The paper used in this Handbook is opacified and brightened with Titanox A (Titanium Dioxide).

Printed in U.S.A.

Handbook No. 2412

Presented to Mr. W. R. Sieplein

Address 101 Prospect Avenue, N.W.,
Cleveland, Ohio.

Company Sherwin Williams Company

PARALLEL with the tremendous advances in the use of Titanium Pigments over the past few years many problems have arisen among consumers, particularly those engaged in the paint industry, in the solution of which their knowledge and experience with other white pigments is not particularly useful. This is true in a large measure because the physical and chemical properties of Titanium Pigments are so at variance with those of the basic white pigments with which the trade has become familiar over long years of experience.

Such problems are the subject of constant study in the laboratories and at the experimental stations of the Titanium Pigment Corporation. As a result, much helpful information has already been accumulated and new data are being disclosed continually.

It is the desire of the Service and Sales Staffs of this organization to be of help to you in your attempts to formulate products with Titanox Pigments successfully. To that end the most pertinent and valuable data presently available have been assembled herewith in convenient form. As other problems are worked out and additional data completed, they will be arranged in similar form and supplied for addition to the matter here presented.

Occasionally corrections to this Handbook may be deemed advisable or necessary. If so you will be asked to return certain sheets which will be replaced promptly with the corrected text.

We trust that our efforts to serve you will be fruitful and that they will meet with your approval.

TITANIUM PIGMENT CORPORATION
111 BROADWAY,
NEW YORK, N. Y.

PATENT DISCLAIMER

The sales policy of the Titanium Pigment Corporation is based upon the respect of patent rights of others. The pigments described in this Handbook are stable articles of commerce and have a great variety of uses in the production of many different products, for instance, surface-coating compositions, rubber, paper, glass, etc. These pigments are sold for the buyer's own consumption without knowledge on the part of the Titanium Pigment Corporation of the details of the use to which they are put by the buyer and without intent that the pigments be employed by the buyer in either direct or contributory infringement of any United States Patent. The Corporation accepts no responsibility if, contrary to its intentions, its pigments are so used.

TITANIUM PIGMENT CORPORATION
111 Broadway
New York, N. Y.

TITANIUM PIGMENT COR
111 Broadway, New York,

Sole Sales Agents fo

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"TITANOX"-B—(Titanium Bariu
"TITANOX"-B-30—(Titanium Ba
"TITANOX"-C—(Titanium Calciu
"TITANOX"-L—(Lead Titanate)
"TITANOX"-M—(Titanium Magn
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Warehouses

Albany, N. Y.	Detro
Atlanta, Ga.	Houst
Baltimore, Md.	Jerse
Boston, Mass.	Kansa
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Pacific Coast Distribut

National Lead Co., Pacific Co
San Francisco, Los Angeles, Por

"TITANOX"

Process of Manufacture

The two most important titanium ores are ilmenite and rutile. Ilmenite is frequently described as an iron titanate ($FeTiO_3$) or ($FeOTiO_2$) but it seldom, if ever, corresponds to this formula. Iron is practically always present in both conditions of valence. In the usual commercial ores the titanium dioxide (TiO_2) content varies from 35% to 55%, ferrous oxide (FeO) from 5% to 40%, and ferric oxide (Fe_2O_3) from 5% to 32%. Ilmenite commonly occurs in both rocks and sand and is black in color.

The most important deposits are the beach sands of Travancore, India; the massive ilmenite of Egersund, Norway; the nelsonite deposit, a "pepper and salt" mixture of apatite and ilmenite, in Nelson County, Virginia, and large massive ilmenite deposits in the Adirondack Mountains of New York.

Rutile is a natural titanium dioxide. The composition varies from 90 to 98% TiO_2, the chief impurity being iron oxide. Rutile also occurs both in massive form and as sand, and usually is reddish brown in color, but sometimes is yellowish, bluish, or violet. Rutile is not used as a source of titanium for pigment manufacture. It finds its chief application in the metallurgical and ceramic industries.

In the usual process of manufacture of titanium dioxide pigment the titanium ore concentrates are first pulverized to a fine powder and then treated with concentrated sulphuric acid. A reaction takes place resulting in the formation of a mixture of titanium and iron sulphates. These sulphates are taken up in water and passed through a series of settling and washing tanks in which the insoluble impurities are removed. The clarified solutions are then adjusted to a definite concentration with respect to titanium, iron and sulphuric acid content.

This clarified solution is then pumped to precipitation tanks, where under suitable conditions the titanium sulphate is hydrolized and precipitated in the form of a complex hydrate. The hydrate

pulp is then washed, calcined and milled. This description is, of course, only a brief outline of a complicated and carefully controlled procedure in the production of "TITANOX"-A.

If "TITANOX"-B is to be made, blanc fixe is introduced at precipitation in the proportion of 70% to 30% of titanium dioxide, so that the titanium hydrate is actually precipitated upon the finely dispersed blanc fixe. Succeeding operations similar to those indicated above in the production of "TITANOX"-A result in the production of an intimately mixed and coalesced pigment.

When "TITANOX"-C is made, calcium sulphate (anhydrite) is used instead of blanc fixe in the same manner. The calcination step in this process is very carefully controlled to insure the production of maximum physical and chemical stability in the pigment.

"TITANOX"-L, which is chemically, lead metatitanate ($PbTiO_3$), is made by controlled calcination of a mixture of litharge (PbO) and purified, hydrous titanium dioxide. Rigid control of the calcination process is practised in order to accomplish complete combination of the litharge with the titanium dioxide, and to develop optimum pigment properties.

"TITANOX"-M, the titanium, magnesium-silicate base pigment, is made by thorough and careful blending of "TITANOX"-A with a selected and treated magnesium silicate extender in a ratio of 30 to 70 per cent by weight.

The most evident and striking quality of "TITANOX" pigments is their high opacity. This varies with the percentage of titanium dioxide in the different grades.

May, 1941.

Titanox Pig

History and Develo

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About 1860 a British compa ing concession in Norway and the titanium from ore at a pla to many difficulties met in th ore, they were soon forced int of the partners of this ventu brought a boatload of the cru Birmingham about 1869, reduce der, heated it to remove the and ground it into paint with mixture of boiled oil and t John Overton of Louisville, anti-fouling composition prep rutile to a fine powder and bituminous composition.

These primitive application attempts to utilize titanium a but their instigators appear entirely any conception of the the oxide in a pure state—a later on, was to prove so imp

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May, 1941.

Titanox Pigments

History and Development

THE element Titanium which forms the base of Titanox pigments, was discovered in 1791 by the Rev. William Gregor, a priest in the parish of Menachan in Cornwall, England. It occurred in the form of a black sand composed of oxides of iron and an unknown metal. This sand was christened Menakanite. No further attention was paid to the discovery until 1795 when M. H. Klaproth, in Austria, extracted and identified from a mineral now called Rutile, the element previously discovered by Gregor. To Klaproth is given the credit of naming the mineral "Titanic Earth," having reference to the mythological Titans, the first sons of the earth, from which the name "Titanium" was derived. Subsequently, extensive deposits of a similar mineral were found in the Ilmen Mountains of Russia, and the name Ilmenite superseded Menakanite as the group name for Titanium bearing ores. Later deposits were found in Norway, Canada, India, North Africa, Madagascar, Brazil, and many parts of the United States.

About 1860 a British company obtained a mining concession in Norway and attempted to smelt the titanium from ore at a plant in England. Due to many difficulties met in the handling of the ore, they were soon forced into liquidation. One of the partners of this venture, J. W. Ryland, brought a boatload of the crude titanium ore to Birmingham about 1869, reduced it to a fine powder, heated it to remove the moisture, cooled it and ground it into paint with a vehicle such as a mixture of boiled oil and turpentine. In 1870 John Overton of Louisville, Ky., patented an anti-fouling composition prepared by reducing rutile to a fine powder and grinding it in a bituminous composition.

These primitive applications marked the first attempts to utilize titanium as a paint pigment, but their instigators appear to have missed entirely any conception of the idea of separating the oxide in a pure state—a development that, later on, was to prove so important.

Strangely enough titanium occupies a paradoxical position in that it was, and, to a con-

siderable extent, still is considered a chemical curiosity and a rare element in spite of the fact that, actually, it is the ninth most abundant of the eighty-three elements which make up the lithosphere. It is exceeded in abundance only by oxygen, silicon, aluminum, iron, calcium, sodium, potassium and magnesium. Lead and zinc, the two metals which serve as the bases for the other major opaque white pigments, are well known and are thought of as occurring in abundance, but if tin, antimony, nickel and copper were added to the list, the combined world supply of these six well known elements would be exceeded by titanium.

Development in America by the Titanium Alloy Mfg. Co., and the Titanium Pigment Company

About 1870 a young French chemist, Dr. A. J. Rossi, came to America and was engaged in a blast furnace operation at Boonton, N. J., where titaniferous ores were successfully smelted into pig iron. During this experience he became very much interested in the subject of titanium, especially as it occurred in iron ores.

The McIntyre Iron Company in previous years had operated a blast furnace in the Adirondack Mountains for the reduction of titanium bearing ores. Mr. James McNaughton, who controlled the large acreage on which this enterprise was conducted, was cognizant of the richness and extent of the titaniferous ore deposits here available and of the doubt expressed by blast furnace operators regarding the possibilities of the use of such ore in furnace practice. He secured the services of Dr. Rossi as the only individual in the country who knew anything about the practical smelting of such ores. About 1890, with Dr. Rossi and several friends, he organized a syndicate and erected a very small blast furnace in Buffalo, where titaniferous ores were smelted in various proportions. Dr. Rossi secured patents on the processes of smelting such ores and also on the manufacture of various titanium alloys. Shortly after this date Mr. McNaughton passed away and his affairs were taken over by two nephews in Albany, J. McNaughton Thompson and Andrew Thompson. They in turn enlisted the interest and support of Wm. T. Meredith & Company, an investment house in New York City, and, in 1904, Wm. F. Meredith and Jos. D. Meredith be-

came actively engaged in the
their assistance the Titanium All
incorporated in 1906 and a pla
Niagara Falls, N. Y., for the pro
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and scavenging of steel.

In 1912 Mr. L. E. Barton becar
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Rossi and Barton developed a m
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About 1913 two engineers,
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As an outgrowth of their effo
Pigment Company was incorpor
a factory built at Niagara Falls
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After an exhaustive investiga
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in the pigment field, the Nationa
purchased a substantial interest
Pigment Company in 1920. Th
partners in the enterprise until la

they acquired the entire stock of the subsidiary company. In October, 1936, the Titanium Pigment Company, Inc., was dissolved, and the manufacturing interests, property, and stocks were taken over by the National Lead Company—Titanium Division. Sole selling rights for Titanox pigments were vested in a new company, The Titanium Pigment Corporation.

