-Base; Basic-Sulfate, Linseed-Oil, Ready-Mixed
TT–P–20, Jan. 12, 1940
Amendment 1, Sept. 1, 1943*

Blue-lead paint is a dark slate-gray paint intended for priming and body (see glossary) coats on iron and steel. It is characterized by very good working and keeping properties, and is durable. One or two coats may be applied but two are preferable. This paint weighs 20 lb/gal and has a

PV of 29; one gallon contains 0.27 gal of blue lead and 0.92 gal of film-forming solids.

The amended specification reduces the amount of linseed oil from not less than 90 percent by weight to not less than 65 per cent and not more than 70 percent by weight. Although the emergency paint does not have as high gloss as the basic paint, it is durable. Successive coats can safely by applied sooner than when the basic paint is used. It is estimated that 1 gal of paint meeting this amendment weighs 19 lb and contains 0.26 gal of pigment, 0.71 gal of solids, and not over 3.75 lb of linseed oil. The PV is 36, an increase from 29 in the basic paint.

(g) Paint; Iron-Oxide, Ready-Mixed, and Semipaste, Red and Brown
TT–P–31a, Sept. 12, 1941
Amendment 1, July 20, 1943*

Iron oxide paint is a durable and economical paint; it is used widely on exterior wood and metal (particularly on tin roofs) and is frequently referred to as roof and barn paint, red metallic paint, metallic brown paint, mineral red and brown paint, or freight-car red. It may be used both as a priming and a finish, or cover, coat on structural steel.

Because of the iron oxide, the color of the paint is red or brown, of which many different hues and shades can be furnished under this specification. The only practical method of getting the desired color is to have a color chip or preferably a wet sample of paint meeting the specification. The sample is used for color only.

The ready-mixed paint contains a small amount of spar varnish and zinc oxide, thus increasing color retention and decreasing the susceptibility of the paint to mildew.

Ready-mixed paint meeting the basic specification weighs 14 lb/gal and has a PV of 28; one gallon contains 0.24 gal of pigment and 0.84 gal of film-forming solids.

The amendment, which applies only to the ready-mixed paint, reduces the amount of linseed oil from 82 percent by weight to not less than 65 nor more than 70 percent, thereby producing a paint that dries with less gloss than the original. Actual use will determine whether or not the paint with less oil is as satisfactory as paint meeting the basic specification.

One gallon of the conservation paint weighs 14 lb and contains 0.24 gal of pigment, 0.69 gal of solids, and not over

3.75 lb of linseed oil. The PV is 34, an increase from 28 in the basic paint.

(h) Paint; Outside, Ready-Mixed, Medium-Chrome-Yellow
TT–P–53 Feb. 12, 1937
Amendment 1, Sept. 1, 1943*

This is a durable bright-yellow paint (not enamel) intended for application to exterior wood and metal. It is used with black paint on radio towers and highway directional signs. If a close match is desired, a standard should be designated. Tinted paints on a white base (cream, ivory, or buff, for example) should be purchased under Federal Specification TT–P–40.

Under the basic specification the paint weighs 16 lb/gal and has a PV of 28; one gallon contains 0.25 gal of pigment and 0.88 gal of film-forming solids.

The amendment reduces the amount of linseed oil from 80 percent by weight to not less than 65 nor more than 70 percent, and broadens the color range of the basic specification to include light to medium chrome yellow (including Highway Marking Yellow, formerly called Federal Yellow, Army-Navy Aircraft Yellow, and War Department Yellow No. 120).

One gallon of the conservation paint weighs 15 lb and contains 0.24 gal of pigment, 0.69 gal of solids, and not over 3.75 lb of linseed oil. The PV is 34, an increase from 28 in the basic paint.

(i) Paint; Ready-Mixed, International Orange
TT–P–59, June 17, 1937
Amendment 1, Sept. 1, 1943*

Specification TT–P–59 covers the requirements for a high-grade exterior paint of a color known as International Orange (approximately the color of a ripe tomato). Three types of paint are included in the basic specification.

The most durable of the three, type A, is a heavily pigmented, linseed-oil house paint recommended particularly for large-scale painting. It forms a soft film overnight and requires several days for drying between coats. As indicated in Federal Specification TT–P–59, the wet paint hides black and white checkerboard at the rate of nearly 500 ft^2/gal.

Although a small amount of spar varnish is added to the vehicle to improve color retention, the paint has a tendency to fade or dull somewhat on exposure. The pigment is a blend of 79 percent of opaque pigment by volume and 21 percent of transparent pigment. Type A paint weighs 18 lb/gal and has a PV of 28; one gallon contains 0.25 gal of pigment and 0.87 gal of film-forming solids.

Type B is a chrome orange, synthetic enamel (see glossary) paint. The paint hides about 300 ft^2/gal. It has more pull under the brush than type A paint and dries faster, an overnight drying period between coats being sufficient. On weathering, type B holds its color better and picks up less dirt than type A but is generally not as durable. The pigment is the same as that in type A paint, but the vehicle is a synthetic resin varnish of the glyceryl phthalate (see glossary) type. Type B paint weighs 13 lb/gal and has a PV of 24; one gallon contains 0.12 gal of pigment and 0.5 gal of solids.

Type C is a synthetic enamel of the glyceryl phthalate type, similar to type B, except that the pigment is a vivid, light-fast, orange red, organic pigment dye of the dinitroaniline type. A typical enamel, hiding 220 ft^2/gal, it should be applied as a finish over flat ground coats of the same color. This enamel is outstanding in color retention on exposure to the weather. As it has the pull under the brush typical of enamel paints, type C paint is recommended for small-scale painting, particularly on metal that has been built-up with ground coats of the same color. The properties of this enamel are similar to those of toluidine red enamel in Federal Specification TT–E–531a, and give a color of greater brilliance than types A and B. Under normal conditions, an overnight drying period between coats is sufficient.

Type C paint weighs 7.8 lb/gal and has a PV of 20; one gallon contains 0.1 gal of pigment and 0.47 gal of solids.

Amendment 1 to TT–P–59 applies only to type A paint; it reduces the amount of linseed oil from approximately 85 percent by weight to not less than 65 nor more than 70 percent. One gallon of paint meeting this amendment weighs 18 lb and contains 0.27 gal of pigment, 0.74 gal of solids, and not over 3.75 lb of linseed oil. The PV is 36, an increase from 29 in the basic paint.

(j) Paint; Ready-Mixed, Olive-Drab
TT–P–81a, Dec. 10, 1943*

This revision of Federal Specification TT–P–81 is intended to conserve linseed oil.

The paint is suitable for use on wood and metal exposed to the weather. It dries to a semigloss finish and shows good color retention. Unless otherwise specified, the color is intended to match War Department Olive Drab No. 108 [5].

Although weight per gallon varies according to the pigments chosen, those suggested in paragraph 1–2 of the Federal Specification produce a paint weighing 12.5 lb/gal and having a PV of 34. One gallon contains 0.24 gal of pigment and 0.68 gal of film-forming solids.

(k) Paint; Ready-Mixed and Semipaste,
Exterior, Chrome Green
TT–P–71a, April 9, 1941
Amendment 1, Sept. 28, 1943*

This specification covers an exterior, chrome-green, linseed-oil paint for application to wood and metal over gray, tinted white-lead undercoats. Type A, semipaste, is rarely used. Type B, ready-mixed paint, is a paint of fair quality. This paint weighs 12.7 lb and has a PV of 25; one gallon contains 0.21 gal of pigment and 0.81 gal of film-forming solids.

The purposes of amendment 1 to Federal Specification TT–P–71a are to improve the basic specification and to conserve linseed oil. The amendment covers a finish-coat paint known in the trade as a "trim enamel." When properly prepared, it shows enamel-like flowing and leveling properties, excellent hiding power, and more pull under the brush than ordinary house paint. The enamel dries to a smooth finish with a high initial gloss, which it retains well.

A successful formula for 1 gallon of this trim enamel paint is 2 lb of chemically pure chrome green (grit-free, easy dispersing type) and 1 lb of fine-particle-size magnesium silicate or aluminum silicate, with a small amount of litharge (5 lb to 100 gal of paint). The vehicle is 85 percent TT–V–121b spar varnish and 15 percent Q-bodied (see glossary) linseed oil, with a small amount of lead-manganese-cobalt drier.

One gallon of medium chrome-green trim enamel paint made under this specification weighs 9.6 lb/gal and contains

0.10 gal of pigment, 0.63 gal of solids, and not over 3.75 lb of linseed oil. The PV is 16, a decrease from 25 in the basic paint.

(l) Primer, Paint; Zinc Dust-Zinc Oxide for Galvanized (Zinc-Coated) or Zinc Surfaces
TT–P–641, Apr. 20, 1939
Amendment 1, Sept. 1, 1943*

The above specification covers three types of zinc-dust-zinc-oxide paint used principally for priming exterior, new or old galvanzed iron and zinc surfaces. They are also satisfactory as finish coats, except under conditions requiring special finishes. Type I is a linseed oil, air-drying paint. Types II and III contain a synthetic resin vehicle; glyceryl phthalate in type II and phenolic resin in type III; both dry faster than type I paint and may be either air-dried or baked at temperatures up to 380° F. For normal service, the adherence of type II appears to be best, although type I is nearly as good and has the advantage of easy brushing; however, if unusually severe moisture conditions prevail, type III is preferable (for example, on the interior of steel water tanks).

This paint can be furnished in class A, semiprepared, and class B, ready-prepared. The zinc oxide in class A is mill-ground in the entire vehicle. The zinc dust comes in a separate container. To blend the ingredients, the zinc dust and a small portion of the paint are stirred to a smooth paste, then the balance of the paint is added and thoroughly mixed. Class A is preferable to class B, as the ready-prepared paint may not keep well in the package.

One coat hides completely and is adequate for many service conditions on new galvanized iron; two coats are ample for rusty (weathered) galvanized-iron surfaces, except where special finish coats are necessary for added protection. The paint retains its gray color on prolonged exposure to the weather. For finish coats the paint may be tinted, although lampblack appears to reduce durability. Chromium oxide green gives a soft, pleasing green that is durable and shows good color retention.

Prior to priming, the new surface should be cleaned with turpentine or mineral spirits and wiped dry. Although not usually necessary, standard chemical treatments for cleaning may be used. Galvanized roofs that have weathered

until the iron-zinc alloy is exposed make an ideal surface for this paint.

Paints covered by the specification are suitable for brushing but may be sprayed if thinned with not more than 1 pt of turpentine or mineral spirits to 1 gal of paint.

Type I paint weigh 23 lb/gal and has a PV of 37; one gallon contains 0.34 gal of pigment and 0.92 gal of film-forming solids.

Type II paint weighs 16 lb/gal and has a PV of 35; one gallon contains 0.17 gal of pigment and 0.48 gal of solids.

Type III paint weighs 23 lb/gal and has a PV of 51; one gallon contains 0.32 gal of pigment and 0.62 gal of solids.

The amendment, which applies to type I only, reduces the amount of linseed oil from 89 percent by weight to not less than 65 nor more than 70 percent. One gallon of this paint weighs 19 lb and contains 0.23 gal of pigment, 0.69 gal of solids, and not over 3.75 lb of linseed oil. The PV is 34, a decrease from 37 in the basic paint.

(m) Paint; Concrete and Masonry
Exterior, Eggshell-Finish
Ready-Mixed, White and Tints
TT–P–24, Feb. 25, 1943

This oil-base exterior paint is a finishing coat for suitably primed concrete, brick, and stucco surfaces, except floors. The paint dries to an eggshell finish. Where a glossy finish is desired, exterior paints for wood and metal should be used (Fed. Spec. TT–P–40).

Type I paint is made in white only. Type II can be bought in tints or in white, to be tinted by the purchaser, who should specify the color and whether it should match a selected sample.

As moisture back of the paint film seriously impairs the life of oil-paint coatings, new masonry should not be painted until the walls are dry. This may require from 3 to 12 months and will depend upon weather conditions and upon the thickness and porosity of the walls. It is equally important to prevent water from entering the wall after painting.

Because paint adheres poorly to highly glazed surfaces, it is suggested that preparatory to painting, such surfaces be either acid washed, lightly sandblasted, or rubbed with coarse grit abrasive stones. This treatment is frequently

necessary for concrete cast against plywood, Presdwood, or steel forms.

Old coatings of organic or cement-base water paint in good condition need not be removed. Peeling, scaling, or flaking paint and whitewash should be completely removed.

A suggested formula (by weight) for paint meeting the specification contains 60 percent of pigment and 40 percent of vehicle as follows:

Pigment	*Percent*
White lead	35
Zinc oxide	30
Titanium dioxide	10
Magnesium silicate	25
	100

Vehicle	*Percent*
Nonvolatile vehicle	45
Thinner	55
	100

An average paint of either type meeting the specification weighs about 14 lb/gal and has a PV of 42; one gallon contains 0.22 gal of pigment and 0.53 gal of film-forming solids.

For surfaces that have not previously been painted, the following Federal Specification priming paint is suggested:

	gal
Paint; TT–P–24	1
Varnish, spar (nonreactive); TT–V–121b	½
Thinner, paint; TT–T–291a	¼

The priming paint weighs 11 lb/gal.

(n) Paint; Traffic, Exterior, White and Yellow
TT–P–115, Apr. 29, 1942
Amendment 1, May 30, 1945

This specification covers a ready-mixed traffic paint known as center line, zone-marking, and road-marking paint. It is obtainable in white and yellow colors, the yellow being called Highway Marking Yellow, formerly called Federal Yellow.

Both paints are intended for application, at a wide range of temperatures, to bituminous and concrete highways bearing heavy traffic. The paints may be applied by a brush or machine. Certain types of spray machines require a paint thinned in the proportions of 1 pt of uncolored gasoline to 1 gal of paint. In not more than ½ hr the paint should set to touch and within an hour (at 70° to 90° F) should dry to an eggshell hard gloss finish. The possible presence of toxic thinners may make these paints unsafe for indoor use unless proper precautions, such as adequate ventilation, are taken.

As some traffic paints have a tendency to settle in the container during prolonged storage, it is advisable not to purchase this paint too far in advance of actual need. Although soft settling is expected, hard packing of the pigment is undesirable. A properly formulated traffic paint should keep in good condition for at least 6 months.

Although the specification is based mainly on performance requirements, a satisfactory white traffic paint weighs 14 lb/gal and has a PV of 49; one gallon contains 0.28 gal of pigment and 0.56 gal of film-forming solids. The pigment is 55 percent by weight of titanium-barium or lithopone, 25 percent of zinc oxide, and 25 percent of silica and silicates; the vehicle is a quick-drying, 15-gal, oleoresinous varnish.

The yellow paint weighs 14 lb/gal and has a PV of 45; one gallon contains 0.24 gal of pigment and 0.54 gal of solids. The pigment is 45 percent by weight of chrome yellow, 20 percent of zinc oxide, and 35 percent of silica and silicates; the vehicle is the same as in the white traffic paint.

(o) Enamel; Heat-Resisting (400° F), Black
TT–E–496, June 6, 1941
Amendment 1, Sept. 14, 1943*

Federal Specification TT–E–496 covers two types of black enamel, type I, bituminous-base (unpigmented) and type II, resin-base (pigmented). Both types are intended for use on surfaces exposed to temperatures up to 400° F, including steam pipes and boiler fronts. Where resistance to hot water and gasoline is also necessary, the use of type II is advisable. Neither type should be applied when the surfaces are hotter than 140° F, and 48 hr of drying time at room temperature should elapse before the coating is subjected to the maximum temperature, 400° F. Because of the nature

of the volatile thinners, these enamels should be applied in well-ventilated areas free from open lights or flames.

Type II enamel generally contains 2 percent by weight of high-grade carbon black and 98 percent of a synthetic resin (alkyd) vehicle. It weighs 7 lb/gal and has a PV of 3; one gallon contains 0.01 gal of pigment and 0.35 gal of film-forming solids.

Amendment 1 is necessary because of the critical shortage of alkyd resins and applies only to type I enamel.

(p) Enamel; Pigmented (Air-Drying and Baking) Black
TT–E–521, July 22, 1930
Amendment 3, Sept. 14, 1943

Material covered by this specification is a high-grade black enamel containing no bituminous materials. It produces an opaque, glossy, durable black coating for exterior and general use. The composition is generally about 2 percent of high-grade carbon black and 98 percent of long-oil, water-resisting varnish.

This enamel weighs 8 lb/gal and has a PV of 2; one gallon contains 0.01 gal of pigment and 0.45 gal of solids.

(q) Enamel; Lusterless, Olive-Drab
TT–E–514, Jan. 28, 1943

The lusterless olive-drab enamel covered by this specification is intended for camouflage. It serves as a *flat* finishing coat on *primed* metal and wood surfaces. The color should match Olive-Drab No. 319[5].

The materials are noncritical but do not produce as durable an enamel as those containing synthetic resins of the alkyd type, such as the finish on Army motor vehicles [6].

Although this is a performance specification and a variety of pigments can be chosen, the following formula is frequently used:

	Weight *Percent*
Yellow iron oxide	18.0
Medium chrome yellow	6.3
Lampblack	3.2
Zinc oxide	0.8
Magnesium silicate	33.2
Diatomaceous silica	26.5
Barytes	12.0
	100.0

These pigments produce an enamel weighing about 10 lb/gal and having a PV of about 45; one gallon contains 0.17 gal of pigment and 0.38 gal of solids.

(r) Enamel; Water-resisting, Red
TT–E–531a, June 4, 1935
Amendment 3, Sept. 14, 1943*

This specification covers a bright-red enamel of high grade intended for general exterior use. This enamel paint is used widely on fire-alarm boxes. It is water-resistant, has a high gloss, and is durable.

The toluidine pigment used in the enamel makes the color of different lots less variable than the color of other bright-red paints that do not contain toluidine. Thus, samples are needed only where a very close match of different deliveries is required. Recently a dark shade of toluidine red has been produced containing pigment dyestuff similar to metanitro-paratoluidine-azo-betanaphthol and meeting the tests described in the specification. When the purchaser indicates red enamel containing this dark shade of toluidine red, the limits on "color", as required in paragraph E-1d of the specification, do not apply. Unless specifically indicated by the purchaser, it is understood that the seller is to supply red enamel strictly meeting the color, as specified in paragraph E-1.

To meet the requirement for hiding power, 220 ft^2/gal, 12 percent by weight of toluidine toner should be used. This enamel weighs 7 lb/gal and has a PV of 16; one gallon contains 0.08 gal of pigment and 0.49 gal of film-forming solids.

Amendment 3 provides for an enamel containing not over 3.25 lb of linseed oil per gallon of enamel.

(s) Enamel; Interior, Gloss, Light Tints and White
TT–E–506a, Dec. 1, 1938
Amendment 1, Sept. 14, 1943*

Enamel paints meeting this specification are intended for use on interior wood, metal, and plaster over suitable undercoats. After being properly applied and allowed to dry thoroughly, they can be washed with mild soap and warm water.

Although white enamel paints may be purchased under the specification without reference to a color standard, the

variation in white surfaces from blue-white to yellow-white makes it advisable for the purchaser who desires a close match to specify color (preferably by having a wet sample of acceptable enamel). Because of the wide range of tints, this method of color matching is the practical one to use.

For white enamel paints, mixtures of strong white opaque pigments, such as titanium dioxide, zinc sulfide, and zinc oxide, can be used; for the tinted paints, pure tinting colors should be chosen. A typical pigment mixture for white enamel is 80 percent by weight of titanium dioxide and 20 percent by weight of zinc oxide.

When the enamel contains 30 percent by weight of this pigment and 70 percent vehicle, it weighs 10 lb/gal and has a PV of 9; one gallon contains 0.08 gal of pigment and 0.49 gal of film forming solids.

Amendment 1 contemplates an enamel containing not more than 2.5 lb of linseed oil per gal.

(t) Paint; Oil, Interior, One-Coat-Flat, Heavy-Bodied (for thinning), Light Tints and White (Combined Sealer, Primer, and Finish)
TT–P–47, Feb. 25, 1943

This specification covers an interior one-coat, "nonpenetrating," flat, heavy-bodied, oil-base paint to be applied directly to porous, absorptive surfaces, such as wallboard, wallpaper, plaster, and wood. It is designed to give a uniform finish without the use of a special primer or sealer, and to conserve shipping space and containers as a war emergency measure. It should find wide use after the war.

Although high dry hiding power is desirable, it should not be obtained at the expense of washability and good sealing properties. The paint should dry to a relatively low gloss with a slight angular sheen, even though a relatively high ratio of binder (see glossary) to pigment is desirable. Where adjoining areas of the surface to be painted show marked differences in porosity, as in the case of patched plaster, the patched areas should be painted and allowed to dry before the entire surface is painted.

The vehicle in this paint is usually a long-oil varnish, containing at least 100 gal of oil per 100 lb of resin, consist-

ing mainly of processed drying oils, ester gum or other resin, plus the required amounts of volatile thinner and drier. One such vehicle of a 200-gallon varnish had a viscosity of 13 poises (see glossary), a nonvolatile content of 35 percent, and passed a 350-percent kauri reduction (see glossary). Pigments should be opaque white titanium-base or zinc-sulfide base and suitable extending pigments. Tinting colors should be limeproof.

The paint is furnished in a heavy-bodied consistency (see glossary), so that it can be thinned with 3 pt of mineral spirits or turpentine to 1 gal of the thick paint, thus obtaining a paint of normal properties. If the purchaser wishes to buy this paint ready for use (instead of the usual heavy-bodied consistency), it should then meet section F–3 of the specification for the reduced paint.

It is estimated that an average paste paint meeting this specification weighs about 12.5 lb/gal and has a PV of 60; one gallon contains 0.33 gal of pigment and 0.55 gal of film-forming solids.

The paint thinned for use weighs about 11 lb/gal and has a PV of 60; one gallon contains 0.23 gal of pigment and 0.38 gal of solids.

(u) Paint; (for) Priming Plaster Surfaces (Plaster Primer and Sealer)
TT–P–56, Oct. 5, 1935
Amendment 1, March 1936

This specification covers a pigmented primer and sealer (see glossary) in white or tints, to be used as a priming or sizing coat on interior walls and ceilings of plaster, brick, and cement wallboard. It may also be used for priming interior woodwork. It should not be applied to damp surfaces.

Many formulas may be used to produce an acceptable plaster primer and sealer, since the requirements and tests are mainly physical. The only limitation of composition is that the vehicles shall contain not less than 42 percent of nonvolatile matter. Usually the pigment portion of the paint contains some titanium dioxide and/or zinc sufide and extending pigments. The pigment of a typical paint is 56 percent by weight of titanium dioxide, 24 percent of calcium

sulfate, and 20 percent of magnesium silicate. The composition of the paint is as follows:

	Weight *Percent*	Volume *Percent*
Pigment	44	18.2
Nonvolatile vehicle	34	45.2
Volatile vehicle	22	36.2
	100	100.0

The weight per gallon is 11 lb and the PV is 29.

(v) Paints; Oil, Interior, Eggshell-Flat-Finish, Ready-Mixed and Semipaste, Light Tints and White
TT–P–51a, Jan. 16, 1937
Amendment 1, Sept. 14, 1943*

This specification covers an interior eggshell to flat wall paint, available in ready-mixed or in semipaste form. The ready-mixed paint produces a washable body and finish coat but is not generally suitable for stipple finish. Although 1 gal may be diluted to make a priming paint by adding from 1 qt to 1 gal of boiled linseed oil, the use of priming paint conforming to Federal Specification TT–P–56 is preferable. The semipaste is seldom used.

Some paints and enamels dry hard quickly, whereas others, the vehicle of which contains more oil and less resin, are more flexible and develop hard films slowly. Gloss paint or enamel (Fed. Spec. TT–E–506a) is more washable than a flat paint, but no paint should be scrubbed within 30 days after application. When a washable paint is desired, as in a kitchen or bathroom, yet the glare of full gloss enamel is objectionable, a semilustrous finish can be produced by mixing TT–P–51a flat wall paint (or TT–P–47 one-coat flat) and TT–E–506a enamel, in varying proportions. Some recent laboratory work at the Bureau indicates that TT–P–47 paint is superior to TT–P–51a paint for this purpose. A Federal Specification for semigloss enamel (TT–E–508) is in preparation.

The specification for TT–P–51a paint is based on performance requirements rather than on composition. The paint is characterized by high hiding power, eggshell to flat finish, easy brushing, and good resistance to scrubbing with mild soap and water.

The purpose of amendment 1 is to conserve linseed oil. It is contemplated that the paint under the amendment will

contain no more than 1.2 lb of linseed oil per gallon of paint (to conform to linseed oil conservation order M-332 of the War Production Board).

Federal Specification TT–P–51a does not require any specific formula, but the following is offered merely as a suggestion:

	Weight *Percent*	Volume *Percent*
Titanium dioxide	15.9	6.8
Calcium sulfate	49.1	34.5
Nonvolatile vehicle	14.0	24.2
Volatile vehicle	21.0	34.5
	100.0	100.0

On gallon of this paint weighs 14 lb and has a PV of 63.

(w) Paint; Varnish-Base (for) Concrete and Wood Floors TT–P–146, June 5, 1942

This paint is intended for interior and exterior use on wood and concrete floors and other flooring not subjected to dampness. It is known to the trade as "floor and deck paint." Concrete basement floors should age for 1 year before painting. The floor should be dry and the best time to paint it is during the winter or early spring (assuming that the basement can be heated), when the humidity in the basement is very low. The paint should be applied in a thin layer and be brushed out well, ample time being allowed for drying between coats. Two coats of paint are generally sufficient. A thin film of wax, which is easily renewed, serves to protect the paint. A liquid floor wax of the organic solvent type (Fed. Spec. P–W–158) is suggested.

On wood floors it is suggested that for the first coat of paint 1 qt of thinner, composed of 2 parts of boiled linseed oil and 1 part of turpentine, be added to each gallon of paint; for the second coat 1 pt of boiled linseed oil per gallon of paint may be added. On concrete floors it is suggested that for the first coat 1 qt of liquid in the proportion of 2 parts of spar varnish and 1 part of turpentine be added to each gallon of paint; the second coat can be applied as furnished.

Floor paints meeting this specification dry "print free" within 12 hr as determined by the new Gardner Drying

Time Recorder, an instrument for measuring the drying time of paint and varnishes. The vehicle in this paint should be a tough, flexible, high-grade floor varnish able to withstand wear on wood and concrete floors as well as outdoor weather. It should be at least 25 or 30 gal long, passing a 40-percent kauri reduction (see glossary).

Although a great variety of pigments may be used in making paints meeting this specification, the following is one example of a durable lightweight gray paint:

	Weight *Percent*	Volume *Percent*
Pigment:		
Titanium dioxide	10.0	3.0
Calcium sulfate	24.0	11.8
Carbon black	1.0	0.6
Vehicle:		
Interior varnish (TT-V-71a)	65.0	84.6
	100.0	100.0

One gallon of this paint weighs 10 lb and has a PV of 29. These values apply only to the formula just given for a lightweight gray paint. The specification covers a variety of colors including grays, browns, reds, buffs, and greens.

(x) Paint; Rubberbase (for) Cement Floors
TT-P-91, May 23, 1939

This is a ready-mixed paint for use on interior concrete flooring subjected to dampness and not exposed to sunlight. It is suitable for concrete basement floors. The paint for the first coat should be diluted with 1 qt of thinner, consisting of equal volumes of mineral spirits and toluol free from water, to each gallon of paint. The surface to be painted should be clean and dry and the room sufficiently ventilated. Smooth, densely troweled concrete floors should be etched with a 10-percent solution of hydrochloric acid, washed with water, and thoroughly dried before paint is applied. New concrete floors should age at least 2 months before being painted; three coats are generally recommended, but two coats are frequently used. In repainting work, this type of paint should be used only when the same type has been used previously on the same surface.

The variety of colors available makes it advisable to designate a sample for color (preferably a wet sample of the paint).

A typical gray paint passing the specification contains:

	Weight *Percent*	Volume *Percent*
Pigment:		
Titanium dioxide	26.9	8.1
Zinc oxide	4.8	1.0
Carbon black	0.3	0.2
Nonvolatile vehicle:		
Rubber base[a]	18.8	23.8
Plasticizer (see glossary)	3.2	4.1
Volatile vehicle	46.0	62.8
	100.0	100.0

[a] Generally either chlorinated rubber or natural crepe rubber.

One gallon of the above paint weighs 10 lb and has a PV of 28. At the present writing, this paint is not available because of the critical situation on rubber.

(y) Fume- and Heat-Resisting White Enamel
National Bureau of Standards
Letter Circular LC489, January 30, 1937

Enamel paint that does not become discolored by continuous heat or chemical fumes is not covered by a Federal Specification. An enamel having the characteristics described in National Bureau of Standards Letter Circular LC489 should prove desirable for use in chemical laboratories, commercial kitchens, tobacco factories, gas works, refrigerator rooms, dairies, and sewage-disposal plants. Paint that will not discolor in such places requires special composition. The pigment must be free from lead and iron and may consist of lightproof lithopone, titanated lithopone, various titanium pigments, zinc oxide, or a mixture of these. The vehicle must also be free from metallic-compound driers, and preferably from linseed, soya, tung, or other drying oils. A vehicle frequently used consists of high-grade damar resin dissolved in turpentine or mineral spirits and plasticized with a softener, such as pine oil. Other more modern vehicles are synthetic alkyd, phenolic, vinyl, and acrylic resins, and the newer type of rubber and chlorinated rubber resins dissolved in solvents.

For color-retention tests, glass panels were coated with white enamel and with this same enamel tinted light gray and pale buff, using lampblack and yellow ocher, respectively. The coated panels were placed in an atmosphere saturated with water and ammonium sulfide vapors. Only

the buff became discolored because of the formation of black iron sulfide. The others retained their original color.

