NATIONAL BUREAU OF STANDARDS REPORT

10 631

PREPARATION OF STANDARD LEAD BEARING SAMPLES

NBS

U.S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

NATIONAL BUREAU OF STANDARDS

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PREPARATION OF STANDARD LEAD BEARING SAMPLES

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ABSTRACT

The evaluation of analytical methods for the detection of lead in paints requires a series of calibration standards that present the analytical chemist with all of the detection problems that he may encounter. A historical survey of paint formulations was used as the basis for the preparation of leaded paint samples having compositions that could interfere with the detection of lead.

TABLE OF CONTENTS

TABLES

PREPARATION OF STANDARD LEAD BEARING SAMPLES

1. INTRODUCTION

Many different types and formulations of paints have been used since 1900. Each change in paint composition can present the analytical chemist with completely new problems in the detection of lead because of interference factors introduced by the various paint components.

The evaluation of analytical techniques for their suitability in the determination of lead requires testing with known materials presenting virtually all of the analytical problems that could be encountered.

Common paint usage from 1900 to the present date was studied to determine the types of paint formulations that could be found in presently existent housing. A detailed literature survey of leaded paints in use since approximately 1900, revealed the compositions of those paints, periods in which they were used, the methods and rates of application, as well as the substrates to which they were applied.

The above information was used as the basis for the preparation of analytical calibration and evaluation samples. A series of paints, representative of various time periods and varying in composition, was prepared using the ingredients specified in the literature. Another series to be used as standards was prepared from chemically pure ingredients.

To meet the varying calibration requirements of detection methods being developed, further samples will be prepared when requested by the Analytical Chemistry Division.

2. PAINT COMPOSITION - 1900-1070

From the 1700's up to around 1930, white lead was the most important white pigment used, although zinc oxide, alone or in combination with lead, was also used in later years. These pigments were used for both exterior and interior surfaces, either as white paint or as a base for tinted paints. By 1930, lead-base white pigments (white lead and leaded zinc) had dropped below 40% of total white pigments used in paint. (1) In 1950 they represented 22 1/2%, droping to 8.3% and 2.4% in 1960 and 1969, respectively.(2)

The color pigments used were mostly of natural origin, such as the earth colors. In the early days these colors were mulled by hand with linseed oil to produce fine dispersions before addition to the white base paint. Dark color paints were also made in the same manner with little or no white pigment. Toward the end of the 19th century, factories were established for production of paste white lead, paste zinc oxide and combinations of the two, together with ready-mixed paints--white and colored and colors-in-oil. As a result, painters no longer had to hand-make their paints and colors.

With the advent of paint manufacture, other pigments were developed and adopted, including the low-hiding extender pigments. Around 1900, lithopone--a zinc sulfide/barium sulfate composite pigment--was developed and when perfected became very important, particularly for interior paints. Since much better hiding could be obtained with lithopone than with lead or zinc, use of these latter two pigments in interior paints gradually diminshed in factory-made products, particularly flat paints. Individual painters and contractors continued to use paste white lead paints, in diminishing quantities, for both interior and exterior paints, up to recent years. The increasing labor cost for painter-mixed paint, together with the technological advances which made ready-mixed paint much better, were largely responsible for these changes.

While the use of lead base white pigments in interior paints had decreased considerably by 1945, they continued to be popular for exterior paints in later years, but in lower proportions, due to partial replacement with titanium base pigments. Lead-base color pigments such as the chrome yellows and greens were traditionally used in both exterior and interior paints, but these may exhibit a lower hazard than the white-leads because of their lower solubility. The chrome colors are still used today, particularly for exterior paints, because they have better durability and color-permanence than non-lead yellow pigments. For green <u>tints</u>, phthalocyanine greens (non-lead) have been increasingly used in recent years as replacements for chrome green, in both interior and exterior paints, since the phthalos have good durability and color permanence.

