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P A I N T

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The subject of paint is a very broad one [illegible] interesting historical and development background but I feel this talk should have practical value rather than dramatic interest so I will deliberately confine it to [illegible] and painting materials as they exist and are available today.

Paint is a coating material [illegible] to protect [illegible] decorate the surfaces of [illegible] such as residence buildings, [illegible] permanent structures of steel, concrete [illegible] industrial and military equipment and many [illegible] products of manufacture too numerous to mention.

Paint is used in liquid form and is applied in thin films which become relatively dry and hard after application. Paint may be applied by brush, by atomizing spraying machines and for some industrial purposes by dipping, but the scope of this talk is not great enough to include all kinds of painting work and different methods of paint application, so I will limit it to the general principles of the painting of industrial and residence structures and naval vessels, which I assume are of the greatest interest to the War and Navy Departments, and I will not try to cover such special phases of the subject as industrial finishes which require baking at fairly high temperatures, nitrocellulose lacquer coatings which are used on automobiles and various other uses of paint for specific purposes, many of which are almost complete industries in themselves and could well fill the entire time allotted for this discussion.

Although many uses for paint will not be mentioned, what may be said about the general principles of painting to a large extent apply to many other paint problems.

As paint is used both for protection and decoration it must have certain essential characteristics if it is to give satisfactory service. It must be in convenient form for easy application, must have great hiding power to obliterate old surfaces on which it is applied, must have the desired color or appearance and lastly must continue to retain its good appearance and give satisfactory service for a considerable length of time and when repainting is necessary the old painted surface must be in such condition that new paint may be applied without excessive cost for putting the old surface in condition to receive the new paint. This is a large order and I am sure everyone in the paint industry will acknowledge that even the best paints fall far short of perfection, but nevertheless by the selection of the best paints for any particular use, a much greater degree of satisfaction will result than if inferior paints or improperly designed paints are chosen.

HIDING POWER.

When we consider all painted structures we realize that white paints are predominately important and by white

paints I mean paints [illegible]
which are limited to light colors because such light colored
paints are essentially white base paints with very small
amounts of added tinting materials. Statistics will show that
considering all exterior and interior paint finishes, the white
and light tinted white base paints constitute about 90% of
painted surfaces.

Paints are not strictly liquids in the true scientific
sense as they are a mixture of liquid vehicles and [illegible]
particles, but practically speaking they largely have the
characteristics of liquids and are generally referred to as
in liquid form.

Confining the discussion to white paints it could be said
that they consist essentially in an intimate mixture of liquid
vehicles and very finely powdered white solid pigments. There
are a large number of finely divided white solid materials used
in various paint formulas but they may be rather clearly divided
into two classes with the few real opaque white pigments with high
hiding power in one class and a number of so-called extender
pigments with practically no hiding power, which are not pigments
in the true sense of the word, in the second class. Although
the extender pigments in dry powder form appear to have hiding
power, they lose their opacity and become practically transparent
when mixed with the paint vehicles.

The true white opaque pigments available to-day might
be listed as follows.

Basic Carbonate White Lead

Basic Sulphate White Lead

Titanium Oxide

Titanium Barium Pigment

Titanium Calcium Pigment

Zinc Oxide

Leaded Zinc Oxide

Zinc Sulphide

Lithopone

For fundamental consideration this group might almost be reduced to basic carbonate white lead, basic sulphate white lead, titanium oxide, zinc oxide and zinc sulphide because the other pigments in the list are mixed or diluted forms of these fundamental white pigments.

The transparent extender pigments might be listed as follows:

Silica

Magnesium Silicate (Asbestine)

Barium Sulphate (Barytes or Blanc Fixe)

Calcium Carbonate (Whiting)

Calcium Sulphate (Gypsum)

China Clay

All of these white opaque pigments and extender pigments have very much the same appearance in dry powder form and the reason that the real opaque pigments have hiding power in oil paint vehicles and the extenders are practically transparent in such vehicles is because of the difference in their refractive indexes. The refractive index of a substance indicates its ability to refract or bend the rays of light entering it from a surrounding atmosphere or air. When a white paint film hides a surface of another color on which it is applied, the light rays striking the paint are said to be reflected and do not go on through the paint film to illuminate and make visible the color of the surface [illegible]. If the light rays go through the film of coating [illegible] strike the colored surface underneath, the surface is [illegible] to the observer, as would be the case with a clear film of oil or varnish applied over a colored surface of any kind.