To obtain resistance to discoloration, it may be necessary to subordinate other properties. Fume-resisting enamel paint may be less flexible than the usual architectural white enamel and less water resistant than the "4-hour" type of white enamel (Fed. Spec. TT–E–506a, type A).

The reader is referred to NBS Letter Circular LC489 for additional details on the subject.

(z) Enamel; Drum-Coating, Exterior, Rust-Inhibiting, Solvent-Resistant
TT–E–485 March 15, 1944

This is an olive-drab, semigloss enamel prepared to conserve zinc during the war emergency. It is used as a one-coat painting system on the exterior of steel storage drums for the armed forces. Because of the shortage of certain materials required for its manufacture, such as glyceryl phthalate resin, this enamel is temporarily not available for civilian use.

5. VARNISHES AND ANALOGOUS PRODUCTS

Oil varnishes are blends of drying oil and resins, natural or synthetic, driers, and volatile thinners (see glossary). Spirit varnishes do not contain drying oils. This section deals first with oil varnishes, then with spirit varnishes.

(a) Varnish; Asphalt
TT–V–51a, Feb. 2, 1944

This is a general utility asphait varnish for interior and exterior surfaces and is particularly suitable for painting indoor water and gas pipes. It dries with a smooth, black, lustrous finish similar to black enamel. Its composition is hard native asphalt or asphaltite fluxed and blended with drying oils, then thinned with solvents and driers.

Although the specification is based mainly on performance requirements, a linseed oil-Gilsonite varnish that met the specification was composed of 7 gal of heat-bodied linseed oil to 100 lb of Gilsonite selects, fluxed and blended, then thinned with a mixture of turpentine, petroleum naphtha, and lead-manganese driers.

A typical varnish shows:

	Weight *Percent*	Volume *Percent*	*lb/gal*	*gal/lb*	sp gr
Varnish	..	..	7.40	0.1365	0.888
Nonvolatile	45	40	...	.....	....
Volatile	55	60	...	.....	....
	100	100			

(b) Varnish; Interior
TT–V–71a, Sept. 9, 1939
Amendment 2, Sept. 14, 1943*

Material covered by this specification is generally about a 20- to 25-gal varnish (see glossary) intended for general interior use, including floors, except where rubbing properties are necessary. (For cabinet rubbing varnish, see Fed. Spec. TT–V–86). Although the unamended specification is a very good general purpose interior varnish, the amended specification has lowered the requirements for drying time and water resistance, because of the scarcity of certain war materials.

Varnish meeting both the basic specification and the amendment shows the following characteristics:

	Weight *Percent*	Volume *Percent*	*lb/gal*	*gal/lb*	sp gr
Varnish	..	..	7.40	0.1365	0.888
Nonvolatile	45	40	...	.....	....
Volatile	55	60	...	.....	....
	100	100			

(c) Varnish; Mixing (for) Aluminum Paint
TT–V–81a, Oct. 5, 1939
Amendment 2, Sept. 14, 1943*

Mixing varnish covered by this specification is intended for use as the vehicle in aluminum paint, not as a clear varnish. Type I varnish is a very long-oil varnish (80 to 100 gal) and should be used in preparing paint for priming exterior wood subjected to severe weather conditions. Type II varnish should be used in paint intended for general use (particularly for metal). For spraying, the paint may be thinned with 1 pt of turpentine to 1 gal of paint (although it is recommended that aluminum paint be sprayed at the same consistency as for hand brushing).

Because aluminum paste contains about 35 percent by weight of volatile thinner, varnish with lower viscosity

[class A, 0.65 to 1.00 poise (see glossary)] is suitable for use with aluminum powder, and varnish with the higher viscosity (class B, 0.85 to 1.25 poises) for use with aluminum paste.

Varnishes meeting this specification have the following characteristics:

	Weight *Percent*	Volume *Percent*	*lb/gal*	*gal/lb*	sp gr
Type I varnish	..	..	7.49	0.1335	0.899
Nonvolatile	55	49			
Volatile	45	51			
	100	100			
Type II varnish	..	..	7.40	.1350	.888
Nonvolatile	50	44			
Volatile	50	56			
	100	100			

(d) Varnish; Rubbing, Cabinet
TT–V–86, June 29, 1939
Amendment 1, Oct. 8, 1941

Cabinet-rubbing varnish is intended for interior wood surfaces where a rubbed finish is desired. It does not cover the requirements of a baking varnish for use on metal and is not recommended for floors. However, it may be used on wood or metal, particularly chairs, tables, and desks. (Varnish for general interior use is covered by Federal Specification TT–V–71a.)

A typical rubbing varnish is about 10 gal in length and has the following characteristics:

	Weight *Percent*	Volume *Percent*	*lb/gal*	*gal/lb*	sp gr
Varnish	..	..	7.326	0.1365	0.879
Nonvolatile	45	39.6			
Volatile	55	60.4			
	100	100			

(e) Varnish; Spar, Water-resisting
TT–V–121b, Dec. 10, 1943
Amendment 1, Jan. 24, 1944*

Water-resisting spar varnish is a durable general utility varnish, suitable for both interior and exterior use where

high gloss or initial hardness of film is not required. Because certain materials were critical, it was difficult to obtain varnish meeting the unamended specification during the war emergency. Tung oil and phenolic resins are used widely in this type of spar varnish.

The amended specification produces a slower drying varnish than the original and provides less rigid requirements for water resistance.

Varnish meeting this specification is generally about 50 gal in length and shows approximately:

	Weight *Percent*	Volume *Percent*	*lb/gal*	*gal/lb*	sp gr
Varnish	..	..	7.49	0.1335	0.899
Nonvolatile	55	49.4	....	.....	....
Volatile	45	50.6			
	100	100.0			

The nonvolatile portion of this varnish (amendment 1) generally consists of linseed oil and available resins, such as congo, terpene resins, ester gum, and fortified rosin esters.

(f) Sealer, Floor; Varnish-Type (for Wood and Cork)
TT–S–176a, Sept. 20, 1941
Amendment 1, Jan. 7, 1944*

This floor sealer is intended for use in sealing and treating wood or cork floors and floor coverings; it provides a satisfactory foundation for varnish, for liquid, paste, or water-emulsion wax. The sealer is furnished in one grade and two classes: class 1 is suitable for use on floor surfaces having a rapid and high absorption rate, and class 2 for flooring of denser structure. When the floors are of open-grained wood or cork tile, they should be treated with wood filler (Fed. Spec. TT–F–336a) before the sealer is applied. This sealer is similar to spar varnish but contains more volatile matter and correspondingly less nonvolatile matter.

Class 1 sealer may be thinned with turpentine or mineral spirits; class 2 sealer should require no thinning. Floor sealer meeting the amended specification is slower drying and less water-resistant than one meeting the unamended specification.

Sealers conforming to either the basic or the amended specification contain approximately the following:

	Weight *Percent*	Volume *Percent*	*lb/gal*	*gal/lb*	sp gr
Class 1 sealer	..	..	7.246	0.138	0.88
Nonvolatile	40	34.8			
Volatile	60	65.2			
	100	100.0			
Class 2 sealer	..	..	7.02	.1425	.842
Nonvolatile	25	21			
Volatile	75	79			
	100	100			

Spar varnish TT–V–121b may be used as a sealer that will be somewhat similar to class 1 if thinned with one-half its volume of mineral spirits or turpentine and somewhat similar to class 2 if mixed with an equal volume of mineral spirits or turpentine.

(g) Varnish; Damar
TT–V–61, Apr. 20, 1939
Amendment 1, Jan. 7, 1944*

Damar varnish specified in TT–V–61 is a spirit varnish to be applied to indoor surfaces, both as a transparent finish and as a vehicle for white or light-colored enamels exposed to high temperatures (radiators, for example). It is not intended for use under conditions that require an abrasion-resistant, moisture-resistant, or indentation-resistant varnish. Suitable Federal specifications cover varnishes for these purposes.

Damar resin has the lowest acid and saponification numbers (see glossary) of all the important natural resins, commercial samples having acid numbers from approximately 25 in the best grades to 35 in the poorest and saponification numbers from 27 to 50. The resin is light in color and on exposure to sunlight, bleaches to water-white. As a contrast to damar resin, manila resins have high acid numbers, 125 to 143, and high saponification numbers, 158 to 169. Damar resin is soluble in petroleum spirits, turpentine, coal-tar naphtha, chlorinated solvents, and hot drying oil [7]. It adheres tenaciously to surfaces.

Damar varnish meeting this specification shows approximately the following characteristics:

	Weight *Percent*	Volume *Percent*	*lb/gal*	*gal/lb*	sp gr
Damar varnish	..	..	7.466	0.1339	0.896
Nonvolatile	45	38.4			
Volatile	55	61.6			
	100	100.0			

As amendment 1 is a temporary measure to conserve critical materials during the emergency, the following finishes are suggested as substitutes for damar varnish:

Varnish; Interior, TT–V–71a.
Varnish; Spirit (Shellac Varnish Replacement), TT–V–130.
Paints; Oil, Interior, Eggshell-Flat-Finish, TT–P–51a (painting radiators).

(h) Shellac; Orange
TT–S–271, April 29, 1930
Amendment 1, May 27, 1944*

All shellac (see glossary) is a manufactured product of stick lac, the secretion of the *Laccifer Lacca Kerr.* Four types of orange shellac are covered by Federal Specification TT–S–271. Type A includes the grades of shellac known to the trade as Double Triangle G, Diamond I, Superfine, the highest grades, D.C. and V.S.O., and the so-called machine-made shellacs, CV and CVTN.

Type B includes Fine, Good, and Heart, the grades considered in the trade as lower than Superfine but higher than Pure T.N.

Type C represents the grade known in the trade as Pure T.N. This shellac is rosin-free (see glossary), but is darker and contains more insoluble material than types A or B.

Type D represents the grade known in the trade as U.S.S.-A.T.N. and usually contains rosin up to a maximum of 3 percent. It is lighter in color than type C but is darker and contains more insoluble material than type A or B.

The color of orange shellac (see glossary) used in orange shellac varnish is immaterial as it results in only a slight difference in the color of the varnish films. However, if the buyer desires to consider color, he should furnish a selected sample and should state which of the two methods given in section F-3g of the specification should be used in determining the color. It should be noted that, when tested

by method 1, shellacs containing appreciable amounts of wax and orpiment are lighter in color than those containing small amounts of these substances. A shellac may be darker than the selected standard when tested by method 1 but lighter when tested by method 2.

(i) Varnish; Shellac
TT–V–91a, Feb. 26, 1940
Amendment 2, Jan. 7, 1944*

Federal Specification TT–V–91a is expected to meet all Government needs for shellac varnish (see glossary). It comes in type I, bleached (white), and type II, orange. Each type covers two grades, A and B, and each grade three kinds of body—light, medium, and heavy. The desired type, grade, and body should be stated in the invitation for bids.

Ordinarily, grade A of type I fulfills all the needs for a white shellac varnish and grade B should be used only in cases requiring a clear, bleached varnish almost entirely free from wax or other suspended matter.

Grade A of type II usually includes rosin-free shellac. It is lighter in color than grade B, which is intended for use where small percentages (not over 3 percent) of rosin are not objectionable and where lightness of color of shellac varnish is not essential.

The thinner, or solvent, used in shellac varnish may be either one of two formulas. It may consist of specially denatured alcohol made of 100 gal of 95-percent ethyl alcohol (190 proof) and 5 gal of methyl alcohol. It may consist of a proprietary solvent composed of materials authorized by the U. S. Bureau of Internal Revenue as follows: 100 gal of the above-described specially denatured alcohol, 5 gal of denatured ethyl acetate, and 1 gal of aviation gasoline. Isopropyl alcohol (99 percent) is permitted by the U. S. Army Air Corps as an alternative for the above-described formulas, and the Navy Department requires that unless otherwise specified, the solvent must be denatured alcohol made from U. S. P. grade ethyl alcohol denatured by the addition of 0.05 percent of croton oil U. S. P. and dyed by the addition of fuchsin, 1 part in 500,000 [8].

Light-, medium-, and heavy-bodied varnishes correspond respectively to 4-, 4.5-, and 5-lb "cuts" (see glossary) of shellac. The minimum allowable percentages of nonvolatile matter for each body of varnish given in section E of this

specification have been corrected for 2-percent maximum moisture, including volatile matter, and 3 percent of insoluble matter in flake orange shellac; and for 6 percent of moisture and volatile matter in bleached dry shellac. Thus, varnishes made by cutting 4, 4.5, and 5 lb of either orange or bleached shellac in 1 gal of specified solvent should meet the nonvolatile requirements of the specification. Wm. H. Gardner has prepared directions for making and blending shellac varnishes of various bodies [9].

An average light-bodied shellac varnish meeting this specification has the following characteristics:

	Weight *Percent*	Volume *Percent*	*lb/gal*	*gal/lb*	sp gr
Light-bodied shellac varnish	..	..	7.176	0.1394	0.861
Nonvolatile	35.5	30.6			
Volatile	64.5	69.4			
	100.0	100.0			

An average heavy-bodied shellac varnish has the following characteristics:

	Weight *Percent*	Volume *Percent*	*lb/gal*	*gal/lb*	sp gr
Heavy-bodied shellac varnish	..	..	7.262	0.1377	0.871
Nonvolatile	41.0	35.7			
Volatile	59.0	64.3			
	100.0	100.0			

(j) Varnish; Spirit (Shellac Varnish Replacement) TT–V–130, Sept. 28, 1943

This specification covers the improved spirit varnishes and is intended (as a conservation measure) primarily to replace shellac varnish, which it resembles in appearance. It can be applied to wood, metal, paper, and textiles, and may also be used in place of oil-resin varnishes where rapid drying is more important than length of service.

Shellac varnish replacement (a wartime product) conforming to the specification may be produced from a number of available domestic materials without the use of drying oils and metal driers. However, difference in composition produces a variation in properties. A typical shellac varnish replacement may consist of about 50 to 75 percent by

weight of an alcohol-soluble, polymerized (see glossary) rosin blended with about 25 to 50 percent by weight of zein (protein derived from corn) and dissolved in alcohol; a plasticizer (for example, low-titre fatty acids) may also be present. Blends of polymerized rosin and ethyl cellulose have also been used. The method of blending these materials appears to affect the quality of the product. The ordinary spirit varnishes composed of simple solutions of copals (see glossary) and rosin dissolved in alcohol do not meet this specification.

Performance tests show that the good grades of shellac varnish replacement appear to be equivalent to shellac varnish in color, gloss, drying time, film clarity, coverage, ease of sanding, water resistance, and abrasion resistance. On the other hand, the film is less resistant to the action of various solvents, such as alcohol, than films of shellac varnish dried the same length of time.

The varnish should not be mixed with ordinary paint, varnish, or lacquer, or be thinned with turpentine or mineral spirits.

The material should be applied in thin coats by either spray gun or brush.

Some of the earlier shellac replacement varnishes tended to thicken or gel in the package. On the other hand, certain brands have always exhibited good stability in the package. This would indicate that, when the ingredients are correctly formulated and combined, there should be no gelling.

As an aid in keeping the material in satisfactory condition, it is suggested that the buyer request that shellac replacement varnish be packed in glass containers. These should be kept in a relatively cool place not exposed to direct sunlight. The material should not be stored in an excessively hot or cool place.

Although the material is a wartime product, it served a very useful purpose at a time when shellac varnish was unobtainable.

(k) Lacquer; Spraying, Clear and Pigmented (General Use) TT–L–58, April 29, 1942

Spraying lacquer (see glossary) purchased under this specification should contain cellulosic derivatives. This lacquer is intended for indoor or outdoor use, and is to be

applied by a spray gun. It is not intended to be a brushing lacquer. Metal surfaces should be primed with a suitable primer, and wood surfaces should be sealed with a suitable seal before applying this lacquer.

For application by spraying, the lacquer is usually satisfactory for use without a thinner, unless one is furnished. However, should thinning be necessary, material covered by Federal Specification TT–T–266 is suggested.

The nonvolatile base for type I clear lacquer may consist of:

	Weight *Percent*	Volume *Percent*
Cellulose nitrate	31	23.5
Alkyd resin	60	65.0
Dibutyl phthalate	6	7.3
Fish oil	3	4.2
	100	100.0
The above nonvolatile vehicle	15	10.4
Lacquer thinner TT–T–266	85	89.6
	100	100.0

Type II (pigmented lacquer) can be made from 100 lb. (or 13.4 gal) of the above type I lacquer and about 6¼ lb of a suitable pigment. The weight per gallon of either type does not vary much from 7½ lb; type I may be about 7.45 lb. and type II with a medium chrome yellow pigment about 7.8 lb.

(C) Sealer; Floor; Lacquer-type (for Oiled Wood Floors) TT–S–171, April 8, 1942

This floor sealer is intended for sealing oil-treated flooring and oiled wood floors that have been sanded and cleaned. Sealing the oil within the flooring prevent subsequent marring of the finished surface. This lacquer-type sealer also smooths and integrates the surface to which it is applied, thus producing a finished appearance and furnishing a base for wax and varnish. Open-grained flooring should be treated with wood filler, Federal Specification TT–F–336a, before the application of sealer.

Precautions should be taken adequately to ventilate the room while applying the sealer.

6. WATER PAINTS

Water paints were probably the first paints used by man and are still widely used. The following four Federal Specifications have been prepared for water-reducible paints.

(a) Calcimine; (Cold- and Hot-Water Types) TT–C–96, May 4, 1940

Calcimine, or kalsomine, is an inexpensive powdered mixture of pigments, such a whiting, china clay, and glue made ready for application by the addition of water. It is intended for temporary interior use and is easily removed by sponging the surface with warm water.

The specification covers two types of calcimine: type I, cold water, and type II, hot water. Type I is more convenient for mixing, as water at ordinary temperatures can be used. Type II calcimine, considered a smoother brushing calcimine than type I, requires boiling water for mixing.

Unpainted plaster walls should be sized with either a glue-water size or, if the plaster is dry, a varnish size; the latter can be bought ready-prepared or made by thinning 1 gal of interior varnish (Fed. Spec. TT–V–71a) with 1 qt of turpentine. For the best results, a foundation can be made for the calcimine by applying one coat of flat wall paint (TT–P–51a) over either the varnish size or over one coat of primer (TT–P–56).

One thick coat of calcimine is usually sufficient. If a second coat is necessary, it must be brushed on skillfully to avoid lifting the first coat. After the calcimine has been applied, the room should be aired thoroughly to dry the calcimine quickly.

In repainting with calcimine, the old calcimine should first be sponged off with warm water, thus removing all the old calcimine (and the dirt) before applying the fresh coat.

A typical white calcimine powder has about the following composition:

Ingredients	Weight *Percent*	Volume *Percent*
Pigment:		
Whiting	75	70.8
China clay	21	20.6
Binder:		
Glue	3	6.0
Phenol (carbolic acid)	1	2.6
	100	100.0

One gallon of this white calcimine powder free from all voids weighs 21 lb and has a specific gravity of 2.6. The actual shipping weight of the calcimine will be less than this theoretical weight.

(b) Paint; Cement-Water, Powder, White and Tints (for Interior and Exterior Use) TT–P–21, June 30, 1941

Portland-cement–water paint covered by this specification is intended for use on porous surfaces of masonry, concrete, stucco, common brick, masonry block, and rough plaster (except gypsum plaster). It does not bond to steel, but some brands are used satisfactorily on galvanized iron. It is furnished in two types and two classes, in white and tints.

Type I powder contains not less than 65 percent of portland cement and not more than 25 percent of hydrated lime; type II powder contains not less than 80 percent of portland cement and not more than 10 percent of hydrated lime. Both types include from 3 to 5 percent of titanium dioxide, zinc sulfide, or a mixture of these, and from ½ to 1 percent of the water repellents, calcium or aluminum stearate. Both types should give satisfactory service, but where there is excessive moisture, as in swimming pools and water tanks type II paint should be used.

Class A powder has no siliceous aggregate, but class B contains from 20 to 40 percent. Class A is suitable for all surfaces except open-textured masonry. Class B is suggested for open-joint walls and materials such as cinder block, lightweight aggregate block, and similar surfaces where a heavy coating is necessary to fill voids and crevices. The aggregate in class B tends to lessen map cracking and crazing. If the texture resulting from the use of paint containing class B powder is too rough, a coat of paint containing class A powder may be used.

Cement-water paint should bond with the surface and with succeeding coats of paint of either type to form a finish of high durability. Durability of the coating is determined more by the paint surface, the method of application, and the curing of the paint film than by the composition of cement-water powder used in the paint.

Most cement-water paint films have adequate opacity when dry, but during rainy weather they frequently become nearly transparent. Inclusion of from 3 to 5 percent of the

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opaque pigments titanium dioxide or zinc sulfide tends to improve the opacity of the wet film.

The surface to which the paint is applied must be clean, damp, and free from dirt, dust, oil, "form-lacquer", or any other substance that would prevent the paint from striking in or bonding to the wall. If the surface to be painted has been previously treated with an organic waterproofing compound or a sealing type of paint, the coating must be removed (preferably by sandblasting). The surface must be sufficiently porous to afford "tooth" for the paint. If there is doubt, as in the case of monolithic concrete, the surface should be lightly sandblasted, etched by washing with "builder's acid" (see glossary), and rinsing thoroughly with water, or dry rubbed with an abrasive stone.

Although cement-water paint can be applied by whitewash brushes or spray guns, the best results are obtained by scrubbing the paint into the surface with a stiff-fiber brush. Thus, a good bond is produced between the paint coating and the wall surface and between coats of the paint itself. This method is particularly recommended for application of type II paint and where waterproofing is desired. Soft brushes are not recommended.

Tints and white may be intermixed to produce a variety of colors; however, the addition of dry tinting colors should be avoided as they should be milled-in by the manufacturer to avoid color streaking.

(c) Paint; Cold-Water, Exterior, Powder (with mixing liquid) TT–P–22, August 30, 1943

This specification covers a low-cost powder paint and a mixing liquid to produce a dry porous film. This "breathing" type of paint is intended for surfaces permeable to moisture and where durability and protection from weather are not required. It is applied chiefly to exterior surfaces of cement, cinder block, and brick, and may be used for weather-beaten wood and for firm interior surfaces such as concrete, brick, and cement.

The paint is obtainable in white and light tints. However, a note in the specification indicates that it may be obtained in dark solid colors, such as camouflage colors. For tints and solid colors, the purchaser should specify the color required and whether the tint should match a designated sample.

To meet the requirements for wet and dry opacity for white and light tints it is necessary to use some titanium dioxide or some of the types of zinc sulfide pigments. Satisfactory white material passing this specification was found to contain 13 percent of milk casein and not less than 4 percent of hydrated lime. Camouflage colors, such as Field Drab, No. 303, Earth Yellow, No. 305, and Sand, No. 306, should match the appropriate standard shown on the color card [5]. Paint mixed as in section F-3b of the specification, when brushed on the type of hiding-power chart (see glossary) described in section F-3g (1), should show the following minimum wet and dry capacities:

> No more than 7.5 ml of paint spread over an area of 1 sq ft shall be required to attain complete visual dry hiding.[2]

In addition to matching the color standard, darker camouflage colors should show the following minimum opacity:

> No more than 6 ml of paint spread over an area of 1 sq ft shall be required to attain complete visual dry hiding.

The opacity requirements for colors other than camouflage colors should approximate those of the camouflage colors that they most nearly match.

The use of linseed oil, raw or boiled, and spar varnish, in addition to water, as mixing liquids for casein powder paint has long been a common practice. Drying oils, which impart weather resistance and flexibility, readily produce an oil-in-water emulsion in casein powder paints. Currently available are specially processed drying oils which contain emulsifier and stabilizer to disperse the oil directly in the water. Such "water-dispersible" oils contain at least 80 percent by weight of solids. Either type of oil should produce satisfactory paints, but when the invitation for bids specifies emulsified oils, the testing laboratory should be notified because the emulsified oil will not conform to the Federal Specification for boiled linseed oil.

The surface to which the paint is applied should be clean and uniformly damp. Loose paint, dirt, and dust can be

[2] Lighting and viewing conditions [10].

removed by scraping and by brushing with a wire brush; calcimine and glue-bound water paint can be removed by washing. Metal should be primed with a suitable oil paint (such as red lead paint, Fed. Spec. TT–P–86) before water paint is applied.

Powder paint should be purchased by net weight. In the case of tints, the purchaser should specify the color required and whether it shall match a selected sample.

Although this is a performance specification, a typical paint made from 100 lb of white powder, 10 gal of water, and 1 gal of oil contains the following ingredients:

	Weight *Percent*
Titanium dioxide	7.9
Calcium carbonate	18.3
Hydrated lime	2.1
Clay	16.7
Casein	6.8
Preservative	0.5
Linseed oil	4.1
Water	43.6
	100.0

Such a paint weighs about 11.1 lb/gal and has a PV of about 59. This is merely an example, as other formulations may be used under the specification.

(d) Paint; Cold-Water, Interior Light Tints and White TT–P–23a, Mar. 22, 1940

The cold-water paint covered by this specification is furnished in powder and in paste form. It is intended chiefly for decorating plaster and other dry interior masonry surfaces but is sometimes used for temporary exterior work. It is not recommended for use on basement walls if dampness is present because of its tendency to mildew.

The binder in this paint is milk casein, soya bean protein, or other forms of protein. However, the specification is based on physical tests, not on composition.

Dry opacity tests made according to the specification have shown that the same hiding power is obtained from 3.5 qt of one paste and 4.25 qt of another paste with the same content

of zinc sulfide and total solids. The degree of dry opacity of a paste is also affected by the inerts chosen.

Some users are interested in the washability of cold-water paints. In practice, the time required for the paint coat to age before it can be washed varies from 5 to 30 days. Paints that develop washability slowly may be cleaned more easily than those that develop it quickly. Mild white soap and tepid water are recommended for washing this paint.

Before cold-water paint is applied, the surface to be covered should be free from powdery material, such as loose plaster and calcimine, and should present a sound, firm surface for painting. Iron and steel should be coated with oil paint to prevent rust stains.

The possible variation in porosity of adjacent plaster surfaces may frequently make advisable the application of an initial priming or sealing coat to overcome uneven suction effects. Such sealers are obtainable in both the oil- and water-base types. An oil-base primer meeting Federal Specification TT–P–56 is satisfactory if such a primer penetrates and fills the surface, drying to a dull, hard finish within 18 hr.

Although Federal Specification TT–P–23a is based mainly on performance requirements, a typical white powder may contain (percentage by weight) about 54 lithopone, 22 whiting, 12 hydrated lime, 1 trisodium phosphate, 1 preservative, and 10 casein. This mixture has a specific gravity of about 2.74, and 1 gal of the powder weighs about 23 lb. Type II paste may contain (percentage by weight) about 66.7 of the above pigments and casein (total nonvolatile) and 33.3 water. This paste weighs about 14 lb/gal and has a PV of about 72. These are merely examples, as other formulations may be used under the specification.

Directions for mixing with water are usually printed on each package of powder and paste. In the absence of directions, the material should be thinned to a suitable consistency for brushing. Although paints should meet the remixing requirements stated in sections E–1b, E–2b, and F–3b of the specification, it is better practice to use them the same day they are mixed.

Samples are not usually necessary. If required, they should be called for in the invitation for bids. The purpose of the bid sample should be stated, the specification to apply in all other respects.

(e) Paint; Resin-Emulsion, Interior, Paste Light Tints and White TT–P–88a, May 26, 1945

This specification covers a water thinned paste paint of the resin-emulsion type that may be applied as a decorative coating on interior walls and ceilings of plaster. In addition to plaster, it may be used on concrete, brick, masonry, wallboard, and fabric. Paint meeting this specification is not intended for wood and metal but may be used on such surfaces if they are suitably primed.

This cold-water paint dries in 1 to 3 hr and may be recoated in 6 to 8 hr. The film becomes hard after drying overnight.

Before this paint is applied, the surface should be free from powdery material, such as dust, calcimine, or loose plaster, and should present a sound, firm surface for painting.

Attention is called to suggestions regarding porous surfaces and washing, given in section III–4–(d) of this manual, which also apply to this and similar paints.

The paint can be applied either by brush or spray, but not in freezing weather. The brushes should be washed with soap and water before the paint dries on the brush. Although emulsion paint is usually applied by brush, it can be applied by spraying and by "roller" coating. The latter procedure has become very popular as a quick and easy method for applying emulsion paint to the surfaces of walls and ceilings.

Directions for mixing the paste with water are usually printed on each package. Nothing but water should be added to the material unless otherwise recommended by the manufacturer. For application to plaster, 2 parts by volume of paste are usually thinned with 1 part by volume of water so that 1 gallon of paste makes 1½ gal of paint. For porous surfaces, 3 parts of paste can be thinned with 2 parts of water. For spraying, 5 parts of paste are thinned with 2 parts of water. These proportions are approximate. When given, the manufacturer's directions should be followed.

Federal Specification TT–P–88a is based mainly on performance requirements, and considerable latitude is allowed the manufacturer regarding composition. The product is an oil-in-water emulsion in which the vehicle is an emulsion of film-forming oils, resins, etc., in an aqueous phase. The

water or outer phase contains a number of ingredients, including water; an emulsifying agent (see glossary), such as casein; a bodying agent, such as alginate or methylcellulose; a preservative, such as phenol and its derivatives; an antifoaming agent, such as pine oil or butyl alcohol; and salts or alkalies, such as ammonia. The oil phase may consist of oils, resins, and driers. A type used before the war consisted of an oil-modified alkyd resin (see glossary). When alkyd resins became critical because of the war, the oil phase consisted of materials such as ester gum and linseed oil. The formulation of such a product requires considerable skill and experience on the part of the manufacturer.

The pigments used are the same as in high-grade oil paints, consisting of titanium-base and zinc sulfide–base pigments, together with extenders such as clay, mica, and magnesium silicate for white colors.

