LEAD INDUSTRIES ASSOCIATION

420 LEXINGTON AVENUE
NEW YORK 17, N. Y.

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SUBJECT: WHITE LEAD IN READY-MIXED HOUSE PAINTS

To the Members of the White Lead Technical Committee:

Enclosed is a revision proposed by Mr. A. C. Coste, of the outline of the booklet on ready-mixed white lead paints.

We expect to discuss this revision and changes proposed by other members of the Committee at the next meeting.

Very truly yours,

C. J. Vander Valk

Revised Draft Proposed by A. C. Coats, Oct. 18, 1950

WHITE LEAD IN READY-MIXED HOUSE PAINTS

FOREWORD

White lead has held a high place in the paint industry since paint was first used. This position has been due to the many excellent properties - the many obvious advantages - that only "lead" provides in exterior house paints.

The purpose of this book is to bring to paint manufacturers in condensed, yet relatively complete form, information and data covering general characteristics, chemical and physical properties, and formulation, which help to show

- why white lead is vitally needed in mixed pigment house paints, and
- how white lead should be used to obtain optimum results in mixed pigment house paint formulations.

The application of the present day concept of the use of "lead" for its beneficial chemical reactivity in paints will aid materially in the production of more durable protective and decorative coatings for American homes - better paints which produce more consumer satisfaction and larger sales.

A man's property - his home, his factory, barns and other buildings - is his largest investment. It deserves the best protection obtainable, and that is most conveniently and economically obtainable by the use of paint containing white lead.

I - THE STABILIZING EFFECT OF WHITE LEAD

A - The life of outside house paint would be relatively short were it not for a reactive pigment in the paint film. White lead as the

reactive pigment enters into very beneficial chemical reactions right in the paint film as it slowly weathers. Although the amount of materials involved at any one time is small, these reactions are highly significant in prolonging the life of the protective film.

1. White lead inhibits premature chemical breakdown of the paint film by preferentially reacting with the organic acids resulting from the normal breakdown, of the vehicle on exposure of the paint to the weather. If a non-reactive pigment were substituted for the "lead", these acids not being neutralized would accelerate film deterioration.

a) The combination of sunlight, oxygen and water causes a slow breakdown of the vegetable oil vehicles, composed of glycerides of long chain fatty acids, to lower molecular weight acidic compounds, such as formic, hydroxyacetic, propionic, and related acids, which tend to liquefy or soften the film.

b) "Lead" reacts chemically to slowly neutralize these acidic decomposition products of the vehicle by the formation of relatively stable salts, which materially help to prolong the life of the film, and improve its water resistance and other properties.

B - Illustrations:

1. Photograph of two self-primed painted panels, (a) white lead pigmented, and (b) no white lead, after 30-months, south vertical, exposure in Florida. (Describe as: Conventional White Lead-Zinc-Titanium Extender Paint
Conventional Zinc-Titanium Extender Paint;
both in rosin-bodied oil type vehicle.)

II - PAINT FILMS ARE TOUGHENED BY WHITE LEAD

A - Paints containing "lead" are toughened by the lead soaps which are formed by the reaction of the white lead with the long chain

fatty acids in linseed oil.

1. These soaps form spiney-shaped, microscopic crystals (see photograph) which plasticize the film to increase the tensile strength (coherence) and the flexibility (aiding adherence) of the paint film. This increases the film's ability to stand up under (a) the stress of the expansion and contraction caused by the relatively large temperature differences from day to night, and season to season, (b) the differences in the expansion-contraction factors of the paint and the surface to which it is applied and between paint coats, and (c) the degradation of the film due to ultraviolet effects and the adverse effects of water, ice, and snow on the homogeniety of the film. "Lead" also helps to maintain an impervious, unbroken surface to the elements as the film slowly erodes during its life span for these reasons, -

a) Because of the interfacial reaction between white lead pigments and the linseed oil, they cling together with a tenacity that is difficult to break. This close affinity between pigment and vehicle promotes integrity of the paint film, and guards against premature breakdown of the film under normal service conditions.

b) As paint films containing white lead age, they increase in toughness to an optimum degree, because the lead soaps that are formed improve the coherence, the flexibility, the distensibility and the other factors that contribute to long life and improved protective ability of the paint film. The accompanying photomicrograph illustrates the physical form of these lead soaps. It is apparent from this picture how these spiney like particles reinforce a paint film.