About 1922 the interests of Buckman and Pritchard, Inc., were acquired by the Titanium Pigment Co., who thus became the outright owners of the Florida properties. However, it became more expedient and economical to obtain titanium ores from other sources and the Florida operation was suspended, the equipment dismantled and moved to other localities where it could be put to advantageous use. The property in Florida, lying on the east coast about twenty-five miles below Jacksonville, has been developed into a very attractive resort known as the Ponte Vedra Country Club.

In the experimental and development work of Rossi and Barton, four types of titanium pigments were produced as follows:

Titanox-A—The Dioxide of Titanium

Titanox-BX—Consisting of 16% Titanium Dioxide precipitated on Blanc Fixe.

Titanox-BXX—Consisting of 25% Titanium Dioxide precipitated on Blanc Fixe.

Titanox-C—Consisting of Titanium Dioxide precipitated on Calcium Sulphate.

Titanox-BX did not prove to be of commercial interest and was soon discontinued. Later developments, in some of which Mr. Barton participated, resulted in other pigments as follows:

Titanox-L—Wherein Titanium Dioxide and Lead Oxide are fused to form Lead Titanate.

Titanox-B-30—Consisting of 30% Titanium Dioxide precipitated on Blanc Fixe.

Titanox-M—Consisting of 30% Titanium Dioxide admixed with Magnesium Silicate.

The commercial operation at Niagara Falls at the start was confined entirely to the production of Titanox BXX, later known as Titanox-B (Titanium Barium Pigment). This factory was of limited tonnage capacity and the interest in Titanox pigments increased so rapidly that in 1922 it became necessary to make some importa-

tions from Europe in order to
mestic demand.

The Niagara Falls plant thu
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Shortly thereafter the conti
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township of Sayreville, N. J.,
broken in 1934 for a large new
manufacturing unit of which w
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manufacturing units have bee
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The Niagara Falls plant, wh
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of Titanox-B in March, 1934, and
facturing for two years, whe
closed, the equipment partially
the factory sold in 1937 to Th
Mfg. Co.

European Development b
Company A/S

One of the most extensive an
sources of ilmenite is on the

This deposit was first exploited about 1860 by an English Company which obtained a mining concession and imported the ore into England for metallurgical use. Nothing further was done with this deposit until about 1908 when a Goverament Commission was appointed to investigate the available iron ores of Norway, and attention was again focused on this titaniferous ore deposit.

Professor Farup, one of the members of the Commission, with Dr. Gustav Jebsen conducted a joint investigation on the smelting of these ores and came to realize the difficulty of such treatment. Thereupon other methods of utilizing the ores were sought, and this research led to the development of white titanium pigments. The first product, made from ilmenite, was a reddish yellow pigment of great hiding power known as Titanium Ochre. This was not attractive from the standpoint of either color or cost, so little was done with it. However, it resulted in the idea of extracing titanium oxide in a pure state and introducing it as a pigment. This was accomplished as evidenced by a Norwegian patent granted in October, 1912, to Dr. Jebsen and production of the composite titanium pigments was begun in Fredrikstad, almost simultaneously with the initial production of similar pigments at Niagara Falls. To facilitate the development of the pigments, the American and Norwegian groups of workers, who had long worked independently, came together in 1920 through the establishment of relations including a cross licensing of patents, which enabled them to progress more rapidly through a mutual interchange of experience and ideas.

In 1927, the relationship thus established was made closer through the acceptance by The National Lead Company of an offer for the sale to it of a controlling interest in the Norwegian company, Titan Co. A/S, and in its French affiliate, Societe Industrielle du Titane. Later in the same year, with a view to a wider exploitation of the European and Asiatic fields, an arrangement was concluded between Titan Co. A/S and I. G. Farbenindustrie A.G., leaders in the German chemical industry, for the formation of a jointly owned German Company, Titangesellschaft m.b. H.; the construction by the latter of a plant at Leverkusen to supersede the Fredrikstad plant and supply the requirements of the European and Asiatic markets, and the sale of the resultant product by each interest in certain specified ter-

ritory. The general management of
interests of National Lead Comp
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who also retained his original in
Norwegian company.

Early in 1930, for the more conv
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Company and of Dr. Jebsen, a hol
was formed under the laws of Del
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The pigments made by Titangese
H. are sold in Denmark, Estonia,
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Sweden, by Titan Co. A/S, Fredrik
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Titane, Brussels, Belgium; in Fran
Industrielle du Titane, Paris; and i
tries of the eastern hemisphere (exc
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Early in 1933 a further step was
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A manufacturing plant was const
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In 1936 Titan Company, Inc., w
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a new corporation to supply that
the name of Titan Kogyo Kabushi

Kobe, jointly owned by Doitsu Senryo Goemi Kaisha (representing Titan Company, Inc. and its European associates) and Kokusan Kogyo Kabushiki (representing the Japanese interests), both of Kobe, Japan; and for the exchange of patent licenses between the various parties in interest for their respective territories. Pursuant to these arrangements Titan Kogyo has built a factory in Japan from which the demand for titanium compounds in the Japanese territory is now being supplied.

Late in 1936, the National Lead Company arranged for the sale of its rights to the titanium business in Canada to Canadian Industries, Limited, and in payment, therefor, accepted an interest in a new organization known as Canadian Titanium Pigments, Limited.

This organization, with headquarters at Montreal, took over the sale of titanium pigments in Canada on January 1st, 1937, continuing with the Titanium Pigment Corporation and British Titan Products Company, Ltd., as their temporary sources of supply. A suitable site will be selected and the building of a plant for the production of titanium pigments in Canada will be started in the near future.

Titanox Pigments

Raw Materials and Process of Manufacture

The two most important ores used in the production of titanium pigments are ilmenite and rutile. Theoretically, ilmenite is an iron titanate ($FeTiO_3$) or ($FeOTiO_2$) but it seldom, if ever, corresponds to this formula. Iron is practically always present in both conditions of valence. In the usual commercial ores titanium oxide (TiO_2) varies from 35% to 55%, ferrous oxide (FeO) from 5% to 40%, and ferric oxide (Fe_2O_3) from 5% to 32%. Ilmenite commonly occurs in both rocks and sand and is black in color.

The most important deposits are the beach sands of Travancore, India; the massive ilmenite of Egersund, Norway, and the nelsonite deposit, a "pepper and salt" mixture of apatite and ilmenite, in Nelson County, Virginia. Large deposits also are known in the Adirondack Mountains of New York and in Quebec Province, Canada, but these are not being exploited at present (1937).

Rutile is a natural titanium oxide. The composition varies from 90 to 98% TiO_2, the chief impurity being iron oxide. Rutile also occurs both as rocks and sand and usually is reddish brown in color, but sometimes is yellowish, bluish, or violet. However, rutile is not used as a source of titanium for pigment manufacture; it finds its chief application in the metallurgical and ceramic industries.

In the process of manufacture the titanium ore concentrates are first pulverized to a fine powder and then treated with concentrated sulphuric acid. A violent reaction takes place resulting in the formation of a mixture of titanium and iron sulphates. These sulphates are taken up in water and passed through a series of settling and washing tanks in which the insoluble impurities are removed. The clarified solutions are then adjusted to a definite concentration with respect to titanium, iron and sulphuric acid content and pumped to storage tanks.

Blanc Fixe, which serves as the base in Titanox-B, is prepared by roasting pulverized barytes ore with powdered coal and then leaching out the soluble barium sulphide thus formed. From this solution the barium sulphate is precipitated by the addition of sodium sulphate. The precipitated sul-

phate is thoroughly washed and then stored in the form of a paste or sludge. The sodium sulphide is recovered from the precipitation, concentrated and sold as a by-product.

Calcium Sulphate, which is used as a base in Titanox-C, is prepared by treating lime or pulverized limestone with sulphuric acid under carefully controlled conditions to obtain the desired properties in the finished composite pigment.

For the production of the composite barium and calcium base pigments, a definite quantity of the titanium sulphate liquor is pumped to a precipitating tank. The requisite amount of either barium sulphate or calcium sulphate in pulp form is suspended in the solution and the titanium is then precipitated upon the respective base by hydrolysis at the boiling point. After precipitation is completed the composite mass is thoroughly washed, partially dehydrated, then calcined at a temperature approximating 1550° Fahrenheit. It is then distintegrated and packed either in bags or barrels.

In the production of Titanox-A (Titanium Dioxide), the processes are essentially the same except that no inert base is employed at the time of precipitation. The calcined titanium dioxide is wet-milled and water floated to insure uniformity of particle size.

Titanox-L, which is chemically lead metatitanate ($PbTiO_3$), is made by controlled calcination of a mixture of litharge (PbO) and purified, hydrous titanium oxide. Rigid control of the calcination process is practised in order to accomplish a complete combination of the litharge with the titanium dioxide, and to develop optimum pigment properties of the lead titanate.

Titanox-M, the titanium, magnesium-silicate base pigment, is made by thorough and careful blending of Titanox-A with a selected and treated magnesium silicate extender.

Qualities of Titanium Pigments

From their inception titanium pigments have attracted the attention of the consuming trade because of their several outstanding qualities. The most evident and striking of these is their high opacity. This varies with the different grades, Titanox-B being the weakest and Titanox-A (Titanium Dioxide) the strongest, but even Titanox-B will hide from 40% to 120% more surface than the older white pigments made from lead

and zinc bases. It is safe to say
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The next most interesting q
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priming coats are applied, the
sequent coats is improved and
failures of such coats, if made
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In aggregate size, titanium pig
the very finest of the white pig
and Titanox-C vary in dimensio
scopic to a little more than

mean diameter being about one-half micron; while the mean diameter of Titanox-A is about three-tenths of a micron.

Other white pigments possess many of the above qualities, but no one of them, outside of the titanium pigments, possess them all.

The "TITANOX" Ha

This handbook is divided into nine by Roman numerals. The pages of numbered separately.

TABLE OF CONTEN

"TITANOX"-L

The Original Lead Titanate ($PbTiO_3$) Pigment

"TITANOX"-L (lead titanate), a unique addition to the "TITANOX" line of pigments, was first offered to the trade in 1935, after a development period of several years in the laboratories of Titanium Pigment Company. It met with the immediate interest of the paint formulator because of its unusual properties, particularly with respect to its influence on improvement in durability of all types of exterior coatings.