It should be realized that many types of non-lead paints have been used on exterior and interior surfaces during the past 100 years. Dark colors based on earth pigments were extensively used and a great deal of interior surfaces, both walls and ceilings, were coated with glue-bound kalsomines or water-thinned paste paints which contained little or no lead pigments, except in the case of yellow or green tints which would have contained low amounts of lead chromate color pigments. The amount of kalsomine and water paste paints sold, up to about 1950, was very high. Converted to mixed paint as applied, the volume in 1929 reached a top level of approximately 20,000,000 gallons--12 1/2% of total paint (3) produced that year. Starting about 1940, non-lead emulsion and latex base paints gradually replaced kalsomines and water pastes for interior painting until today the latex paints represent approximately 70% of the interior paint used, the balance being mostly alkyd base flat wall paints and enamels (solvent thinned). Latex paints also account for over 50%

of the exterior paints used today. Thus, the advent of interior and exterior latex paints has automatically greatly reduced the accumulation of lead-bearing paint films on present surfaces.

3. LEAD PAINT FORMULATIONS - LITERATURE SEARCH

In order to formulate standard samples for the Lead Paint Poisoning Program, the paint technology literature has been surveyed to find out what materials were used historically in paint formulations and putty manufacture. The literature surveyed consists of books published on paint technology from 1907-1957. Listed below are formulations for interior and exterior use as well as pertinent observations which may throw some light on the use of lead pigments in coatings.

White lead is the oldest of all white pigments having been in use for approximately two thousand years. Prior to the middle of the 19th century it was the only white pigment in use with the exception of a little zinc and bismuth. Inert fillers such as aluminum and magnesium silicates, silica and calcium carbonate were regarded as adulterants and cheapening materials. However, many scientific investigators were of the opinion that a paint pigment consisting of lead, zinc, a tinting pigment and an inert material was far more durable than one containing only lead. The consuming public and the painter were not sufficiently educated to understand the merits of extender pigments and the paint manufacturer was reticent in his statements regarding their use. Therefore there was a great deal of opposition to the use of these materials.

In the early part of the 1870's, exterior exposure tests were made on the Maine coast. It was found that pure white lead would not stand exposure to the seashore environment for more than a year. A paint made from silica, zinc oxide and white lead (equal parts by weight) ground in linseed oil produced a superior paint.

The United States Light House Department ordered their white mixed paint to be composed of 75% zinc oxide and 25% white lead. At the seashore this mixture is better than either pigment alone.

In 1885, a paint containing white lead, zinc oxide and barytes in equal parts was exposed on a building wall in New York City. It proved to be superior to a paint based on only white lead.

At the turn of the century, the following was the most common formula for producing white lead paint:

60 lbs dry white lead
40 lbs linseed oil
4 lbs of volatile thinner such as benzene or turpentine. (4)

For centuries, white lead paints were the only quality paints available. North Dakota was the first state to enact legislation to protect the consumer from abuses in paint formulation. The North Dakota paint law stated that "any person who sells within this state any mixed paint which contains any ingredients other than pure linseed oil, pure white lead, zinc oxide, turpentine, Japan drier and pure colors shall be deemed guilty of a misdemeanor and upon conviction shall be punished by a fine not less than $25 and not more than $100, or by imprisonment in the county jail not exceeding 60 days. If the can is properly labelled showing the amount of each and every ingredient, there will be no violation." (5)

Sublimed lead became available commercially about 1883. Average compositions were 75% lead sulfate, 20% lead oxide and 5% zinc oxide. Generally, lead sulfate was used in combination with other products.

In the early 1900's typical ready-mixed commercial paint formulations became more sophisticated as the following pigment formulations indicate.