A typical paste paint contains (percentage by weight) about 50 percent vehicle (25 to 30 percent nonvolatile) and 50 percent pigment. An average paste weighs about 13 lb/gal and the PV is about 54.

(f) Whitewash

Whitewash is one of the oldest paints [11]. It is used for both exterior and interior surfaces; for example, sheds, telephone poles, roadside obstructions, concrete masonry, and brickwork.

The principal ingredient in whitewash is lime paste. A satisfactory paste can be made with hydrated lime but better results are obtained by using quicklime that has been slaked with enough water to make a moderately stiff paste and has been kept in a loosely covered container for several days, or preferably months. Eight gallons of stiff lime paste are produced by slaking 25 lb of quicklime in 10 gal of water or by soaking 50 lb of hydrated lime in 6 gal of water. The paste should then be strained through a fine screen to remove lumps or foreign matter.

Whitewash can be made from various combinations of lime paste and other ingredients. Two good formulas for whitewash are

FORMULA NO. 1

Casein	5 lb.
Trisodium phosphate	3 lb.
Lime paste	8 gal.

The casein should be soaked in 2 gal of hot water until thoroughly softened (approximately 2 hr). The trisodium phosphate dissolved in 1 gal of water is added to the casein mixture and the casein allowed to dissolve. This solution should be mixed with the lime paste and 3 gal of water. Such a whitewash shows the following characteristics:

Ingredients	Weight *Percent*	Volume *Percent*
Hydrated lime	29.0	15.0
Casein	2.6	3.1
Trisodium phosphate	2.6	1.9
Water	65.8	80.0
	100.0	100.0

The whitewash weighs 10 lb/gal and has a specific gravity of 1.21; one pound bulks 0.099 gal. The PV is about 75.

FORMULA NO. 2

Common salt	12 lb
Powdered alum	6 oz
Molasses	1 qt
Lime paste	8 gal

The salt and alum are dissolved in 4 gal of hot water, after which the molasses is added to the mixture. The resulting clear solution is then added to the lime paste, stirred vigorously, and thinned with water to the desired consistency. This whitewash has a yellow tinge when first applied, but the color disappears in a few days, leaving a white film. Material made according to this formula is used by highway departments for marking trees, poles, and other objects on highways.

If skim milk is available, a satisfactory whitewash or cold-water paint can be made by diluting a moderately heavy, cold, lime paste (about 33 lb of hydrated lime and 8 gal of water) with 5 gal of skim milk.

For additional information on whitewash the purchaser is advised to consult the bulletin of the National Lime Association mentioned in reference [11].

7. MISCELLANEOUS MATERIALS USED BY PAINTERS

This group covers materials that cannot be classified, such as fillers, putty (see glossary), paint and varnish removers, waxes, bituminous plastic cement, and asphalt roof-coating.

(a) Filler; Wood, Paste
TT–F–336a, Sept. 20, 1941

Wood filler is a mixture of silex or ground quartz and quick-drying varnish used to fill the pores of open-grained wood, such as oak, before varnish is applied and sometimes before painting. The paste filler is thinned to brushing consistency with turpentine or mineral spirits. Paste wood filler covered by this specification is intended for use on open-grained floors and flooring. When thinned, it can be substituted for a pigmented liquid wood filler.

In applying the filler, a thick coating should be rubbed into the wood with a stiff brush. After 15 min the excess paste can be wiped off across the grain of the wood, which should then be rubbed well with excelsior or a cloth pad.

Paste wood filler should be purchased by net weight. Samples are not usually necessary. If required, they should be called for in the invitation for bids. The purpose of the bid sample should be stated, the specification to apply in all other respects. (For colored filler see section E-1 in the specification).

The lightest and heaviest uncolored paste fillers meeting this specification show the following characteristics:

	Weight *Percent*	Volume *Percent*	*lb/gal*	*gal/lb*	sp gr	PV
Light filler	..	..	15.82	0.063	1.898	64
Pigment	78	56	....	....	....	..
Nonvolatile	17	32	....	....	....	..
Volatile	5	12	....	....	....	..
	100	100				

	Weight *Percent*	Volume *Percent*	*lb/gal*	*gal/lb*	sp gr	PV
Heavy filler	..	..	17.24	0.058	2.07	76
Pigment	85	66	....	....	....	..
Nonvolatile	10	21	....	....	....	..
Volatile	5	13	....	....	....	..
	100	100				

When 10 lb of the lightest paste is thinned with 6⅔ lb (1 gal) of mineral spirits, a lightweight wood filler with the following characteristics is produced:

	Weight	Volume			sp gr	PV
	Percent	*Percent*	*lb/gal*	*gal/lb*		
Thinned light filler	..	..	10.22	0.097	1.226	64
Pigment	47	22	....	....	....	..
Nonvolatile	10	12	....	....	....	..
Volatile	43	66	....	....	....	..
	100	100				

(b) Putty and Elastic Compound; (for) Metal-sash Glazing TT–P–781a, July 12, 1941 Amendment 1, July 20, 1943

(c) Putty; Pure-Linseed Oil; (for) Wood-Sash Glazing TT–P–791a, June 25, 1938 Amendment 1, July 20, 1943

Before glazing, both old and new surfaces should be free from dampness, ice, dirt, and loose paint. Such substances can be removed by drying the surfaces, then wiping them clean with a cloth saturated with turpentine, mineral spirits, or similar solvent. Suitable priming coats should be applied to the bare clean wood or metal before applying the putty. These priming coats on wood should be allowed to dry and should prevent excessive loss of oil or other vehicle from the putty or glazing-compound. Many glazing technologists do not recommend a primer, such as shellac, that dries to a hard glazed surface. Suitable materials for priming wood are thin white-lead–linseed-oil paint, Federal Specification TT–P–40, amendment 1, type II; exterior primer paint, TT–P–25, amendment 1, or spar varnish, TT–V–121b, thinned with one-fourth its volume of mineral spirits or turpentine. These coatings should be allowed to dry hard before putty or elastic glazing compound is applied.

All steel sash should be primed with a rust-inhibitive paint, for example, red-lead paint conforming to Federal Specification TT–P–86, amendment 1.

Putty and elastic glazing compound should be painted within 2 months after application. However, the paint should not be applied until the putty is hard and thoroughly set, as the formation of an airtight film retards drying and may later cause the surface of the paint to check. Certain special quicksetting putties must be painted within a week of exposure to the weather to avoid deterioration of the

putty. Paint should be applied carefully over putty, the paint coat to extend slightly beyond the edge of the putty on the glass to form a seal.

Glazing materials covered by Federal Specification TT–P–781a are intended for general use for the glazing of metal sash and are analogous to (but not always identical with) the best plastic calking compound conforming to TT–C–598. Insofar as it is practicable, glazing materials should be formulated to afford maximum ease of application without detracting from durability.

Type I covers elastic glazing compounds that may be used mainly for glazing either interior or exterior metal sash and also properly primed wood sash. It should dry to a hard surface but should remain slightly soft and plastic underneath for a reasonable period of time. This soft, or plastic, condition is desirable where windows, glazed doors, swinging transoms, and elevator housings are subject to considerable vibration, and on skylights, where maximum durability is necessary. Consequently, type I material should be specified where low annual maintenance cost is of primary importance. If available, it should always be used on permanent structures.

Type II covers a metal sash putty of lower quality than type I, but is probably satisfactory for temporary buildings. Both types of glazing material should be applied according to the manufacturer's directions.

Glazing materials should be used while they are still fresh and as they come from the container, without addition of any thinner. Therefore, the materials should be purchased in relatively small amounts for immediate use.

Type I elastic glazing compound meeting the specifications may contain whiting, a small amount of asbestos fiber, a mixture of bodied drying and semidrying oils, such as fish and soybean, drier, and thinner. It has approximately the following characteristics:

	Weight	Volume			sp gr	PV
	Percent	*Percent*	*lb/gal*	*gal/lb*		
Elastic glazing compound	..	..	17.42	0.0574	2.09	70
Pigment	85	65.9	....	.....	...	..
Nonvolatile	13	28.9	....	.....	...	..
Volatile	2	5.2	....	.....	...	..
	100	100.0				

Federal Specification TT–P–791a covers the requirements for high-grade linseed-oil putty for general use on woodsash glazing. It is furnished in types I and II. Although the two types may be used interchangeably, type II is recommended where a hard material is desirable, such as for filling holes and cracks. Some users consider it more durable than type I putty.

Type I whiting putty with the maximum pigment has the following characteristics:

	Weight *Percent*	Volume *Percent*	*lb/gal*	*gal/lb*	sp gr	PV
Putty, type I	..	..	18.18	0.055	2.18	74
Pigment (whiting)	88.0	71.2	....	....	....	..
Nonvolatile vehicle	10.8	25.5	....	....	....	..
Volatile vehicle	1.2	3.3	....	....	....	..
	100.0	100.0				

Type II white-lead–whiting putty with maximum pigment shows the following characteristics:

	Weight *Percent*	Volume *Percent*	*lb/gal*	*gal/lb*	sp gr	PV
Putty, type II	..	..	19.43	0.051	2.33	74
Pigment (white lead)	10.0	3.44	....	....	....	..
Pigment (whiting)	79.0	68.33	....	....	....	..
Nonvolatile	9.9	25.02	....	....	....	..
Volatile	1.1	3.21	....	....	....	..
	100.0	100.00				

Often putty contains less pigment than the maximum specified, usually not less than 85 percent in type I. A typical putty shows:

	Weight *Percent*	Volume *Percent*	*lb/gal*	*gal/lb*	sp gr	PV
Putty, type I	..	..	17.37	0.057	2.08	68
Pigment	85.0	65.6	....	....	....	..
Nonvolatile	13.5	30.5	....	....	....	..
Volatile	1.5	3.9	....	....	....	..
	100.0	100.0				

(d) Remover; Paint and Varnish (Organic-Solvent Type) TT–R–251a, Aug. 28, 1942 Amendment 2, Oct. 28, 1944

Paint and varnish removers are intended principally for application to interior surfaces but may be utilized for exterior work if this can be done efficiently. They are furnished in two types.

Type I paint and varnish removers are intended for use in places that are relatively free from fire hazards. Type II removers are intended for use where some protection against fire hazard is desired. Although removers of this type may be considered nonflammable in their original condition, some discretion must be employed in their use as the nonflammable solvents that commonly constitute a portion of the active ingredients tend to evaporate faster than the flammable portion. Thus it is important not to use remover of this type from damaged or leaking containers and to prevent evaporation, as far as practicable, during actual use of the material.

NBS Letter Circular LC749, Paint and Varnish Removers, contains detailed information on the composition of various kinds of paint and varnish removers.

(e) Wax, General Purpose; Solvent Type, Liquid and Paste (for Floors, Furniture, etc.) P–W–158, Sept. 17, 1942 Amendment 1, March 11, 1943

This general purpose wax, as the title of the specification indicates, is intended for use as a polishing wax on such surfaces as floors (except asphalt or rubber) and furniture. It is available in one grade and in type I (liquid) and type II (paste). The latter may be used for maintaining the finish on automobiles.

(f) Wax, Floor; Solvent Type, Liquid (with Resins) P–W–134, Oct. 29, 1942

The floor wax specified herein is intended for use on all flooring except composition containing asphalt or rubber.

(g) Wax, Floor; Water-Emulsion P–W–151a, April 8, 1942

This liquid wax is intended for use on bituminous floors, rubber flooring, and linoleum. It is the type of wax that

does not have to be polished after application. It is a water-wax emulsion, and should be kept in clean containers. Severe or prolonged freezing may break the emulsion, and thus it is suggested that it be not subjected to severe or prolonged freezing temperatures.

(h) Cement; Bituminous, Plastic
SS–C–153, Aug. 1, 1933

Bituminous plastic cement is black in color, and composed of a bituminous binder (asphaltic-base in type I and coal-tar base in type II), inorganic filler, such as asbestos fiber, and a solvent. The material is a soft, pliable paste that holds its shape within 2 or 3 days after application and gradually hardens to a tough rubber-like coating that is waterproof and durable. One hundred pounds of the cement spread ⅛ in. thick will cover approximately 150 ft^2.

Bituminous plastic cement is used on coal-tar pitch, for repairing leaks and cracks in all types of roofs—concrete, tin, composition, or shingle—for repairing chimneys, flues, gutters, spouting, eaves, and cornices, or as expansion-joint material for concrete and masonry. It adheres to brick and mortar and remains elastic, expanding and contracting with the surface. Type I, asphaltic-base cement, is similar to roof coating meeting Federal Specification SS–R–451, except in consistency; it should be used with Federal Specification HH–F–191a flashing felt.

(i) Roof-Coating; Asphalt,
Brushing-Consistency
SS–R–451, Aug. 1, 1933

Material meeting this specification is known in the trade as asphalt-asbestos roof coating. It is an inexpensive black paint, usually composed of asphalt base (with or without fatty oils), a volatile solvent, and a mineral filler such as asbestos fiber. Because the durability of the coating is dependent upon its thickness, the paint is of heavy brushing consistency and can be spread at the rate of 52 ft^2/gal for a film $\frac{1}{32}$ in. thick and at 26 ft^2/gal for a film $\frac{1}{16}$ in. thick. Unlike ordinary paint, this coating should not be brushed out thin.

Asphalt roof-coating is recommended for use on corroded tin roofs that leak. Ordinary linseed-oil paints would be

too thin for this purpose. However, for metal roofs in good condition, linseed-oil paints (Fed. Spec. TT–P–31a) are preferable.

IV. PREPARATION OF SURFACES AND APPLICATION OF PAINTING MATERIALS

The success of a painting job depends principally on four factors: (1) the condition of the surface to be painted, (2) the condition of the preceding paint coat in a repainting job, (3) the prevailing atmospheric conditions, (4) quality of the paint and its suitability for the service expected. It is probable that the disregard of these factors is the chief cause of paint failures with all materials.

1. WOODWORK

(a) EXTERIOR SURFACES

(1) *New Work.*—Painting should be done only in clear, dry weather. The surface should be free from dew or frost and should not be painted until it feels dry to the hand. Painting should not be done when the temperature is below 50° F or in urgent cases below 40° F, and in no case when the temperature is expected to drop 20 degrees or well below 50° F. Precaution should be taken not to paint after a sudden drop in temperature. This is accomplished by stopping the work early enough in the afternoon to allow the paint to set before a sudden drop in temperature occurs. Paint should not be applied while rain, snow, or sleet is falling on the surface. As a rule, dry woodwork can be painted immediately after erection. If the lumber or finish is green when placed or has been made very wet for some other reason, it is suggested that at least 1 week of dry, sunny weather precede the painting.

Oil paint applied over knots and sappy wood is likely to alligator and peel and with pine woods to discolor. There is apt to be more alligatoring of paint over knots on southern exposure, because of more sunshine, and more yellow discoloration of the paint over knots on the north side, where sunshine is weakest. The knots may be spot painted with Orange Shellac Varnish (Fed. Spec. TT–V–91a), Shellac Varnish Replacement (Fed. Spec. TT–V–130), or a high-grade aluminum paint applied a day or two before applying the priming-coat paint. The Western New York Club of

the Federation of Paint and Varnish Production Clubs found that an effective sealer for knots consists of pure shellac varnish plasticized with 6 liquid ounces of blown castor oil to the gallon of shellac varnish. This formula originated at the Forest Products Laboratory, Madison, Wis. However, experience in painting army cantonment buildings constructed of No. 2 common southern yellow pine containing many knots indicates that ordinary shellac varnish or aluminum paint is of little value in sealing knots (see section VIII). When shellac varnish is applied too liberally over the knots, the paint on weathering tends to peel off. When the shellac varnish is applied thin, the paint may not peel, but yellow discoloration may show through from the pitch. All pitch should be scraped or burned from knots and other places; it is suggested that these areas then be scrubbed with turpentine prior to painting.

Excessive moisture back of the paint film is responsible for many failures of paint on exterior wood surfaces. The interior plaster in a frame dwelling house contains a great deal of moisture that dries slowly and is drawn through walls into the exterior wood by the heat of the sun. A properly formulated priming coat will permit this moisture to pass through the film. If paint is applied to the exterior wood siding before the new plaster is dry, it may blister (see glossary) and peel.

The usual system of painting houses in white and light tints includes raw-linseed-oil paints like the unamended Federal Specification TT–P–40 and white-lead paints mixed on the job according to the formulas in table 2 for mixing white-lead paint. These paints have the advantage of easy brushing properties and can be spread over large areas, 600 to 700 ft^2/gal. Three coats are usually required on new wood. The cost of labor and the length of time required to complete the job has resulted in the introduction of the two-coat system. These paints may contain heat-treated oils (or varnish) in the vehicle, like that covered by amendment 1 of TT–P–40 and the formulas in table 3 for white-lead paint mixed on the job. A typical primer for a two-coat paint system is exemplified in Federal Specification TT–P–25.

The first coat should always be carefully brushed and crossbrushed, if practicable, over all parts of surfaces so that cracks and nail holes receive enough paint to wet the

surfaces. The older, unbodied, linseed-oil first coat should be brushed out to cover about 600 ft^2/gal, the newer type priming paints like those in Federal Specification TT–P–25, amendment 1, June 5, 1943, and the white-lead mixed-on-the-job paints used on a two-coat job should be applied at about 450 ft^2/ gal. In good weather for painting, all coats should be allowed to dry for 3 days.

Nail holes and cracks should be properly filled with putty (Fed. Spec. TT–P–791a, amendment 1, July 20, 1943) as soon as the priming coat is dry. After about a week of clear, warm weather, the putty should be hard enough to receive the second coat.

Window sills and outside doors are sometimes varnished. For this work no wood filler is necessary (if the wood is close-grained), but several coats of spar varnish TT–V–121b should be applied. While the finish on exterior woodwork properly painted with two or three coats of high-grade oil paint approximately the color of the wood should last at least 4 years before repainting, similar exposed woodwork finished with good quality spar varnish will probably need to be revarnished annually.

(2) *Refinishing.*—Unlike application of paint, which is limited to good weather conditions, the preparation of the surface can proceed under any weather conditions where it is feasible for men to work. The success of a repainting job depends on how well any scaling paint as well as insecurely attached paint is removed from the wood. It is imperative that all insecurely attached paint be thoroughly removed from the surface, otherwise, no matter what paint is used, failure is apt to occur over any loose paint on any improperly prepared surface.

(a) Loose Paint.—All loose paint should be removed by wire brushing or scraping. A combination of these two methods, depending upon the condition of the paint and the nature of the surface, has been found to be practical and effective. Following wire brushing and scraping, the surface should be sanded with No. 1½ or No. 2 garnet paper to further insure the removal of loosely adhering paint and to better prepare the surface for a smoother finish repaint job. It is recommended that all old paint that is peeling or flaking be removed, preferably by burning it off with a torch or by the use of paint and varnish remover.

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(b) KNOTS.—All pitch should be scraped or burned from knots. In general, no further preparation, such as spot painting of knots with shellac varnish or aluminum paint, is necessary, although customary practices may be followed.

(c) ADDITIONAL MEASURES FOR SMOOTHING SURFACES.—Decayed or split boards that cannot be suitably prepared for repainting should be removed and replaced. All loose boards should be securely fastened, using large-headed nails, preferably galvanized. Protruding nails should be removed or driven into the wood. Open nail holes, and countersunk nails, should be filled with putty. Gaps between ends of siding and corner boards, or window and door casings should be filled with calking compound (Fed. Spec. TT–C–598). Surfaces soiled with foreign matter, such as roofing pitch and tar, should be scraped free from this foreign matter and the surface thoroughly washed with mineral spirits.

(d) MILDEW.—To combat mildew, it is extremely important that mildew-infected surfaces be thoroughly scrubbed with water containing some trisodium phosphate (phosphate cleaner, Fed. Spec. O–T–671a). It is a white powder that can be purchased in small lots as "Technical Trisodium Phosphate," or in grocery stores under brand names. The infected surfaces should be scrubbed with a solution of about three tablespoons of trisodium phosphate dissolved in a gallon of water, using floor scrubbing brushes. The surface should then be rinsed with clean water and allowed to dry before applying the paint.

The most efficient method of combatting badly mildewed areas is to wash the areas with a solution of 1 part of bichloride of mercury dissolved in 300 parts of water. However, this is a dangerous poison, and consequently the use of trisodium phosphate solution is recommended.

When mildew is particularly severe, the priming and finishing paint should contain a fungicide. The bid should specify that, in addition to meeting the Federal Specification, the paint should contain 1 part by weight of mercuric chloride to every 600 parts by weight of paint. The bichloride should be properly ground and evenly dispersed in the paint liquid. The content of mercuric chloride should be stated on the paint container label with the necessary precautions for use. Commercial brands of fungicides other than mercuric chloride have also been developed especially

for use in paint. They are available in paste form so as to be dispersed easily in the paint by the user at the time of application.

(e) APPLICATION OF PAINT.—After the surface is prepared for repainting, all bare spots should be spot-primed with TT–P–25 exterior primer, followed by TT–P–40 finish coat (or any other color desired). If all the old paint has been removed, the entire surface should receive a coat of TT–P–25 exterior primer.

(3) *Staining of Shingles and Wood.*—Shingle stains are thin, fluid paints in which the shingles are dipped before being laid. Suitable stains properly applied to shingles or rough siding give a durable finish on exterior woodwork.

With the exception of some dark-brown stains, which are refined coal tar or creosote and volatile thinner, shingle stains are usually made from very finely ground pigments, drying oils, and volatile thinners. Many commercial shingle stains contain some creosote oil. However, for positive preservation of wood, creosote must be forced into the wood by a hot-pressure treatment. As oil paint applied over creosote is likely to be ruined by the creosote bleeding through (see glossary), pigment-oil shingle stains without creosote are preferable if repainting is contemplated. A good liquid for making shingle stains from suitable pigments-in-oil, such as TT–P–381, is a mixture of 3 parts of mixing oil (TT–O–356a, class 2) and 1 part of either raw or boiled linseed oil. Federal Specification numbers for the colors-in-oil are given in table 10 and color designations in table 11.

The following is a list of the most widely used colors. Some of these colors may not be obtainable until after the war emergency:

Brown:	Metallic brown.	Red:	Indian.
	Sienna, burnt.		Mineral red.
	Umber, burnt.		
Green:	Chromium oxide.	Yellow:	Yellow iron oxide.

Other stains are made by dissolving organic colors in oil solvents or other liquids, including water. Probably ready-made stains are used oftener than those mixed on the job. The manufacturer's directions for application should be followed. Some of these stains will bleed into paint applied over them. Usually it is difficult to lighten the color of previously stained wood; it can readily be darkened. Exterior

and interior wood stains are covered in Federal Specifications TT–S–706 and TT–S–711.

(4) *Porch Floors.*—Wood porch floors should be as carefully prepared for painting as other exterior surfaces. A priming coat of paint mixed on the job can be made according to the formulas in tables 1 or 2. The paint should be well brushed out, not flowed on in a thick film. If ready-mixed paint is used, it should comply with Federal Specification TT–P–146. Each gallon of paint should be diluted with 1 qt of thinner containing 2 parts of boiled linseed oil and 1 part of turpentine for the priming coat. After the first coat is dry, joints, cracks, and other defects should be filled with putty firmly pressed in and smoothed over with a putty knife. When the putty is dry, the surface should be lightly sandpapered.

The second coat may be mixed according to the formulas in tables 1 or 2, tinted to a shade of gray darker than the first coat but lighter than the finish coat. If ready-mixed paint (Fed. Spec. TT–P–146) is used, 1 pt of the mixture used to thin the priming coat should be added to each gallon of the paint. A third coat (if desired) can be made by adding 1 pt of high-grade spar varnish to each gallon of a desired gray finish-coat prepared according to the finish-coat formula in tables 1 or 2. Ready-mixed paint (Fed. Spec. TT–P–146) can also be used for the third coat; if too thick to be spread easily, the paint can be thinned slightly with turpentine or mineral spirits.

(b) INTERIOR SURFACES

The same directions for preparing the surfaces of new exterior wood for painting apply to interior woodwork. In addition to having the surface clean and dry, it is advisable to roughen very smooth wood slightly with fine sandpaper.

(1) *New Work.*—Durable and attractive finishes on interior woodwork and wood furniture are obtained from varnish and analogous materials. Linseed-oil paints used on exterior wood may not be suitable for interior work because of slow drying and tendency to turn yellow.

There are some hardwoods with strongly colored heartwood that tend to become lighter in color in strong light, but most of our important native woods darken in sunlight, even under a good coating of white paint, and remain relatively unchanged in darkness. Wood when kept dry will last for centuries indoors.

Varnishes applied to interior surfaces also darken with age. Consequently, wood coated with interior varnish and kept indoors may darken if not exposed to direct sunlight, but otherwise remain in good condition for many years. On the contrary, wood kept indoors and exposed to direct sunlight may result in the failure of the varnish by cracking in a few years.

Wood stains are widely used to either change or modify the color of interior wood without obscuring the natural grain. Wood stains can be purchased under Federal Specification TT–S–711 or may be made in two ways. By the first method, colors-in-oil (Fed. Spec. TT–P–381) can be mixed with flatting oil (Fed. Spec. TT–O–356a, class 1). By the second method, wood stains can be made by mixing ½ pt of color-in-oil with 1 gal of thinning liquid. This liquid is composed of 1 part raw linseed oil, 1 part turpentine, and ½ part drier (Fed. Spec. TT–D–651a). Light oak is usually obtained from raw sienna. Dark-oak color can be obtained by mixing a small quantity of burnt umber with the light-oak mixture. Mahogany and cherry color can be obtained by using burnt sienna.

The usual system of staining and varnishing interior wood trim is to apply the coats in the following order:

1. Stain coat (Fed. Spec. TT–S–711).

2. Filler coat for open-grain woods only (Fed. Spec. TT–F–336a).

3. Sealer coat, bleached shellac varnish (Fed. Spec. TT–V–91a). This coat is needed only if the stain contains aniline dye, for example, mahogany stain.

4. First coat, varnish (Fed. Spec. TT–V–71a) thinned with ½ pt of turpentine per gallon. The dried surface should be sanded lightly when dry with No. 4/0 sandpaper.

5. Second-coat, varnish (Fed. Spec. TT–V–71a) applied without thinning. Should be sanded same as first coat.

6. Third coat, varnish (Fed. Spec. TT–V–71a). Where a dull rubbed finish is wanted, let the last coat of varnish dry hard for 72 hours; then rub with powdered pumice and water to a uniform dull finish.

The best results will be obtained if varnish is used according to the following instructions:

1. Smooth, thin coats should be applied, preferably at a temperature between 70° and 80° F, and in a well-ventilated room.

2. Varnish should be brushed on with the grain of the wood, crossbrushed, then brushed again with the grain of the wood.

3. The minimum number of coats necessary to attain the desired finish should be applied.

4. Ample time should be allowed for the coats to dry.

5. Freshly varnished work should be kept clean and dust free.

6. Each coat should be rubbed lightly with fine (No. 4/0) sandpaper to a dull finish before the next coat is applied.

7. Brushes and varnish cans should be kept free from dust.

A durable and attractive finish on interior furniture (particularly on a mahogany table top) is an oil-rubbed finish. The unfinished wood should be frequently rubbed with boiled linseed oil thinned with turpentine or mineral spirits, the excess oil being wiped off. Raw linseed oil alone is also used. This process is repeated four or five times, after which the oil need only be applied at occasional intervals. After the pores of the wood have been filled with linseed oil by the first series of applications, any animal or vegetable oil or fat may be used. The more the finish is rubbed, the better it will be. After long years of use, a beautiful patina is developed. Hot dishes placed on a table top do not turn this finish white. Because the process of oil polishing is tedious and slow, it is not used much today. Modern production schedules in finshing wood furniture at the factory call for either nitrocellulose lacquers, or low-bake (140° F), thermosetting, synthetic-resin finishes.

PAINTING AND ENAMELING.—In painting interior woodwork for flat finish, the first coat may be primer and sealer covered by Federal Specification TT–P–56, followed by one or two coats of TT–P–51a eggshell flat paint. The TT–P–56 primer does not dry hard enough to sand, and thus should not be considered as an "enamel undercoater." This material can be made by adding ½ gal of TT–P–56 primer to a gallon of TT–P–51a paint. This could be used directly on the wood, omitting the TT–P–56 primer, or as an enamel undercoat over the TT–P–56 primer.

A semigloss finish on interior wood may be produced by using two coats of paint composed of equal parts by volume of TT–P–51a paint and TT–E–506a enamel. The first coat should be thinned with 1 pt of turpentine to 1 gal of paint.

A full-gloss finish on interior wood can be obtained by

the application of two coats of TT–E–506a enamel. The first coat should be thinned with 1 pt of turpentine to each gallon of enamel. For better hiding power, as an alternate gloss finish, two coats of enamel undercoater may be used (equal volumes of TT–P–51a and TT–E–506a), followed by a single coat of TT–E–506a enamel.

(2) *Refinishing.*—Surfaces that have previously been finished should be properly prepared for refinishing. Gloss can be removed by sanding the surface lightly with No. 0 sandpaper. Holes or cracks should be filled with plastic wood (see glossary) that has been stained to match the surface, sanded, and spot-varnished. After this preliminary treatment, the woodwork is ready for the finish coat of varnish.

Cherry and mahogany stained wood may contain aniline dyes that "bleed" through paint or enamel. If paint or enamel is to be applied to such surfaces, the woodwork should first be sealed with a thin coat of shellac varnish or with a freshly mixed aluminum paint in the proportions of 2 lb of aluminum powder to 1 gal of Interior Varnish, Federal Specification TT–V–71a (see also formula in table 9).