To produce "TITANOX"-L, titanium dioxide (TiO_2) and lead oxide (PbO) are reacted together at a high temperature to form an entirely new compound with the empirical formula $PbTiO_3$. Due to the method of manufacture, lead titanate contains a small proportion of lead sulphate. In color, the pigment is a very pale yellow.

The hiding power of lead titanate in linseed oil paints is about 50% that of "TITANOX"-A (titanium dioxide) in a similar paint. Because of its high hiding power, and its remarkable retardation of chalking and erosion, a considerable proportion of inexpensive extender pigments may be safely used with "TITANOX"-L. Dilution with extender is quite practical in the production of tinted paints, and offers an economical means of obtaining a required pigment volume without the undesirable effects which accompany the use of high extender with many other opaque pigments.

The small percentage of impurities in "TITANOX"-L do not make it sufficiently reactive to preclude its use in practically any type of vehicle. No tendency to thickening or livering has been observed, even in the most reactive types of varnishes.

"TITANOX"-L is the only light colored, chemically inert pigment which has an ultra-violet light absorption of practically 100%. In this respect, and also in its behavior in oils and oleo-resinous vehicles, upon exposure, it closely parallels carbon black. In consequence "TITANOX"-L imparts extreme durability to those paint coatings in which it is used. It has a strongly protective

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	Com
Lead Titanate ($PbTiO_3$)	
Lead Sulphate ($PbSO_4$)	
Bulki	
Specific Gravity	
Pounds per gallon....	
Gallons per 100 lbs....	
Tintin	
Tinting Strength*	

Other Phy

Total brightness in gl

Reflection	
Purple Blue	Blue Green
74.0	84.5

In a material relati
at the purple-blue en

* Standard Method o
of White Pigments, A
ing Materials, D-332-3

the red end of the spectrum, the appearance of whiteness, even at low brightness, is not possible. However, all tints ordinarily used in paints may be produced on a lead titanate base.

Refractive Index .....about 2.7

Aggregate Size—Average mean diameter .....3 micron

Oil absorption—About 10 pounds of oil to 100 pounds of pigment, paste oil absorption method.

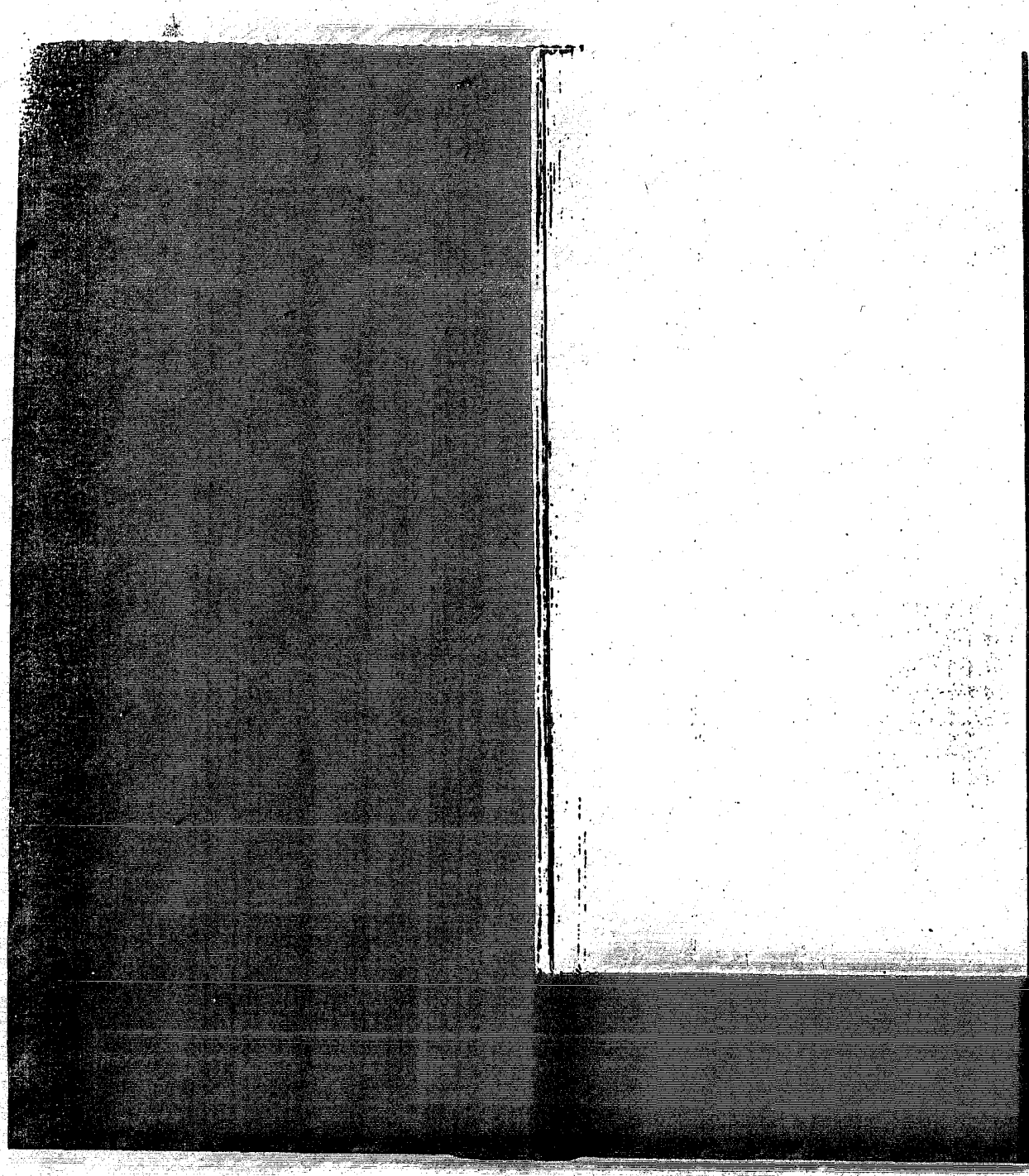
To mill Grind—Requires about 9 pounds of oil to 100 pounds of pigment.

Chemical Properties

Chemically stable—Non-reactive with paint vehicles.

Uses of "TITANOX"-L

Exterior house paints.
Exterior enamels.
Industrial paints.
Industrial enamels.
Rust-inhibitive paints.
Porch and deck paints and enamels.
Miscellaneous coatings, especially for tint retention and durability.



Federal Specification

TT-P-25

Dec. 9, 1942

PAINT: EXTERIOR-PRIMER, READY-MIXED, WHITE (UNDERCOAT FOR WOOD)

"TITANOX"-B 30 applicable.

Specification

Pigment: 38%-42% p.v.c.

	% by weight
White lead (⅔ carbonate, ⅓ sulfate)	min. 50
Titanium dioxide	min. 10
Barium sulfate, silicates, or mix	max. 40
Water soluble	max. 0.8

(It is preferred that the titanium dioxide be added in the form of titanium-barium pigment.)

Vehicle: Min. non-volatile 58% by weight

	% by weight
Raw linseed oil	max. 29
Bodied linseed oil (min. visc. Z-4)	min. 26
Resin (pale coumarone or ester gum)	3.0 to 4.0
Thinner and drier	max. 42

Properties of Paint: Except where otherwise indicated the methods of testing of Fed. Spec. TT-P-141 are to be used. *Package condition* as specified; *Consistency* 75-90 K.U. @ 25° ± .25° C.; *Working* to brush easily on unprimed 6 in. x 12 in. board, permitting lapping for minimum of 7 min.; *Sealing* to provide the characteristic high gloss in a dried film of E-TT-P-101a, Type A tinted putty gray applied 550 sq. ft. per gal. over a 48 hr. dry film of the primer which has been applied 450 sq. ft. per gal. over western red cedar panel (A.S.T.M. D358-38) not less than ½ sq. ft. area; *Drying* to touch max. 6 hr., to recoating max. 48 hr.; *Adhesion* of 1 week aged film on tin panel such that strip of Scotch tape (¾ in. width) not less than 1 in. length applied over

(*Continued on over page*)

TT-P-25 (Continued)

a cut in the film and at right angles to the cut, shall not pull off more than ¼ in. of the film, when removed; *Toughness* indicated by no cracking or flaking at 7.5 x mag. of a baked (5 hr. @ 105°-110°C.) film on steel when bent after cooling to 25° ± 2°C over a ⅛ in. rod; *Absorption* of vehicle from paint into No. 2 Whatman filter paper shall not be greater than ¼ in. radially from the rim of a one-half pint friction top can plug (5½ cm. diameter) filled with the paint over which the filter paper has been placed concentrically and allowed to remain for 3 hr.; *Color* to match standard if specified; *Kauri reduction of vehicle which has been separated from paint* by centrifuging shall pass 275 percent test.

Suggested Formulation

Our tests indicate that products made according to the following formula will meet the requirements of the specification, but such products are not guaranteed to do so. The formula is suggested for experimental purposes only.

MW 939

Pigment 65.7% (40% p.v.c.)

	Pounds	Gallons
"TITANOX"-B 30	334	9.5
Basic carbonate white lead	250	4.4
Basic sulfate white lead	250	4.7
Magnesium silicate (med. oil abs.)	166	7.0
Litharge	10	
Vehicle 34.3% (59% non-volatile; 4% resin)		
Raw linseed oil	151	19.5
Heat bodied linseed oil (Z-4 visc.)	135.4	16.7
10 lb. ester gum cut	34.4	4.3
Mineral spirits	196.0	30.2
4% Cobalt drier	3.7	.5
PAINT TOTAL	1530.5	96.8
Weight per gal.	15.8	
Pigment per gal. of paint	10.3	
Pigment per gal. of vehicle	14.0	

PAINT: F

LIG (COM

"TITAN(specification

Stipulates does not res performance

Pigment Vehicle (3 Water Coarse pa Total soli

Performa readily 1 ga thus thinned

Consistenc no pull und good; *Colo* rel. to MgO *tion*—film ex in color fr than 0.18 b tional Burea tained under to touch ½ *Specular glo bility* baked after cooling over ¼ in.

Part III

E-TT-P-88 (Continued)

To obtain a smooth paste of uniform texture whi will be reducible readily with water (2 parts pas to 1 part water) it is advisable to adopt the follo ing procedure:

1. Mix the casein or soya protein in ⅓ of the water which should be hot.
2. To this mixture add the pine oil.
3. Prepare a solution of the sodium hydroxide and Dowicide A or equivalent in the remaining water, then add it to the casein slurry prepared as above mentioned.
4. Mix the driers, ester gum solution, blown linseed oil and lanolin until smooth, then add this mixture to the casein slurry and agitate until viscosity increases or until there is an indication of the casein swelling.
5. Add pigments and mix until smooth.
6. Grind through roller or stone mill.