House Paint - Sample 1 (5)

	% (by weight)
White lead	23
Lead sulfate	19
Lead oxide	6
Zinc oxide	26
Barium sulfate	22
Other constituents	4

House Paint - Sample 2 (5)

	% (by weight)
White lead	25
Lead sulfate	25
Zinc oxide	25
Barytes	25

House Paint - Sample 3 (5)

	% (by weight)
White lead	38
Lead sulfate	8
Zinc oxide	26
Calcium carbonate	20
Barytes, silica and undetermined	8

Typical Analysis of White Paint (5)

	% (by weight)
Vehicle	36.9
Pigment	63.1
	100.00

Vehicle Analysis

	% (by weight)
Linseed oil	89.6
Benzine drier	10.1
Turpentine	-
Water	0.3
	100.00

Pigment Analysis

	% (by weight)
White lead	21.56
Lead sulphate	1.09
Zinc oxide	49.25
Calcium carbonate	1.80
Barytes	-
Silica	-
Magnesium silicate	25.87
Color, undetermined, etc.	0.43
	100.00

Typical Sublimed Lead Paint (5)

	% (by weight)
Pigment	57.0
Vehicle	43.0
	100.0

Vehicle Analysis

	% (by weight)
Linseed oil	90.5
Drier	9.3
Water	0.2
	100.00

Pigment Analysis

	% (by weight)
White lead	0.00
Lead sulphate, sublimed	58.37
Lead oxide	5.99
Zinc oxide	35.24
Barium sulphate	0.00
Undetermined color, etc.	0.40
	100.00

Mixed White Paint for Inside Use (5)

	% (by weight)
Pigment	62.9
Vehicle	37.1
	100.00

Vehicle Analysis

	% (by weight)
Linseed oil	60.1
Turpentine	39.9
Water	0.0
	100.0

Pigment Analysis

		% (by weight)
White lead		-
Lead sulphate		2.57
Zinc oxide		70.27
Lithopone		26.33
Barium sulphate	20.12	
Zinc sulphate	6.13	
Silica		0.28
Undetermined		0.55
		100.00

Various devices were used for cheapening the cost of production: short volume, low pigment content, practical absence of all lead pigments, excessive use of drier, high per cent of water and high per cent of cheap inert pigments.

Mixed White Paint for Inside Use (5)

	% (by weight)
Pigment	55.1
Vehicle	44.9
	100.0

Vehicle Analysis

	% (by weight)
Linseed oil	72.5
Benzine drier	9.1
Water	18.4
	100.00

Pigment Analysis

	% (by weight)
White lead	-
Lead sulphate	0.89
Zinc oxide	53.86
Calcium carbonate	43.39
Magnesium carbonate	0.73
Barytes	-
Silica	0.60
Undetermined color, etc.	0.53
	100.00

The following comments were made in a compilation of replies to questions on painting and decorating problems sent to a paint magazine by its readers in or about 1920. (6)

Proportions of Vehicle and Thinner for Exterior Painting (6)

Prime Coat - For each 100 lbs of white lead in oil use:

4 1/2 gallons of raw linseed oil
1/2 gallon of turpentine
1 pint to 1 quart of best liquid driers

Second or Finishing Coat - For each 100 lbs of white lead in oil use:

5 gallons of raw linseed oil
1 pint to 1 quart of best liquid driers

Painting a Front Door a Dark Bottle or Bronze Green (6)

Prime Coat - Flat coat of white lead tinted with lampblack, thinned with turpentine and adding a little drier.

If door is in bad shape, apply a second coat of the same mixture, let dry, then sandpaper.

Then apply bottle green ground in japan and thinned with turpentine.

To this mixture add a tablespoon of spar varnish and apply for a final coat.

Painting a Porch Floor or Stoop Deck (6)

Prime Coat - Pure white lead and raw oil, colored to suit the desired finish.

Second Coat - Pure white lead and raw oil, plus color and enough japan to make the finish dry and hard.

Putty up cracks after priming and before applying the second coat - use whiting and linseed oil putty to which some dry white lead has been added by kneading and pounding. Putty should be colored to match the paint.

Final Coat - Equal parts of white lead and zinc white in oil, thinning with best brown japan and turpentine to painting consistency, adding enough varnish for gloss.

Painting Yellow Pine - Exterior Surface (6)

Prime Coat - Equal parts of white lead in oil and dry red lead - beat this mixture with two parts of pure raw linseed oil and one part turpentine. Use no drier. The red lead acts as such.