If we have a sufficient amount of opaque white pigment particles suspended in the oil in the form of paint the light rays are reflected from the paint and the surface underneath is not perceptible. This so-called reflection from a paint containing opaque pigment is not true reflection, but is the result of [illegible] refraction or bending of the light rays as they pass from the oil vehicle into the pigment particles which, in themselves, are transparent. This multiple refraction if sufficiently continued finally results in the light rays being thrown back from the outer surface of the paint and of course, under these conditions the surface underneath the paint film is hidden. For this reason the higher the refractive index of a pigment, the higher will be its [illegible] power or more correctly stated, the greater the difference in refractive index between the pigment and the oil vehicle, the greater will be the hiding power of the paint mixture.

All of the true opaque white pigments and also the extender pigments have refractive indexes sufficiently higher than the refractive index of air to be opaque pigments with considerable hiding power when they are spread on a colored surface in a layer of dry powder, that is with an air vehicle, but when mixed with linseed oil, or other paint oils which have a higher refractive index than air, the results are quite different.

The refractive indexes of the extender pigments are almost the same as the refractive index of linseed oil so that a mixture of linseed oil with the extender pigments is optically homogeneous and light rays which strike the surface go right on through without being refracted. This is the reason paints made with these extender pigments have no hiding power and are practically transparent.

The refractive indexes of the true opaque white pigments are much higher than the refractive index of linseed oil and when light strikes a paint film made with linseed oil and any of these opaque white pigments, the light rays are strongly refracted at the oil and pigment contacts and such paint films have great hiding power. It is rather interesting to note that all of the commercial white powdered solid materials used as pigments or extender pigments in paints may be definitely divided into two distinct classes; those with low refractive indexes which have practically no hiding power in paint mixtures, and those with high refractive indices which have great hiding power with practically none in between. This explains why paints containing certain white pigments have great hiding power and other paints made with extender pigments have very little, if any, hiding power. As hiding power is a primary requirement of paints, it is obvious that one or more of the true opaque white pigments must be used and the extender pigments are introduced with the opaque pigments to give body and in some instances, certain other physical characteristics. Generally speaking the extender pigments are much cheaper than the opaque white pigments and the extender pigments are usually used to give body at low cost. Paints containing large amounts of extender pigments are not only lacking in hiding power but are also less durable under weather exposure than paints which contain no extender pigments or only a very small amount of extender pigments.

OPAQUE WHITE PIGMENTS.

I have already listed the true opaque white pigments which have satisfactory hiding power when used in paint oil vehicles and I will now briefly describe each of them from the point of view of their usefulness in paint.

Basic Carbonate White Lead:

Basic Carbonate White Lead is generally known as "white lead" and that term should be used exclusively to describe this pigment. White lead is the oldest known white pigment and was used by the Egyptians, Greeks and Romans prior to the Christian era. It has been continuously used during all stages in the development of civilization and to-day is one of the most important white pigments with certain outstanding properties not possessed by any other white pigment.

Basic Carbonate White Lead, as its name implies, is the hydrated basic carbonate of lead. It is made from refined pig lead by a number of different processes in which the pig lead by corrosion or by chemical conversion is changed to white lead.

This pigment has many important characteristics including its great affinity for linseed oil and other paint oils, its good hiding power and its moderate degree of reactivity with linseed oil which causes the formation of small amounts of lead soap compounds that are probably instrumental in giving to paint the necessary elasticity and long durability possessed by paint containing large proportions of white lead.

The oldest methods of manufacture are the Dutch and Carter corrosion processes and of later years some precipitation and other chemical processes have been introduced. Generally speaking, white lead made by the corrosion processes is preferred to white lead made by most other methods because of its superior paint-making qualities.

Basic Carbonate White Lead, in both dry and paste form, is covered by Federal Specification TT-W-251a and A.S.T.M. Standard Specification D 81-34.