III - PAINT FILM IS PLASTICIZED BY WHITE LEAD

A - To provide satisfactory protection a house paint must form a flexible film after it has been applied to a surface. It must adhere

tenaciously to the surface, whether it be irregular or smooth, and must not break its bond and flake off, or split or crack under the stress and strain caused by the expansion and contraction of the surface due to variations in temperature. In other words, the film must be flexible - not brittle.

1 - In the manufacture of some materials such as plastics, flexibility is obtained by the use of a plasticiser added for the purpose. Sometimes the flexibility is provided by inherent properties of one of the materials used in compounding the plastic. The material added should also insure adequate tensile strength, and provide a film that is not only flexible, but also tough and strong.

In the case of paint while some forms of plasticisers could be added to a paint to obtain flexibility, this is not a general practice.

The paint maker does not generally add a plasticiser and need not when white lead is used in the pigmentation, because:

a) White lead permits the formulation of paint to provide films that are flexible not only immediately after application, but throughout the life of the paint. The "lead" reacts with the fatty acids in the organic binders to form lead soaps, which reenforce the film and increase its strength, and also help to plasticise the film and give it flexibility and distensibility, producing a coating that will not crack despite the natural stresses and strains to which it is subjected.

2. The elimination of brittleness in the film results in greater resistance to cracking, better protection due to improved integrity, better appearance during the life of the film, and a much more satisfactory repaint surface.

3. The accompanying photograph shows typical paint films, with and without white lead, which illustrate respectively good and poor flexibility. The center specimen, which contains white lead, has excellent flexibility as indicated by the absence of cracks and flaking. The other two films, which are lead-free, were too inflexible and brittle to withstand the bending of the paint film around a conical mandrel, they have cracked and are flaking off the surface.

4. The second group of photographs shows three specimens of house paint on wood, with the center one containing white lead. Note the absence of cracks and of flaking in this, while the top and bottom panels (without white lead) show severe cracks (top) and flaking.

B - Illustrations:

1. Photo of "Paint Film Bent Around Conical Mandrel."

2. Photo of three specimens of paint on wood, with two of them inflexible and brittle, while the one containing "lead" is "ideal".

IV - WHITE LEAD PROVIDES CONTROLLED HARDNESS WITHOUT BRITTLENESS

A - On aging in all climates, paint films in general continue to increase in hardness which tends to make films brittle, with ultimate cracking and scaling. When white lead is used as the predominant or prime reactive portion of mixed pigment formulations, the hardness of the film after initial drying is comparatively low, and the rate of increase in the hardness as the paint film ages in service is slow. That is particularly true of paint films in temperate climates because:

1. (a) the lead soaps, which are formed, retard hardening of the paint film to a beneficial low rate of increase; and (b) the "lead" pigmented film surface gradually and slowly erodes and chalks off, exposing a new surface to the weather.

2. This is illustrated in Chart 4 which shows the hardness levels obtained with the use of two different reactive pigments (of which white lead is one) as the base for the mixed pigment paints. Both the lower initial level of hardness and the lower rate of increase in hardness of the white lead pigmented paints, as the film weathers, add to the durability and the long life of the paint film.