Final Coat - White lead and oil.

Priming Cypress (6) (Cypress is used on cornices and weather boarding.)

Use equal parts of white lead in oil and red lead, thin with six parts of raw linseed oil, three parts of turpentine and one part 30% benzol.

Painting Exterior Woodwork in the Country where the Air is Pure (6)

Use white lead with 20-25% zinc oxide plus pure linseed oil and not over 5% drier.

Painting Exterior Woodwork in a Factory Area where Sulfur Gases are Prevalent (6)

Use basic lead sulfate with 15-20% zinc oxide plus pure linseed oil and not over 5% drier.

Exterior Painting - Salt Atmosphere (6)

Prime Coat - Pure white lead in oil

Top Coat - Combination of two-thirds white lead in oil by weight and one-third zinc white in oil by weight.

For Exterior Surfaces - Best Wearing Paints (6)

Use a mixture of pigments, for instance, 60 parts of white lead, 20-25 parts zinc oxide, the balance an inert white pigment such as barytes or silica, ground in well-settled linseed oil, raw or refined and thinned with raw linseed oil and a minimum portion of drier.

Green Paint to Imitate Oxidized Copper on Ornamental Iron Work (6)

Use Paris green and white lead or white lead tinted with a bluish tone chrome green of medium shade.

Painting Hot Water Pipes and Steam Radiators (6)

First Coat - Red lead or a mixture of red lead and red oxide or Venetian red, thinned with raw oil plus turpentine and driers. This may be followed with one or two coats of any desired color or oil paint.

Interior Painting - Gloss Work (6)

Prime Coat - Lead in oil, thinned with equal parts of raw oil and turpentine plus drier.

Second and Third Coats - Flake white lead in japan, thinned with turpentine only.

Fourth Coat - French zinc white, ground in damar varnish and thinned with turpentine.

Flat Painting - Interior (6)

Prime Coat - White lead, two-thirds turpentine and one-third raw linseed oil plus sufficient drier.

Second Coat - White lead, turpentine and less raw oil than in the prime coat.

Third Coat - Three-fourths white lead and one-fourth French zinc and turpentine plus white varnish.

Fourth Coat - One-half white lead and one-half zinc white and turpentine and varnish.

Fifth Coat - Three-fourths zinc white and one-fourth white lead plus turpentine and varnish

Sixth Coat - Pure zinc oxide, turpentine and a little white varnish. (zinc white)

Painting Woodwork in Imitation of Mahogany (6)

After cleaning and sanding, prepare a ground color using one-third (by weight) white lead in oil, one-third (by weight) Venetian red in oil, the remaining third (by weight) equal parts of yellow ocher in oil and chrome yellow orange in oil, thinning this with one part japan and three parts turpentine to the right consistency.

Filling Cracks in Plastered Walls Successfully (6)

Fill cracks with freshly calcined plaster to about 1/16 inch below the surface. Level with white lead putty made from dry white lead kneaded with coach japan and an equal quantity of glazier's putty.

Painting Plastered Walls (6)

Use paint made with equal parts of white lead and zinc white in oil, thinned with eight parts of raw linseed oil, 15 parts of turpentine and 5 parts of pale japan drier.

For priming the paint was reduced with one-half its volume of raw linseed oil.

The Amount of Linseed Oil and White Lead Required for One Gallon of Paint (6)

Priming white lead - 15 lbs white lead in oil plus 4 lbs of pure raw oil and 1/4 gal. japan.

Second Coat - 16 lbs. pure white lead plus 3 3/4 lbs. pure linseed oil and 1/4 gal. japan.

Third Coat - 17 lbs. pure white lead, 3 1/2 lbs. pure linseed oil and 1/4 gal. japan.

F. N. Wanderwalker, in Interior Wall Decoration, indicated that in approximately 1938, the following paint formulations were commonly used. (7)

First Class Putty - Add dry whiting to white lead paste until a stiff mixture is obtained. Pound mixture with a mallet and knead by hand until thoroughly mixed. If mixture gets too dry and thick, add a few drops of linseed oil.