Basic Sulphate White Lead:

This white pigment has been in the industry for many years and is basic sulphate of lead as its name indicates. The pigment varies somewhat in composition depending on the process used and the perfection of control. Basic Sulphate White Lead was formerly made directly from lead ores by a furnace treatment but to-day is almost entirely made from refined pig lead by volatilization or chemical processes.

Basic Sulphate White Lead has many characteristics similar to basic carbonate white lead and is of the basic carbonate white lead type but is slightly less satisfactory as paints in which it is used are somewhat lacking in durability as compared to paints made with basic carbonate white lead.

Basic Sulphate White Lead is covered by Federal Specification TT-W-261 and A.S.T.M. Standard Specification D 82-34 although both of these specifications are somewhat obsolete and revisions are being proposed.

Titanium Oxide:

This pigment, also known as titanium dioxide, is the white oxide of titanium which is one of the metals fairly common in the earth's crust. Titanium Oxide is the newest white pigment and its development has occurred almost entirely during the past 20 years. It is made by a chemical process and has excellent color and very desirable paint-making prope but its special value is due to [illegible] the highest refractive index and by far the highest hiding power of any white pigment. Because of its unusual qualities, and particularly because of its very great hiding power, the use of titanium oxide has grown very rapidly and it is now being consumed in large tonnage.

Titanium Oxide is covered by A.S.T.M. Standard Specification D 384-36.

Titanium-Barium Pigment:

This pigment marketed under the name of "Titanox-B" by one manufacturer, is a composite pigment containing titanium oxide precipitated on and coalesced with a barium sulfate base. Titanox-B is marketed in two strengths - containing 25% and 30% of titanium oxide. To a large extent titanium-barium pigment resembles titanium oxide and as compared to most of the other white pigments, it has great hiding power although the hiding power is much less than that of pure titanium oxide. Titanium-Barium pigment has excellent paint-making properties and with its high hiding power has developed large tonnage use.

Titanium-Barium pigment is covered by A.S.T.M. Standard Specification D 382-35.

Titanium-Calcium Pigment:

This pigment marketed by one manufacturer under the trade name of "Titanox-C" is somewhat similar in composition to titanium-barium pigment except that the base is calcium sulphate instead of barium sulphate. It contains 30%

of titanium oxide and has many of the qualities of titanium barium pigment including high hiding power.

Titanium-Calcium pigment is covered by A.S.T.M. Standard Specification D 58[illegible]-[illegible]5.

Zinc Oxide:

Next to basic carbonate white lead this pigment is the oldest white pigment used in the painting industry. It has been known and used for many years and is a valuable pigment for many purposes because of its special characteristics. It is the white oxide of zinc and has good color and [illegible] hiding power. It is made directly from zinc ores by a fire treatment and also by the distillation and oxidation of metallic zinc.

It is a strongly basic pigment and is highly reactive with linseed oil and the other paint oils forming zinc soap compounds in large amount in paints in which it is used. This reactivity of zinc oxide is valuable in certain paint products but limits the use of zinc oxide to some extent.

Zinc oxide is covered by Federal Specification TT-Z-[illegible]91 and A.S.T.M. Standard Specification D 79-24.

Leaded Zinc Oxide.

This pigment is very similar to zinc oxide except that it contains a considerable proportion of lead sulphate or basic lead sulphate usually varying from [illegible]5% to [illegible]0%.

Leaded zinc oxide is made directly from zinc-lead ores by a process similar to the one used for making much of the zinc oxide, the principal difference being that zinc oxide is made from fairly pure zinc ores and leaded zinc oxide is made from zinc ores containing large amounts of lead mineral.

Leaded Zinc Oxide is covered by Federal Specification TT-Z-321 and A.S.T.M. Standard Specification D 80-[illegible]1.

Zinc Sulphide:

This is one of the newer white pigments and is the white sulphide of zinc. It is made by a chemical process. It has high hiding power and is used where considerable hiding power at low cost is desired.

Zinc Sulphide is covered by A.S.T.M. Standard Specification D 386-36.