Federal Specification

TT-P-101a

Mar. 11, 1936

and Amend.-1

Jan. 30, 1940

PAINT: TITANIUM-ZINC AND TITANIUM-ZINC-LEAD OUTSIDE, READY-MIXED, WHITE

The emergency alternate specification E-TT-P-101a may be requested to replace this specification. See E-TT-P-101a.

Specification

Ready mixed outside white paint containing titanium dioxide; Type A—Titanium-Zinc-Lead; Type B—Titanium-Zinc.

	Type A %	Type B %
Pigment	68 max.	58 min.
Liquid (at least 85% linseed oil) max.	32	42
Lead in any form.....	..	none
Pigment Portion		
Titanium dioxide....min. %	7	15
Zinc oxide .....max. %	25	35
White lead .....min. %	58	none
Extenders .....max. %	10	55
Water soluble .....max. %	0.8	0.8

"TITANOX"-A MO, 168 MO indicated for this specification.

Titanox-L

(Lead Titanate)

TITANOX-L (Lead Titanate), a unique addition to the Titanox line of pigments, was first offered to the trade in 1935 after a development period of several years' duration. It met with the immediate interest of the paint formulator because of its unusual properties.

To produce Titanox-L, titanium dioxide (TiO_2) and lead oxide (PbO) are reacted together at a high temperature to form an entirely new compound with the empirical formula $PbTiO_3$. Due to the method of manufacture, Lead Titanate contains a small proportion of lead sulphate. In color, the pigment is a pale, dull yellow.

The hiding power of Lead Titanate in a linseed oil paint is about 50% that of Titanox-A (Titanium Dioxide) in a similar paint, or about 40% greater than that of Titanox-B (Titanium Barium Pigment). Because of this high hiding power, a considerable proportion of inexpensive extender pigments may be used with Titanox-L. Such dilution is quite practical in the production of tinted paints, and offers an economical means of obtaining desired pigment volume.

The small percentage of impurities in Titanox-L does not make it sufficiently reactive to preclude its use in practically any type of vehicle. No tendency to thickening or livering has been demonstrated thus far even in the most reactive of varnishes.

Titanox-L is the only light-colored, chemically inert pigment which has an ultra violet light absorption of practically 100%. In this respect, and also in its behavior in oils and oleoresinous vehicles upon exposure, it closely parallels carbon black. In consequence Titanox-L imparts extreme durability to those paint coatings in which it is used. It has a strongly protective action upon tints and generally reduces fading to a marked degree in comparison with other white or light-colored pigments as bases. In addition, it acts as a definite retardant to chalking, checking, cracking and flaking.

Comparative tests have shown that an ordinary paint loses all distensibility after eight to eleven weeks of vertical exposure to the South, while a single coat of lead titanate in linseed oil, exposed at 45 degrees South, still retained 5% of its original distensibility after two years.

The chief value of Titanox-L lies in its use in bases for tinted paints, and in such bases it is effective in quantities ranging from 20% upwards of the pigment portion. Tinted paints so formulated will demonstrate remarkable resistance to fading and exceptional durability and gloss retention.

PHYSICAL AND CHEMICAL CONSTANTS

Composition

Lead Titanate ($PbTiO_3$) ....about 93.00%
Lead Sulphate ($PbSO_4$) ....about 7.00%

A fine, pale yellowish pigment, consisting of titanium dioxide and lead oxide in chemical combination as $PbTiO_3$, with a small percentage of free lead sulphate.

Bulking Figures

Specific Gravity	7.30
Pounds per gallon	60.83
Gallons per 100 lbs.	1.64

Tinting Strength

Tinting Strength* 540

Hiding Power

One pound of Titanox-L in linseed oil will completely hide 57 square feet of black surface.

A solid gallon of Titanox-L in linseed oil will completely hide 3,640 square feet of black surface.

The complete hiding of 1,000 square feet of black surface requires 17.5 pounds, or .35 gallons of Titanox-L in linseed oil.

The hiding power of Titanox-L in linseed oil is about 50% that of Titanox-A (Titanium Dioxide) or about 25% greater than that of Titanox-B-30 (Titanium Barium Pigment). This high hiding power ratio suggests that in tint bases for house paint, an equivalent weight of inexpensive extender pigment may be used with Titanox-L to attain desired pigment volume economically.

Other Physical Properties

Total brightness in glycerine 85%

* Standard Method of Test for Tinting Strength of White Pigments, D 332-35; American Society for Testing Materials Standards, 1934, Part II, Non-Metallic Materials, Pp. 647-55. See also Reynolds Constant Volume Method, "Physical and Chemical Examination of Paints, Varnishes, Lacquers, Colors"; H. A. Gardner, Eighth Edition, Pp. 93-95; also Titanox Handbook, Part IV.

Reflection Characteristics

Purple Blue	Blue Green	Green	Yellow	Red
74.0	84.5	85.0	86.0	87.0

In a material relatively low in reflection value at the purple-blue end and moderately high at the red end of the spectrum, the appearance of whiteness, even at low brightness, is not possible. However, all tints ordinarily used in paints may be produced on a lead titanate base with the possible exception of blue-gray, which is difficult of attainment because of the yellowish color of Titanox-L.

Other Physical Properties

Refractive Index ..... about 2.7
Aggregate Size—Average mean diameter, .3 micron.
Oil Absorption—About 10 pounds of oil to 100 pounds of pigment, paste oil absorption by spatula method.
To Mill Grind—Requires about 9 pounds of oil to 100 pounds of pigment.
Light Resistance—Unaffected by light.

Chemical Properties

Chemically Inert—Non-reactive in all types of vehicles or media with which paint pigments are ordinarily combined.

USES OF TITANOX-L

Exterior tinted house paints
Exterior tinted enamels
Industrial tinted paints
Industrial tinted enamels
Rust-inhibitive paints
Porch and deck tinted paints and enamels

Titanox-L

(Lead Titanate)

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The hiding power of Lead Titanate in a linseed oil paint is about 50% that of Titanox-A (Titanium Dioxide) in a similar paint, or about 40% greater than that of Titanox-B (Titanium Barium Pigment). Because of this high hiding power, a considerable proportion of inexpensive extender pigments may be used with Titanox-L. Such dilution is quite practical in the production of tinted paints, and offers an economical means of obtaining desired pigment volume.

The small percentage of impurities in Titanox-L does not make it sufficiently reactive to preclude its use in practically any type of vehicle. No tendency to thickening or livering has been demonstrated thus far even in the most reactive of varnishes.

Titanox-L is the only light-colored, chemically inert pigment which has an ultra violet light absorption of practically 100%. In this respect, and also in its behavior in oils and oleoresinous vehicles upon exposure, it closely parallels carbon black. In consequence Titanox-L imparts extreme durability to those paint coatings in which it is used. It has a strongly protective action upon tints and generally reduces fading to a marked degree in comparison with other white or light-colored pigments as bases. In addition, it acts as a definite retardant to chalking, checking, cracking and flaking.

Comparative tests have shown that an ordinary paint loses all distensibility after eight to eleven weeks of vertical exposure to the South, while a single coat of lead titanate in linseed oil, exposed at 45 degrees South, still retained 5% of its original distensibility after two years.

The chief value of Titanox-L lies in its use in bases for tinted paints, and in such bases it is effective in quantities ranging from 20% upwards of the pigment portion. Tinted paints so formulated will demonstrate remarkable resistance to fading and exceptional durability of gloss retention.

PHYSICAL AND CHEMICAL CONSTANTS

Composition

Lead Titanate ($PbTiO_3$) ...about 93.00%
Lead Sulphate ($PbSO_4$) ....about 7.00%

A fine, pale yellowish pigment, consisting of titanium dioxide and lead oxide in chemical combination as $PbTiO_3$ with a small percentage of free lead sulphate.

Bulking Figures

Specific Gravity	7.30
Pounds per gallon	60.83
Gallons per 100 lbs.	1.64

Tinting Strength

Tinting Strength* 540

Hiding Power

One pound of Titanox-L in linseed oil will completely hide 57 square feet of black surface.

A solid gallon of Titanox-L in linseed oil will completely hide 3,640 square feet of black surface.

The complete hiding of 1,000 square feet of black surface requires 17.5 pounds, or 2½ gallons of Titanox-L in linseed oil.

The hiding power of Titanox-L in linseed oil is about 50% that of Titanox-A (Titanium Dioxide) or about 25% greater than that of Titanox-B-30 (Titanium Barium Pigment). This high hiding power ratio suggests that in tint bases for house paint, an equivalent weight of inexpensive extender pigment may be used with Titanox-L to attain desired pigment volume economically.

Other Physical Properties

Total brightness in glycerine 85%

* Standard Method of Test for Tinting Strength of White Pigments, D 332-36; American Society for Testing Materials Standards, 1936, Part II, Non-Metallic Materials, Pp. 641-50. See also Reynolds Constant Volume Method, "Physical and Chemical Examination of Paints, Varnishes, Lacquers, Colors"; H. A. Gardner, Eighth Edition, Pp. 84-93; also Titanox Handbook, Part IV.

Reflection Characteristics

Purple Blue	Blue Green	Green	Yellow	Red
74.0	84.5	85.0	86.0	87.0

In a material relatively low in reflection value at the purple-blue end and moderately high at the red end of the spectrum, the appearance of whiteness, even at low brightness, is not possible. However, all tints ordinarily used in paints may be produced on a lead titanate base with the possible exception of blue-gray, which is difficult of attainment because of the yellowish color of Titanox-L.

Other Physical Properties

Refractive Index ..... about 2.7
Aggregate Size—Average mean diameter, .3 micron.
Oil Absorption—About 10 pounds of oil to 100 pounds of pigment, paste oil absorption by spatula method.
To Mill Grind—Requires about 9 pounds of oil to 100 pounds of pigment.
Light Resistance—Unaffected by light.

Chemical Properties

Chemically Inert—Non-reactive in all types of vehicles or media with which paint pigments are ordinarily combined.

USES OF TITANOX-L

Exterior tinted house paints
Exterior tinted enamels
Industrial tinted paints
Industrial tinted enamels
Rust-inhibitive paints
Porch and deck tinted paints and enamels

FEDERAL SPECIFICATIONS

T-P-21

June 30, 1941

CEMENT-WATER PAINTS

"TITANOX"-A reg. has been used to meet requirements.