Window Glass Putty - For glazing a window sash, use whiting and a little white lead with linseed oil and mix well. For a steel sash, use a putty made by mixing dry red lead and linseed oil.

Knifing Putty - For repairing damaged places in walls and woodwork, make a putty by adding white lead paste to fine bolted whiting to make a stiff putty with equal parts of japan gold size, linseed oil and turpentine.

Standard Formulas for White Paint - New Plaster Walls (7)

First Coat

100 lbs. pure white lead
5 gal. pure boiled linseed oil
1 gal. pure turpentine
Makes about 8 3/4 gal. paint

Second Coat

100 lbs. pure white lead
1 1/2 gal. pure boiled linseed oil
1 1/2 gal. pure turpentine
Tinting Colors
Makes about 6 gal. paint

Finishing Coat - Flat

100 lbs. pure white lead
2 1/2 to 3 gal. pure turpentine
Tinting Colors
Makes about 5 1/2 to 6 gal. paint

Finishing Coat - Semi-Flat

100 lbs. pure white lead
1 1/2 to 2 gal. pure turpentine
3/4 gal. white enamel varnish or 1 gal. pure boiled linseed oil
Tinting Colors
Makes 5 to 5 1/2 gal. paint

Finishing Coat - Gloss

100 lbs. pure white lead
3 1/2 to 4 1/2 gal. pure boiled linseed oil
1 pt. pure turpentine
Tinting Colors
Makes 6 1/2 to 7 1/2 gal. paint

Radiator Painting (7)

First Coat - Red lead thinned with one-quarter linseed oil and three-quarters turpentine.

Second Coat - Flat Paint, Bronze Coats or Glaze Coats.

Enamels on Plaster and Canvas (7)

These coats should be the same on new and old plaster and canvas as would commonly be used for an ordinary painted surface.

First Coat

100 lbs. pure white lead
3 to 4 gal. pure boiled linseed oil
2 gal. pure turpentine
Makes 7 3/4 to 8 3/4 gal. paint

Second Coat

100 lbs. pure white lead
1 1/2 to 2 gal. boiled linseed oil
1 1/2 gal. turpentine
Makes about 6 gal. paint

Third Coat

50 lbs. pure white lead
50 lbs. pure zinc oxide
3 to 3 1/2 gal. turpentine
1 qt. white enamel
Makes about 7 to 7 1/2 gal. paint

In the early 1940's the following formulas were recommended by the white-lead manufacturers for mixing exterior gloss and interior flat paints from paste white lead:

New Wood (8)

Materials	First Coat	Second Coat	Third Coat
White-lead soft paste	100 lb.	100 lb.	100 lb.
Raw linseed oil	4 gal.	1 1/2 gal.	3 1/4 gal.
Turpentine	2 gal.	1 1/2 gal.	-
Liquid drier	1 pint	1 pint	1 pint
Gallons of paint	9 3/8	6 3/8	6 5/8

Previously Painted Wood (8)

Materials	First Coat	Finish Coat
White-lead soft paste	100 lb.	100 lb.
Raw linseed oil	2 gal.	3 1/4 gal.
Turpentine	2 gal.	-
Liquid drier	1 pint	1 pint
Gallons of paint	7 3/8	6 5/8

Unpainted Plaster (8)

Materials	Priming Coat	Second Coat	Third Coat
White lead - soft or heavy paste	100 lb.	100 lb.	100 lb.
Special mixing vehicle	4 to 5 gal.	3 to 4 gal.	3 to 4 gal.
Gallons of paint	7 1/4 to 8 1/4	6 1/4 to 7 1/4	6 1/4 to 7 1/4

There were two main types of mixed pigment exterior paints which contained white lead: the white lead-zinc oxide paints and the white lead-titanium pigment-zinc oxide paints. Both types may or may not have contained extender pigments.

Mixed Pigment Exterior Paint - Fed. Spec. TT-P-36a (8)

Class A Paint - Pigment composed of 70% white lead, 20% zinc oxide and 10% extender.