B. Illustrations:

1. Chart 4: Sward Hardness Rocker.

Chart 1 also illustrates this aging factor. The curves show the tensile strength vs. months of exposure as evidence that white lead films increase in tensile strength up to an optimum as the film ages. At the end of the exposed time the strength of the white lead is of the order of 1000 pounds per square inch. That of the film without white lead is of the order of pounds per square inch. (give formulation details).

a) Chart 2 compares the tensile strength of a film containing white lead with that of one pigmented without white lead. Although the reactive pigment used in each paint helps to impart strength, it is obvious that the film containing white lead as the prime reactive portion of the mixed pigment shows the tensile strength of the film increased at a beneficial rate./ (give formulation details) This slower rate of increase allows the film to retain the required elasticity and flexibility to avoid cracking and scaling during the life of the film.

Chart 3 shows the percentage of elongation that is retained in paint films as such films age during exposure to weathering. When the percentage of elongation is low, the paint film will rupture as the surface contracts and expands. Note how the necessary flexibility for

good durability and long life is retained by the mixed-pigment paint film in which white lead is the prime reactive pigment.

B. Illustrations:

1. Photomicrograph of lead soap

2. Chart 1. Tensile Strength of Paint Films after one-year's exposure (A longer exposure would be better)

3. Chart 2. Tensile Strength of Paint Films with (a) Mixed Pigment-No white lead, and (b) Mixed-Pigment - with white lead

4. Chart 3. % Elongation - Stripped Film, with (a) Mixed Pigment - with white lead, and (b) Mixed Pigment - No white lead

V - WHITE LEAD IMPARTS HIGH WATER RESISTANCE TO PAINT FILMS

It is generally agreed that water has many detrimental effects on paint; it decomposes the film to a great extent; it causes paint films to swell, split and crack; it softens a paint film, permitting additional water to enter the film; and the continued transfer of water even in very small amounts through the film sooner or later breaks not only its cohesion bond but its adhesion.

White lead improves paint resistance to water by resisting the pickup of water into the paint film and by resisting its transfer through the film. This resistance of white lead pigmented paint films to water is made evident by the appearance of water on the surface of films that have started to weather. On white lead pigmented films water exists only as droplets on the surface, whereas on other pigmented films, water wets the film and spreads uniformly across its surface. (See illustration B-1)

This ability on the part of "lead" pigmented films to resist the penetration of water is due to the strong affinity between "lead" and oil. The simple process used in the final phase of the production

of white lead-in-oil pastes is a good illustration of what probably happens. Before this final phase, white lead is in the form of a thick water slurry. The oil is poured into this slurry. Immediately the water starts to separate, actually forced to separate from the white lead by the oil, and the water rises to the top for decantings. The final white lead-in-oil paste contains not more than one-half of one percent of water. (See drawing B-2).

1. Charts 5 and 6 show how white lead pigmented films pick up considerably less water than non-lead films, especially in the earlier period of life of the paint film. This high repellency of water not only resists surface pickup of water into the film, but also checks its transfer through the film, thus preventing water's attempts to dissolve and emulsify portions of the paint film. This "lead" produces in another way more durable paints.

2. Photograph (if available) showing surface condition of films after exposure to water: (a) white lead films with droplets, and (b) other, with general wetted surface; or a drawing depicting these effects. Pictures of film disintegration.

3. Drawing indicating slurry-paste to oil-paste process in manufacture of white lead in oil: (a) jar of slurry of white lead, (b) slurry of other pigment (zinc), (c) jars after pouring in the oil.

4. Chart 5: Water Sorption; Mixed Pigment - No white lead, Mixed Pigment - with white lead.

5. Chart 6: Water sorption; % by weight, zinc oxide, white lead.

VI - WHITE LEAD PIGMENTS PROVIDE OTHER GOOD PAINT PROPERTIES

A - Weathering Characteristics:

1. Controlled Drying: White lead has a beneficial effect on film drying after application. The slow drying, from inside of the film outward, due to presence of white lead is probably the chief factor in the controlled hardness of the film during its life. This adds to durability.