If the surface is to be refinished by painting, a coating intended for interior use should be applied. A suitable primer for interior wood is Plaster Primer and Sealer, TT–P–56. This can be followed by Eggshell, Flat-finish, Ready-mixed Paint, TT–P–51a, the finish coat most frequently applied to interior surfaces. If a very high gloss is desired, Gloss Enamel, TT–E–506a, can be used. To obtain finishes with intermediate degrees of gloss, the two paints can be mixed in various proportions. A mixture of equal parts of these two paints, TT–P–51a and TT–E–506a, may be used as a finish coat for bathroom and kitchen.

2. MASONRY, CONCRETE, AND PLASTER

(a) EXTERIOR SURFACES

(1) *Oil Paints.*—Exterior surfaces that are to be coated with oil paints require careful preparation. As moisture back of the paint film will seriously impair the life of oil- or varnish-base paints, when applied to concrete, stucco, or masonry, walls made of these materials should be thoroughly dry before being painted. The drying may require from 3 to 12 months and will depend upon weather conditions and upon the thickness and porosity of the walls. It

is equally important to prevent water from entering the wall after painting.

To seal open-textured walls, cinder block for example, it is advantageous to apply a cement-sand grout as the base coat. The grout can be used on new masonry that has not been coated previously with a sealing type of paint or with an organic waterproofing compound. The grout is composed of approximately equal parts by volume of portland cement, fine sand passing a No. 18 sieve, and water.

Before the grout coating is applied to the walls, water should be forced into them by means of a garden hose. They should then be allowed to drain until no free water remains on the surface. The grout coating should be scrubbed in with a stiff-fiber brush, thereby forcing the grout into the openings and producing a surface of uniform porosity. It is advisable to avoid hot, sunny days in applying the grout coating.

To insure proper hydration of the portland cement used in grout, damp-curing is necessary. The grout should be wet with the fine spray of a garden hose. This operation can be started after the grout has set sufficiently that it will not be damaged by the spray (usually about 6 hours) and should be repeated about twice a day over a period of 48 hours, depending upon weather conditions.

Faulty mortar joints and map cracks in stucco or concrete may be filled with grout. Large cracks in masonry walls should be cut V-shape and filled with mortar composed of 2 or 3 parts of sand with 1 part of portland cement, and enough water to give a putty-like consistency. After the mortar has set, it should be damp-cured by the same method suggested for the grout. A minimum of 90 days of good drying weather should elapse before oil paint is applied over the grout- or mortar-filled joints and cracks.

Adequate preparation and cleaning of the surface to be painted improves the durability and appearance of the paint coating. Dirt and dust can be removed with brushes of stiff fiber or wire. Efflorescence can be removed by wetting the surface with water, applying a solution of muriatic acid at least 20 percent in strength and, after 5 minutes, scouring off the salt deposits with a stiff brush. After each acid treatment the surface must be promptly and thoroughly washed with an abundance of water. Traces of oil can be removed with steel brushes, abrasive stones, or a lye solution. However, if the surface is generally contaminated

with oil, it is more effective to lightly sandblast the area to be painted or to postpone painting until all oil has been removed by action of the weather.

Because paint does not adhere well to very smooth or glazed surfaces, it is suggested that, preparatory to painting, they be either acid-washed, lightly sandblasted, or rubbed with coarse-grit abrasive stones. This treatment is frequently necessary for concrete cast against plywood, Presdwood, or steel forms. Brick that is hard-burned or glazed should also be roughened with abrasive.

Old coatings of organic waterproofing compound or cement-water paint still in good condition may be left intact. However, whitewash and peeling, scaling, or flaking paints should be completely removed.

Oil gloss paints, which are suitable for use on exterior wood or metal, may also be used on properly treated, clean, dry masonry. Paints meeting Federal Specification TT–P–40 are suggested for white and light tints, such as grays, creams, light buffs, and ivory; TT–P–31a is recommended for dark reds and browns. For a dull-finish paint in white and light tints TT–P–24 should be used. A priming paint can be made by thinning each gallon of the ready-mixed finish coat paint with 1 qt of spar varnish for average surfaces and 2 qt for rough porous surfaces and, if necessary, ½ pt of mineral spirits or turpentine. The finish coat can be applied without thinning.

Oil paints should not be applied during damp or humid weather or when the temperature is below 50° F. At least 1 week of clear, dry weather should precede the application of the first coat. As masonry surfaces tend to chill and to collect condensed moisture, painting early in the morning and late afternoon should be avoided except in dry climates.

(2) *Water Paints.*—Exterior masonry can be successfully coated with water paints if the surface is properly prepared and directions for applying the paint are carefully followed.

Cement-water paint should bond with the surface and with superimposed succeeding coats of either type of paint to form a cementitious finish of high durability. The durability of the coating is influenced more by the paint surface, the method of application, and the curing of the paint film than by the composition of the cement-water paint powder.

For additional information on painting with cement-water paint, the reader is referred to section III, 6, (b) of this manual.

(b) INTERIOR SURFACES

Interior surfaces of masonry concrete and plaster should be prepared for painting in the same way as similar new exterior surfaces. Finish coats may be either oil paints or water paints.

(1) *Flat Finish.*

OIL-TYPE PAINT.—In painting new walls of plaster or concrete, the first coat should be primer and sealer (Fed. Spec. TT–P–56). This should be applied without thinning. The second coat should be TT–P–51a eggshell flat paint, applied without thinning. In place of this system, the wall may be painted with 2 coats of TT–P–47 paint. For repainting, the surface should be primed and sealed with TT–P–56 primer, followed by a coat of TT–P–51a eggshell flat. As an alternate, the surface may be painted with a single coat of TT–P–47 paint.

WATER-THINNED PAINT.—The plaster or concrete should be free from grease, wax, dirt, or calcimine. Cracks and holes should be filled with patching plaster. These areas should be spot-primed with the water paint. On old painted walls that are glossy, the surface should be washed with water in which is dissolved some trisodium phosphate (about 2 oz per gallon) before applying water paint. On porous surfaces, particularly when the porosity varies, a special primer may be necessary before applying casein paint, Federal Specification TT–P–23a. Resin-oil emulsion paint, TT–P–88a, can generally be applied directly to the plaster or wallboard. One gallon of paste is thinned with 4 pints of water. One or two coats of this paint is sufficient.

(2) *Semigloss Finish.*—For both new and repainted work, the first coat should be Federal Specification TT–P–56 primer and sealer. If suction spots appear after this paint is dry, they should be spot-primed with the primer. The second coat should be semigloss wall paint. This may be prepared by mixing 1 gallon of either TT–P–51a flat or TT–P–47 flat and 1 gallon of TT–E–506a enamel.

(3) *Full-Gloss Finish.*—First coat should be TT–P–56 primer and sealer, allowed to dry 24 hours. Second coat should be enamel undercoater (equal parts by volume of either TT–P–51a flat or TT–P–47 flat and TT–E–506a gloss), allowed to dry 24 hours. Third coat should be TT–E–506a enamel.

For a discussion of paint failures on plaster the reader is referred to NBS Letter Circular LC304, Painting Plaster.

(c) CEMENT FLOORS

(1) *General Suggestions for Preparing Concrete Floors.*—The surface of interior and exterior concrete floors to be painted should be clean, dry, and in a suitable condition to receive the paint. It is suggested that concrete basement floors age for 1 year prior to painting. The coating should be applied when the humidity is very low. For satisfactory results, the application of two coats is recommended. The type of floor coating to be used should be determined by prevailing conditions and by the limitations of the various floor paints.

(2) *Floor Paints and Enamels.*—One of the most popular finishes for cement floors is a paint or enamel that dries to a solid, opaque film. This type of film is produced by using as a paint base, natural resins, synthetic resins, for example phenol formaldehyde and coumarone-indene, and chlorinated and crepe rubber. Tung oil is used widely with these materials to give water- and alkali-resistance and flexibility.

(3) *Varnish-Type Paints.*—Where a concrete floor is laid above grade and not on the ground, and where moisture is not encountered, the varnish type of floor enamel should give good service. A satisfactory varnish-base paint for concrete and wood floors is Federal Specification paint TT–P–146. If this material is used, a priming paint can be made by thinning 4 parts of the paint with 1 part of a mixture consisting of 2 parts of spar varnish and 1 part of turpentine. The finish coat can be applied without thinning.

(4) *Rubber-Base Paints.*—Where a concrete floor is laid below grade directly on the ground, as in most basements, and where dampness due to condensation is prevalent, rubber resin-base paint, Federal Specification TT–P–91, is suggested. This type of paint is not a "cure-all," but is alkali resistant and does not soften when the floors become damp.

Surfaces to be coated with rubber-base paint require special preparation in that cement floors are frequently troweled hard and smooth. Because this type of paint does not adhere well to smooth surfaces, the floor should be roughened by etching with a solution contaning from 1 pt to 1 qt of muriatic acid to each gallon of water. For additional details the reader is referred to section III, 4, (x) in this manual.

When the floor is clean and dry, at least two coats of rubber-base paint should be applied. For the first coat

each gallon should be thinned with either 1 qt of mineral spirits or the thinner recommended by the manufacturer and should be spread at the rate of 300 ft^2/gal. The second coat should be applied directly at the rate of 600 ft^2/gal. It should not be used over other types of floor paint.

(5) *Maintenance.*—A thin film of wax protects any of the finishes described. The wax can be renewed at frequent intervals where the floor is particularly worn. A liquid floor wax of the organic solvent type is generally more serviceable than a water-emulsion wax. For a detailed explanation of the use and preparation of waxes, see NBS Letter Circular LC764, Care of Floors. The reader is also referred to NBS Letter Circular LC758, Finishes for Concrete Floors.

(6) *Refinishing.*—The method of preparing floors for refinishing depends upon the condition of the surface. If the paint has been waxed and is in good condition, except for worn areas, the wax should be removed by applying turpentine or petroleum spirits and scouring with steel wool while still wet. Paint applied over wax does not dry satisfactorily. Paint that is peeling can be removed in several ways. One method is to soak the surface for about 30 minutes with a solution of 2 lb of caustic soda (household lye) dissolved in 1 gal of hot water. Another method is to cover the floor with a thin layer of sawdust that has been soaked in the lye solution, allowing it to remain overnight. In either case, the old paint can then be removed with a wide steel scraper and the surface rinsed thoroughly with clean water. CAUTION: The operator should be protected by rubber gloves and goggles. If the solution is spilled on the skin, the spot immediately should be flushed with water and brushed over with vinegar to prevent severe burning.

3. FERROUS METAL: STRUCTURAL IRON AND STEEL

Nonmetallic structural materials are painted primarily for decoration. However, the chief purpose of painting structural iron and steel is for protection, the decorative value being secondary. In painting structural steel, such as bridges, water towers, and any other similar type of structure that must stand for many years exposed to the weather, the price of the paint alone is not an accurate "yardstick" with which to measure the cost of maintenance painting. As the cost of the paint seldom represents more than 25 percent of the total cost of painting such structures, it is good prac-

ice to apply a durable paint and a sufficient number of coats to insure long service. New work should have two priming coats and two covercoats, or topcoats. Although the initial price of the paint may be relatively high, the price per gallon should not be the yardstick by which the cost of a painting job is judged. It costs at least as much to apply a paint of poor or fair quality as it does one of the highest quality. Thus, over a period of years, the most durable paint is the cheapest, the real yardstick being the cost per square foot of paint applied per year of service.

To illustrate: A water tower with an area of 6,000 ft^2 is to be repainted with one coat of paint requiring 10 gal of paint; paint A costs $3.00 per gallon, and paint B, $2.50 per gallon; the labor cost is three times the cost of the paint. Paint A gives 5 years of service and paint B, 3 years. Then the cost per square foot per year of service for each paint is as follows:

Paint A	*Paint B*
\$ 30.00 for paint	\$ 25.00 for paint
90.00 for labor	75.00 for labor
\$120.00	\$100.00
6000)120.00(.20	6000)100.00(.166+
5).20(.04	3).166+(.055+

In the above example, A and B paints were assumed to have the same spreading rate (600 ft^2/gal). Frequently paint that costs less per gallon does not spread as far as higher-priced paint.

The inference to be drawn from this example is not that the highest-priced paint is necessarily the most durable, but that over a period of years, the most durable paint, figured on a cost per square foot basis, is the best choice, regardless of the price per gallon of the paint.

(a) CLEANING

Proper cleaning of steel surfaces is the initial and one of the most important operations to be carried out prior to painting. Because the life of any paint coating is so dependent upon surface preparation, the subject has received considerable attention by technologists in this country (American Institute of Steel Construction) and in England (Iron and Steel Institute). To attain a good bond, the paint must make intimate contact with the surface to which

it is applied. Any foreign substance present on the steel (such as dirt, grease, oily scum, moisture, acids, alkalies, rust, or loose scale), even though the substance may be invisible, separates the paint from the steel.

There are a variety of methods of cleaning and preparing steel for painting, including mechanical cleaning processes (sand, shot, or grit blasting, scraping, wire-brushing, chipping, and simple hand wiping); flame cleaning; and various chemical cleaning processes (hot alkaline solutions, organic solvents, including solvent vapor degreasing, alcoholic phosphoric acid cleaners, hot acid phosphate cleaners containing detergents, and emulsion cleaners).

For example, oily substances can be removed by using organic solvents (by dipping, wiping, but preferably by solvent vapor degreasing), hot alkaline solutions followed by thorough rinsing, or self-emulsifying cleaners.

FLAME-CLEANING.—A relatively new process for the preparation of steel surfaces for painting is "flame-cleaning." This consists of a special torch through which an oxyacetylene flame is applied to the steel surface. This process removes loosely adherent scale and rust. In addition, the process drives moisture from the surface ("dehydrates" it). Thus, if the paint is applied while the steel is still warm, a good bond between the priming coat and the steel should result.

The most widely used but least-efficient method is hand cleaning with a scraper, hand-or power-driven wire brushes, and chipping hammers. This method is used to remove rust and loose scale.

Loose rust and scale can be removed by partial sandblasting, but closely adhering millscale will remain. If the remaining millscale is tightly bonded to the steel and if the surface is properly painted, good service may be expected.

All rust, scale, and other coatings can be removed by pickling, or by complete sandblasting with fine, sharp sand to leave a uniform surface resembling frosted silver. With the former method, the article is pickled in a 5-percent solution of hot (160° to 180° F) sulfuric acid, rinsed with water, dipped in a 5-percent solution of phosphoric acid, and rinsed again with water. Sandblasting and pickling are the best methods of preparing steel for painting. If the steel is not painted soon after these operations, it is advisable to flame-clean the surface immediately before the first coat of paint is applied.

(b) RUST-INHIBITIVE WASHES

Rust-inhibitive washes are solutions which, when correctly formulated, etch the metal and form a dull gray coating of uniformly fine texture, thus producing a rust-inhibitive surface receptive to the priming paint. The application of these washes to iron and steel articles prior to painting is practiced extensively in factories. However, its use on steel work after erection of the structure has increased recently. There are several such processes, the use of which are, for the most part, patented.

Tests on clean, sandblasted steel have been made by the U. S. Engineer Office, Rock Island, Ill., to determine the relative value of various inhibitive wash-coat preparations for steel. The results indicate that correctly formulated wash-coat inhibitors, when properly used, have some value with all types of paint coatings used on steel. They are particularly effective with coatings of the varnish type containing zinc chromate and iron oxide. The tests made at Rock Island indicate that the most satisfactory acid concentration is approximately 8 percent (see formula for inhibitive wash). The washes should be applied to clean, scale-free steel, following the manufacturer's directions.

Tests at the National Bureau of Standards indicate that the rust-inhibitive treatment should be allowed to react with the steel and become dry. It should then be thoroughly washed with water to remove excess inhibitor and allowed to dry before applying paint. Further information on the use of anticorrosive treatments for steel is given in BMS8, Methods of Investigation of Surface Treatment for Corrosion Protection of Steel, BMS44, Surface Treatment of Steel Prior to Painting, and BMS102, Painting Steel.

A satisfactory inhibitive wash originated by the U. S. Engineer Office has the following composition:

	Weight *Percent*
Orthophosphoric acid (commercially pure, H_3PO_4)	7.00
Sodium dichromate ($Na_2Cr_2O_7.2H_2O$)	0.75
Caramel solution	.50
Wetting agent (such as "Cellosolve" (ethylene glycol monoethyl ether) ($C_2H_5OCH_2CH_2OH$)	.50
Water	91.25
	100.00

Some of the patented washes contain small amounts of heavy metals, such as zinc, manganese, and copper.

The following description illustrates the use of the wash on structural steel in the field [12]:

"–02. *General Painting Provision.—(a) Surface Cleaning and Preparation.*

"*(1) Unpainted Ferrous Surfaces* of parts to be fabricated or erected at the site where the structure is completed shall be shipped from shops or places of manufacture without paint. After erection or complete permanent installation in place, they shall be entirely cleaned of all millscale and other foreign substances to base metal, by sandblasting. As soon after cleaning as practicable and prior to formation of any form of corrosion from atmospheric moisture or other causes, all metal surfaces to be painted shall be thoroughly treated with the chemical rust-inhibitor, applied by brush and permitted to dry. This chemical inhibitor, however, shall be applied only under conditions such that the temperature of the surfaces to which applied and the air in contact therewith, are between 50° F and 110° F. in order to insure proper chemical reaction with the metal. After drying, any unneutralized reactive residue (characterized by a sticky, black, or dark-green appearance) on the surfaces shall be removed by thorough wiping with wet cloths and the surfaces redried. The inhibited surfaces shall then be given a priming coat of paint, as soon thereafter as practicable, but in any event prior to deterioration or destruction of the inhibited surface. Should the inhibited surface be damaged or destroyed at any point by any means whatsoever, the surfaces shall be cleaned and reinhibited in an approved manner prior to application of the paint.

"*(2) Alternate pre-erection cleaning and inhibiting.*—Upon specific written request by the contractor, the contracting officer may authorize alternate mill or shop pickling, or sandblasting and inhibiting, prior to fabrication or erection, in lieu of the field sandblasting and inhibiting after erection as specified in subparagraph (1) above. Where this is desired, however, the contractor shall provide at his expense an original additional coat of zinc chromate-aluminum primer-metal which shall be applied immediately following the application and drying of the chemical rust-inhibitor, in order to protect the surfaces against corrosion during the period of fabrication and erection or until the specified painting is begun, provided that this period shall not exceed 9 months for one coat. This pre-erection or construction period coating shall be maintained in good condition by re-inhibiting and repainting any areas damaged during the construction period, and after 9 months of service the coating shall be completely renewed. Prior to the application of the specified permanent field paints, the surfaces of the construction coating shall be thoroughly cleaned with mineral spirits and all welds or other unpainted areas shall be properly cleaned and inhibited."

(c) PRIMING PAINTS

Both inhibitive washes and paints are usually applied to structural steel by brushing, but they may also be applied by spraying. The paints used for spraying are mostly of the oil type, which require considerable time for drying. A widely used priming paint for structural steel exposed to

the weather is red lead meeting either the basic specification, TT–P–86, or amendment 1 to that specification. Red lead can also be used for other intermediate coats, preferably by darkening each coat with the addition of small amounts of lampblack-in-oil, but it is unsuited for the final coat. Blue-lead paint (Fed. Spec. TT–P–20) is also used widely for priming and body coats. Iron oxide paint can be used for all coats. An aluminum paint may be used for the finish coat (but not the priming coat) on highway steel bridges subjected to rural exposure; black paint (Fed Spec. TT–P–61a) may also be used for the finish coat. For industrial exposures, flake graphite paint (Fed. Spec. TT–P–27) or iron-oxide paint (Fed. Spec. TT–P–31a) are durable topcoats. A durable system of painting steel bridges consists of two coats of a rust-inhibitive priming paint (for example, red-lead, TT–P–86, or blue-lead paint, TT–P–20), followed by two coats of a topcoat, or finish-coat, paint (for example, carbon black paint, TT–P–61a; flake graphite paint, TT–P–27; iron oxide paint, TT–P–31a; aluminum paint, etc.)

The National Bureau of Standards has prepared Letter Circular LC422, The Painting of Structural Metal, which contains additional information on this subject.

4. NONFERROUS METAL

(a) METALLIC ZINC COATINGS

The best coatings to protect iron and steel in uncontaminated atmospheres are galvanized, sherardized, and electroplated zincs. It has been estimated that a galvanized coating of 2 oz/ft^2 will last approximately 150 years in certain dry tropical locations, 25 years in rural England, 5 years in urban industrial England, and 1 year in an English railway tunnel.

Most paints do not adhere well to new galvanized metal. Exposing the metal to the weather for 6 months or more improves this condition, but a better method is to use a good proprietary phosphate chromate treatment prior to painting. A more effective method is to remove oil and grease by washing the surface with turpentine or mineral spirits. After drying the surface, a coat of zinc dust–zinc oxide primer paint, TT–P–641, types I or II, should then be applied, followed by succeeding coats of the paints used on the rest of the structure.

(b) TREATMENT OF ALUMINUM AND MAGNESIUM

Aluminum and aluminum-magnesium alloys should be anodized before being given one or more coats of a suitable high-grade paint. Zinc-chromate primers are widely used are are known to give good results. Trim paint, aluminum paint, iron oxide paint, graphite paint, or the usual outside house paints can be used over the primer with good results.

(c) COATINGS FOR CERTAIN OTHER METALS

Metals such as tin, terne plate, copper, and bronze are easily painted. Oil and grease should be removed from these metals with mineral spirits or turpentine, then dried. After the metal has been cleaned, copper flashings, downspouts, and similar parts should be slightly roughened with very fine sandpaper, then coated with the paint used on adjacent surfaces. Iron oxide, Fed. Spec. TT–P–31a, is a good paint for tin plate and terne plate. Copper and bronze fly screens can be kept in good condition by washing with a solvent, such as mineral spirits, to remove grease, followed by an application of Air-drying Black Enamel, Fed. Spec. TT–E–521, type A, thinned with one-eighth its volume of turpentine. Zinc-dust paints (Fed. Spec. TT–P–641, types I or II) are also recommended for galvanized screens.

5. STEEL SUBMERGED IN WATER

Extensive studies have been made in recent years on the problem of paints suitable for use on steel submerged in water. Among groups doing research on this subject are various companies, including pigment producers, the U. S. Navy Yards, the U. S. Engineer District of the War Department, the U. S. Maritime Commission, and the Tennessee Valley Authority. All the studies have shown the importance of proper preparation of the surface to be painted and have revealed that *priming paints that give excellent service under ordinary atmospheric exposure may be unsatisfactory when used on steel submerged in water.* Likewise, paints that give good results in fresh water may not give good results in salt water and vice versa. Paints show a greater tendency to blister in fresh water than in salt water. Surfaces covered with a priming paint only may appear satisfactory in immersion tests but when topcoated may prove unsatisfactory. Thus, an attempt to evaluate primers independently of topcoats is of question-

able value. Some paints may give satisfactory service when used both for priming and topcoat, but usually a special paint is used for priming. The reason for this may be intercoat compatibility and a difference in the relative physical properties of primer and topcoats. Therefore, it is essential to test paint *systems* rather than *individual paints.*

(a) COAL-TAR-BASE ENAMEL

(1) *Hot Application.*—Coal-tar-base enamels are used on steel submerged in water. The enamels are composed of processed coal tar usually combined with an inert mineral filler. The ability of these enamels to withstand atmospheric temperature changes and to resist mechanical shock varies widely and depends upon the service conditions for which the enamel was formulated. They are usually designated by trade name, such as "waterworks" or "pipe line" enamels, or according to their softening points as determined by the ring and ball method, such as 200° F enamels or 180° F enamels.

Waterworks enamels are capable of withstanding temperatures ranging from —20° to +160° F without showing any tendency to flow, sag, flake, or crack from metal surfaces. Enamels of this type conform to specfications of the American Water Works Association [13] and the Navy Department [14].

Pipe-line enamels are an unplasticized type of coal-tar-base enamel intended primarily to furnish a protective coating for the exterior of underground metal pipes carrying oil or gas. They are usually more susceptible to shock and temperature changes than the waterworks type.

Enamels having physical characteristics intermediate between the pipe-line and waterworks enamels are available and can usually be obtained from the manufacturer of either of these types.

Before the hot, molten enamel is applied, the surface should be coated with a primer that produces a firm bond between the metal and the enamel. The primer should be an air-drying liquid coating that can be easily applied by brushing or spraying. This necessitates one that has good flowing and leveling properties, that shows little tendency to foam during application, and that dries hard, preferably to a matt finish. Its spreading rate and drying time prior to the application of the subsequent coating of enamel

should conform to the requirements established by the manufacturer. Surfaces to be primed should be free from rust, mill scale, oil, and moisture. A shot or sandblasted surface is the most satisfactory. In no case should the primer be applied to surfaces coated with an oil-base paint.

In heating the enamel for application, great care should be taken to prevent coking, caused by local overheating, or loss of volatile components, caused by general overheating. The maximum temperature to which the enamel can be heated and the length of time that it may be kept in the working kettles at this temperature are obtainable from the manufacturer. The rather narrow limits set by producers usually fall within the range of 325° to 450° F. The method of applying coal-tar-base enamels is determined by the character of the surface to be coated. They can be applied either by pouring or by daubing with a palmetto bristle brush. Although the temperature of the material to be applied depends chiefly upon the type of enamel used, it is determined also by the nature and temperature of the surface to be coated. The variation in these surface characteristics often necessitates different temperature of application for the same enamel.

The enamel should be applied only to clean, dry surfaces that have been primed with a bituminous primer recommended by the manufacturer of the enamel. Traces of moisture, frost, or oil will prevent good bonding between the primer and the enamel. If properly bonded to the primer and metal, the enamel fractures within itself when an attempt is made to chip it off with a screwdriver or chisel.

Coal-tar-base enamels are applied hot in a uniform coating approximately 1/16 in. thick. Steel surfaces coated by daubing should be reasonably free from brush marks and should show no tendency to honeycomb or pinhole. Pipe linings or coatings applied centrifugally should present a smooth surface, free from objectionable ridges, corrugations, projections, and depressions.

(2) *Cold Application.*—Coal-tar-base enamels for cold application are composed of a processed coal-tar vehicle and an inert inorganic filler thinned with a solvent. Although heavy-bodied, these enamels possess thixotropic (see glossary) properties and can be applied easily by hand brushing at normal working temperatures. Because of its consistency, this type of enamel when applied to vertical metal surfaces

in one coat up to a thickness of approximately 1/16 in. shows no appreciable flow or sag while still wet. When applied at a spreading rate of approximately 100 ft^2/gal, under normal drying conditions, it sets sufficiently within 24 hr to permit recoating. This type of coating is intended for application directly to dry clean metal, but if a priming coat is used, it should be one recommended by the manufacturer.

The second coat should be brushed perpendicular to the strokes of the undercoat. A film built up by the application of several thin coats will offer better protection than a film of equal thickness applied as a single coat. When dry, the coating is capable of withstanding temperature changes between —10° and +140° F without chipping, cracking, flowing, sagging, or otherwise losing its protective value. The amount of volatile thinner used in this type of coating usually makes forced ventilation necessary when the enamel is applied in closed places, and because of the danger from fire and explosion, the enamel should not be applied near fire or open flames.

A coating material of this type is covered in section Na 1–05 of reference [14].

(b) VARNISH-TYPE PAINTS

Linseed-oil paints that give good service on structural steel exposed to the weather are usually too slow drying and are not sufficiently water resistant for application to surfaces subject to intermittent or prolonged exposure in water. The vehicle for underwater paints is generally a pure phenolic resin-tung oil varnish, from 25 to 33 gal in length, with or without linseed oil. Usually, the same vehicle is used in both the primer and topcoat, or finish coats.

Aluminum paint has been widely used by the Corps of Engineers, Upper Mississippi River Valley Division, War Department, as the topcoat on steel submerged in fresh water. This paint consists of a mixture of 2 lb of aluminum paste to 1 gal of varnish (a 25-gal, pure phenolic resin-tung oil varnish). One primer consists of equal parts by weight of aluminum paste and zinc chromate in the same type of varnish. Other priming paints have been used in various localities. For example, good results have been obtained with primers of blue lead–zinc chromate or zinc

dust–zinc oxide (with or without iron oxide) in suitable phenolic resin varnishes. The zinc dust–zinc oxide paint has given very good results in the Ohio River tests (steel parts of the Montgomery Island Dam) near Pittsburgh conducted by the Ohio River Division, Corps of Engineers, War Department. A pure blue-lead paint in a phenolic-tung oil varnish likewise has given good results as a priming coat in the Montgomery Dam tests.

Another formula for a primer that has shown good results in fresh water is zinc dust 25.0 lb, zinc oxide 4.4 lb, red iron oxide (84 percent) 0.6 lb, vehicle, 1.0 gal of a 33-gal length, 100-percent tung oil, pure phenolic resin varnish. Another is red iron oxide (84 percent) 4.0 lb, zinc chromate yellow 2.0 lb, diatomaceous silica 1.0 lb, magnesium silicate 1.0 lb, to either 1 gal of a 25-gal length, 100-percent tung oil, pure phenolic resin varnish or 1 gal of a 25-gal length, 50-percent tung oil–50-percent linseed oil, pure phenolic resin varnish.

Aluminum paint (2 lb of aluminum paste to 1 gal of a 25-gal length, 100-percent tung oil, pure phenolic resin varnish) has given good results as a topcoat on steel submerged in fresh water, but the steel should be primed with a special rust-inhibitive primer, such as blue lead, red lead, or zinc chromate before applying the aluminum paint.