Class B Paint - Pigment composed of 60% white lead, 30% zinc oxide and 10% extender.

TT-P-101a-Type A - Pigment 58% white lead, 7% titanium dioxide, 25% zinc oxide.

The following formulas were recommended by red-lead manufacturers for mixing structural metal paints from paste red lead. (93% red lead and 7% raw linseed oil) (8)

	Prime Coat	Second Coat
Paste red lead	100 lb.	100 lb.
Red linseed oil	1 8/8 gal.	1 7/8 gal.
Lampblack-in-oil	-	3/4 pt.
Turpentine	1 1/2 pt.	1 1/2 pt.
Liquid drier	1 1/2 pt.	1 1/2 pt.
Gallons of paint	4 1/2	4 5/8

Composition of Widely Distributed Commercial Red-Lead Linseed Oil Paint (8)

Pigment - 81%

Pigment portion
Red Lead 100%

Vehicle - 19%

Vehicle portion
Raw linseed oil 94.7%
Liquid drier 5.3%

Walker and Hickson, in the NBS Paint Manual of 1945, indicated the following as the most common for paint formulations (9)

Interior Paint

For unpainted interior, plaster and wallboard

100 lbs. soft paste white lead
5 gallons linseed oil
Makes 8 1/4 gallons paint

Exterior Paint (9)

Pigment

	% (by weight)
White lead	50
Titanium barium pigment	35
Magnesium silicate	15
	100

Vehicle

	% (by weight)
Bodied linseed oil,	28
Raw linseed oil	28
Coumarone resin or low acid number ester gum	4
Mineral spirits and drier	40
	100

Formulation for Exterior House Paint - TT-P-40 (10)

	Pounds
Titanium	153
White lead (basic carbonate and basic sulfate white lead)	445
Zinc oxide	312
Magnesium silicate	158
Raw linseed oil	170
Bodied linseed oil, acid value 8-10	185
Mineral spirits	182
Liquid drier	18
	1623

Output 100 gallons

Typical Formula of a Wall Primer and Sealer for Plaster and Wallboard (10)

	Pounds
Lithopone	400
Rutile titanium dioxide	100
Magnesium silicate	80
Aluminum stearate	1
Ester Gum - Wood Oil, 50 gallons	
Linseed oil varnish 50% solids	193
Blown linseed oil	144
Ester gum solution 62%	138
Mineral spirits	131
Lead naphthenate 6%	9
Cobalt naphthenate 6%	1
	1197

Output 100 gallons

Enamel Undercoater (10)

	Pounds
Rutile titanium dioxide	55
Rutile titanium calcium pigment	218
Magnesium silicate	98
Calcium Carbonate	357
Aluminum stearate	2
Castor - linseed varnish 50% Non Volatile	236
Ester gum solution	40
Mineral spirits	130
Soap Solution, 1%	17
Pine oil	7
Kerosene	59
Lead naphthenate, 24%	2
Cobalt naphthenate, 6%	4
	1225

Typical House Paint Formulation (10)

Pre-World War II House Paint

	Pounds
Titanium dioxide, anatase, chalking	125
Leaded zinc oxide, cofumed, 35%	425
Magnesium silicate	300
Refined linseed oil	435
Bodied linseed oil	39
Mineral spirits	98
Cobalt naphthenate, 6%	2
Manganese naphthenate, 6%	1
Lead naphthenate, 24%	4
	1429 lbs. (101 gal.)

Typical House Paint Formulation (10)

World War II

	Pounds
Titanium dioxide, anatase, chalking	125
Leaded zinc oxide, cofumed, 35%	425
Magnesium silicate	300
Refined linseed oil	187
Linseed oil	176
Mineral spirits	195
Cobalt naphthenate, 6%	2
Manganese naphthenate, 6%	1
Lead naphthenate, 24%	3
	1424 lbs. (102 gal.)