2. Contribute to Foolproofness: - White lead imparts such a high degree of flexibility, film strength and water resistance, that paints containing them are better able to withstand faulty handling and misapplication. Paints containing "lead" are more likely to assure customer satisfaction in spite of use under adverse conditions over which the manufacturer has no control.

VII - WHITE LEAD PROVIDES MANY DESIRABLE PROPERTIES FOR PAINT

No other single pigment provides so many desirable properties to paint as white lead.

A review of the different properties of a white lead pigmented paint shows that:

1. White lead stabilizes paint film, retards decomposition.

2. White lead plasticizes paint film, retards cracking, and other serious defects.

3. White lead toughens and hardens paint film, without brittleness, providing good film surfaces for long life.

4. White lead imparts water resistance, and contributes to resistance to peeling, flaking, blistering and other defects.

5. White lead provides good adhesion and cohesion characteristics, makes film smooth and uniform.

6. White lead makes it possible to control the erosion and dirt collection of the paint film, and thus maintains a good surface for appearance and repainting.

B - White lead has other advantages:

1. Mixing and Grinding: It has been long recognized that white lead aids in mixing and grinding of other pigments in a mixed pigment paint. This is because each "lead" particle is thoroughly wetted quickly, which aids in the wetting and dispersion of particles other than "lead" to form a uniformly smooth mixture.

2. Brushing: Good brushing has always been known to be of white lead paints, due principally to the ideal pigment structure of a paint system which contains white lead as one of the mixed pigments. The particles of white lead pigment being well wetted and dispersed insure good, easy spreading under the brush.

3. Package Stability: White lead pigments commonly used in house paints, even without suspending agents in the formulation, settle out but gradually, and the resultant settling is soft and easily restirred by simple mechanical stirring (with a paddle, as an example). Even after exceptionally long storage, lead pigmented paints do not harden in the package.

C - Illustrations:

1. Brushing photos, with and without brush marks.

2. Perhaps also mixing and grinding time charts, if available.

VIII - FORMULATION DISCUSSION

It is a generally accepted fact that no exterior house paint will give better protection longer under average exposure conditions than a paint in which the chief reactive pigment is white lead, alone or in combination with other pigments. "Lead" improves the paint formulation by providing durability by plasticizing and stabilizing the film, and by strengthening and toughening the coating and by increasing the water resistance.

White lead imparts these desirable characteristics to a high degree and results in added reliability under many abnormal conditions of handling and application. The manufacturer can never be sure that the label instructions will be followed and paints are often applied under adverse conditions over which the manufacturer has no control. Painters, both amateur and professional are prone to add excessive oil or thinners or disregard other instructions. The difficulties, often traceable to faulty handling and misapplication of paint, can be minimized by the inclusion of the proper proportion of white lead in house paint formulations.

Specialty paints are designed to meet certain specific conditions or requirements. Such paints include sash and trim colors, fume-proof paints, porch and floor enamels. These are not intended for use as general house paints and are therefore excluded from this discussion.

A - Primers

The requisites of a paint to be used as a primer or undercoat on bare wood or sometimes on other absorptive surfaces in exterior exposures are:

1 - It must provide a flexible, elastic film that has strong adherence and a high degree of coherence to withstand without damage, the stresses and strains

a. set up by the underlying surface during expansion and contraction; and also

b. The stresses and strains set up by contraction and expansion within the paint film itself and

c. The combination of these stresses and strains

2 - It must be of a nature to have good adherence on woods that are hard to paint - do not ordinarily hold paint well.

3 - It must provide for optimum oil content both by nature and amount of oil to

a. provide good adherence to the surface and yet

b. Take the next succeeding coat of paint without undue absorption of oil from the succeeding coat. This is to prevent highlights, shiners, etc.

c. Provide a film with high degree of moisture resistant - to seal the surface.

It has long been recognized based on many years of satisfactory experience that white lead provides the best characteristics and properties for the prime coat, especially when the "lead" is introduced in substantial amounts.