Specification

Two types of paint (I and II) for two classes (A and B); A—without aggregate; B—with aggregate. Class A and aggregate-free portion of Class B, requirements:

	Type I	Type II
Portland Cement min. %.....	65	80
Hydrated Lime max. %.....	25	10
Titanium dioxide or zinc sulfide % (1)	3-5	3-5
Reflectance of white min. %.....	80	80
Carbon dioxide, max. %.....	3	3
Water repellants, calcium or aluminum stearate, %.....	0.5-1.0	0.5-1.0
Hygroscopic Salts, calcium or sodium chloride %.....	3-5	3-5

(1) May be replaced by tinting pigments.

XV, XVI, XVII, XVIII.
U.S. Treasury Department:
No. 359, July 8, 1939.
U.S. Navy Dept., Bureau of Ships:
Formula 27A.
U.S. Treasury Department:
"TITANOX"-C or C K..... Titanium calcium pigment.....

T-P-23a

March 22, 1940

PAINT: COLD-WATER, INTERIOR, LIGHT-TINTS AND WHITE

"TITANOX"-A reg.; A-WD; B-30; B-30 WD applicable.

Specification

Covers Type I (powder) containing no water and Type II (paste containing max. 35% water. *Pigment*—no limitations as to properties or composition; *Binder*—milk casein or other protein type, as soybean protein. *Performance* requirements: *reflectance* (min. 86%); *drying time* touch, 2 hours, dry max. 6 hours; *cleansing; rubbing; wet abrasion;* opacity Type I 4.5 gm. solids/sq. ft. wet film contrast min. 0.68, dry film

min. 0.91; Type II 3.73 ml. paste/sq. ft. wet film contrast min. 0.7, dry film min. 0.917; *yellowing; odor; etc., also specified.*

TT-P-36a

July 23, 1938

PAINTS: LEAD-ZINC-BASE, READY-MIXED, AND SEMI-PASTE, WHITE AND TINTED

Specification

Two types of paint (I and II, semi-paste and ready-mixed) divided into two classes (A and B), as follows:

Type I—Semi-paste (min. 79% pigment); Type II—ready-mixed (min. 68% pigment); Class A—"70 White Lead-20 Zinc Oxide-10 Extender"; Class B—"60 White Lead-30 Zinc Oxide-10 Extender".

Emergency alternate specification E-TT-P-36a may be requested as an alternate to this specification, and is covered by E-TT-P-101a. (*See page A-7.*)

E-TT-P-36a

Feb. 24, 1942

PAINT: LEAD-ZINC-BASE

Covered by emergency alternate specification:

E-TT-P-101a TITANIUM-ZINC-LEAD OUTSIDE READY-MIXED PAINT. (*See page A-7.*)

TT-P-51a

Jan. 16, 1937

PAINTS: OIL, INTERIOR, EGGSHELL-FLAT-FINISH

READY-MIXED AND SEMI-PASTE

"TITANOX"-RC-HT is preferred for this specification.

Specification

Stipulates limits of pigment and vehicle content, does not restrict chemical composition and provides performance requirements:

Paste: 100 grams paste thinned with 15 grams turpentine shall conform to the requirements for Ready-Mixed Paint.

Ready-Mixed: *Pigment*, min. 62%; *Non-volatile in liquid* min., 38%, max. 40%; *Water*, max. 1%; *Coarse particles*, max. 2%.

Performance: *Skinning* in half-filled closed pint can, none after 48 hours; *Set-to-touch*, 30 min. to 4 hours; *Dry hard*, max. 18 hours; *Flexibility*, film on tin plate baked 5 hours, must not crack bent over a ⅛ inch rod; *Diffuse reflectance of white paints*, 85% min.; *Hiding Power of white paints*, min. 250 sq. ft. per gal.; *tinted paints*, min. 275 sq. ft. per gal. at 82% reflectance; min. 590 sq. ft. per gal. to 54% reflectance; *Washability*—the paint after drying for not less than 14 days shall meet specified washing test; also *gloss, color, color retention* stipulated.

Note that E-TT-P-51a may be an alternate to this specification.

Tests indicate that products made from the following formula (F-3335) will meet all of the requirements of the specification, but such products are not guaranteed to do so, and the formula is suggested for experimental purposes only.

(*See next page*)

F-3335 11

Pigment—63.4% (57.9% P.V.C.)

	Pounds	Gallons
"TITANOX"-RC-HT	675	24.9
Whiting	325	14.4
Litharge	10	
Aluminum stearate (high acid)	5	
Carbon Black	0.125 oz.	
Vehicle—36.6% (contains 40% non-volatile) (calculated oil length—50 gal.)		
Blown soya bean oil (Z-6 visc.)	66.4	8.0
Bodied Linseed Oil (Z-2 to Z-3 visc.)	64.0	8.0
Refined Linseed Oil (Acid No. 4-6)	57.2	7.5
Ester Gum Cold Cut (10 lb.)	76.5	10.0
Kerosene	67.5	10.0
Mineral Spirits	252.2	39.0
6% Cobalt Naphthenate	1.8	0.2
PAINT TOTAL	1600.7	122.9
Weight per Gallon	13.4	
Pigment per Gallon Paint	8.32	
Pigment per Gallon Vehicle	12.28	

E-TT-P-51a

Apr. 25, 1942

PAINT: OIL, INTERIOR, EGGSHELL-FLAT-FINISH, READY-MIXED EMERGENCY ALTERNATE TO TT-P-51a

"TITANOX"-RC-HT applicable. (See TT-P-51a.)

Specification

As TT-P-51a ready-mixed, except *non-volatile in vehicle* min. 37%, *hiding power* white paint min. 225 sq. ft./gal. by specified test, *hiding power* tinted paint min. 250 sq. ft./gal. at 82% reflectance to 540 sq. ft./gal. at 54% reflectance.

Oct. 5, 1935

PAINT: (FOR) PRIMING PLASTER SURFACES (PLASTER PRIMER AND SEALER

"TITANOX"-RC-HT is preferred for th specification.

Specification

Pigment content or composition not specified; Vehicle of processed type not less than 42% non-volatile matter; *Hiding power* min. 110 sq. ft. per gal.; *Flexibility* and *adhesion*, coating baked 4 hours 105°-110° C must not crack or flake when bent over 3 mm. rod; *Set-to-touch*, 60 min.-4 hours; *Dry hard*, max. 18 hours; *Sealing properties* equal to standard primer; *Standard primer*, 100 lb. semipaste white lead, 4 gallons interior varnish, 2 gal. kettle bodied linseed oil, ¼ gallon turpentine.

Tests indicate that products made from the following formula (MW-825) will meet all of the requirements of this specification, but such products are not guaranteed to do so, and the formula is suggested for experimental purposes only.

MW-825

Pigment—40.7% (35% P.V.C.)

	Pounds	Gallo
"TITANOX"-RC-HT	425	15.0
Whiting	575	25.4
Litharge	5.0	
Vehicle—59.3% (42.2% non-volatile 100 gal. cal oil length)		
VM-1767—Dehydrated Castor Oil (4)-Linseed Oil (6) varnish (Visc. V/W at 71% non-volatile)	699.0	92.0
6% Sodium Hydroxide Solution	13.8	1.5
6% Zinc Naphthenate	8.5	1.0
VM-1937—10 gal. oil length—Linseed Oil ester gum varnish (Visc. Z-4 at 100% non-volatile)	120.8	14.2
Mineral Spirits	540.0	83.0
Solvesso #3	73.3	10.0
6% Cobalt Naphthenate	8.0	1.0
TOTAL PAINT	2468.4	243.9

TT-P-56 (Continued)

MW-825

Weight per Gallon.....	10.13
Pigment per Gallon Paint.....	4.13
Pigment per Gallon Vehicle.....	4.96

The sodium hydroxide solution is added to the VM-1767 in the mixer, followed after a short mixing period by the addition of the zinc naphthenate. The pigments are then added, and if additional vehicle is required, the VM-1937 and part of the mineral spirits may be added.

TT-P-88
Dec. 27, 1940

PAINT: RESIN-EMULSION, INTERIOR, PASTE LIGHT-TINTS AND WHITE

"TITANOX"-A reg., "TITANOX"-A WD should be applicable to this specification. Flat emulsifiable paints should be of interest as bases for development.

Specification

Resin emulsion paste paint only; no restrictions as to quantity or identity of pigment or binder; *Solids*—total loss, dried 3 hours @ 105°-110° C. not more than 35%; *Water*—not more than 35%; *Drying*—touch min. 2 hours, hard, min. 6 hours; *Wet abrasion*—after 5 days, not less than 4,000 oscillations to remove ½ of film; *Opacity*—3.73 ml. max. paste per sq. ft. min. wet film contrast 0.7, dry film contrast 0.885; *Yellowing*—not greater than standard; *flexibility, cleansing, rubbing, chalking* also stipulated.

E-TT-P-88
April 25, 1942

Emergency alternate to TT-P-88 which makes it clear that an emulsified phenolic or alkyd resin need not be used.

Emulsifiable oleoresinous paste paints pigmented with "TITANOX"-RC-HT should be of great interest in connection with this specification.

TT-P-101a
March 11, 1936

PAINT: TITANIUM-ZINC AND TITANIUM-ZINC-LEAD OUTSIDE, READY-MIXED, WHITE

The emergency alternate specification E-TT-P-101a may be requested to replace this specification. See E-TT-P-101a.

Specification

Ready mixed outside white paint containing titanium dioxide; Type A—Titanium-Zinc-Lead; Type B—Titanium-Zinc.

	Type A %	Type B %
Pigment	68 max.	58 min.
Liquid (at least 85% linseed oil) max.	32	42
Lead in any form.....	—	None
Pigment Portion		
Titanium dioxide min. %.....	7	15
Zinc Oxide max. %.....	25	35
White Lead min. %.....	58	None
Extenders max. %.....	10	55
Water Soluble max. %.....	0.8	0.8

"TITANOX"-A MO, 168 MO indicated for this specification.

E-TT-P-101a
Feb. 24, 1942

TITANIUM-ZINC-LEAD-PAINT BOTH WHITE AND LIGHT TINTS

Emergency alternate specification for TT-P-101a, TT-P-36a and TT-P-156.
"TITANOX"-AA is applicable to this specification.

Specification

Pigment—min. 63%
Titanium dioxide (1) min..... 10%
(2) Zinc Oxide min. 26%
(2) White Lead min. 24%
(3) Extenders max. 40%
Vehicle—max. 37%
(Containing min. 85% linseed oil; Iodine value of recovered fatty acids, min. 170.)