Lithopone:

This white pigment has been used for many years and is related to zinc sulphide as it consists in zinc sulphide chemically co-precipitated with a barium sulphate base. Lithopone usually contains about 28% of zinc sulphide, although some of it is made with a zinc sulphide content of 50% to 60%.

Lithopone is covered by A.S.T.M. Standard Specification D 208-33.

Linseed Oil

Practically speaking, the paint industry is made [illegible] by the fact that nature has furnished to mankind certain vegetable drying oils with very remarkable chemical [illegible]istics. These vegetable oils are glycerides of certain [illegible] acids - that is, they are certain vegetable fatty acids chemically combined with glycerine. The unique property [illegible] these drying oils is the fact that as produced [illegible] and pressing certain seeds or nuts they [illegible] in [illegible] form but have the remarkable property of [illegible] to [illegible] oxygen from the air and change to relatively hard [illegible]. This ability to take up oxygen is due to the fact that [illegible] fatty acids in these vegetable drying oils are [illegible] chemically known as unsaturated compounds [illegible] directly into the fatty acid molecules causing the [illegible] the liquid to the solid state.

Linseed Oil is by far the most important vegetable [illegible] drying oil, particularly for paints subjected to exterior exposure. Some other vegetable oils, some not similar in composition to linseed oil, are used in paint to some extent, such as china wood oil (tung oil), perilla oil and poppy [illegible] oil but these other oils are of minor importance compared to linseed oil for exterior paints.

As linseed oil is produced by pressing flaxseed, it is known as raw linseed oil and when it has certain metallic [illegible] incorporated with it by heat, it is known as boiled linseed oil.

Linseed oil refined in different ways is used for many varnish, enamel and specialty products, but raw and boiled linseed oil are the vehicles generally used in exterior paints.

Raw Linseed Oil is covered by Federal Specification JJJ-O-336 and A.S.T.M. Standard Specification D 234-28.

Boiled Linseed Oil is covered by Federal Specification JJJ-O-331 and A.S.T.M. Standard Specification D 26[illegible].

As I have already stated, linseed oil has the property of taking up oxygen from the air and changing to a relatively hard solid, but this action is slow and it has been found that the introduction of very small amounts of certain metal compounds greatly accelerates the oxidation and drying of these vegetable oils. The usual driers are lead, manganese and cobalt which are introduced in the form of linoleates, resinates or naphthanates of the metals. Only very small amounts of these metals are required to give maximum drying effect and generally speaking, the metals in the form of drier are added to linseed oil to the extent of .05% to.2%. The different metals have slightly different drying effect and the results are usually better if two or three of the metal driers are used in combination.

114

These ... may be ... of a heating process, as in making boiled linseed oil ... may be added in the form of solutions of the ... in volatile solvents such as turpentine or petroleum ...

Liquid Solution Drier is covered by Federal Specification TT-D-651.

EXTERIOR PAINT FORMULAS.

Considering broadly paints used for the exterior protection and decoration of wood surfaces on residential and industrial buildings, we find that a wide variety of such paints are offered for sale in the American market. These paints vary greatly in composition and the first natural classification is according to price grade. As in ... industries, the higher priced products are generally ... and the quality, serviceability and general value of paints consistently decrease as the price decreases.

I will only briefly discuss paints of the lower grades in the lower priced classes as the important consideration is a clear understanding of what good paints are and how they may be selected.

Generally speaking high grade exterior paints for wood surfaces are made largely with pure raw or refined linseed oil vehicles, although such paints sometimes contain small proportions of linseed oil treated to have heavy body or consistency which gives certain desired brushing qualities and flow to the paint.

In this country there are two principal schools [illegible] the first of which is the standard practice of the [illegible] and professional painters who use white lead ground in linseed oil in paste form which they thin with various proportions of linseed oil, turpentine and drier to make exterior paints for any purpose. This preparation of the paint by an [illegible] painter makes it possible to properly vary the formulas [illegible] the different coats and for the different conditions [illegible] must be met. Paste white lead is obtainable in the [illegible] of heavy paste ground in linseed oil and in the [illegible] paste ground in linseed oil with a small amount [illegible] added to make the paste easy to mix.