Typical House Paint Formulation (10)

Post World War II

	Pounds
Titanium dioxide, anatase, chalking	125
Leaded zinc oxide, cofumed, 35%	425
Magnesium silicate	300
Refined linseed oil	318
Linseed oil	92
Mineral spirits	150
Cobalt naphthenate, 6%	2
Manganese naphthenate, 6%	1
Lead naphthenate, 24%	4
	1417 lbs. (102 gal.)

Lower Cost First Grade Trim Paint - Medium Green (10)

	Pounds
Anti-Settling and floating agent	3
Chrome green medium	150
Alkyd Vehicle, 60% non-volatile	606
Mineral spirits	98
Cobalt naphthenate, 6%	3
Lead naphthenate, 24%	7
Anti-skinning agent, volatile type	2
	869 lbs. (100 gal.)

In 1910 the French Government passed a law to the effect that, "after the expiration of five years, the use of white lead shall be illegal for every description of painting work. This law is designed to remove the cause of lead poisoning which has effected such a high death-rate amongst those classes directly connected with the production and use of white lead." (11)

In 1917 a paint authority wrote "Lead poisoning is absolutely preventable and so rare, compared with other diseases, that it can hardly be a subject of much apprehension." (12)

3.1. Terminology

White Lead - Also referred to as basic carbonate white lead. It can be represented by the chemical formula:

Lead carbonate 68.9%
Lead hydroxide 31.1%
Theoretical Chemical Formula - $2PbCO_3 \cdot Pb(OH)_2$

However the range of lead carbonate in commercial white lead is from 62 to 75%.

Commercial White Lead Paste

Heavy paste - 91% white lead and 9% linseed oil

Soft paste - 89% white lead, 9% linseed oil and 2% turpentine

Basic Lead Sulfate - Also referred to as basic sulfate white lead and sublimed white lead.

Theoretical Chemical Formula $2PbSO_4 \cdot PbO$

The various grades and types of white basic lead sulfate cover a range of 72 to 85% lead sulfate and 15 to 28% lead oxide.

Leaded Zinc Oxide - For basic lead sulfate and zinc oxide there are three commercial grades, 5, 35, and 50% basic lead sulfate.

Red Lead - Chemical formula Pb_3O_4

Common grades of red lead vary from 85 to 98% red lead.

Terebine or japan - Drier was originally a quick-drying varnish made by running soft copal with linseed oil and litharge (PbO) in the proportion of 100 lbs. resin to 21 gallons of oil and 5 1/4 lbs. of litharge and thinning with turpentine. In modern practice, terebine is more of the nature of a heavy bodied oil, being generally prepared by saturating linseed oil with lead and manganese.

4. PREPARATION OF ANALYTICAL EVALUATION AND CALIBRATION STANDARDS

4.1. Commercial Leaded Paints

Analytically significant commercial leaded paint formulations were selected from the historical survey of paint compositions. A broad spectrum of different paints was selected to try to present the analytical chemist with all of the interference problems that he could encounter with his detection methods. Actual paint ingredients were used, in the proportions specified in the original formulations.

The base paint formulations selected for this study comprised twelve leaded and one non-leaded compositions. The compositions of the above paints are given in Table I, Typical Commercial White Paint Formulations.

Typical inorganic coloring pigments were added to 500 gram aliquots of the above paints. In addition to leaded pigments, such as chrome yellow and chrome green, other pigments, e.g., iron oxide that could interfere with the identification of lead were included. In the case of the non-leaded paint formulation, listed in Table I, all of the lead present was introduced from the tinting color. This represents the situation generally encountered today with custom mixed paints. The types and amounts of color pigments used are given in Table II, Color Pigment Additives.

Test specimens using the above paints are currently being prepared on plexiglass substrates.

The importance of considering actual commercial paint formulations in the development of detection methods for lead and any other elements can not be overestimated. A good analytical method for paint analysis will be applicable to any conditions that may be encountered. Thus colors that are commonly used, e.g., yellow or dark brown, should not interfere with the proposed test method. This is especially important when evaluating spot tests, or other tests dependent on color indicators. Commonly found elements interfering with x-ray techniques for the detection of lead should be considered when evaluating this technique. It is very easy in the laboratory to overlook conditions that will render a technique of limited use for its intended purpose.