In connection with the subject of painting steel submerged in fresh water, experiments on painting the interior of steel tanks holding drinking water were carried out by the Federation of Paint and Varnish Production Clubs and the Engineer Board of the War Department. The most satisfactory finish tested at Fort Belvoir, Va., was a baked thermosetting phenolic resin. Where baking is not possible (as in the field) two paints have given good results. One is a zinc dust–zinc oxide pigment in a 25-gal, pure phenolic-resin–linseed-oil varnish. The other is an iron oxide pigment in a pure phenolic-resin–tung-oil varnish. Prior to painting, the steel is cleaned and then given a phosphate pretreatment with the following solution:

Orthophosphoric acid (75 percent of H_3PO_4)	12 gal.
Chromium sulfate (water soluble)	25 lb.
Monobutyl phenyl phenol sodium sulfonate (Areskap)	1½ gal.
Ethylene glycol monoethyl (Cellosolve)	6 gal.
Water (enough to make)	160 gal.

Two coats of either the zinc-dust–zinc-oxide paint or the iron-oxide paint are applied after the surface has dried. Paints applied over steel which has been treated with phosphate show marked improvement in service over paint applied to steel not phosphate-treated. This point should be especially noted wherever exposure to fresh water is involved.

The Bureau of Ships, Navy Department, after considerable work at the Philadelphia Navy Yard Laboratory, has adopted a zinc-dust coating for fresh-water tanks.

The composition of the zinc dust paint is

	Percentage by weight
Pigment	73 to 77
Vehicle	23 to 27
Pigment:	
Zinc dust	79 to 81
Zinc oxide	19 to 21

Vehicle: Unmodified para-phenyl-phenol-formaldehyde resin varnish, suitable for grinding with zinc oxide. It has an oil-resin ratio of 2 to 1; that is, it is 25 gal in length. The uncooked oil and resin are heated together to a temperature of 560° F in 1 hour and held at this temperature for 1½ hours to body. The varnish is then cooled to a temperature of 450° F in 45 minutes and thinned.

The vehicle contains no rosin or rosin derivatives. The thinner is turpentine, mineral spirits, and/or solvent naphtha. The driers must contain no lead compounds.

The paint weighs not less than 20 lb/gal and dries hard in 6 to 10 hours.

Letter Circular LC744, Painting Steel Potable Water Tanks, may be obtained free of charge from the National Bureau of Standards.

V. CARE AND PREPARATION OF PAINTING MATERIALS

The durability and smoothness of finish of a painted surface depends to a large extent upon the condition of the painting materials at the time of application. To keep paints in proper condition, suitable storage facilities should be provided. Careful mixing and the use of clean brushes will aid in obtaining a satisfactory finish.

1. STORAGE OF PAINTING MATERIALS

Paints, varnishes, lacquers, thinners, and other painting material should be stored in well-ventilated places where they will not be exposed to excessive heat, smoke, sparks, flame, or direct rays of the sun. The packages should be kept tightly closed when not in use. Powder paints should be stored in moisture-proof containers.

Ready-prepared paints and pastes stored in suitable cans or drums should be inverted every month to retard settling of the solid matter. However, unpigmented liquid materials (linseed oil, for example) should be left undisturbed.

2. PREPARATION OF READY-MIXED PAINTS

Ready-mixed paints should be prepared for application in places that are well ventilated and free from flame or direct sunshine.

Small lots of ready-mixed paints can be mixed most satisfactorily by "boxing," a procedure described and illustrated in figure 2 [9].

When preparing ready-mixed tinted paint, about one-third of the paint should be poured into a clean vessel. The remainder should be stirred to a uniform consistency before returning the portion that was removed. The entire quantity is then ready to be boxed and strained through fine wire screen or cheesecloth.

Another method of mixing paint is to insert the unopened can in a power-driven vibrator-type paint mixer for a period of 3 to 10 minutes. Because the violent agitation of this mixer tends to create many small bubbles in enamel paints, it is recommended that they be mixed by boxing.

3. MIXING OF PASTES AND POWDERS

It is important that powder and paste pigments be properly thinned if the desired effect is to be obtained. Some pigments furnished in paste form are to be mixed with oil by the purchaser; others, such as resin-emulsion paints, are to be blended with water.

(a) PASTES

(1) *Pastes-in-Oil.*—Most of the paste-in-oil pigments can be easily broken up by stirring with a strong wooden paddle

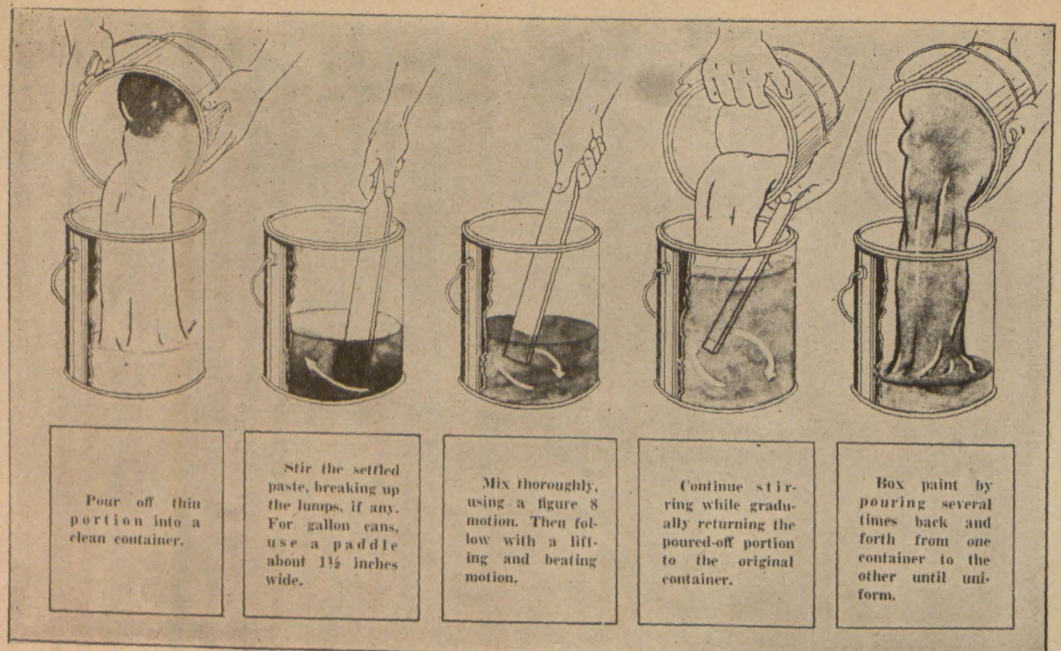

FIGURE 2.—*Mixing a can of paint to make it uniform.*
See page 372 of reference [9].

in the original container, taking care that no heavy sediment is left in the bottom. It may be necessary, even after careful stirring, to pour off some of the partly mixed paste into another clean can in order to thoroughly break up the bottom layer by more vigorous stirring. The part that has been poured off can then be returned to the can and the entire quantity again stirred until uniform.

The amount of paste necessary to make the desired amount of paint should be transferred to a container that has a greater capacity than the total volume of the completed paint. The required amount of oil should be measured and slowly stirred into the paste. When about half of the oil has been added, the mixture can be stirred readily and the lumps broken up easily. The remaining oil should then be mixed with the drier and thinner and stirred slowly into the paste. If two or more white-pigment pastes are used to make the paint, they can be mixed in the proper proportions before the oil is added. After the paste and oil have been combined, the paint is ready to be boxed, by the method shown in figure 2, and strained through fine wire screen or cheesecloth.

Various shades can be produced by tinting previously mixed white-base paint. The tinting paste should be thoroughly mixed with turpentine to a consistency similar to that of the completed white paint. This tinting liquid should be stirred slowly into the white-base paint until a uniform mixture is obtained. Care should be taken to use only the minimum amount of tinting liquid. When oil varnish is part of the vehicle, it is suggested that at least a part of the thinner be turpentine and that the varnish be stirred in after all other mixing operations have been completed.

(2) *Resin-Emulsion Paints.*—These paints are usually packaged in paste form to be thinned with water approximately in the proportion of 2 parts by volume of paste to 1 part of water. It is suggested that the paint be boxed after the ingredients have been thoroughly mixed. When manufacturer's directions are given they should be followed, as paste paints of different companies may vary in consistency. If the paint is applied by spray, additional water may be necessary. However, the paint should not be thinned to the point where more than two coats are needed to give adequate hiding power.

(b) POWDERS

Dry pigments are almost always mixed to pastes at the factory, but when necessary to mix paint from dry pigment on the job, the work room should be free from drafts and the workmen should be protected by all-dust respirators.

(1) *Dry Red-Lead Paints.*—Paints may be made from dry red lead by either of two methods. By the first method, a quart of linseed oil may be poured into a clean bucket of more than 1-gallon capacity and a paste formed by slowly stirring 25 lb of dry red lead into the oil. After allowing the paste to stand for at least 72 hours to insure complete wetting of the red-lead particles, another quart of linseed oil can be added. A few hours before application, a mixture of 2 parts of turpentine or mineral spirits and 1 part of drier may be stirred in.

The second method is to stir 25 lb of dry red lead into a quart of linseed-replacement oil and continue stirring until a paste is formed. This should stand for 72 hours; then 3 pt of linseed-replacement oil and ¼ pt of mineral spirits should be added. The mixture should then be boxed. Pure red lead paint is available in ready-mixed form (Fed. Spec. TT–P–86).

(2) *Cement-Water Paints.*—Cement-water paints are packaged in powder form and require only the addition of water to prepare them for use. In mixing them, the recommended procedure is to make a stiff paste by adding water in small portions to the dry material, stirring constantly. After this, additional water may be gradually stirred into the paste to the desired consistency. The proper amount of water varies with the fineness of the dry materials.

The paint should be stirred vigorously for several minutes until it is of uniform consistency and all particles are thoroughly wetted. Workability will be improved by allowing the mixture to stand from 20 to 30 minutes with occasional stirring. Most paints remain usable for 3 to 4 hours after being prepared, although in hot weather some paints, especially those containing calcium chloride, should be used within 3 hours.

Because cement-water paint tends to stiffen while being used, it is common practice to thin the paint with additional water when necessary to maintain the desired consistency. There seems to be no serious objection to retempering white paint, provided it is done properly. The paint should first

be stirred vigorously, as sometimes this operation restores its fluidity. Any additional water required should be added in small amounts and thoroughly mixed.

(3) *Casein-Powder Paints.*—Cold-water paints are also packaged in powder form. All types require the addition of water and one kind (Fed. Spec. TT–P–22) is furnished with a "mixing liquid" composed of raw or boiled linseed oil or spar varnish to be used in addition to the water.

EXTERIOR.—Powder for exterior paint should be mixed in the proportions of 90 to 100 lb of powder with 10 to 12 gal of water. The powder should be put into a metal or enamelware container. Porcelain and galvanized iron are very satisfactory, but wooden or unpainted iron mixing containers should never be used. The required amount of water at 70° F should be measured carefully in a separate vessel and gradually added to the powder in small portions, stirring constantly. The mixture should be stirred vigorously until it is of a smooth, thin, creamy consistency suitable for brushing, then allowed to stand 30 minutes before being used. It is good practice to strain the mixed paint through a No. 40 sieve but this is not essential. The paint should be used the same day it is mixed.

When mixing liquid in addition to water is used in preparing the paint, it should be used in the proportions of 1 gal to 90 to 100 lb of powder with 10 to 12 gal of water. Two-thirds of the required volume of water at approximately 70° F should be put into a metal or enamelware container. The powder should be added in small quantities, stirring thoroughly between each addition until a paste of uniform consistency is obtained. After the mixture has been allowed to stand for 30 minutes, the mixing liquid should be gradually stirred in, followed by the remaining portion of water.

INTERIOR.—Cold-water casein-powder paints intended for interior use should be mixed with water in the proportions of 8 to 10 lb of powder with 4 qt of water at approximately 70° F. The directions given for mixing powder and water for exterior paints should be followed.

4. CARE OF BRUSHES

Before a new brush is used with oil paint or oil varnish, it should be well shaken to remove loose hairs and dust, and then carefully combed straight. A steel comb is recom-

mended for the purpose. It may also be washed with turpentine or mineral spirits. It is suggested that the new brush be soaked in linseed oil for about 12 hours before being put into the paint. The surplus oil should be pressed out of the new brush before painting. The brush should be dipped into the paint to about half the length of the bristles.

The best time to clean brushes is immediately after use. As much paint as possible should first be wiped off the brush. Then it should be washed in turpentine or special paint brush cleaner until all paint is removed. When drying the brush, it should be laid flat with all bristles straight. It may be necessary to follow this by a final washing with yellow laundry soap and water.

When brushes are to be used a great deal, as in a paint shop, it is considered good practice to suspend the brush 2 or 3 in. above the bottom of a tub or tank containing a mixture of raw linseed oil and a small amount of turpentine so that the bristles are completely submerged. Brushes used for oil paints, enamels, and varnishes should not be kept in water as the bristles become soft and flabby.

After the brush has been washed clean of all material, it should be wrapped in paper and laid flat on a shelf. It is advisable to place a few moth balls near the brushes.

A brush that has become hard and dry with paint can seldom be restored to first-class condition. There are on the market several proprietary materials for reclaiming brushes. One simple method is to immerse the brush in organic-solvent-type paint and varnish remover for 24 hours. When the brush is removed, the paint should be scraped out with a putty knife or steel comb. The brush should then be washed free from paint, small particles or paint being removed by submerging the brush in turpentine and working the liquid through the bristles.

Brushes used with shellac varnish or shellac varnish replacement should be kept either in a "keeper" with denatured alcohol or washed with denatured alcohol before being dried and stored in a horizontal position in a dust-free dry place.

Brushes used with water paints and whitewash need only be washed with soap and water. With some of the new resin-oil emulsion paints, it is necessary to wash the brush with soap and water before the paint dries.

An illustration of various brushes in well-equipped paint shops may be found in the Army Repairs and Utilities Manual [15].

VI. SAFETY MEASURES

The application of paint involves certain hazards for which adequate safety measures should be taken.

The National Bureau of Standards is not qualified to answer inquiries concerning the relative toxicity of various paints and pigments and detailed precautions to be used in spray painting. Questions of this nature should be directed to the U. S. Public Health Service, Federal Security Agency, Washington 25, D. C.

1. FALLS

Most of the injuries sustained by painters are the result of falls from scaffolds or ladders. Precautions that should be taken for the protection of painters are the same as for riggers, carpenters, and other workmen. For information on methods of protection for workmen, see "Safety Requirements for Excavation, Building, and Construction" [16].

2. FIRE

Oil paints, varnishes, and volatile liquids are flammable and should be kept away from fire. As a safety measure, they should be stored in closed containers. In a well-organized paint shop, paints, oils, and volatile liquids are stored preferably in a fireproof room. Many paint manufacturers print a statement on the label of the paint cans cautioning the user to keep the paint away from fire.

Rags used to wipe up linseed or other drying oils are also a frequent source of spontanous combustion. They should be burned or drenched with water and put in an airtight metal-covered container.

3. POISON

The volatile liquids (turpentine, mineral spirits, and gasoline) used by painters are skin irritants. For this reason, the frequent use of such thinners to remove paint from the hands should be discouraged to avoid dermatitis. Prolonged inhalation of toxic fumes such as those emitted from benzol used in paint removers and carbon tetrachloride or

carbon disulfide used in removing old bituminous coatings constitute a health hazard. Some of the pigments, particularly those containing lead and chromates, are poisonous. The inhalation of dust, such as that caused by sandpapering and sandblasting, is a source of danger. The inhalation of lead fumes while burning off old paint is a health hazard.

For precautionary reasons there should be adequate ventilation in shops and rooms where paints are used. Where ventilation is insufficient, respirators supplied with clean air should be used.

Food should not be kept or eaten in a workroom or any other place where it is exposed to dust from sandpapering or fumes from paint thinners. When handling paint or painting equipment, painters should take special precautions to thoroughly clean their hands and faces before eating. Work clothes should be changed before leaving a paint workroom and should be laundered frequently.

VII. SAMPLING AND INSPECTION

The purpose of sampling is to obtain representative specimens for record. The purpose of testing is to determine compliance of the material with the requirements of the purchase-contract specification. Sampling may be done at the factory, while loading or unloading tank cars, ships, or trucks, or after delivery of material. The purpose of inspecting a shipment of material is to determine visually whether it is in good condition and whether it has been sent according to good shipping procedure. The purpose of inspecting surfaces to be painted is to determine what preparation is necessary before applying paint. The purpose of inspecting finished work is to determine its compliance with the contract specification.

1. INSTRUCTIONS AND PRECAUTIONS FOR SAMPLING

Federal Specification TT–P–141a (20 cents, Superintendent of Documents, Washington 25, D. C.) contains the following directions for sampling:

"Official samples should be taken by, or under the immediate supervision of, a person of judgment, skill, and previous experience in sampling.

"The portions taken for samples should represent the general characteristics and average condition of the lot sampled."

Precautions should be taken to assure that the sampling apparatus and the samples themselves are neither contaminated with nor altered by any extraneous matter not representative of the lot being sampled.

A single package from each lot of not more than 1,000 packages should be selected at random as representative of the whole. The seller has the option of being represented at the time of sampling, and when he so requests, is furnished with a duplicate sample.

Directions for sampling apply to liquid materials, dry pigments, pastes-in-oil, and mixed paints. The tests should be made according to the directions given in section F of the applicable Federal specification.

(a) LIQUIDS: THINNERS, OILS, AND VARNISHES

Whenever possible, liquids in original unopened containers should be sent to the laboratory. If this is not practicable, the contents of the container sampled should be thoroughly mixed, making certain the incorporation of any settlings. A clean, dry, glass bottle or tin can should be filled with not less than 1 qt of the sample, securely stoppered with a new clean cork or well-fitted cover or cap, sealed, and distinctly labeled. When requested, a duplicate sample may be taken from the same package for delivery to the seller. A third sample may be held for test in case of dispute.

(b) PIGMENTS, PASTES, AND READY-MIXED PAINTS

(1) *Dry Pigments.*—The package should be opened and a sample of not less than 1 lb taken at random from the contents. This should be placed in a clean, dry, metal or glass container, sealed, marked, and sent to the laboratory.

(2) *Pastes and Ready-Mixed Paints.*—Whenever possible, the original unopened containers of paste or ready-mixed paint should be sent to the laboratory.

When an original container of paint can not be sent to the laboratory for test and there are no facilities for mixing the material mechanically, a representative sample can be obtained by the procedure for boxing paint. Portable mechanical agitators are useful for mixing paint, and can be obtained in various sizes for mixing a gallon or a barrel of paint.

Caking of paint should be determined by stirring the paint with a paddle or spatula. The contents of the container should then be thoroughly mixed and a sample of not less than 1 qt placed in a clean, dry, metal container, sealed, marked, and sent to the laboratory for test, together with the report on caking. A good paint should not cake in the container. A portion of the sample of dry pigment, paste-in-oil, or ready-mixed paint may be retained for comparison in case of dispute.

(c) BITUMINOUS ENAMEL AND PRIMER

(1) *Enamel.*—Samples should be taken at least 3 in. below the surface and at least 3 in. from the side of the container or from the center of the material. At least 150 lb of this solid material should be selected from different parts of the unit or units sampled and thoroughly mixed. A 50-lb sample of the mixture should then be sent to the laboratory for test.

(2) *Primer.*—The method of sampling primers is the same as that for sampling pigments, pastes, and ready-mixed paints. A statement from the manufacturer with regard to the following characteristics of primer and enamel should accompany the test samples.

1. Method of applying primer and coverage in square feet per gallon.
2. Minimum and maximum drying time of primer before application of enamel.
3. Temperature of coal-tar or asphalt-base enamel at time of application.
4. Maximum allowable temperature to which enamel may be heated.
5. Maximum time enamel may be held in heating kettles at applicable temperature.

(d) COAL-TAR-BASE PAINTS

The method of sampling coal-tar-base paints is the same as that for pigments, pastes, and prepared paints. The shipment may be rejected without sending a sample to a laboratory if observations or tests clearly prove that the material does not meet the specifications. *Examples:* the paint delivered is of a different color from that specified or is of lighter weight per gallon than the minimum weight specified.

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2. INSPECTION

Field inspection of new work is for the purpose of ascertaining whether the paint is being used at the required spreading rate, whether the work is being performed under proper weather conditions, and whether the surfaces to be painted are clean and dry. Moisture in wood and masonry can be detected by meters. Information regarding these devices can be obtained from the manufacturer, including William J. Delmhorst, 90 West St., New York, N. Y.; Raymond S. Hart, 7 Lincoln St., Jersey City, N. J.; L. A. Milbrock, 732 N. Lombard Ave., Chicago, Ill.; and C. J. Tagliabue Mfg. Co., Brooklyn, N. Y.

New structural steel should be treated with two shop coats of inhibitive primer slightly different in color. If only one coat is used, the metal should be carefully inspected as soon as delivered at the site, and spot-coated with the primer wherever necessary. Within approximately 2 weeks a second coat should be applied over the whole surface.

Pinholes or cracks in bituminous coatings can be readily detected by means of an "electric holiday detector." The unit usually consists of a high-voltage transformer designed to operate on a 105- to 115-volt, 60-cycle power line, and an adjustable Tesla coil. A metal chain, band, or brush, whichever best conforms to the contour of the surface to be tested, is attached to the discharge terminal of the Tesla coil.

In inspecting the coating for defects, the metal chain, band, or brush is passed slowly over and in contact with the surface tested. The Tesla coil is so adjusted that at all times there is a uniform corona (violet in color) discharge between the metal chain, band, or brush, and the enamel coating. Breaks in the coating are indicated by sparking between the testing unit and the metal under the enamel. Such units are obtainable from electrical supply houses, especially those handling scientific instruments.

In connection with the subject of inspection, a leaflet issued by the National Paint, Varnish and Lacquer Association, "Paint Exposure or Complaint Report" [17], is useful in the inspection of new or previously painted metal and wood. From this leaflet there is reproduced the following field-inspection report sheet:

PAINT EXPOSURE OR COMPLAINT REPORT

HISTORY

Location ..... Date .....
Lumber Used ..... Building used for.....
Age of Structure ..... Area Painted.....
Applied on New or Previously Painted Surface .....

Condition of Old Paint at Time of Painting:

	South	West	North	East
Chalking	.....	.....	.....	.....
Checking	.....	.....	.....	.....
Cracking	.....	.....	.....	.....
Blistering	.....	.....	.....	.....
Peeling	.....	.....	.....	.....
Flaking	.....	.....	.....	.....
Scaling	.....	.....	.....	.....

Type of Paint Previously Used.....Number of Times Painted, etc. .....
Method of Preparing Surface Before Applying Paint.....
.....
Date of Painting .....
Kind of Primer .....
Reduction Made for Priming Coat .....
Kind of Paint.....Quantity Used.....
Reduction Made for Finishing Coats.....
Number of Coats Applied on Body.....Color.....
Number of Coats Applied on Trim.....Color.....
Weather Conditions at Time of Painting.....

INSPECTION

Date .....Inspector.....

	South	West	North	East
General Appearance.....	.....	.....	.....	.....
Discoloration	.....	.....	.....	.....
Gloss	.....	.....	.....	.....
Chalking	.....	.....	.....	.....
Checking	.....	.....	.....	.....
Cracking	.....	.....	.....	.....
Flaking	.....	.....	.....	.....
Scaling	.....	.....	.....	.....
Blistering	.....	.....	.....	.....
Peeling	.....	.....	.....	.....

Structural Defects Found Where Water Could Enter:

Window Frames .....Headers .....
Louvres .....Roof .....
Warped Siding or Trim Boards ..... Absence of Flashings or Defective Flashings .....
Poor Drainage of Surface Water .....Wet Basement .....
Lumber Siding Near Ground ..... Lack of Ventilation in Side Walls .....
Were Siding Butts Leaded? .....
Remarks: .....
.....

Moisture Test: Percentage of Moisture in Wood at Time of Inspection:
Where Failures are Evident.....
Where Failures are not Evident.....

Are Acid Factories, Smelters or Other Industries Near the Job?.....
Are Samples of Wood or Paint Films Available?.....
Location of Area from which Films were Obtained for Laboratory Examination .....
.....

Result of Film Examination:

Number of Old Coats.....
Adherence of Old Coats to Underlying Surface.....
What Photographs were Taken?.....

VIII. PAINT FAILURES

Paint failures are inevitable, as no paint is intended to last indefinitely. In addition, the inadequate repainting of many buildings during the war has multiplied the number of paint failures. For these reasons, the discussion in this section of the manual is significant. However, printed instructions or suggestions can not take the place of the skill and experience of the master painter, who has spent years in acquiring a practical knowledge of how to paint surfaces properly.

Before discussing paint failures and painting troubles, it may be helpful to point out that, in general, white paint is the least durable and black paint the most durable when exposed to the weather; likewise, dark tints and shades are more durable than light tints. For example, a light-gray paint is more durable than a white paint; a dark-gray paint is more durable than a light gray; a red or brown paint (Fed. Spec. TT–P–31a) is more durable than a cream- or tan-colored paint. However, white and light-tinted paints reflect more light than dark-colored paints. A white paint reflects about 80 percent of the light, whereas a black paint reflects only about 2 percent. The word "durable" as used here indicates film integrity rather than appearance. For example, a medium-gray paint on the exterior of a house may change to light gray after prolonged weathering. The owner of the house may feel that the paint has "failed" (from the standpoint of appearance), although the integrity of the film may be unimpaired.

The cause of paint failures may be not only lack of suitable surface preparation prior to painting, but also improper application or unsuitable composition of paint. Factors to be considered in avoiding failures are careful selection and correct proportioning of materials for each coat, allowance of adequate drying time between coats, proper spreading rates, and suitable weather conditions for painting.

There are other causes of paint failures in addition to those listed above, such as construction defects, particularly faulty maintenance, which includes either too frequent or too infrequent painting and the combination of dissimilar paints in a coating. These faults are probably the most common sources of paint failures.

Descriptions of some of the more common types of paint failures and painting troubles with suggested causes and

remedies follow: Examples of paint failures in Army cantonments are shown in figures 3 to 22 and are used through the courtesy of the Office of the Chief of Engineers, War Department. Other illustrations of paint failures, figures 23 to 31, were furnished by the Forest Products Laboratory, Forest Service, United States Department of Agriculture, Madison, Wis. The photographs shown at the end of this chapter were made by F. L. Browne, of the Forest Products Laboratory. The reader is also referred to the photographs of paint failures shown in Federal Specification TT–P–141a.

1. ADHESION

The satisfactory adhesion of the first coat of paint to the underlying surface is extremely important. The success of the paint job depends to a very large extent on the bonding of the first coat to the foundation. Insufficient or unskilled preparation of the surface may result in defective adhesion. Having the surface clean and dry, sanding all glossy coats prior to applying subsequent coats, allowing sufficient time for each coat to dry hard (but no unnecessarily long) are all important factors in promoting good adhesion. In addition to suitable preparation of the surface, the priming paint should be formulated for the particular surface to which it is to be applied. To help obtain a satisfactory paint job, the following Federal specifications have been prepared:

TT–P–20—For priming structural steel
TT–P–86—For priming structural steel.
TT–P–25—For priming exterior wood.
TT–P–56—For priming interior plaster, concrete, brick.
TT–P–641—For priming galvanized iron.

A wide variation will be found in the paint-holding properties of woods in general use. The woods which hold paint longest and suffer least when repainting is neglected are cedar, redwood, and cypress; next in order are northern white pine, western white pine, and sugar pine; the third group in order is Ponderosa pine, spruce, and hemlock; the last group consists of woods which have the poorest paint-holding properties: Douglas fir, western larch, and southern yellow pine.

2. ALLIGATORING

Alligatoring consists of the development of interlacing lines over relatively large areas on a paint film, giving the

appearance of alligator's skin (see fig. 8). One cause of alligatoring is the application of a hard-drying coat of paint or varnish over a comparatively soft undercoat (for example, a flat white paint applied over a bituminous coating). The outer coat tends to oxidize and harden during drying, after which it contracts and shrinks. By applying the hard topcoat over the soft undercoat, the oxidation, and consequent hardening of the undercoat, is stopped. It is good practice to allow the priming coat and all subsequent coats of paint or varnish to dry hard, but not too long, before the next coat is applied.

Alligatoring may begin as checking or cracking, but the break tends to grow wider at the bottom as well as at the top. The top coating contracts, thus exposing portions of the undercoat. In the typical extreme case of alligatoring, the "islands" of coating between interlacing breaks have not only contracted in area but have increased in thickness and, consequently, often have become wrinkled. Alligatoring may be caused by the application of successive coats of incompatible paints or by the application of paints or enamels over resin-impregnated surfaces (see also figs. 23, 24, 27, 30, and 31).

3. BLEEDING

Painting over knots (see figs. 6, 7, 17, and 20) or other resinous wood causes a dissolving action of some of the resin. As a result, white paint turns yellowish. Painting over creosote, bitumen, or colors soluble in oil (mahogany stain, for example) likewise may cause some of the material to dissolve into the paint coat. The remedy is to treat the surface with a sealer prior to applying paint. A freshly made, quick-drying, aluminum paint (2 lb. of aluminum powder or paste to 1 gal. of interior varnish (Fed. Spec. TT–V–71a) for interior work, or spar varnish (Fed. Spec. TT–V–121b) for exterior work) is a good sealer to hold back creosote stains, bituminous materials, and aniline stains. Rosin-free orange shellac varnish (Fed. Spec. TT–V–91a) is used in thin coats over knots prior to painting. In this connection, the reader is referred to what has previously been said regarding the subject of painting over knots.

Where resin has exuded from the wood and formed beads on the surface or has caused alligatoring of the paint, the area should be scraped and sandpapered until the resin is

removed and the wood laid bare. The surface is then ready for sealing and repainting. On prolonged exposure to the weather, copper and bronze screens form soluble salts that "bleed" or wash down and stain the white paint below (see fig. 12). To avoid this condition, the screens should be coated with either spar varnish (to retain the original appearance) or painted with black screen enamel (Fed. Spec. TT–E–521, black enamel thinned slightly with turpentine).