The second school of painting includes the use of a variety of prepared mixed paints which, as put on the [illegible] are ready to apply. Such fully prepared paints are usually designed for the finishing coat directly exposed to the weather and it is possible to make certain additions for the undercoats, but, of course, it is not possible to formulate the undercoats as satisfactorily as can be done when the paints are made from paste white lead. Some pure white lead paint in ready mixed form is available, but most of the manufacturers of prepared paints use a mixture of several white pigments. Considering the best grade of prepared paints there are a [illegible] orthodox formulas which are generally accepted although, of course, they are used with some variations. The pigment [illegible] generally used in high grade exterior white paints [illegible] of course, may be tinted as desired, are as follows:

1. White Lead 60% - Zinc Oxide 40%.
   This formula sometimes contains extender pigments up to 10% with corresponding reduction in the zinc oxide.
   Paints of this type conform to Federal Specification TT-P-36.

2. White Lead 40% - Titanox-B 40% - Zinc Oxide 20%.
   This formula has many variations as in some cases titanium oxide with some extender pigment is used instead of titanox-B and sometimes leaded zinc oxide is used instead of zinc oxide.

3. Titanox-B 70% - Zinc Oxide 30%.
   This formula is used sometimes where paint is required in the few isolated localities where sulphide sulphur fumes are present in the air.
   Paint of this type is covered by Federal Specification TT-P-101a Type B.

These pigment mixtures are used with linseed oil vehicles with minor amounts of turpentine and the necessary drier in high grade exterior ready mixed paint formulas.

The cheaper grades of exterior white paint may contain cheaper vehicles substituted for linseed oil, sometimes even fairly large proportions of water, and may contain considerable amounts of cheap extender pigments and lithopone substituted for all or part of the pigments given in the above formulas. Lithopone is a white pigment of good hiding power sold at low price compared to the other white opaque pigments but it is generally considered to be an unsatisfactory pigment for durable exterior paints.

The following statement is quoted from Letter Circular LC [illegible] dated July 11, 1952, issued by the National Bureau of Standards on the subject of Outside House Painting.

"It is not possible to make any positive statement as to the relative merits of straight white lead-linseed oil paint, generally mixed by the painter on the job, as compared with commercially ready-mixed white or tinted paint. If one were called upon to decide between white lead and all brands of ready-mixed white paint, the answer would be that the white lead paint would be the safest to use. On the whole, while it is probably true that white lead paint mixed on the job averages better than any other white oil paint, this does not necessarily mean that straight white lead is always the best white pigment for oil paint. It is certainly in part due to the fact that painters know more about handling white lead paint than they know about mixed paints. In other words, it is more fool-proof.

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"Lead-zinc paint which will meet the specification given in the Federal Specification TT-P-36 will probably be as good as, and in some respects may be more desirable than the straight white lead paint. Certain mixed paints made of a pigment composed of titanium pigment, zinc oxide, and white lead also give excellent service."

INTERIOR PAINT FORMULAS.

The uses and requirements of interior paints are quite different from exterior paints largely because the surfaces to be painted, such as plaster, are quite different, the paints are not subjected to direct weather exposure and the appearance and finishes desired are specifically interior decoration questions.

Interior paints must have good hiding power and for this reason the high hiding power opaque white pigments must be used to a large extent. All of the high hiding power white pigments are used in interior paints and again there are two schools of painting including the use of paint made from paste white lead by the professional painter and the use of prepared ready mixed paint.

Generally speaking, most interior surfaces require flat finishes to give the artistic appearance and uniform light reflection usually desired. A much lesser proportion of interior finishes requires the other extreme obtained with high gloss enamels.

Interior paints are made with special vehicles both for the flat and high gloss finishes and we might say that linseed oil is of much less importance for interior paints than for exterior paints.

Vehicles for interior paints are frequently quite complicated as they consist in various special varnishes containing treated oils and resins of different kinds. Special thinning liquids are available for thinning paste white lead to make flat paint and the prepared flat paints are made with somewhat similar vehicles to produce similar finishes.

Titanox-C is extensively used in interior paints and enamels where its high hiding power and excellent paint-making properties are of particular advantage. Interior paints are not subjected to severe exposure and lithopone is used in large amount in interior paint products.