E-TT-P-101 a (Continued)

(1) Semi-chalk-resisting, consisting of min. 96% TiO_2, 0.8-1.2% Sb_2O_3, and 0.8-1.2% Al_2O_3.

(2) The lead and zinc pigments may be introduced as any preferred mixture of basic carbonate white lead, basic sulfate white lead, leaded zinc oxide or zinc oxide.

(3) The white mineral pigments shall be either barium sulfate, magnesium silicate, aluminum silicate, silica or a mixture thereof. Calcium carbonate in amounts not exceeding 15% of the total pigment may be used, preferably as the natural product.

TT-P-115

April 29, 1942

(In Press.)

TRAFFIC PAINT, EXTERIOR, WHITE AND YELLOW

"TITANOX"-B 30; "TITANOX"-B 30 AA applicable.

Specification

Drying, touch 5 to 30 min., *Hard*, not over 1 hr.; *Wet hiding power* not less than 200 sq. ft./gal. white; *Reflectance* not less than 80% for white; *Consistency* 70 to 110 K. U. (Approx. 25-150 Mobilometer seconds, 51-hole disc, 100 g., 10 cm.); *Flexibility*, baked 5 hrs. at 105-110° C. shall not crack over a ½ in. rod.; *Bleeding*, none on a bituminous surface; *Wear* equal to the comparison paint; *Accelerated Weathering* equal to the comparison paint; *Light resistance* equal to the comparison paint; *Water resistance* cold distilled for 24 hrs.; *Dilution* thinned, 8 parts paint to 1 part gasoline, shall not curdle or precipitate.

COMPARISON PAINT, White, pigment 63% (titanium-barium—30, 55%, zinc oxide 25%, fibrous magnesium silicate 10%, diatomaceous silica 10%) vehicle 37% (15-gal. varnish, tung: linseed (60:40) modified phenolic resin, non-volatile 45%).

TT-P-156

Sept. 9, 1939

PAINT: WHITE-LEAD-BASE: BASIC-CARBONATE, READY-MIXED, LIGHT-TINTS AND WHITE

E-TT-P-156 is emergency alternate specification which may be requested to replace TT-P-156.

Specification

Min. of 71% White Lead (Federal Specification TT-P-25a), containing max. 2% tinting pigment; max. 29% liquid of which min. 87% linseed oil.

E-TT-P-156

Feb. 24, 1942

Covered by the Titanium-lead-zinc paint specified under E-TT-P-101a.

TT-E-506a

Dec. 1, 1938

ENAMEL: INTERIOR, GLOSS LIGHT-TINTS AND WHITE

"TITANOX"-RC-HT is preferred for this specification.

Specification

White and light tint gloss enamels in two types: A—quick-drying; B—slow-drying. No restrictions on quantity or identity of pigment: *Vehicle non-volatile* min. 55%; *Water*—max. 1%; *Coarse particles*—max. 1%.

Skinning—Type A—48 hours; Type B—none after 48 hours; *Working* shall not sag applied 600 sq. ft./gal.; *Dry*—touch, 30 min., hard—Type A—8 hours, Type B—30 hours; *Diffuse reflectance* white—min. 82%; *Wet hiding power*—200 sq. ft./gal. for White, up to 396 sq. ft./gal. for Tints; *Flexibility; Gas Test* OK; *Yellowing* not greater than standard; *etc.*

Tests indicate that products made from the following formula (E-3148M2) will meet all of the requirements of this specification, but such products are not guaranteed to do so, and the formula is suggested for experimental purposes only.

E-3148M2

Pigment—43.4% (30.2% P.V.C.)

	Pounds	Gallons
"TITANOX"-RC-HT	1000	36.9
Aluminum Stearate (high acid)	5.0	
Vehicle—56.6% (55.3% non-volatile; calculated oil length 24.4 gal.)		
VM-1803—100 gal. oil length ester gum varnish (Dehydrated castor (1)—linseed (1) visc. U/V at 66.3% N.V.)	532.7	70.0
VM-1499—100 gal. oil length ester gum varnish (linseed oil) having visc. B/C at 60% non-volatile	621.6	80.0
Mineral Spirits	132.8	20.0
24% Lead Naphthenate	19.4	2.0
6% Cobalt Naphthenate	5.6	0.7
TOTAL ENAMEL	2317.1	209.6
Weight per Gallon	11.1	
Pigment per Gallon Enamel	4.79	
Pigment per Gallon Vehicle	5.82	

E-TT-E-506a

April 25, 1942

EMERGENCY ALTERNATE FOR ENAMEL; INTERIOR, GLOSS, LIGHT-TINTS AND WHITE (TT-E-506a)

Specification

Eliminates Type A (quick-drying) of TT-E-506a, and provides for a maximum drying time to a hard film of 16 hours.

As above, "TITANOX"-RC-HT is preferred.

WAR DEPARTMENT

OFFICE OF QUARTERMASTER GENERAL
CONSTRUCTION DIVISION

000-E

Mar. 1, 1941

Page 88

STANDARD SPECIFICATIONS FOR TEMPORARY HOUSING PAINTING

A. EXTERIOR PAINT

The use of "TITANOX"-A NC is indicated for this paint.

Specification

	%
Pigment—64% consisting of:	
Chalk resistant titanium dioxide (1) min.	14
Basic Carbonate White Lead (2) min.	15
Zinc Oxide (2) (3) min.	29
Basic Sulfate White Lead (2) (3) min.	16
Magnesium silicate and tinting colors max.	26
Vehicle—36%	
Water max.	0.5
Raw Linseed Oil	83
Heat Bodied Linseed Oil (min. visc.-Z)	5
Drier and Thinner	12

(1) U.S. Navy Department, Bureau of Aeronautics, RM-130-6 Type I—min. 97% TiO_2, 0.8-1.2% ZnO.

(2) Must meet Federal or A.S.T.M. Specifications.

(3) May be added as 35% Leaded Zinc Oxide.

B. INTERIOR PAINT
(Eggshell-Flat-Finish)

"TITANOX"-RC-HT preferred for this paint.

Specification

Same as Federal Specification TT-P-51a, but not more than 1 pint of thinner shall be used per 1 gallon of paint for application.

C. ENAMEL: INTERIOR GLOSS

"TITANOX"-RC-HT preferred for this paint.

Specification

Same as Federal Specification TT-E-506a.

4.B RADIATOR ENAMEL

Type of titanium oxide not specified, therefore any logical grade such as "TITANOX"-A No. 168 LO or "TITANOX"-RA is indicated.

Specification

Pigment—35%	Zinc Oxide	60%
	Titanium Oxide	40%
Vehicle—65%	Damar Varnish	72%
	Pale Baking Varnish	24%
	Turpentine	4%

All materials must meet Federal Specifications if covered thereby.

PAINTING

The use of tung oil, phthalic anhydride, chromium oxide, chromium hydrate, or yellow iron oxide is prohibited.

16-02 b. EXTERIOR PAINT, WHITE AND LIGHT TINTS

"TITANOX"-A NC meets requirements for titanium oxide.

Specification

Pigment 64%	%
Titanium oxide (RM-130-6 Type I)..min.	14
Basic Carbonate White Lead (E-TT-W-251a) .....min.	15
(1) Basic Sulphate White Lead (E-TT-W-261a)	16
(1) Zinc Oxide (American Process, TT-Z-301)	29
Magnesium silicate and tinting.....Balance	

(1) Forty-five (45) per cent leaded zinc oxide, containing thirty-five (35) per cent basic lead sulphate, may be substituted for the basic sulphate white lead and zinc oxide content.

Vehicle 36%	%
Raw Linseed Oil (E-JJJ-O-336).....	83
Bodied Linseed Oil (min. Visc. Z).....	5
Min. Spirits (TT-T-291) and drier (TT-D-651-type 1)	12

16-02 c. CAMOUFLAGE PAINT

For all surfaces except roofs and bituminous surfaces, shall conform to requirements of Corps of Engineers tentative specification T-1215—see page J-2 of this handbook.

"TITANOX"-RC particularly adaptable.

16-02 d. INTERIOR OIL PAINT

Conforms to Federal Specification E-TT-P-51a. Not more than one pint of thinner to 1 gallon of paint shall be used to attain proper brushing consistency.

"TITANOX"-RC-HT applicable—see page A-4 of this handbook.

The primer for interior oil paint on all surfaces except metal shall meet the requirements of Federal Specification TT-P-56.

"TITANOX"-RC-HT applicable—see page A-5 of this handbook.

16-02 f. RADIATOR PAINT

One (1) gallon of eggshell-flat interior oil paint conforming to Federal Specification E-TT-P-51a, mixed with one (1) pint of interior enamel conforming to Federal Specification E-TT-E-506a. For these Federal Specifications see pages A-4 and A-10 of this handbook.

16-02 g. PAINT FOR MASTIC SURFACES IN COLD STORAGE ROOMS

This specification prescribes rutile titanium calcium pigment. Any requirement demanded of a rutile calcium pigment in a paint of this type will be met by "TITANOX"-RC-HT.

Specification

	Lb.
Rutile titanium calcium pigment	62
Whiting	34
Vehicle	110

Vehicle shall consist of:	Lb.
Manila resin	70
ADM 100 Oil (on non-vol. basis)	30
Denatured Alcohol	160

16-02 i. TITANIUM OXIDE

Chalk resistant to conform to U. S. Navy Department, Bureau of Aeronautics Specification RM 130-4, Type I.

"TITANOX"-A NC meets the requirements.

U. S. ARMY SPECIFICATIONS
Quartermaster Corps, Custodian

3-61A
Dec. 7, 1942

PAINT, STENCIL-PASTE; WHITE

"TITANOX"-AA or "TITANOX"-A NC having TiO_2 content not less than 97% will meet this specification although other grades having higher TiO_2 content might be used.

Specification

Pigment—53-57% consisting of:	%
Zinc Oxide	max. 25
Lead Sulphate	min. 25
Titanium Dioxide	10
Calcium Carbonate	remainder

Vehicle—43-47% consisting of:	
Spar Varnish (Fed. Spec. TT-V-121)	70
Drier (not less than 10% Pb), thinners	remainder

The titanium dioxide shall be *97 per cent pure.*

Performance: Shall be as *white as standard paint; Water and Gasoline tests*—five cycles alternate washing with gasoline, drying—followed by washing with water, drying—running of letters not worse than with standard and color satisfactory, etc.; *Flat finish.*

House Paints

Exterior

During the past several years, the hiding power of house paints and of all other types of paint coatings, whether for exterior or interior use, has been greatly increased. The demand for more hiding power by the user of paint products has been insistent and the development of titanium pigments, has made it possible for the paint manufacturer to meet this demand economically. Titanium pigments because of their high hiding, have made a greater contribution than any other factor to the changes which have taken place in house paint formulation over the past decade. In addition to the influence of the high hiding power of titanium pigments, they have, by their brightness and whiteness, set new standards for white house paints from the standpoint of color.