4. BLISTERING AND PEELING

Blistering of paint (see fig. 29) is caused by fluid (gas or liquid) pressure beneath an airtight coating. Water usually plays a secondary part, chiefly that of making it possible for fluid pressure to be developed within the wood. Wood can be very wet without causing paint blistering, otherwise, marine painting would be largely impracticable. Usually, suitable temperature gradients have a more direct bearing on blistering than does water. Likewise, the permeability of the coating to moisture, as long as the coating is not physically porous, has little, if any, bearing on its sensitivity to blistering. White paints, such as Federal Specification TT–P–40, types I and II, which are relatively impermeable to moisture, are only moderately sensitive to blistering, whereas many dark-colored paints, which are more permeable to moisture, are also more sensitive to blistering. Similarly, aluminum primer decreases the permeability of a coating but may increase, decrease, or fail to alter the sensitivity to blistering, according to the nature of the topcoat. Where blistering is prevalent, the building should be checked for adequate ventilation, and the installation of a vapor barrier on the inside of exterior walls given consideration. Blisters should be scraped off, rough edges sanded smoothly, and bare spots touched up with the priming coat, followed by the finishing coats.

The peeling paint may be caused by the application of paint to a glossy surface. A glossy surface should be sanded before applying paint. It is not good practice to apply a glossy paint over a glossy undercoat.

5. CHALKING

Chalking, or powdering, of the paint film is generally caused by the destruction of the outside (the side exposed to the weather) binding material in the film. In normal weathering of outside paints, chalking follows loss of gloss. Cer-

tain pigments (for example, titanium dioxide) cause more chalking of the paint film than others (for example, zinc oxide). The usual outside white paint lasts about 4 years before it is time to repaint. If the paint does not chalk to any considerable extent, continued repaintings will result in the building up of a thick coat of paint, and cracking and scaling are apt to follow. Thus, a certain amount of mild chalking is desirable, as this results in a gradual reduction in the thickness of the coating because of the wearing away of the film. On the other hand, excessive chalking is undesirable, as this will result in bad erosion of the paint film. Early chalking may be caused by the application of too thin a coat of paint, or by heavy rain, fog, dew, or frost, settling on the paint film before it is dry.

6. CHECKING

Checking starts at the exposed surface, works progressively deeper into the coating, tends to take on a V-shaped cross section with the open part at the exposed surface, but gives no sign of widening at the bottom by contraction of the coating, though the checks may be widened slightly by erosion. Slight checking is not a serious defect, as it indicates a relieving of the shrinkage stresses in a paint film. If the film does not check, because of its great tensile strength, it may crack with the expansion and contraction of the surface to which the paint is applied; scaling may then result (see figs. 11 and 26).

7. CRACKING AND SCALING

Cracking and scaling (see figs. 3, 4, 5, 15, 19, and 28) is a very serious and all too common type of paint failure. As stated in the previous paragraph under "checking," if the tension of the paint film is not broken in some way when the surface to which it is applied contracts and expands, cracking and subsequent scaling is apt to result. Cracking differs from checking or alligatoring in that the cracks extend all the way through the coating to the underlying surface. Subsequently, the coating may separate from the edges of the crack and curl outward without widening caused by contraction of the coating. On wood the cracking may occur at right angles to or parallel with the grain. Moisture enters through the cracks, works under the paint film, and causes scaling. Cracking and scaling usually take

place when a paint has very little elasticity, particularly when a thick coat builds up (see Chalking) with continued repaintings. Certain paints are inclined to fail by cracking, curling, and scaling, whereas others fail by moderate chalking with or without checking. A surface on which the paint fails by moderate chalking is the least serious type of paint failure and the most economical for repainting.

Before repainting, the safest plan is to remove all scaling paint by burning and scraping off. If some of the old paint is not removed, it will eventually scale off, taking the new paint with it. The degree of scaling of paint depends on the kind of wood to which the paint is applied. For example, a paint that fails normally by cracking and scaling may exhibit this defect to a minimum extent on a wood that holds paint well, such as western red cedar and redwood. When applied to a wood that does not hold paint well, for example, southern yellow pine and Douglas fir, the paint may exhibit this defect to the maximum extent.

8. CRAWLING

Crawling is the tendency of a paint or varnish to form a discontinuous film by drawing up into drops or globules shortly after application and results from surface tension caused by either the surface or the paint. Oil paint applied at room temperature over a cold or greasy surface may also cause crawling. Others causes are the application of a glossy coat of paint over a fresh glossy coat, particularly when an outside house paint contains an excessive amount of linseed oil; the application of paint or varnish over previous coats that are not hard and dry; the presence of moist finger marks on a surface prior to varnishing; the mixing together of various brands of varnish; the use of varnish that has become thick and viscous; the presence of a thin film of wax on the surface left by the use of liquid paint removers; the application of paint in cold or foggy weather.

The remedies for many of the above causes are the elimination of these conditions. It is best not to apply paint or varnish in cold, foggy, or damp weather; undercoats should be thoroughly dry before applying subsequent coats; if the undercoats are glossy, they should be sandpapered. Rubbing the surface with turpentine and steel wool before applying the paint is helpful. If the paint seems to be subject to crawling, brushing it thoroughly into the surface

may correct the trouble. If such is the case, the application of paint by spraying will aggravate the defect.

9. "FADING" OF COLOR

Most paints change color on prolonged exposure to the weather. This may be a true fading of color, but generally it is the result of either a chemical change in the pigment on exposure to the weather or excessive chalking of the paint. Some paints chalk unevenly, which results in a blotchy effect on the color, particularly in dark grays. Other paints chalk evenly and self-clean themselves evenly. This is the preferred type of "fading" of color. Blotching or so-called fading of color occurs in spots where the porous surface has not received sufficient coats of paint or a suitable primer. This is one of the reasons why Federal Specification TT–P–25 was made available to cover an exterior wood primer.

The so-called fading of color of paint on interior plaster because of "hot spots" in the plaster ("lime burning") is really due to the variable suction or porosity of the plaster. Thus, unpainted plaster should be primed with a suitable primer (for example, Fed. Spec. TT–P–56) before applying subsequent coats of oil paint.

The change in color of outdoor paint may be caused by dirt. Some paints hold dirt, whereas others tend to shed the dirt by chalking ("self-cleaning"). If too much oil is used in paint, it will hold dirt. For example, if three paints are made of white lead, using 100 lb of white-lead paste in each paint with the addition of 3 gal of linseed oil in paint No. 1, 4 gal of oil in paint No. 2, and 5 gal of oil in paint No. 3, on exposure to the weather, paint No. 3 will collect the most dirt and paint No. 1 the least. An exterior white paint that remains unusually clean is one meeting Federal Specification TT–P–40, type 1, Class B.

Paints containing lead pigments will discolor if there is hydrogen sulfide in the atmosphere. The discoloration appears as a brownish or grayish film because of the formation of lead sulfide. This discoloration may be "bleached out" with hydrogen peroxide.

Mildew generally forms in black splotches on a paint film, causing an unsightly change of color. This condition is fairly common in the south. Commercial fungicides for the

prevention or retarding of mildew are now available in paste form to be added by the user.

Copper and bronze fly screens cause unsightly discoloration on white and light-tinted paints. The discoloration is a result of corrosion products from the copper or bronze and may be avoided by varnishing or painting the screens before corrosion takes place (see fig. 12).

10. LOSS OF GLOSS

On outdoor paints the first sign of weathering is loss of gloss, followed by chalking. Doubtless, both are different aspects of the same defect and are brought about by the same cause. Gloss is produced by an excess of oil or other binding material (linseed oil or varnish) and forms a smooth, glass-like film on the surface. Air, moisture, and sunlight cause these organic binding materials to deteriorate rapidly resulting in loss of gloss. Among other conditions causing loss of gloss are inadequate preparation of the surface; insufficient drying time between coats; painting in cold weather, particularly if there is a sudden drop (20 degrees F) in temperature during the fall or winter months before the paint has dried; incorrect use of paint removers and alkaline cleaners on paint; or exposure of the freshly painted surface to frost, fog, or moisture. When there is a possibility of dew or frost, the application of paint should be discontinued early in the afternoon.

11. RUNNING AND SAGGING

Running and sagging may ocur when the paint contains too much oil or is applied too freely. If an old paint surface is too glossy, the fresh paint may show sagging. A method of test for running and sagging of a red lead paint is given in Federal Specification TT–R–191a. A method of test for the sagging of red enamel is given in Federal Specification TT–E–531a.

12. TACKINESS AND SLOW DRYING

As pointed out under "alligatoring," each coat of paint or varnish should dry firm and hard before a subsequent coat is applied. Dirt and mildew may collect on paint that dries tacky or sticky. Slow drying may be caused by (1) insufficient drier in the paint or varnish, (2) the use of poor quality linseed oil, (3) too liberal application of paint, (4)

the application of paint or varnish over an undercoat that is not dry, (5) the application of paint or varnish during damp, wet, or foggy weather, and (6) the application of paint during cold weather. Dark-colored paints such as black (Fed. Spec. TT–P–61a) and green (Fed. Spec. TT–P–71a) dry more slowly than white and light-tinted paints. If there is insufficient drying time between coats, the topcoat may lose its gloss, alligator, and even crack and peel on prolonged exposure to the weather. Wax on the surface is a common cause of tackiness and slow drying.

Certain kinds of paints and varnishes lose drying power if stored too long in the original containers. This happens more frequently to the "fast-drying" types of enamels and varnishes than to the older types of paints. Therefore, if there is a possibility that paint is old stock, its drying time should be tested before use. If the drying power has been lost, a little paint drier should be added to restore it.

13. WASHING

Washing is the leaching out of the soluble part of a pigment in a paint during rain storms. Washing sometimes occurs when a paint contains a pigment that is either water-soluble or is converted from a water-insoluble to a water-soluble material through chemical action as the result of weathering.

14. WRINKLING

When a paint is applied too liberally, particularly during cold, damp weather, the top of the film surface dries first, leaving the paint beneath this skin soft. The result is that the finished surface has a wrinkled appearance (see figs. 16 and 22). To avoid this, each coat of paint should be well brushed out in a skilled manner, especially during cold weather. Also, it may be advisable to add a small amount of turpentine (about 1 pint to the gallon of paint) to overcome this tendency. When painting in cold weather (45° to 50° F), the weather forecasts should be consulted daily. When a marked drop in temperature (20 degrees F) is predicted for the evening of the day that paint is to be applied, painting should be discontinued early in the afternoon. In any event, paint should be applied between the hours of 10 a. m. and 3 p. m. during cold weather.

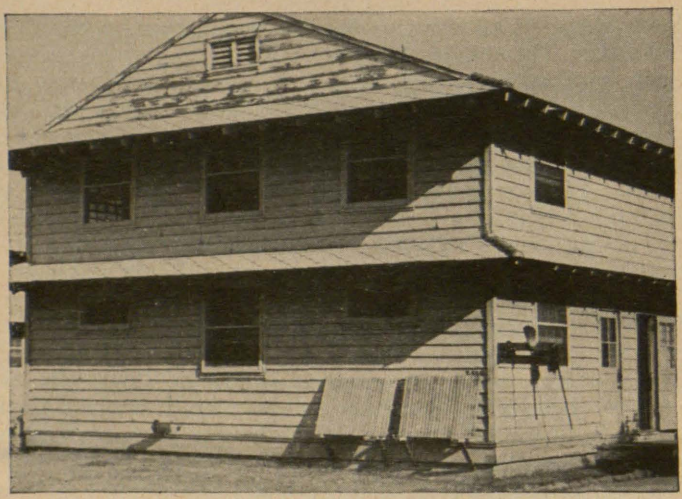

FIGURE 3.—*South and east sides of building show paint cracking and scaling at gable end of building.*

Paint is about 4 years old and is applied over southern yellow pine. Protection is given paint by overhanging eaves, which keep off direct sunlight and rain.

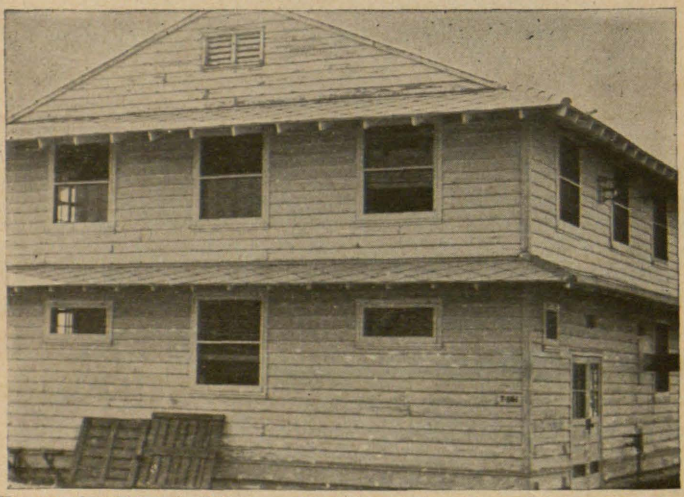

FIGURE 4.—*Same building as figure 3, showing north and west sides.*

Paint generally fails worse on south and east sides.

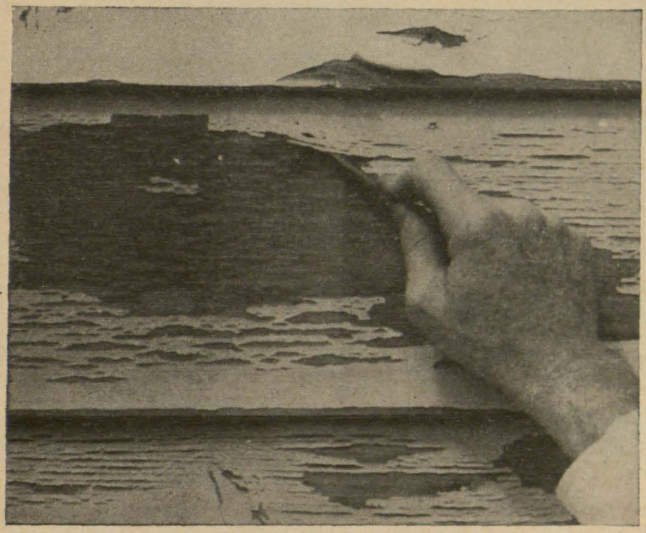

FIGURE 5.—*Wood siding on which paint has cracked and flaked.* Just before the photograph was taken, the area was vigorously wirebrushed. The remaining paint was found to be insecurely attached when spatula was slipped between the paint film and the wood. It is suggested that all old paint be removed before repainting.

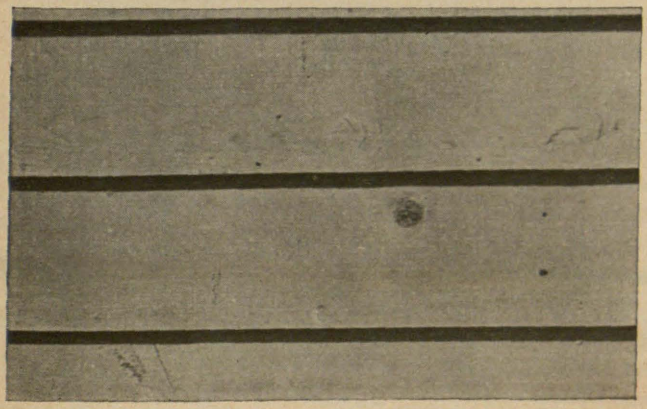

FIGURE 6.—*Failure of paint over knot.*

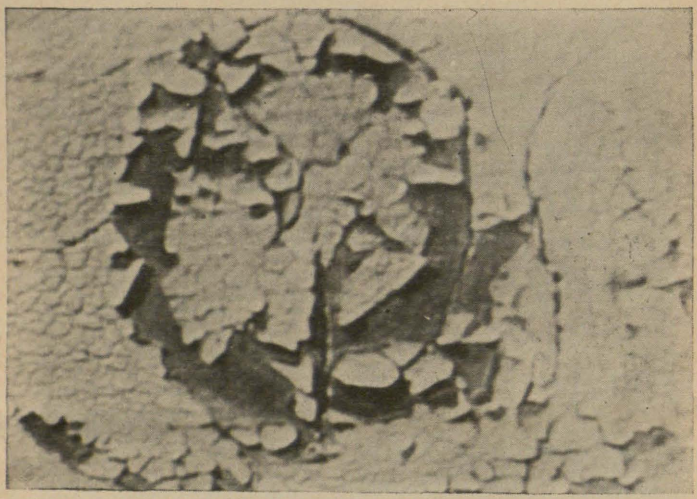

FIGURE 7.—*Close-up view of paint failure over knot shown in figure 6.*

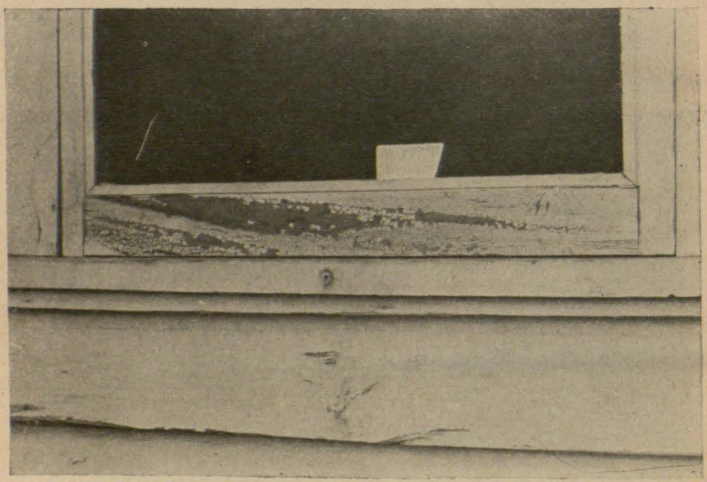

FIGURE 8.—*Alligatoring and crumbling of paint over resin streak in frame of fly screen.*

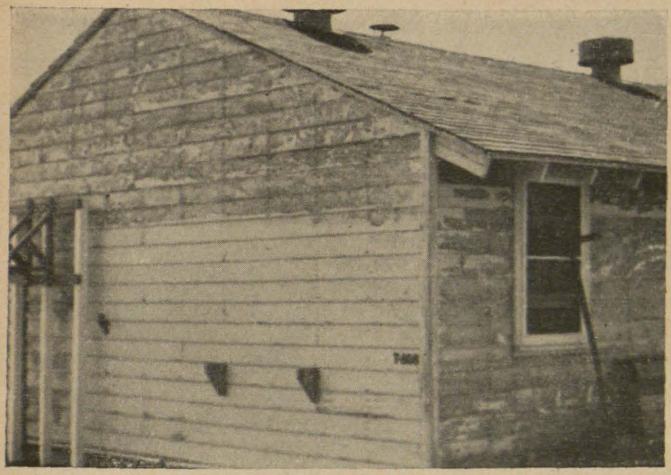

FIGURE 9.—*Paint failure on exterior wood buildings due to condensation of moisture within the walls.*

Paint covering area shown on north side from water table to a little over head height, and from northwest corner to first post, is in reasonably good condition. The reason for this is that shower bath located immediately inside this area has metal wall covering, which acts as a vapor barrier, preventing condensation during cold weather. The peeling of the paint on the rest of building developed after first winter of service.

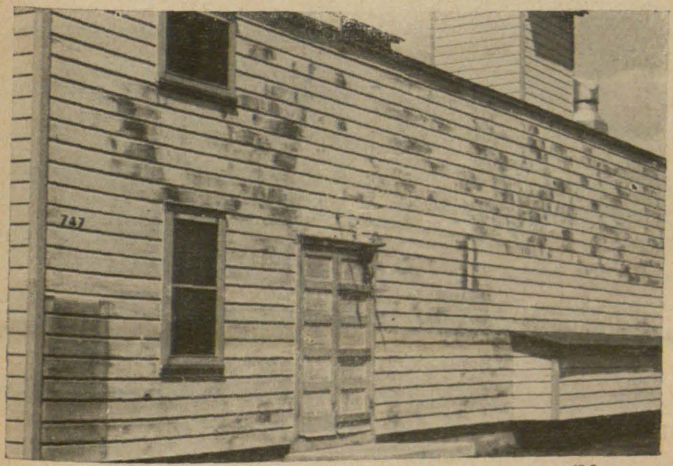

FIGURE 10.—*Typical discoloration of paint due to mildew.*

Before repainting, surface should be scrubbed with water containing some alkaline cleaner, for example, trisodium phosphate.

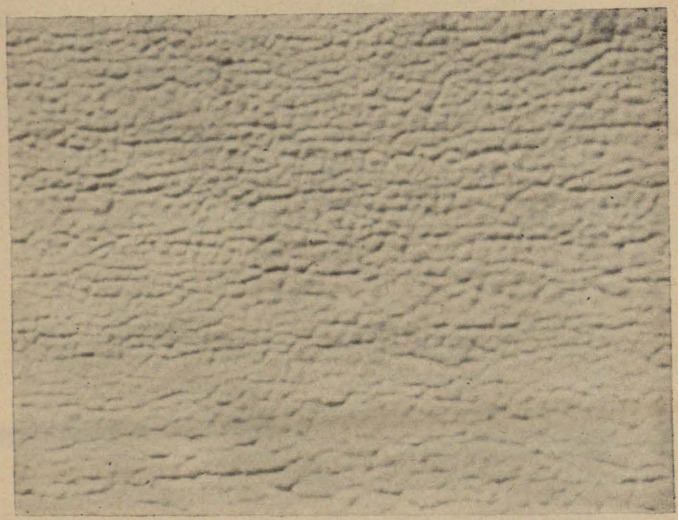

FIGURE 11.—*Typical checking pattern of paint on the outside of building after 5 years of service.*

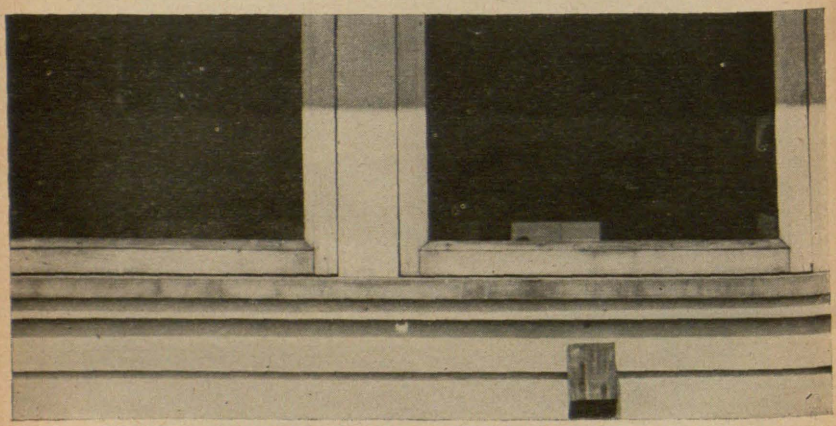

FIGURE 12.—*Discoloration of light-colored paint underneath fly screens, due to the corrosion of the screens.*

Screen wire should be painted to avoid this trouble.

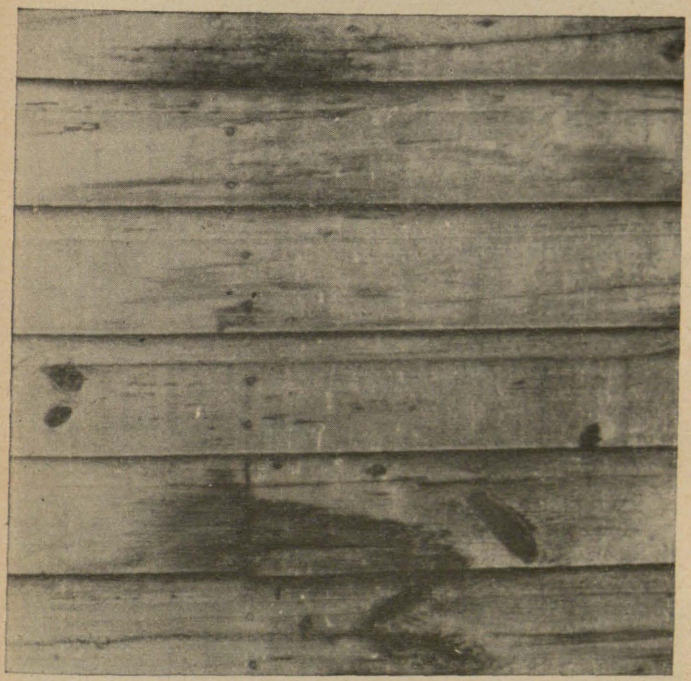

FIGURE 13.—*Rot on painted wood siding of a building.*

Surface should not be repainted until siding is replaced. More important, the basic structural fault causing the trouble should be located. In this case it was due to inadequate flashing at junction of roof and sidewalls.

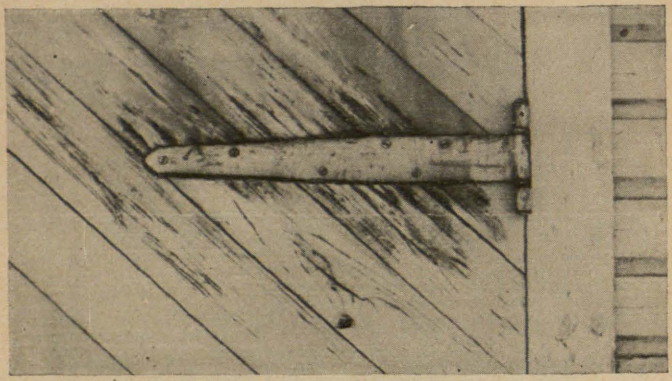

FIGURE 14.—*Illustration of how painted wood starts to decay around a hinge, which holds water.*

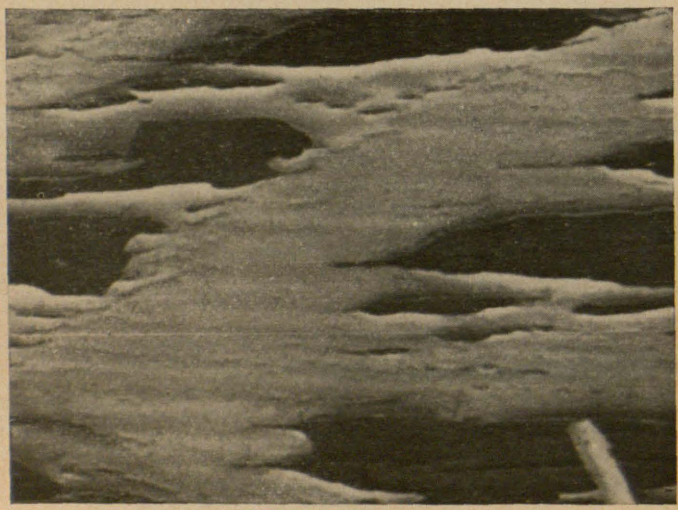

FIGURE 15.—*Close-up view of cracking, curling, and scaling of paint on southern yellow pine.*

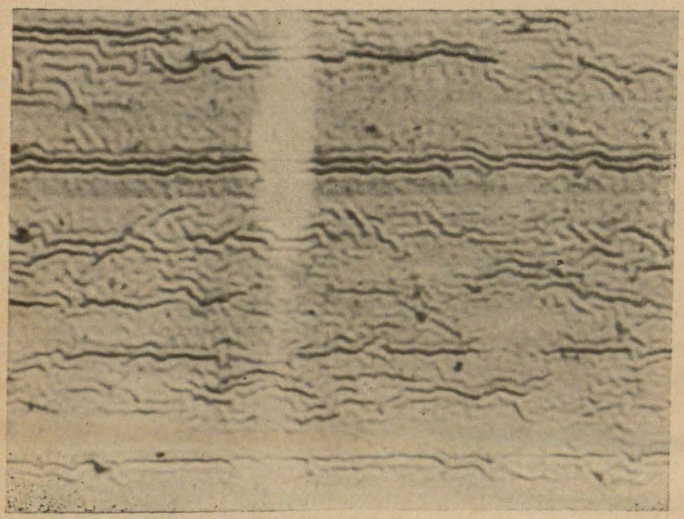

FIGURE 16.—*Wrinkling of paint.*
Wrinkling occurred during application of paint and still shows after 3 years of exposure.

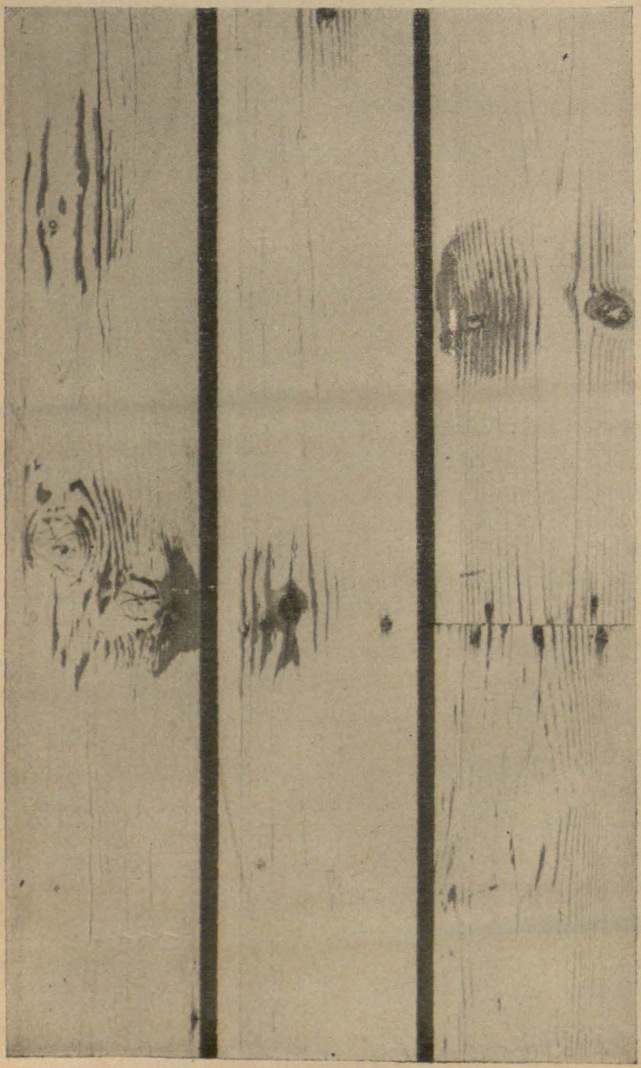

FIGURE 17.—*Typical paint failure over knots.*
Knots were shellacked generously prior to painting.