One of the problems of interior painting is the decoration of plaster walls which are usually quite porous and are frequently badly cracked. Special plaster primers with varnish type vehicles are available and are very useful for such surfaces.

1000

IRON and STEEL PAINTS.

The painting of industrial steel structures is of the very greatest economic importance with protection the dominant factor, although decorative appearance must also be considered.

The painting of steel structures consumes a very large amount of paint but the practice is fairly simple. It is generally accepted that paint made with red lead and linseed oil is the best priming coat for iron and steel and protects the surface and prevents rust more economically and efficiently than any other kind of paint. Red lead paint for this purpose is fairly simple in composition as it consists in pure red lead mixed with linseed oil with a small amount of drier which may be added in the form of boiled linseed oil or as liquid drier solution.

Red Lead is available in the market in both dry and paste form and is covered by Federal Specification TT-R-191 and A.S.T.M. Standard Specification D 83-41. Red Lead is also available in the form of prepared pure red lead paint ready to apply.

Paint made with basic lead chromate and linseed oil is also a good priming coat paint for steel but is much more expensive than red lead paint and unless pure basic lead chromate unadulterated with other pigments is used such paint is not effective.

If the surface is primed with red lead paint it is good practice to apply a second coat of red lead paint followed by a finishing coat, the composition of which depends on the color desired. One of the most durable finishes is obtained with linseed oil paint containing red lead, lamp-black and Prussian blue proportioned to give a rich blue black color. Two coats of red lead paint with a finishing coat of this black red lead paint will frequently give service for 8 to 10 years before repainting is necessary. Light colored finishes are made by tinting white lead paint to the color desired and sometimes some of the other white or tinted white paints discussed under Exterior Paint Formulas are used.

Aluminum paint made by adding aluminum powder to spar varnish is also used as a finishing coat where its color is desired.

As in all other kinds of paint there are many kinds and grades of paint sold for use on iron and steel. Some of the cheaper paints contain some red lead mixed with cheaper pigments and others contain no red lead. In general the cheaper paints offered for use on iron and steel do not give service commensurate with even very low cost and in considering the permanent upkeep of an industrial steel structure the greatest economy results in the use of the best paints obtainable.

Letter Circular LC 422 issued by the National Bureau of Standards under date of August 10, 1934, on the subject of Painting of Structural Metal contains the following statement:

"Various exposure tests made at the National Bureau of Standards and similar work done by other observers indicate that in general the nonvolatile portion of priming coats for steel should contain at least 29 per cent by volume of pigment, and that two pigments stand out, bulk for bulk, as superior to all other pigments for priming coats for iron and steel. These are basic lead chromate and red lead.

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"For many years, unadulterated red lead-linseed oil paints have been considered the best paints for priming structural steel. This opinion is held by by an overwhelming majority of unbiased engineers, as well as by other observers, and has prevailed ever since structural steel came into use."

SHIPBOTTOM PAINTS.

What has been said concerning the painting of iron and steel structures applies generally to the painting of steel ships, particularly the superstructures and portions above the boot-topping.

The hulls of steel ships submerged in water offer a very special problem as it is of vital importance to coat the hulls with anti fouling paints which will prevent the development and growth of animal and vegetable marine life which is so detrimental to the submerged portion of ships in salt water.

There are really two problems involved in the painting of the hulls of ships, one of which is to protect the steel against corrosion and the other to prevent the growth. The so-called anti-corrosive paints applied to the bare steel are very similar in character to the paints used for industrial steel structures. Pure red lead paint is the best anti-corrosive paint and some other paints containing red lead and other pigments are also used.

The anti-fouling paint which goes over the anti-corrosive paint may vary considerably in composition, but is usually a rather soft paint which can readily be scraped when a ship is cleaned and repainted in dry dock and the essential requirement is that it must contain certain toxic materials to prevent the marine growth. A.S.T.M. Standard Specification D 277-31 specifies the desirable toxic materials which consist in cuprous oxide and mercuric oxide in various proportions for tropical, semi-tropical and non-tropical waters.