Where either "TITANOX"-A or "TITANOX"-B has been used in house paints, they have tended to reduce checking, cracking and flaking and have made a material contribution to improved durability. The chemical stability of these pigments has made their general use possible without the necessity for material changes in formulation methods. Their resistance to various kinds of fumes and gaseous atmospheric impurities, particularly as they exist in industrial centers, has made it possible to formulate exterior house paints that remain white under these conditions. Equally important is the fact that titanium pigments have contributed to economy as well as quality.

Present day house paints have been evolved from lead and zinc combinations represented, in a general way, by the familiar one of 60% white lead, 30% zinc oxide and 10% extender, which represented the first grade paint prior to the introduction of titanium pigments. In order to obtain greater hiding, higher brightness and improved appearance, titanium dioxide, either as "TITANOX"-A or "TITANOX"-B has replaced a part of the white lead content and the percentage of extender has been varied for economic

or other reasons. This applies to white paints, and since the introduction of "TITANOX"-A No. 24 and "TITANOX"-A NC, to tints as well.

The only branch from this evolutionary tree has been the utilization of "TITANOX"-L ($PbTiO_3$) in tinted paints.

These—titanium dioxide, white lead and zinc oxide—represent the only white pigments which have been used to produce first grade house paints, as judged by generally accepted standards, so that any consideration of pigments other than lead, zinc, titanium dioxide and more recently, lead titanate for tints, can be dismissed in connection with the problem of formulating high quality house paints.

With a few well established points in mind, the formulation of white linseed oil house paints is a comparatively simple undertaking.

1. It is generally conceded, on the basis of carefully controlled tests and also observations from practical experience, that from about twenty to thirty percent of zinc oxide is in the range of an optimum content of this pigment, calculated on the total weight of the pigment in the paint.

2. That from ten to twenty percent of titanium dioxide meets the requirements for hiding power and that these percentages are practical; the amount within this range depending upon desired hiding and the type of titanium dioxide selected for use—that is, for example; "TITANOX"-A, "TITANOX"-A 168, "TITANOX"-AA, "TITANOX"-A No. 24 or "TITANOX"-A NC. These grades are listed in the order of their increasing resistance to chalking, with "TITANOX"-A NC having the greatest retarding effect on chalking. Generally, the percentage of extender has been increased with increasing percentages of titanium dioxide, for the reason that hiding will be great, even with added extender, when the titanium dioxide content is high. Economy is, of course, an important consideration and this has tended to cause the introduction of more extender, when it could be done without sacrifice of hiding. (There is always the natural desire for low costs which has had the effect of making people want to believe all of the good things claimed for high extender paints.)

3. A reasonable percentage of white lead* in some form is necessary to avoid excessive erosion, washing and other troubles. For best results the white lead content should not be less than approximately one-third of the total pigment. This factor limits the amount of extender which can be legitimately added to the previously established amounts of titanium dioxide and zinc oxide.

4. A pigment volume concentration, that is, percent of pigment by volume on the total volume of pigment and vehicle solids in the paint, has been established within a range of twenty-eight to thirty-two percent, as giving the best general results. A fair average for first grade linseed oil paints is about twenty-nine percent.

With these four recognized factors in mind, we arrive, of necessity, at something like 15% titanium dioxide, 25% zinc oxide, 35% white lead and a maximum of 25% magnesium silicate, as about the present recognized standard for a first grade paint. It is obvious that in order to use more extender, the hiding must be cut by a reduction in titanium dioxide or something less than the minimum reasonable amount of either zinc oxide or white lead or both, must be used.

Assuming that the titanium dioxide content is fixed at an arbitrary amount for desired hiding—say fifteen percent—it then becomes necessary to balance the three other components to best advantage. Starting with the maximum amount of extender, in the form of magnesium silicate, which can be justified for any reason other than to reduce costs—namely twenty percent, we have 30% zinc oxide, 35% white lead and 20% magnesium silicate, plus the fixed amount of titanium dioxide —15%. This probably represents as good balance between the various constituents, as is possible in the light of the sum of the industry's total experience and knowledge at the present time and somewhat better than general practice as indicated above.

When the amount of extender is increased above this amount, there can be only one objective—to reduce the cost—and while as much as this equivalent volume of extender, represented by twenty percent of magnesium silicate can be justified on the basis of its tendency to reduce crack-

*The term "white lead" is intended to indicate either basic carbonate or basic sulphate, or a combination of the two.

ing without any significant impairment of other properties, additional quantities should be viewed as a diluent and treated in exactly that manner. In other words, the relative proportions of lead and zinc should be maintained, just as would be the case if we added water to a mixed solution for the purpose of dilution.

Following the above procedure to the point where the zinc oxide content reaches twenty percent, which is a practical minimum for that pigment, we would have 20% zinc oxide, 23.4% white lead and 41.6% magnesium silicate, plus the original 15% of titanium dioxide. This would probably represent the best pigment balance for any combination with an equal amount of extender and titanium dioxide, or the best cheap paint at equal hiding. If, for any reason, it is required that the pigment cost be reduced beyond this by adding extender, it should be done at the expense of hiding, that is, if five percent more extender is added, the titanium dioxide content should be dropped from fifteen to ten percent in order to retain the minimum amounts of zinc oxide and white lead indicated.

In order, therefore, to cheapen the initial balanced formula by adding extender, successive logical changes would be represented in steps as follows:

	1.	2.	3.	4.	5.	6.
Titanium dioxide	15.0	15.0	15.0	15.0	15.0	10.0
Zinc oxide	30.0	27.5	25.0	22.5	20.0	20.0
White lead	35.0	32.0	29.2	26.8	23.4	23.4
Extender	20.0	25.5	30.8	35.7	41.6	46.6
	100.0	100.0	100.0	100.0	100.0	100.0

The successive changes are for the sole purpose of cheapening the paint and we should not attempt to justify them on any other basis. At the same time, we should recognize the effects which are to be expected. If the changes are made as indicated, the principal effect will be to increase the rate of erosion of the film under conditions of exposure. This will be further accelerated by failure to keep a reasonable balance between the zinc oxide-white lead components as previously indicated. It would not be fair to classify any of these formulas beyond No. 2 as a first grade paint, at the present time. It is, of course, possible that the industry will eventually lower its standards to a point where some of the others will represent first grade paints, for the reason that nothing better is being produced.

A reduction in the white lead content at a more rapid rate in relation to the zinc oxide content, will also tend to cause trouble resulting from unsatisfactory drying and a further acceleration of the rate of erosion. Basic carbonate of lead is more effective than basic sulphate in assuring satisfactory drying. It also assists in preventing dirt collection. When chalking begins, basic carbonate is more readily removed from the surface than basic sulphate by the action of the weather and thus promotes cleaning and a bright appearance. The high extender combinations produce a film which is less smooth than those containing little or no extender and this, in combination with the factor of high basic sulphate of lead and no basic carbonate is an important appearance factor during the first two years of exposure.

Just because leaded zinc happened to contain thirty-five percent of basic lead sulphate is, of course, no reason for assuming that it constitutes a proper relative proportion of lead and zinc for the correct formulation of a house paint, although some technologists have apparently made this assumption. Therefore, in order to keep within the limits of best practice as previously outlined, it will be necessary to introduce an additional amount of white lead, when thirty-five percent leaded zinc is used and for the reasons stated, this addition should be kept in the form of basic carbonate, rather than basic sulphate. Assuming, therefore, that leaded zinc oxide is used in pigment formula No. 1, the pigment should be made up as follows:

15% titanium dioxide, 45% leaded zinc, 20% basic carbonate white lead and 20% magnesium silicate.

If a suitable acicular, lead-free zinc oxide is used, all of the white lead can be basic carbonate or it may be divided about equally between basic carbonate and an acicular type of basic sulphate. Either of these combinations will be somewhat superior to the use of ordinary "co-fumed" leaded zinc oxide.

"TITANOX"-L in Tint Bases

The use of "TITANOX"-L ($PbTiO_3$) in tinted paints has been well established on a basis of outstanding merit and represents one of the most notable advances in house paint formulation which has occurred over the past two decades.

The subsequent introduction of "TITANOX"-A NC, a non-chalking titanium dioxide, has also found acceptance in tinted house paints and approaches "TITANOX"-L ($PbTiO_3$) in tint retention and durability effects. It fits readily into the pattern outlined for the formulation of white paints.

Formulation with "TITANOX"-L for tinted paints is essentially the same kind of an outgrowth from lead and zinc paints as previously described in connection with the introduction of titanium dioxide in whites. There are, however, a few modifying factors which do not exist when pigments other than "TITANOX"-L are used.

1. The nature of "TITANOX"-L permits its substitution to some extent for white lead.

2. Its remarkable reinforcing effect and consequent contribution to great durability and long life of the coating tends to overcome some of the disadvantages of a high extender content.

3. The hiding power requirements for tint bases are not so great as for white paints and consequently the lower tinting strength of "TITANOX"-L compared with "TITANOX"-A, fits readily into the picture.

4. It has been shown that about twenty percent of "TITANOX"-L is the minimum for best results.

5. The use of "TITANOX"-L reduces the tendency of high percentages of zinc oxide to cause cracking.

It is possible to start off, therefore, with a minimum of 20% "TITANOX"-L, 30% zinc oxide and divide the remaining 50% between white lead (basic carbonate or basic sulphate) and extender, with some advantage in keeping the maximum extender in the form of magnesium silicate about equal, by weight, to the total "TITANOX"-L content. Hiding power will be sufficient if an equal weight of "TITANOX"-L and a high bulking extender such as magnesium silicate is used.

As previously mentioned, "TITANOX"-L itself gives some of the desirable effects, which in white paints can be obtained only by the use of white lead, so that when this pigment is used, it is not so essential to keep the white lead content up to the standards set for best results in white paints which are opacified with titanium dioxide.

High percentages of extender used in conjunction with "TITANOX"-L do not produce the erosion effects observed where "TITANOX"-L is not used. If the zinc oxide content is fixed at about thirty percent—five percent more or less making little difference in formulas containing twenty percent or more of "TITANOX"-L—and extender is used as above indicated, we obtain the following representative pigment combinations:

	1.	2.	3.
"TITANOX"-L	20	25	30
Zinc oxide	30	30	30
White lead	30	20	10
Extender	20	25	30

The above combinations, with not more than five percent variation in any one of the constituents, will cover the entire range of accepted best practice.