FIGURE 18.—*Serious peeling of paint.*

Peeling is particularly noticeable at corners. It was caused by collection of water behind certain parts of siding, probably the result of condensation in winter. At ground level the building is poorly ventilated.

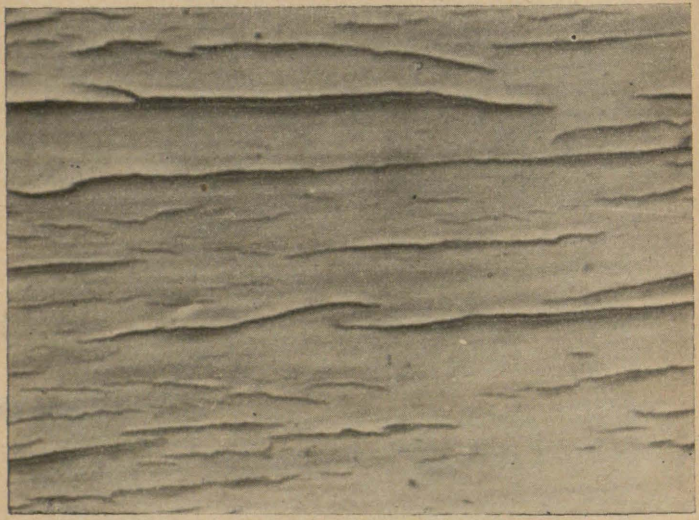

FIGURE 19.—*Details of paint cracking on exterior of wood building.*

FIGURE 20.—*Failure of paint over a knot that had been shellacked prior to painting.*

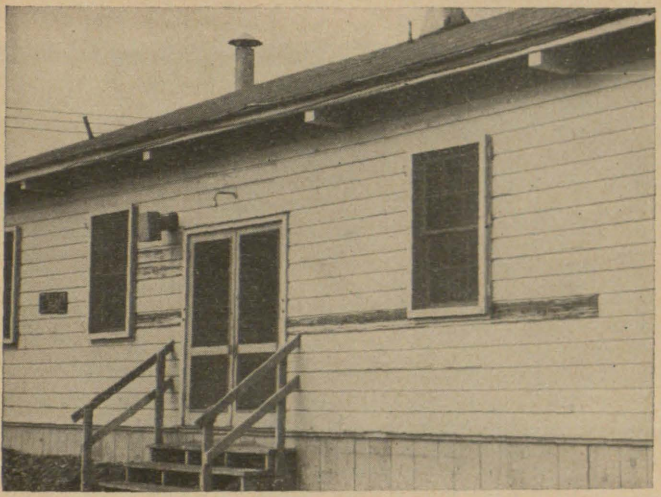

FIGURE 21.—*Satisfactory appearance of paint on side of building, except over a few boards of summer wood.*

These boards will always give trouble and should be replaced.

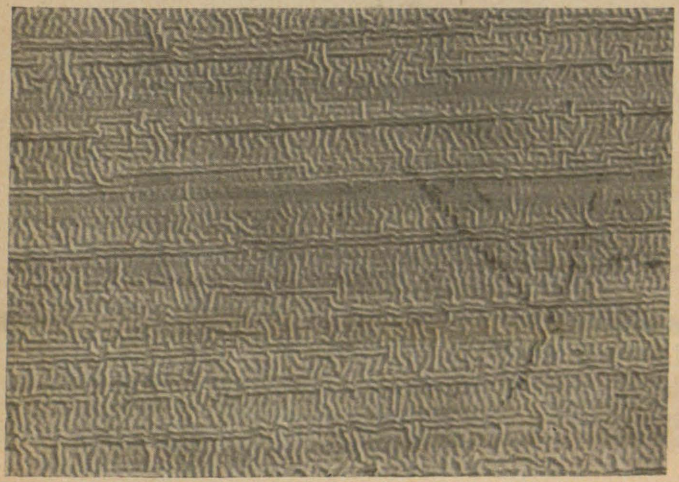

FIGURE 22.—*Paint that has wrinkled soon after application.*

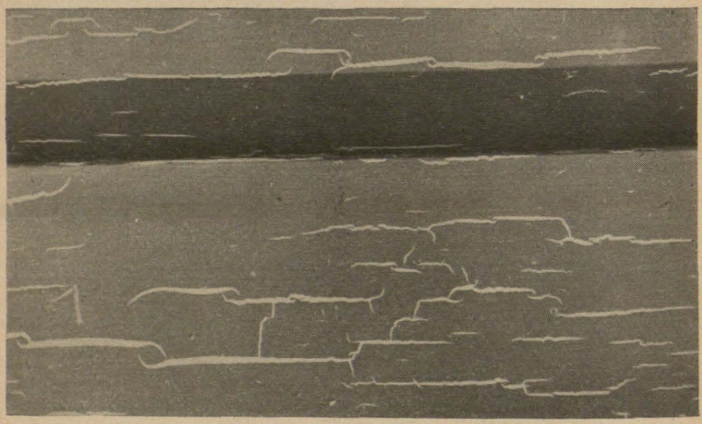

FIGURE 23.—*Typical alligatoring of finish coat of dark-brown paint (soft type) applied over white paint (hard type).*

Compare with figure 31.

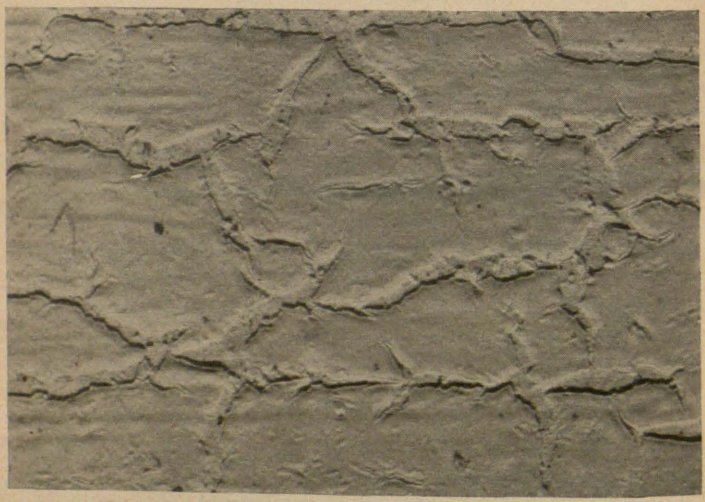

FIGURE 24.—*Additional example of alligatoring of paint.*

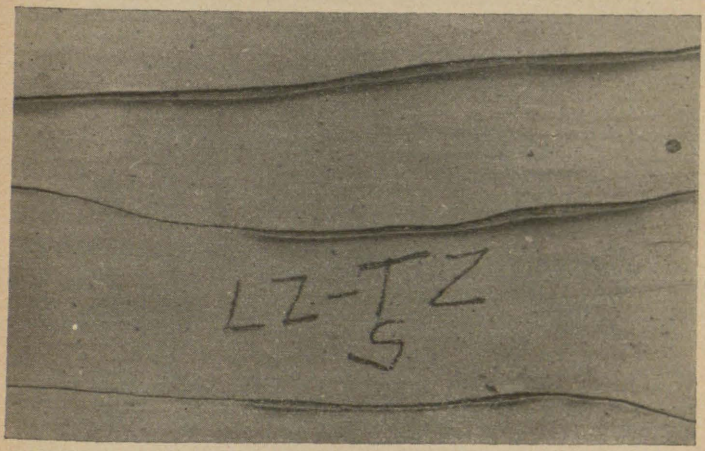

FIGURE 25.—*Typical example of "curling" at edges of long paint cracks.*

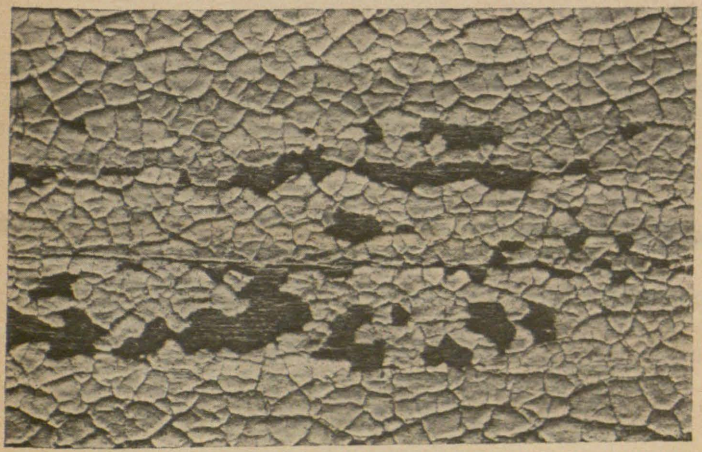

FIGURE 26.—*Checking and crumbling of white-lead paint on southern yellow pine.*

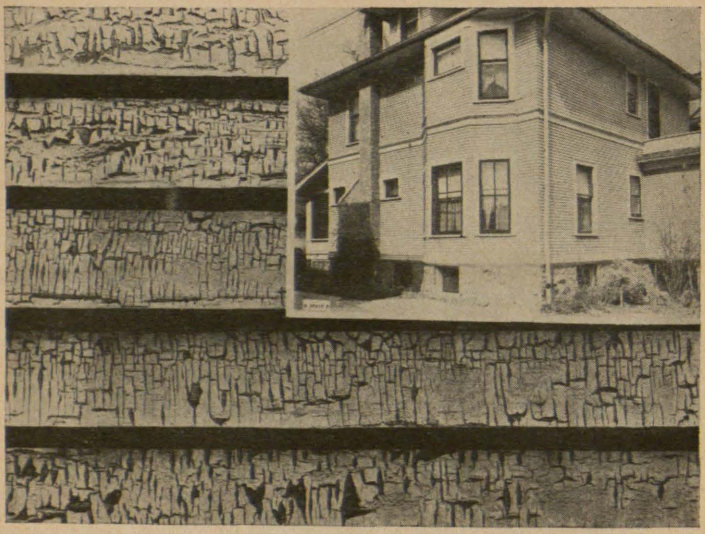

FIGURE 27.—*Example of alligatoring.*
Satisfactory service may be obtained only by removing all old paint before repainting.

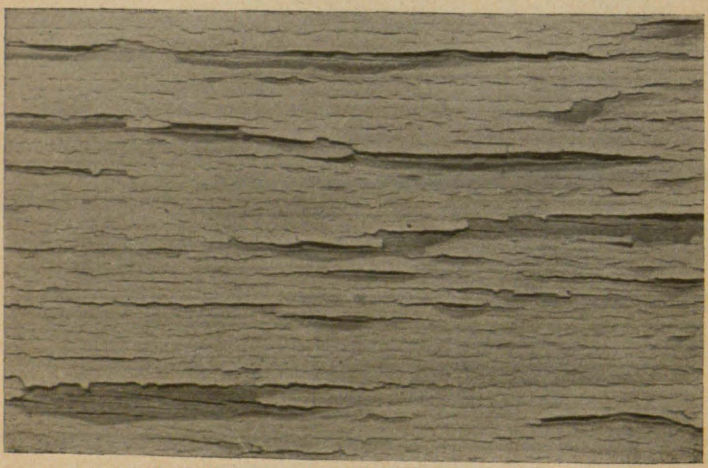

FIGURE 28.—*Checking, cracking, curling, and flaking of paint on southern yellow pine.*

Figure 29 is upside down,
but the legend is correct.

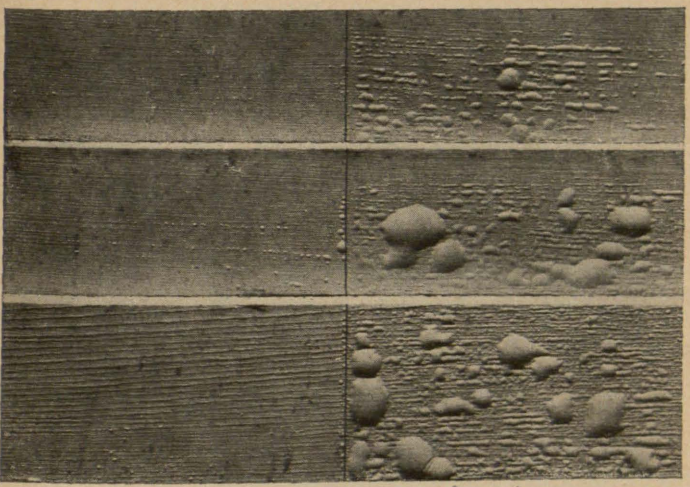

FIGURE 29.—*Blistering of paint on red-cedar siding.*

Siding on the left was covered with three coats of titanium-lead-zinc paint; that on the right, with two coats of this paint applied over aluminum primer.

FIGURE 30.—*Alligatoring of paint on fence.*

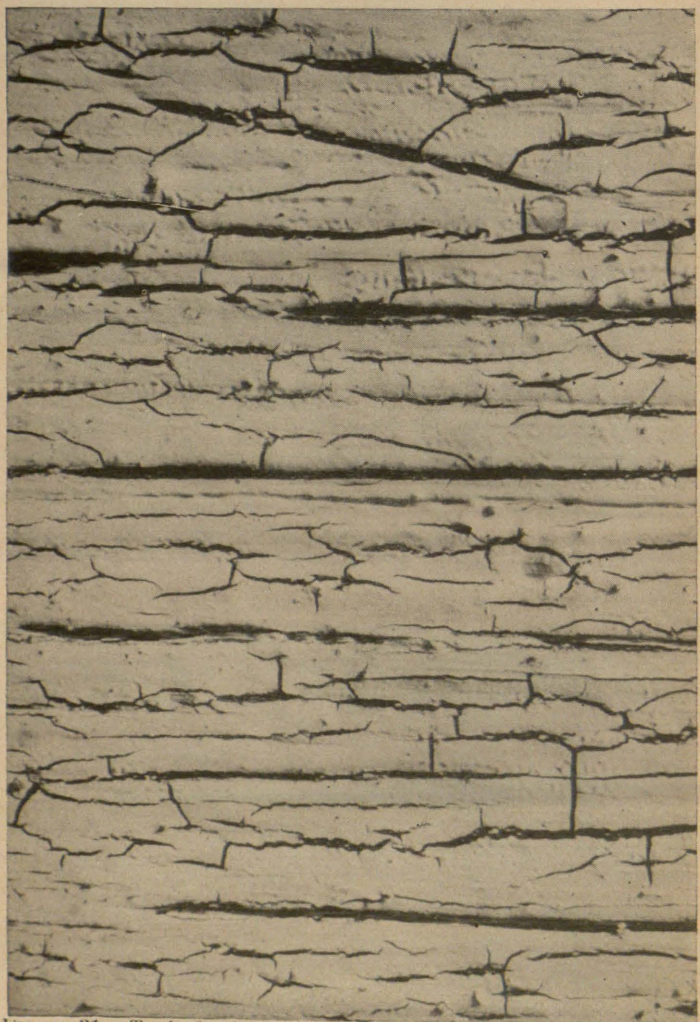

FIGURE 31.—*Typical alligatoring of finish coat of white paint (hard type) applied over dark-red paint (soft type).*

Compare with figure 23.

IX. BULKING VALUES OF PIGMENTS AND LIQUIDS

The following tabulations, with slight changes, are reproduced from Circular 667, Bulking Value Tables (September 1943), issued by the Scientific Section, National Paint, Varnish & Lacquer Association [18]. The standard temperature for these tables is 15.5° C.

1. PIGMENTS

The bulking values of such pigments as chrome green, chrome yellow and iron oxides vary rather widely. If these pigments are used in substantial percentages in a composition, that is, in deep tints or solid colors, their actual values should be determined or obtained from the producer.

Also, the large number of organic colored pigments in use vary so widely in type and bulking value that only a few of the more important ones have been included.

Pigment	Gallons per pound	Pounds per gallon	Specific gravity
Aluminum bronze, standard	0.0471	21.24	2.55
Aluminum bronze, lining	.0480	20.83	2.50
Aluminum paste, 65% solids	.0816	12.25	1.47
Aluminum hydroxide	.0399	25.07	3.01
Aluminum silicate	.0462	21.66	2.60
Antimony oxide (Sb_2O_3)	.0209	47.90	5.75
Antimony sulfide	.0259	38.65	4.64
Barium carbonate	.0277	36.07	4.33
Barium sulfate (barite)	.0270	37.07	4.45
Barium sulfate (blanc fixe)	.0275	36.32	4.36
Basic lead carbonate	.0178	56.23	6.75
Basic lead sulfate	.0188	53.31	6.40
Black iron oxide	.0254	39.32	4.72
Blue lead	.0177	56.64	6.80
Cadmium red lithopone	.0270	36.99	4.44
Cadmium yellow	.0277	36.15	4.34
Calcium carbonate (chalk)	.0445	22.49	2.70
Calcium sulfate, anhydrous	.0406	24.63	2.95
Calcium sulfate, hydrated	.0511	19.58	2.35
Carbon black	.0671	14.91	1.79
Clay (kaolin)	.0462	21.66	2.60
Chrome green, light	.0234	42.65	5.12
Chrome green, medium	.0296	33.82	4.06
Chrome green, dark	.0364	27.49	3.30
Chrome oxide	.0235	42.48	5.10
Chrome oxide, hydrated	.0352	28.41	3.41
Chrome yellow	.0207	48.31	5.80
Chrome orange	.0177	56.64	6.80
Chrome orange, molybdate	.0207	48.31	5.80
Cobalt blue	.0313	31.90	3.83
Copper bronze powder	.0150	66.64	8.00

Pigment	Gallons per pound	Pounds per gallon	Specific gravity
Cuprous oxide	0.0207	48.23	5.79
Diatomaceous earth	.0520	19.24	2.31
Gold bronze powder	.0150	66.64	8.00
Graphite	.0541	18.49	2.22
Guignet's green	.0352	28.41	3.41
Hansa yellow	.0811	12.33	1.48
Indian red (98% Fe_2O_3)	.0235	42.57	5.11
Iron blue (prussian)	.0656	15.24	1.83
Iron oxide black	.0254	39.32	4.72
Iron oxide, red or brown, 97% Fe_2O_3	.0235	42.57	5.11
Iron oxide, red or brown, 70% Fe_2O_3	.0292	34.64	4.11
Iron oxide, red or brown, 40% Fe_2O_3	.0329	30.40	3.65
Iron yellow, natural	.0353	28.32	3.40
Iron yellow, synthetic	.0304	32.90	3.95
Kaolin (clay)	.0462	21.66	2.60
Lampblack	.0674	14.83	1.78
Lead, metallic (90:10 paste)	.0250	39.98	4.80
Lead, titanate	.0164	60.98	7.32
Litharge	.0127	78.64	9.44
Lithol red	.0765	13.08	1.57
Lithopone, regular	.0279	35.82	4.30
Lithopone, titanated	.0282	35.40	4.25
Magnesium carbonate	.0663	15.08	1.81
Magnesium silicate	.0421	23.74	2.85
Mercuric oxide	.0107	92.80	11.14
Metallic brown	.0304	32.90	3.95
Mica	.0424	23.57	2.83
Mineral black	.0480	20.83	2.50
Molybdate orange	.0207	48.31	5.80
Ochre	.0406	24.66	2.96
Orange mineral	.0136	73.53	8.82
Para red	.0811	12.33	1.48
Para red (15% on $CaCO_3$)	.0494	20.24	2.43
Para red, chlorinated	.0770	12.99	1.56
Paris green	.0371	26.99	3.24
Phthalocyanine blue	.0770	12.99	1.56
Phthalocyanine green	.0597	16.74	2.01
Prussian blue	.0656	15.24	1.83
Red lead	.0136	73.53	8.82
Sienna, burnt	.0326	30.65	3.68
Sienna, raw	.0365	27.41	3.29
Silica, quartz	.0453	22.07	2.65
Silica, diatomaceous	.0520	19.24	2.31
Slate flour	.0429	23.32	2.80
Talc (magnesium silicate)	.0421	23.74	2.85
Titanium-barium (25%) anatase	.0279	35.82	4.30
Titanium-barium (30%) anatase	.0283	35.31	4.24
Titanium-calcium anatase	.0384	26.07	3.13
Titanium-calcium, rutile	.0369	27.07	3.25
Titanium dioxide, anatase	.0309	32.32	3.88
Titanium dioxide, rutile	.0286	35.00	4.20
Titanium-magnesium	.0387	25.82	3.10

Pigment	Gallons per pound	Pounds per gallon	Specific gravity
Toluidine red	0.0854	11.83	1.42
Tuscan red	.0341	29.32	3.52
Ultramarine blue	.0513	19.49	2.34
Umber, burnt	.0331	30.24	3.63
Umber, raw	.0353	28.32	3.40
Van dyke brown	.0746	13.41	1.61
Venetian red (40% Fe_2O_3)	.0345	28.99	3.48
Venetian red (20% Fe_2O_3)	.0414	24.16	2.90
White lead, carbonate	.0178	56.23	6.75
White lead, sulfate	.0188	53.31	6.40
Whiting	.0445	22.49	2.70
Zinc chromate (zinc yellow)	.0347	28.82	3.46
Zinc chromate (tetroxy)	.0300	33.32	4.00
Zinc dust	.0170	58.81	7.06
Zinc oxide	.0214	46.65	5.60
Zinc oxide (5% leaded)	.0213	46.98	5.64
Zinc oxide (35% leaded)	.0204	48.98	5.88
Zinc oxide (50% leaded)	.0200	49.98	6.00
Zinc sulfide	.0300	33.32	4.00
Zinc sulfide—barium	.0282	35.40	4.25
Zinc sulfide—calcium	.0387	25.82	3.10
Zinc sulfide—magnesium	.0360	27.74	3.33
Zirconium oxide	.0211	47.40	5.69

2. OILS

The scope of this table will suffice for all ordinary purposes. Patented oils are not included as their types are not always stabilized.

Oils	Gallons per pound	Pounds per gallon	Specific gravity
Castor	0.1250	8.00	0.960
Castor, dehydrated	.1284	7.79	.935
Castor, dehydrated, Z 3	.1264	7.91	.950
Cottonseed	.1299	7.70	.924
Fish—(see also Menhaden, Pilchard, and Sardine)	.1291	7.75	.930
Linseed, raw or boiled	.1289	7.76	.932
Linseed, blown	.1213	8.25	.990
Linseed, heat-bodied, E	.1266	7.90	.948
Linseed, heat-bodied, Q	.1257	7.96	.955
Linseed, heat-bodied, Z and higher	.1238	8.08	.970
Menhaden	.1291	7.75	.930
Oiticica, raw	.1241	8.06	.967
Oiticica, liquefied	.1229	8.14	.977
Perilla	.1289	7.76	.931
Pilchard	.1289	7.76	.931
Sardine	.1306	7.66	.919
Soybean	.1299	7.70	.924
Tall	.1238	8.08	.970
Tung	.1277	7.83	.940

3. SOLVENTS

In addition to the liquids in this list, a large number are not included. The solvents not included are specialties used in relatively small amounts and it is hoped that their omission will not detract from the usefulness of the table.

Solvents	Gallons per pound	Pounds per gallon	Specific gravity
Acetone	0.1514	6.61	0.793
n-Amyl acetate	.1380	7.25	.870
n-Amyl alcohol	.1380	7.25	.870
Benzene, industrially pure	.1364	7.33	.880
n-Butanol	.1478	6.76	.812
n-Butyl acetate	.1370	7.30	.876
sec-Butyl acetate	.1393	7.18	.862
Butyl lactate	.1233	8.11	.974
Carbon tetrachloride	.0750	13.33	1.600
Cyclohexanone	.1270	7.87	.945
Diacetone alcohol	.1276	7.84	.941
Diethyl carbonate	.1232	8.12	.975
Diethylene glycol monoethyl ether	.1213	8.25	.990
Dipentene	.1396	7.16	.860
Ethanol, 95%	.1471	6.80	.816
Ethanol, S.D. 1	.1473	6.79	.815
Ethyl acetate	.1334	7.50	.900
Ethylene dichloride	.0952	10.50	1.26
Ethylene glycol monobutyl ether	.1331	7.51	.902
Ethylene glycol monoethyl ether	.1289	7.76	.931
Ethylene glycol monoethyl ether acetate	.1233	8.11	.974
Ethylene glycol monomethyl ether	.1243	8.05	.966
Ethylene glycol monomethyl ether acetate	.1189	8.41	1.01
Ethyl lactate	.1166	8.58	1.03
Hexahydrophenol	.1261	7.93	.952
Isopropanol	.1520	6.58	.790
Kerosene	.1510	6.62	.795
Methanol	.1514	6.61	.793
Methyl acetate	.1322	7.56	.908
Methyl acetone (48% acetone, 28% methyl acetate, 24% methyl alcohol)	.1444	6.92	.831
Methylene chloride	.0903	11.08	1.33
Methyl ethyl ketone	.1491	6.71	.805
Methyl isobutyl ketone	.1499	6.68	.802
Mineral spirits—			
Approx. distn. range, 155° to 200° C.	.1525	6.56	.787
Approx. distn. range, 180° to 250° C.	.1477	6.77	.813
Naphtha, aromatic petroleum—			
Approx. distn. range, 90° to 150° C.	.1501	6.66	.800
Approx. distn. range, 135° to 190° C.	.1421	7.04	.845
Approx. distn. range, 170° to 220° C.	.1380	7.25	.870
Naphtha, lacquer diluent	.1626	6.15	.738
Naphtha, solvent—			
Approx. distn. range, 130° to 155° C.	.1396	7.16	.860
Approx. distn. range, 150° to 200° C, Hi-flash	.1380	7.25	.870
Heavy, wire enamel solvent	.1291	7.75	.930

Solvents	Gallons per pound	Pounds per gallon	Specific gravity
Naphtha, V. M. & P.—			
Approx. distn. range, 100° to 160° C.	0.1603	6.24	0.749
Nitroethane	.1143	8.75	1.05
Nitromethane	.1053	9.50	1.14
1-Nitropropane	.1200	8.33	1.00
Petroleum spirits—			
Approx. distn. range, 155° to 200° C.	.1525	6.56	.787
Approx. distn. range, 180° to 250° C.	.1477	6.77	.813
Pine oil	.1283	7.80	.936
Toluene, industrially pure	.1381	7.24	.869
Trichloroethylene	.0816	12.25	1.47
Turpentine	.1383	7.23	.868
Xylene, 5°	.1388	7.21	.865

4. RESINS AND OTHER FILMOGENS

Most of the synthetic resins and filmogens (film-forming compositions) in use today vary so widely in their bulking values that any attempt to classify them would be misleading. Most of them that have been entered have been assigned maximum and minimum values and the user of these tables should obtain the values he needs from the producer.

In the few cases that have been investigated, the observed bulking values of filmogens in solution differ from the calculated values. Assuming no change in the bulking value of a solvent, the cellulosic filmogens occupy less volume in solution than as films. The values for the cellulosic filmogens given in the accompanying table apply to their solution in typical solvents or solvents blends.

Resins and other filmogens	Gallons per pound	Pounds per gallon	Specific gravity
Accroides	0.1000	10.00	1.20
Alkyd	.1177 to .1000	8.50 10.00	1.02 1.20
Asphalt, oxidized petroleum	.1213 to .1133	8.25 8.83	99 1.06
Asphalt, steamblown petroleum	.1189 to .1062	8.41 9.41	1.01 1.13
Beeswax	.1250	8.00	.96
Candelilla wax	.1238	8.08	.97
Carnauba wax	.1207	8.29	.99
Casein	.1154	8.66	1.04
Cellulose acetate	.0847	11.81	1.42
Cellulose acetate-butyrate	.0907	11.03	1.32
Cellulose nitrate	.0704	14.16	1.70
Ceresin	.1291	7.75	.93
Chlorinated diphenyl, 65% chlorine	.0698	14.33	1.72
Chlorinated rubber	.0735	13.61	1.63
Congo	.1133	8.83	1.06
Congo ester	.1112	9.00	1.08

Resins and other filmogens	Gallons per pound	Pounds per gallon	Specific gravity
Cumarone	0.1112	9.00	1.08
Damar	.1143	8.75	1.05
East India	.1155	8.66	1.04
Elaterite	.1166	8.58	1.03
Ester gum	.1062	9.41	1.13
Ethyl cellulose	.1035	9.66	1.16
Gilsonite	.1143	8.75	1.05
Kauri	.1155	8.66	1.04
Lac	.1000	10.00	1.20
Manila	.1122	8.91	1.07
Mastic	.1122	8.91	1.07
Melamine	.0984	10.16	1.22
Paraffin	.1349	7.41	.89
Phenol-formaldehyde	.1166 to .1000	8.58 to 10.00	1.03 to 1.20
Pontianak	.1122	8.91	1.07
Rosin	.1112	9.00	1.08
Rosin, limed, 4 to 6% Ca	.1091	9.16	1.10
Urea-formaldehyde	.0961	10.41	1.25
Vegetable oil pitch	.1177	8.50	1.02
Vinyl	.090	11.08	1.33
Zinc rosinate, 6% Zn	.1044	9.58	1.15

5. PLASTICIZERS

Plasticizers	Gallons per pound	Pounds per gallon	Specific gravity
Benzyl benzoate	0.1062	9.41	1.13
Blown castor oil, Z	.1200	8.33	1.00
Blown castor oil, Z6	.1166	8.58	1.03
Butyl acetyl ricinoleate	.1277	7.83	.94
Butyl phthalyl butyl glycollate	.1091	9.16	1.10
Butyl stearate	.1396	7.16	.86
Camphor	.1200	8.33	1.00
Diamyl phthalate	.1166	8.58	1.03
Dibutyl phthalate	.1143	8.75	1.05
Dibutyl sebacate	.1277	7.83	.94
Dibutyl tartrate	.1112	9.00	1.08
Dibutoxy ethyl phthalate	.1291	7.75	.93
Diethyl phthalate	.1072	9.33	1.12
Dihydromethyl abietate	.1166	8.58	1.03
Dimethyl phthalate	.1009	9.91	1.19
Ethyl phthalyl ethyl glycollate	.1016	9.84	1.18
Methyl abietate	.1177	8.50	1.02
Methyl phthalyl ethyl glycollate	.0980	10.20	1.22
Toluene ethyl sulfonamide	.1009	9.91	1.19
Tributyl citrate	.1143	8.75	1.05
Tributyl phosphate	.1225	8.16	.98
Tricresyl phosphate	.1017	9.83	1.18
Triethyl citrate	.1053	9.50	1.14
Triphenyl phosphate	.1009	9.91	1.19

Grateful acknowledgment is made to F. L. Browne, chemist, Forest Product Laboratory; H. A. Gardner, director, Scientific Section, National Paint, Varnish and Lacquer Association; A. C. Goetz, consultant, Protective Coatings Branch, War Production Board; N. F. Harriman, vice-chairman, Federal Specifications Executive Committee, Procurement Division, Treasury Department; and B. A. Howes, Materials Unit, Technical Division, Federal Public Housing Authority for their technical assistance in the preparation of this manual and to Louise D. Card and Eleanor R. Garner, of the Building Practices and Specifications Section of the National Bureau of Standards, for their painstaking effort in reviewing the entire report.