B - Primer Formulations

1. Designed for use as primer or undercoater only for paint that is to be used only as the undercoat in an exterior paint system, good formulation practice generally calls for a white lead content of 40% to 60% by weight of the pigment total. This type of paint is usually formulated with a pigment-volume ratio (PV) of the order of 35

to 40 and applied at a spreading rate of about 450 square feet per gallon. A typical formulation is represented by paint meeting the requirements of Federal Specification TT-P-25 (

The composition requirements for both the pigment and vehicle are given below. No attempt has been made here to give the requirements of this specification in full, except for details of formulation.

Pigment Ingredients	Percent by weight	
	Maximum	Minimum
White lead	-	50
Titanium Dioxide	-	10
Barium sulfate, white siliceous mineral pigments (containing no lead or titanium compounds) or any mixture thereof	40	-
Matter soluble in water	0.8	-
Vehicle Ingredients		
Linseed oil, raw	32	-
Bodied linseed oil (minimum viscosity Z on the Gardiner-Holdt Scale)	-	32
Resin (pale colored coumarone or ester gum)	4	-
Thinner and drier	32	-

The white lead specified above provides a good, flexible, water-resistant coating, and an excellent surface for recoating.

2. House paints are formulated so that the finish coat paint, suitably thinned may be used as the prime coat. Modern formulation concepts recognize the practicableness of such systems only when the finish coat of paint contains enough white lead in the primer or primer and body coat to provide the strong, flexible, water-resistant film to hold succeeding coats of paint to the surface of the new wood. This is particularly true in the case of specialty paints, which provide special properties to meet specific conditions but sometimes do so at the sacrifice of ultimate durability. If such paints, containing no white lead,

are used as the prime coat as well as the finish coat, the durability may be reduced materially.

D - Exterior Finish Paints

2. Three classes of ready-mixed exterior house paints usually are formulated: (a) white paints to be used for their whiteness; and (b) tinted paints on a base designed for tinting. (c) Solid color paints in which little or no white lead is used. Formulation concepts may vary widely, depending on conditions of application, of exposure in use, and of cost.

a) White house paints should be long lasting; resistant to moisture, to weather, and to too easy soiling; and preferably free chalking so that a clean and bright appearance is maintained until repainting for protection becomes necessary. The paint should brush easily, it should have high hiding power, and it must dry to a desirable gloss. Its spreading rate should be approximately 550 sq. ft. per gallon, for two-coat systems, and 600 to 700 sq. ft. per gal. for 3-coat systems.

An example of a general purpose, white exterior house paint providing these properties, over a suitable primer is illustrated by one meeting the requirements of a pending Federal Specification, as outlined below.

Pigment Ingredients	Percent by weight	
	Maximum	Minimum
White Lead	-	21
Zinc Oxide	27	25
Sum of white lead and zinc oxide	-	50
Titanium dioxide, anatase type	17	15
All other pigments	20	-
Matter soluble in water	0.8	-
Vehicle Ingredients		
Raw, boiled, or refined linseed oil	-	68.6
Bodied linseed oil bodied tung oil	16.0	8.0
Thinner and drier	15.4	-

Tinted, ready mixed, paints for tinting, generally have the properties of all-white paints and in addition require high chalk resistance to prevent faded, blotchy appearance after weathering. The high hiding white pigment titanium dioxide must be of the chalk resistant type. An example of such a paint is illustrated by one meeting the requirements of Proposed Federal Specification TT-P-102, Class B as outlined below.

Pigment Ingredients	Percent by weight	
	Maximum	Minimum
White lead	-	31
Zinc Oxide	27	25
Sum of white lead and zinc oxide	-	56
Titanium dioxide, rutile, chalk resistant type	23	21
All other pigments	32	-
Matter soluble in water	0.8	-
Vehicle Ingredients		
Raw	-	60
Bodied linseed oil	80	16
Thinner and drier	20	-