"TITANOX"-A NC may be substituted for "TITANOX"-L on a volume basis for a part or all of the "TITANOX"-L in any of these pigment formulas without detracting greatly from their good performance, particularly if the substitution is for only one-half or less, of the "TITANOX"-L.

Even one hundred percent substitution of "TITANOX"-A NC will produce a better tint base than was possible before the advent of these two pigments.

When "TITANOX"-L is used, tint retention is improved by an actual reduction in the rate of surface failure. In contrast to this, other pigment combinations which have been widely promoted for use in bases for tints have variously been dependent, for their results upon, rapid erosion, washing, dilution by extremely high extender content, or darkening upon exposure. Effects arising from the use of these methods are actually attained at the expense of durability.

As a result of its protective action in a paint film, "TITANOX"-L reduces checking, cracking, flaking, scaling and adds materially to the maintenance of the integrity of the coating under conditions of use.

"TITANOX"-RC in House Paints

With the introduction of "TITANOX"-RC (January, 1941), a new factor has come into the general question of pigmentation for exterior linseed oil paints. This new pigment has demonstrated such amazing resistance to chalking that it compels consideration. The low bulk cost and extremely high tinting strength of "TITANOX"-RC add a further strong motive for its consideration—economy.

All tests indicate that the resistance of "TITANOX"-RC to chalking is of the same order as a combination of "TITANOX"-A NC and extender. This fact at once suggests the possibility of making a white paint and a tint base of the same composition. This possibility is certainly of very great interest and offers obvious advantages.

On the basis of direct experimental evidence about all that can be said at the present time, is that combinations of fifty to sixty percent of "TITANOX"-RC and forty to fifty percent of white lead and zinc oxide at usual pigment volume concentrations in linseed oil are sufficiently resistant to chalking to assure their equality with the best previous pigmentations designed for tinted paints.

Previous experience with calcium base pigments ("TITANOX"-C) has established the fact that checking and cracking will not be a problem where "TITANOX"-RC is used.

More specific suggestions for the use of "TITANOX"-RC in house paints will be furnished upon request.

Vehicle and Drier

In considering the vehicle for house paints, one of the most important features is drier. A simple lead-manganese drier may be used, but somewhat better results will be obtained with a carefully balanced three metal drier—lead, manganese and cobalt. The lead content should be sufficient to

equal about one percent of the total oil. This amount is not always required, but it does afford a factor of safety under adverse drying conditions, as it promotes through drying and also prompt drying with the least amount of manganese or manganese-cobalt. One combination of proven merit consists of 1.0% lead, 0.025% manganese and 0.005% cobalt, calculated on total oil. While other proportions are used with satisfactory results, a careful evaluation indicates that this is one of the best and may be conveniently made up by adding sufficient lead naphthenate (16%) to an oil drier containing suitable amounts of lead, manganese and cobalt to give a liquid drier containing 10.0% lead, 0.5% manganese and 0.1% cobalt. When used at the rate of about one part to twenty parts of oil, the metal content will be as above indicated except that the lead content will be 0.5% instead of 1%. The additional 0.5% of lead can then be made up by the use of litharge in the paint, or the lead content left at 0.5% of the oil instead of 1.0% as above indicated.

The type of oils used will depend to some extent upon the effects desired—that is, consistency, levelling, flow and color. Generally, the acid value of the raw oils should be kept close to that of ordinary unrefined oil and the iodine value should be kept to as high a standard as is practical.

In making variations for effect on consistency, levelling and flow, two important facts are useful. First, consistency increases with increasing acidity of the uncooked oils. Second, consistency decreases and levelling and flow are promoted with increasing acidity of the cooked or bodied oils. High acid bodied linseed oil is readily obtained by bodying at a relatively high temperature—for example—600° F. as compared with 550° F. to 575° F. These factors can be used advantageously to control consistency, levelling and flow, within reasonable limits, although there are times when special types of bodying agents are required—such as lead tungate, lead easfolate, hydrated magnesia treated oil and solutions of various kinds. The use of stearates, palmitates and other similar saturated fatty acid soaps should be avoided.

From five to ten percent of bodied oil is generally used, the balance being raw oils—refined or not, depending upon the desire for color in the

package. The percentage of total volatile and drier ranges from ten to fifteen percent of the total vehicle with little preference, technically, for either limit.

The details of house paint formulation with regard to type of pigment, pigment volume concentration, drier, thinner, and type of oil, are important and require special consideration for individual cases. Many years of testing paints at the experimental station of the Titanium Pigment Corporation have developed a large amount of valuable data. This information is available in connection with our advisory customer service. Suggestions based upon specific individual requirements and discussion of details which it would be impractical to cover in this handbook, will be furnished upon request.

Primers and Undercoaters

Many of the problems in relation to the formulation of a satisfactory house paint arise from the fact that finish coat requirements call for qualities and composition factors which are in direct conflict with the essential qualities which painting conditions demand for satisfactory priming.

For example:—

1. Excessive penetration of undercoats results in irregular or spotty failure, yet raw linseed oil, which will be absorbed readily into porous surfaces, is the established vehicle for house paints.

2. Chalk must be removed as it develops in order to give a clean appearance and avoid masking of tints. To accomplish this, water soluble compounds are introduced through the use of zinc oxide to promote a detergent action, notwithstanding the fact that water solubility in the priming coat is known to reduce adhesion and promote flaking and scaling.

3. The desirability of comparatively low hiding power in tints as a means to reduce masking of the color is universally admitted or implied, but two coat painting is demanded.

These inconsistencies can be eliminated only by doing exactly what they suggest, that is, make two separate paints, one for undercoats and one for finish coats.

The advantages of a separate primer may be briefly summarized as follows:

1. Hiding power need not be restricted for better tint retention and can easily be made adequate for two coat painting.
2. Appearance factors do not have to be considered in the primer, consequently a combination of pigments may be selected for best adhesion, without reference to type of surface failure and consequent dirt collection, or fading of tints.
3. A vehicle may be used which will be best suited for the purpose of limiting the penetration of the first coat.
4. Pigment-vehicle reactions in the priming coat can be more readily controlled, thus avoiding an accelerated destruction of the binder and the development of the difficulties which arise from the progressive embrittlement of the film.

"TITANOX"-A or "TITANOX"-B with white lead and extender, will meet these pigment requirements to best advantage. Either "TITANOX"-A or "TITANOX"-B offers sufficient latitude for any hiding power requirement. Basic carbonate white lead has such a long record of superior qualities for priming that it needs no explanation or defense. Both "TITANOX"-A and "TITANOX"-B have the further advantage of being chemically inert and consequently do not disturb the effects of the white lead.

With high labor costs, two coats, rather than three coats had become the general practice in house painting, even before the advent of special primers, so that in addition to other requirements, it is necessary to make the primer fit this practice of two coat painting with a view to obtaining the equivalent of three coats by the application of only two coats. This means the application of a thicker film in the priming coat than has been the practice before with any kind of first coat, whether lead-in-oil or ready-mixed.

These factors—increased film thickness and limited penetration—introduce the only new problems involved in the formulation of a satisfactory house paint primer. Otherwise, it would only be necessary to add about ten percent of titanium dioxide to white lead in an ordinary linseed oil

vehicle and apply the usual thin coat. This method would result in a sufficiently hard film because of the absorption of oil into the surface and thinness of coat, but would not give either adequate film thickness or uniform sealing. A thick coat of lead-in-oil either with or without the added titanium dioxide, is, on the other hand, too soft for the usual hard, zinc-containing top coats.

With these facts in mind, the requirements in the formulation of a primer are quite obvious and logical and are also entirely within our common knowledge and experience.

It is clear that we must limit the degree of vehicle absorption into the surface to prevent irregular penetration and a consequent spotty appearance and also to control pigment volume concentration in the actual film after application. These problems have been met in three coat painting by the application of a thin, low hiding first coat which sealed the surface sufficiently for the two succeeding coats.

With a film thickness in one coat of about the same *order as the usual first two coats required* for durability, it is at once apparent that a considerable percentage of extender can be used and still obtain hiding.

Further, it has been found, as might be expected, that the plasticizing effect of white lead is so great in thick coats that the percentage in relation to total non-reactive pigment, that is, "TITANOX"-B or "TITANOX"-A and extender, must be limited in order to aid in obtaining a film with a sufficient degree of hardness to be satisfactory under brittle, zinc oxide containing top coats.

Why, then, shouldn't we establish some arbitrary pigment volume concentration, say thirty-five to forty percent, add polymerized oil for its non-penetrating effect and reduce the white lead in a titanium dioxide-white lead combination of desired opacity, by substituting extender for white lead, until the required degree of hardness is obtained? There are two reasons why this doesn't work out. In the first place, the percentage of white lead becomes so low in relation to extender that the paint lacks durability and erodes away with extreme rapidity, once the top coat fails, and the life of the paint becomes practically the life

of the finish coat only. Second, somewhere between thirty and fifty percent of white lead is a minimum necessary to impart the characteristics of white-lead-in-oil with respect to adhesion, repaintability and durability.

The situation is met by the addition of a small percentage of resin to the vehicle to obtain a satisfactory degree of hardness with thirty to forty percent of white lead for durability.

Following this conception of the problem, which is wholly derived from the general experience of the industry, we arrive at a combination of something on the following order:

Pigment:
- 35% to 40% white lead
- 35% to 40% titanium barium pigment (or its equivalent in titanium dioxide and extender)
- 20% to 30% extender

Non-volatile Vehicle:—
- 55% to 60% raw linseed oil
- 30% to 40% bodied oil
- 5% to 8% resin

Volatile and Drier—40% to 45%

Pigment by volume on total non-volatile—about 40%.

A paint of this general character has given excellent results in both tests and practical service over a period of many years.

The subject of house paint formulation lends itself in an almost unique way to controversy. In the first place, the construction of houses, the kinds of material used and the wide variation in climatic conditions cover such an enormous range of variables that painting conditions, even on new construction are always being confused with the character of the paint itself. In the second place, the kind and degree of failure of the old paint and the technique in application of the new paint, to say nothing of weather conditions at the time of application, greatly multiply the variables in connection with repainting.

If we take individual examples of results obtained in painting houses, it is possible to show that almost any paint is either very good or very bad and thus perpetuate an endless circle of discussion and controversy.

On the other hand, we can rationalize our
experience in a broad manner and not only elim-
inate points of no significance which consume
time and energy, but probably at the same time
raise the general level of the quality of the
average house paint.