X. LITERATURE REFERENCES

1. REFERENCES CITED IN TEXT

[1] Dutch Boy Quarterly **22**, No. 2, p. 13 (1944).
[2] National Lead Co., Handbook on painting (National Lead Co., 111 Broadway, New York, N. Y.)
[3] A. Maerz and M. Rea Paul, A dictionary of color (McGraw-Hill Book Co., Inc., New York, N. Y., 1930.)
[4] A. H. Munsell, Munsell book of color (Munsell Color Co., Baltimore, Md., 1929.)
[5] Color card supplement to U. S. Army specification 3–1, revised April 21, 1943. (Office, Chief of Ordnance, War Department, Washington 25, D. C.)
[6] Specification TAC–ES–680B. General specification for protective coating materials, synthetic type, September 1943. (Tank Automotive Center, Specification Section, Fisher Building, Detroit, Mich.)
[7] C. L. Mantell, C. W. Kopf, J. L. Curtis, and E. M. Rogers, Technology of natural resins, p. 31–43. (John Wiley & Sons, Inc., 1942.)
[8] Federal specification TT–V–91a. (Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C., 5¢.)
[9] Henry A. Gardner, Physical and chemical examination of paints, varnishes, lacquers, and colors, Ed. 9, p. 345–46, 372. (Institute of Paint Varnish Research, 1500 Rhode Island Avenue, Washington 5, D. C., 1939.)
[10] Deane B. Judd and Kenneth L. Kelly, Method of designating colors, J. Research NBS **23**, 355 (1939) RP1239.
[11] G. J. Fink, Investigation of whitewashes and aqueous lime paints, J. Ind. Eng. Chem. **14**, 503 (1922). This paper is the basis for Bulletin 304D, Whitewash and cold-water paints. (National Lime Association, 927 15th St., N.W., Washington, D. C. Copies free on request.)
[12] U. S. Engineer Dept., St. Louis, Steel and masonry fixed structures, standard specification for paint and painting, March 20, 1941. (Upper Mississippi Valley Division, U. S. Engineer Dept., St. Louis, Mo.)

[13] American Water Works Association standard specification (1A.5 1940, 7A.6 1940) for coal-tar enamel protective coatings for steel water pipe. (American Water Works Association, Inc., 500 Fifth Avenue, New York 18, N. Y., 1940.)

[14] Navy Department Bureau of Yards and Docks, specification for bituminous coating of steel surfaces No. 34Yb (1943). (Bureau of Yards and Docks, Washington 25, D. C.)

[15] Repairs and utilities manual, RU 0603.04. (Office of the Chief of Engineers, U. S. Army, Washington 25, D. C. This manual is on file at all U. S. Army posts.)

[16] Safety requirements for excavation, building, and construction, sections 8305.01 to 8306.08 (Construction Division, Office of the Chief of Engineers, War Department, Washington 25, D. C.).

[17] Paint exposure or complaint report (National Paint, Varnish & Lacquer Association, 1500 Rhode Island Avenue, N.W., Washington 5, D. C.).

[18] Circular 667, Bulking value tables, September 1943. (Scientific Section, National Paint, Varnish & Lacquer Association, 1500 Rhode Island Avenue, N.W., Washington 5, D. C.)

2. ADDITIONAL REFERENCES

The following list of references gives additional information on paint and painting materials. Federal Specifications are priced at 5 cents a copy unless otherwise indicated in the Federal Standard Stock Catalog. Request and remittance for them and for the following publications where a price is indicated should be made to the Superintendent of Documents, Government Printing Office, Washington 25, D. C.

Letter Circulars and TIBM Reports may be obtained free of charge from the National Bureau of Standards.

(a) BUILDING MATERIALS AND STRUCTURES REPORTS

Rolla E. Pollard and Wilbur C. Porter, Methods of investigation of surface treatment for corrosion protection of steel, NBS BMS8 (1938) 10¢.

Herman V. Cottony and Richard S. Dill, Solar heating of various surfaces, NBS BMS64 (1941) 10¢.

Rolla E. Pollard and Wilbur C. Porter, Surface treatment of steel prior to painting, NBS BMS44 (1940) 10¢.

Cyrus C. Fishburn and Douglas E. Parsons, Tests of cement-water paints and other waterproofings for unit-masonry walls, NBS BMS95 (1943) 15¢.

Wilbur C. Porter, Painting steel, NBS BMS102 (1944) 10¢.

(b) LETTER CIRCULARS

Acid-proof coatings for concrete surfaces, NBS LC42 (1923).
Bluing of iron and steel, NBS LC630 (1941).
Care of floors, NBS LC764 (1941).
Color charts: A descriptive list, NBS LC665 (1941).
Color harmony, NBS LC525 (1938).
Color and legibility, NBS LC730 (1943).
Conservation of linseed oil in paint, NBS LC717 (1943).
Control of humidity by saturated salt solutions, NBS LC752 (1944).
Corrosion and protection of underground tanks and burial vaults, NBS LC521 (1938).
Corrosion in soils, NBS LC689 (1942).
Dampness in masonry walls above grade, NBS LC721 (1943).
Drainpipe cleaners or solvents, NBS LC756 (1944).
Finishes for concrete floors, NBS LC758 (1944).
Inside wall paint for chemical laboratories (heat- and fume-resisting enamel paint), NBS LC489 (1937).
Luminous and fluorescent paints, NBS LC703 (1942).
Outside house painting, NBS LC603 (1940).
Paint, varnish, and bituminous materials: Publications by members of the staff of the National Bureau of Standards and a list of Federal Specifications, NBS LC795 (1945).
Paint and varnish removers, NBS LC749 (1944).
Painting exterior walls of porous masonry, NBS LC747 (1944).
Painting Plaster, NBS LC304 (1938).
Painting of steam and hot-water radiators, NBS LC445 (1935).
Painting Steel Potable water tanks, NBS LC744 (1944).
Painting of structural metal (steel, galvanized metal, tin plate, and copper), NBS LC422 (1934).
Paints and other protective coatings for tires, NBS LC709 (1942).
Paints for swimming pools, NBS LC746 (1944).
Polishes, NBS LC753 (1944).
Protection of track-scale parts from corrosion, NBS LC54 (1922).
Protective coatings for underground piping systems, NBS LC510 (1938).
Refinishing wood furniture, NBS LC748 (1944).
Reflectance of paints and pigments, NBS LC470 (1936).
Salt-spray test (for metal corrosion), NBS LC530 (1938).
Sources of information on paint and related materials, NBS LC671 (1941).
Specifications for paint for use on railroad track scales, NBS LC81 (1922).
Spray painting, NBS LC773 (1944).
Sweeping compounds (also known as "floor sweep" and "dust down"), NBS LC754 (1944).
Tests for nonmetallic protective coatings for underground pipes, NBS LC480 (1936).
Wood and shingle stains, NBS LC464 (1936).

(c) SIMPLIFIED PRACTICE RECOMMENDATIONS

Paint and varnish brushes, R43–28, 5¢.
Color for school furniture, R111–30, 5¢.
Paints, varnishes, and related products, R144–43, 5¢.

Color code for marking steel bars, R166–37, 5¢.
Color marking for anesthetic gas cylinders, R176–41, 5¢.

(d) TECHNICAL INFORMATION ON BUILDING MATERIALS

Aluminum paints, NBS TIBM43 (1937).
Federal specification paint pigments and mixing formulas, NBS TIBM33 (1936).
Federal specification ready-mixed paints, semipaste paints, and mixing formulas, NBS TIBM34 (1946).
Miscellaneous paint drying oils and paint driers, NBS TIBM45 (1937).
Paint drying oils—linseed, NBS TIBM44 (1937).
Paint pigments—black, red, and lakes, NBS TIBM31 (1936).
Paint pigments—white, NBS TIBM30 (1936).
Paint pigments—yellow, brown, blue, green, and bronze, NBS TIBM32 (1936).
Paint for priming plaster surfaces, NBS TIBM11 (1936).
Painting of ferrous metals, NBS TIBM28 (1936).
Painting plaster, NBS TIBM18 (1936).
Preparation of paints from paste and dry pigments, NBS TIBM35 (1936).
Preparation of paints from semipaste paints, thinning ready-mixed paints, and preparation of water paints, NBS TIBM36 (1936).
Shellac, NBS TIBM48 (1937).
Varnish and lacquer, NBS TIBM47 (1937).
Volatile paint and varnish thinners, NBS TIBM46 (1937).
Wood and shingle stains, NBS TIBM49 (1937).

(e) COMMERCIAL STANDARDS

Colors for sanitary ware, CS30–31.
Colors for kitchen accessories, CS62–38, 5¢.
Colors for bathroom accessories, CS63–38, 5¢.
Artists' oil paints, CS98–42, 5¢.

XI. GLOSSARY OF SELECTED PAINT TERMS

The purpose of this glossary is to assist the reader in becoming better acquainted with the definitions and explanations of a limited number of terms currently used in the field of protective coatings. No attempt has been made to cover the entire field. For those interested in the definition of terms not included, the following references used in preparing this glossary are suggested:

Webster's New International Dictionary, Second Edition, unabridged.
Standard Chemical and Technical Dictionary by H. Bennett. Chemical Publishing Co., Inc., New York, N. Y.
The National Paint Dictionary, by J. R. Stewart. Stewart Research Laboratory, Franconia, Va.

Federal Specification TT-P-141a, Paint, Varnish, Lacquer and Related Materials; General Specification for Sampling and Test Methods (20 cents, Superintendent of Documents).
Definition of Terms Relating to Paint, Varnish, Lacquer and Related Products, A.S.T.M. Standards, 1942. Part II, American Society for Testing Materials.

Acid number.—A value obtained in analysis of oils fats, etc.; the number of milligrams of potassium hydroxide required to neutralize the free fatty acid in a gram of the substance.

Alkali-refined oil.—Drying oil refined with alkali to reduce its acid number.

Alkyd resin.—A group of synthetic resins made by reacting polyhydric alcohols, such as glycerin and the glycols, with dibasic organic acids such as phthalic, maleic, succinic, and sebacic. A modifying agent is generally present to impart certain properties. Some of these agents are drying, semidrying, and nondrying oils; fatty acids of the oils; natural resins such as rosin; synthetic resins; and other substances. An average alkyd resin may contain, by weight, about 50 percent of modifier such as linseed oil fatty acids, 30 percent of diabasic acid, and 20 percent of polyhydric alcohol (see glyceryl phthalate).

Aromatic.—Derived from or characterized by the presence of the benzene ring—as applied to a large class of cyclic organic compounds—many of which are odorous.

Binder.—The nonvolatile portion of a paint vehicle.

Bleeding.—When coloring material from either the wood or an undercoat works up into succeeding coats and imparts to them a certain amount of color, paint is said to "bleed."

Blistering.—Formation of bubbles on the surface of paint film, usually caused by moisture behind the film.

Bloom.—Haze or clouded effect that appears on the surface of dried enamel or varnish, affecting the gloss of the film.

Bodied linseed oil.—Bodied linseed is oil that has been thickened by heat treating or blowing, thus increasing the "body" or consistency. It may be obtained in various degrees of body or viscosity, indicated on the Gardner Holdt scale by letters of the alphabet.

Body coat.—Intermediate coat of paint between the priming or first coat and the finishing, or last, coat.

Boiled linseed oil.—Raw linseed oil that has been heated in the presence of metallic drying compounds. The older

method consisted in heating the oil by direct fire to a temperature of about 550° F, at which point oxides of metals, such as red lead, litharge, and manganese dioxide were added. More modern methods add soluble driers, such as resinates, linoleates, and naphthanates of lead, manganese, and cobalt, to the oil, which is heated to lower temperatures than in the older process.

Boot-topping paint.—A water- and weather-resistant marine paint used on the boot-topping area of vessels. The boot-topping area is that area on the exterior of the vessel extending from the light-load water line to 6 in. above the full-load water line.

Builders' acid.—An acid prepared on the job by adding 1 part by volume of muriatic (hydrochloric) acid to 4 parts by volume of water. The solution, which should be mixed in a wood pail and applied to the surface by means of fiber scrub brushes, will remove mortar stains from brick.

Bulking value.—Void-free volume of a unit weight of material expressed as decimal fraction of a gallon per pound.

Calcimine.—A wash consisting of a mixture of whiting, glue, china clay, and water (see Fed. Spec. TT–C–96).

Chalking.—A phenomenon of paint coatings manifest by loose powder coming from the film itself, at or just beneath the surface.

Consistency.—Relative firmness, limpidity, body, or resistance to agitation or deformation of a coating material in bulk.

Copals.—A group of resinous substances exuding from various tropical trees. Copal is collected from living trees or is dug from the ground as a fossil. The main sources are East India, New Zealand, and Africa. Some of the resins are amber, congo, kauri, manila, Pontianak, West India gum, and zanzibar.

Crazing.—A type of paint failure consisting of minute interlacing cracks on the surface of a finish caused by unequal contraction while drying.

Cut.—The dispersion of a certain number of pounds of shellac or resin per gallon of volatile liquid. For example, a 4-lb cut of shellac varnish contains 4 lb of dry shellac and 1 gal of alcohol.

Drier.—A composition that accelerates the drying of oil, paint, or varnish. Driers, usually compounds of metals, are available in solid, paste, and liquid form.

Drying oil.—An oil which possesses to a marked degree the property of readily taking up oxygen from the air and changing to a relatively hard, tough, elastic substance when exposed in a thin film to the air.

Efflorescence.—A white powdery substance exuding from brick walls and similar masonry surfaces. Should be removed by builders' acid before surface is painted.

Emulsifier or emulsifying agent.—Substances of a chemical nature that intimately mix and disperse dissimilar materials ordinarily immiscible, such as oil and water, to produce a stable finished emulsion. Thus the emulsifier has the double task of promoting the emulsification and of stabilizing the finished product. Some examples of emulsifying agents are alkali soaps (sodium oleate and ammonium oleate); metallic soaps (aluminum stearate and calcium oleate); amino soaps (morpholine); sulfated castor oil (Turkey red oil); and casein (the natural emulsifying agent and stabilizer in milk that keeps the butterfat droplets emulsified).

Enamel.—A paint that is characterized by its ability to dry to an especially smooth, hard, glossy or semiglossy finish.

Film integrity.—The serviceability of a paint coating may be described by (1) the appearance of the coating: discoloration by dirt, loss of gloss, fading of color, ability to hide, chalking, and checking visible from a distance of at least 6 ft, and (2) film integrity: cracking, slitting, flaking, and scaling of the film or discontinuities in the film that lay bare the underlying surface.

Filmogens.—General word for film-forming materials, such as linseed oil and varnish resins.

Foots.—Slimy mucilaginous matter that separates from some oils when they stand for a long period of time.

Form lacquer.—Thin varnish or lacquer used to coat concrete forms to prevent the concrete from adhering to the forms.

Garnet paper.—Similar to sandpaper, except that garnet sand used for making garnet paper is the same red mineral as that used for jewelry but of more impure form and usually dark claret in color.

Glazing.—Operation of setting window glass with putty. Also, the process of obtaining Tiffany and antique decorative effects on walls by the application of translucent pigment colors-in-oil such as sienna, umber, and Vandyke brown, thinned with flatting oil (Fed. Spec. TT–O–356a).

Gloss (luster, sheen).—The property of a surface by which it reflects light specularly. Painters use the terms *high*, *enamel*, or *mirror* to indicate the highest gloss or luster; and *semigloss*, *eggshell*, and *flat* to indicate decreasing degrees of gloss in the order given.

Glyceryl phthalate resin (alkyd).—A synthetic resin of the alkyd group, used principally in paints, varnishes, and lacquers; sometimes called phthalic alkyd resin. It is made by reacting glycerin and phthalic anhydride. The alkyd resins as a group are made by reacting polyhydric alcohols, such as glycerin and the glycols, with dibasic organic acids, such as phthalic, maleic, succinic, and sebasic.

Gum.—Viscous vegetable secretion that hardens but, unlike a resin, is water-soluble; name often applied in the varnish industry to natural resins, as, for example, kauri "gum." A more appropriate term is "gum resin."

Hiding power.—The power of a paint or paint material to obscure the surface to which it is applied. In Federal specifications this property is expressed in terms of square feet per gallon.

Iodine number.—In the analysis of oils, fats, etc. the number of centigrams of iodine absorbed by 1 g of the substance.

Kauri reduction test.—A method of determining the relative flexibility of certain oleoresinous varnishes by using a solution of properly treated kauri resin in turpentine. (For details, see Fed. Spec. TT–P–141a, Method 415.)

Krebs units.—Arbitrary values representing viscosity or consistency of paints based on tests with the Krebs-Stormer viscometer.

Lacquer.—The term indicates a coating material that dries by evaporation. The many types include cellulosic lacquers, Chinese lacquers, sanitary or tin-plate lacquers, and spirit lacquers, for example, solutions of shellac in alcohol. Cellulosic lacquers (Fed. Spec. TT–L–58) are the most important and today, the term *lacquer* is applied almost exclusively to this type. Cellulosic lacquers, either transparent or pigmented, contain cellulose esters or ethers and plasticizers, with or without natural or synthetic resins as the basic film-forming ingredients. Lacquer dries rapidly by solvent evaporation.

Mil.—Unit of thickness; 1/1000 in. Used to measure the thickness of paint coats.

Nonvolatile vehicle.—Liquid portion of paint, with the exception of volatile thinner and water.

Oil length of varnish.—The number of gallons of drying oil with which 100 lb of resin, or "gum," is heated. "Long-oil" varnish contains 25 gal of oil or over; "short-oil," 10 gal or less; "medium-oil," from 10 to 20 gal. An example of long-oil is spar varnish (TT–V–121b); short-oil, rubbing varnish (TT–V–86); medium-oil, interior varnish (TT–V–71a).

Oil varnish.—Varnish that contains resin and drying oil as the basic film-forming ingredients and is converted to a solid film primarily by chemical reaction (see *Spar varnish*).

Paint.—A mixture of pigment with vehicle intended to be spread in thin coats for decoration, protection, or both.

Pigment.—Fine solid particles used in the preparation of paint and substantially insoluble in the vehicle.

Pigment volume.—Percentage by volume of pigment in nonvolatile portion of a paint as calculated from bulking value and composition data. The letters PV are commonly used as an abbreviation.

Plasticizer.—An ingredient added to a plastic to soften, increase toughness, or otherwise modify the properties.

Plastic wood.—Mixture designed for the repair of woodwork. Consists of wood flour, resins, volatile solvents, and plastic binding material such as cellulose nitrate.

Poise.—The cgs (centimeter-gram-second) unit of absolute viscosity.

Polymerization.—A reaction in which two or more molecules of the same substance combine to form a product of higher molecular weight without changing the chemical composition of the original material. In the protective coating field, the term is applied to various materials, including drying oils, such as linseed oil and tung oil and resins such as rosin. In most varnishes the oil is polymerized by careful heating. The presence of phenolic resin along with the oil, during the varnish cooking, greatly accelerates polymerization. Such varnishes dry largely by polymerization rather than by oxidation. Varnish films produced mainly by polymerization are characterized by improved water resistance and resistance to sunlight and weathering. A tung oil pure phenolic resin spar varnish is a good example.

Primer.—The paint or analogous substance applied next to the surface of the material being painted. A priming paint.

Putty.—A kind of cement used for fastening glass in sashes, stopping crevices, and similar purposes.

Resin.—A semisolid or solid, complex amorphous mixture of organic compound with no definite melting point, insoluble in water. Resins are usually either partly soluble in alcohols, ethers, and other organic solvents or can be made so by heating. On heating, resins soften, melt, and burn with a smoky flame.

Rosin.—The solid resin obtained as the residue from the preparation of turpentine from the crude resin of the pine tree.

Saponify.—To convert a fat or oil into soap by the action of an alkali. When esters are boiled with strong bases, soaps are formed. Linseed oil contains the glyceryl ester of linoleic acid. Thus, when a linseed-oil paint comes in contact with a surface that contains strong alkali and water, such as damp concrete basement floors, the oil is saponified and thus loses its bonding properties.

Sealer (size).—A liquid coating composition, usually transparent, such as varnish, that also contains pigment for sealing porous surfaces, especially plaster, preparatory to application of finish coats. A thin varnish of 1 gal TT–V–71a interior varnish plus 1 or 2 qt turpentine is frequently used as a "sealer" for plaster, prior to application of finish coats of paint. Federal Specification TT–P–56 is an example of pigmented sealer for plaster. Wood floor sealer (Fed. Spec. TT–S–176) is a thin varnish.

Shellac.—A resinous material commonly known as "flake shellac," secreted by the insect Laccifer Lacca Kerr. Shellac is obtainable in two forms, "orange" and "bleached." (Fed. Spec. TT–S–271).

Spar varnish.—A very durable, water-resistant varnish for severe service on exterior exposure. It consists of one or more drying oils: for example, linseed, tung, or dehydrated castor; one or more resins: for example, rosin, ester gum, 100 percent phenolic resin, or modified phenolic resin; one or more volatile thinners: for example, turpentine or petroleum spirits; and driers: for example, linoleates, resinates, or naphthanates of lead, manganese, and cobalt. It is classed as long-oil varnish (see "oil length of varnish"), and generally consists of 45 to 50 gal of oil to each 100 lb of resin.

Spirit varnish.—A varnish which is converted to a solid film by solvent evaporation. Damar Varnish (Fed. Spec.

TT–V–61) and Shellac Varnish (Fed. Spec. TT–V–91a) are spirit varnishes.

Spreading rate.—The amount of surface or area over which a given volume of paint can be spread by brushing, spraying, etc. Usually expressed in square feet covered per gallon.

Thixotropic paint.—The general term *thixotropy* is the property or phenomenon, exhibited by some gels, of becoming fluid when shaken. The change is reversible. Thixotropic paint applies particularly to the field of interior flat wall paints. Many paints of this type possess marked rigidity like the texture of whipped cream, when not disturbed, but become highly fluid when the paint is stirred and remains so for an appreciable time. After cessation of a mechanical disturbance, such as stirring of the paint or of putting the brush into the paint, rigidity slowly develops again. These are known as thixotropic paints. This rheological property is of practical significance as regards storage, application, and film properties of the paint.

Trim enamel paint.—A subdivision of surface coatings known as house paints, differing from ordinary house paint body colors by faster drying, by having more gloss, and by showing fewer brush marks. Principally designed for use on trim, screens, and shutters. (Fed. Spec. TT–P–71a, amendment 1).

Two-coat paint system.—A system developed for painting new exterior woodwork that consists of special primer and finish paint for application in relatively thick coats. After two coats have been applied evenly and allowed to dry, the thickness of the coating for good durability should be about 0.0045 to 0.0055 in. (4½ to 5½ mils). To obtain such a thickness, the primer should be spread at approximately 450 ft^2/gal and the finish coat at 550 ft^2/gal.

Varnish.—A homogeneous liquid generally composed of resin, drying oil, volatile thinner, and drier. When applied in a thin layer and exposed to the air, the varnish is converted to a transparent or translucent solid film.

Vehicle.—The liquid portion of a paint.

Viscosity.—Internal friction of a fluid; resistance to flow; opposite of fluidity. For example, linseed oil is more viscous than turpentine; bodied linseed oil is more viscous than raw linseed oil. An important physical property of oil, varnish, and lacquer.

Volatile thinner.—The liquid portion of a paint, except water, which is volatile in a current of steam at atmospheric pressure.

Zinc oxide and leaded zinc oxide.—Zinc oxides covered by Federal Specification TT–Z–301 contain practically no lead. Leaded zinc oxides covered by Federal Specification TT–Z–321 are produced from ores containing lead and may contain from 7 to 40 percent of material other than zinc oxide, which is generally basic lead sulfate. The material is really a mixture of zinc oxide and basic sulfate white lead.

XII. LIST OF FEDERAL SPECIFICATIONS

As this publication goes to press, the following is the latest list of Federal Specifications pertaining to paint and related materials.

Federal specifications may be obtained from the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C., for 5 cents each (no stamps), except TT–P–141a Methods of sampling and testing, 20 cents.

Federal Specifications Index, Part 1 of Federal Standard Stock Catalog Section IV may be obtained from the Superintendent of Documents, Washington 25, D. C. Price, 25 cents.

Acetone O–A–51a
Aluminum pigment (powder and paste) .TT–A–468
——, varnish for.....TT–V–81a
Asphalt primer SS–A–701
—— roof coating SS–R–451
—— varnish TT–V–51a
Benzol VV–B–231
Bituminous plastic cement SS–C–153
Black enamel TT–E–521
—— ——, heat resisting TT–E–496
Black paint, carbon...TT–P–61a
—— ——, graphite....TT–P–27
Blue lead, dry and in oil TT–B–486
—— ——, paint.....TT–P–20
Bone black, dry.....TT–B–600
—— ——, paste-in-oil.TT–P–381
Calcimine TT–C–96
Calking compound TT–C–598
Carbon black, dry.....TT–C–120
—— ——, paste-in-oil.TT–P–381
Casein paint, exterior..TT–P–22
—— ——, interior....TT–P–23a
Cement-water paint ...TT–P–21
Chrome green, dry ...TT–C–235
—— ——, paste-in-oil.TT–P–381
Chrome orange, dry ...TT–C–290
—— ——, paste-in-oil.TT–P–381
Chrome oxide, dry ...TT–C–306
—— ——, paste-in-oil.TT–P–381
Chrome yellow, dry ...TT–C–290
—— ——, paste-in-oil.TT–P–381
Cold-water paint, exterior TT–P–22
—— —— ——, interior TT–P–23a
Concrete and masonry paint TT–P–24
Copper phthalocyanine blue TT–C–610
Damar varnish TT–V–61
Drier, liquid paint ..TT–D–651a
Drum-coating enamel..TT–E–485
Eggshell interior paint TT–P–51a

Sienna, raw and burnt, dry TT-S-346
——, ——— ———,
paste-in-oil TT-P-381
Spirit varnish TT-V-130
Stain, exterior TT-S-706
——, interior TT-S-711
Stencil paint TT-P-98
Testing methods TT-P-141a
Thinner, lacquer TT-T-266
——, paint TT-T-291
Titanium dioxide TT-T-425
Titanium-lead-zinc paint TT-P-40
Toluidine red TT-T-562
Traffic paint TT-P-115
Turpentine, gum spirits TT-T-791b
——, steam distd. wood TT-T-791b
——, destructively distd. wood TT-T-792a
Ultramarine blue, dry. TT-U-450
—— ——, paste-in-oil. TT-P-381
Umber, raw and burnt, dry TT-U-481
——, ———, ———,
paste-in-oil TT-P-381
Varnish, aluminum ... TT-V-81a
Varnish, asphalt TT-V-51a
——, damar TT-V-61
——, exterior TT-V-121b
——, interior TT-V-71a
——, rubbing TT-V-86
——, shellac TT-V-91a
——, spar TT-V-121b
——, spirit TT-V-130
Venetian red, dry..... TT-V-226
—— ——, paste..... TT-P-381
Wax, floor, solvent type P-W-134
——, ——, water emulsion P-W-151a
——, general purpose.. P-W-158
White lead, basic carbonate TT-W-251b
——— ———, ——
sulfate TT-W-261a
—— —— paint..... TT-P-40
Yellow exterior paint... TT-P-53
Yellow iron oxide, dry. TT-Y-216
——— ———, paste-in-oil TT-P-381
Zinc dust—zinc oxide primer TT-P-641
Zinc oxide TT-Z-301
—— ——, leaded..... TT-Z-321
Zinc yellow TT-Z-415

The following Federal Specifications are in preparation but are not approved or printed as yet:

Ink; stencil (TT-I-558 and 559).
Paint; luminous, nonradioactive.
Paint; semigloss, wall, interior (TT-E-508).
Primer; paint, iron-oxide (for motor vehicles).
Shellac (revision of TT-S-271).

INDEX

U. S. GOVERNMENT PRINTING OFFICE: 1945