Table I. TYPICAL COMMERCIAL WHITE PAINT FORMULATIONS

Formula A: Basic Paste White Lead Paint

Composition	Weight (grams)
Paste White Lead	
Basic Carbonate White Lead	5624.6
Raw Linseed Oil	567.
Turpentine	127.
Raw Linseed Oil	979.8
Turpentine	907.2
Cobalt Tallate, 6%	5.31
Manganese Tallate, 6%	3.54
Lead Tallate, 24%	10.61
Weight Per Gallon	8225.06

Formula B: Lead Zinc Paint

Composition	Weight (grams)
Basic Carbonate White Lead	2268.0
Zinc Oxide	1360.8
Magnesium Silicate	725.7
Raw Linseed Oil	771.1
Bodied Linseed Oil	816.5
Cobalt Tallate, 6%	5.44
Manganese Tallate, 6%	3.63
Lead Tallate, 24%	10.88
Mineral Spirits	100.0
Weight Per Gallon	6062.05

Formula C: Basic Carbonate White Lead/Leaded Zinc Paint (1930-1940)

Composition	Weight (grams)
Leaded Zinc Oxide, 18%	2268.0
Basic Carbonate White Lead	1134.0
Magnesium Silicate	907.2
Linseed Oil Raw	1496.9
Linseed Oil Bodied	508.0
Mineral Spirits	20.0
Cobalt Tallate, 6%	6.8
Manganese Tallate, 6%	4.5
Lead Tallate, 24%	13.6
Weight Per Gallon	6359.0

Formula D: Titaned Basic Carbonate White Lead/Leaded Zinc Paint (1935-1945)

Composition	Weight (grams)
Anatase Titanium Dioxide	680.4
Leaded Zinc Oxide, 18%	2041.2
Basic Carbonate White Lead	907.2
Magnesium Silicate	907.2
Raw Linseed Oil	1496.9
Bodied Linseed Oil	508.0
Cobalt Tallate, 6%	6.8
Manganese Tallate, 6%	4.53
Lead Tallate, 24%	13.6
Mineral Spirits	50.0
Weight Per Gallon	6565.83

Formula E: Lead - Zinc - Barytes Paint (1919-1939)

Composition	Weight (grams)
Basic Carbonate White Lead	1814.4
Zinc Oxide	1134.0
Barytes (Barium Sulfate)	1814.4
Magnesium Silicate	680.4
Raw Linseed Oil	771.1
Bodied Linseed Oil	816.5
Cobalt Tallate, 6%	5.4
Manganese Tallate, 6%	3.6
Lead Tallate, 24%	10.00
Mineral Spirits	143.7
Weight Per Gallon	7193.5

Formula F: Composite Titanium Dioxide - Basic Carbonate White Lead - Leaded Zinc Paint (1938-1960)

Composition	Weight (grams)
Extended Titanium-Calcium Pigment, 30%	2268.0
Leaded Zinc Oxide, 18%	2041.2
Basic Carbonate of White Lead	907.2
Magnesium Silicate	226.8
Raw Linseed Oil	1496.9
Bodied Linseed Oil	508.0
Cobalt Tallate, 6%	6.8
Manganese Tallate, 6%	4.53
Lead Tallate, 24%	13.6
Mineral Spirits	75.0
Weight Per Gallon	7548.03

Formula G: Lead - Zinc - Silica Paint (1910-1940)

Composition	Weight (grams)
Basic Carbonate White Lead	1814.4
Zinc Oxide	1134.0
Amorphous Silica	1360.8
Magnesium Silicate	453.6
Raw Linseed Oil	771.1
Bodied Linseed Oil	816.5
Cobalt Tallate, 6%	5.4
Manganese Tallate, 6%	3.64
Lead Tallate, 24%	10.88
Mineral Spirits	75.0
Weight Per Gallon	6445.32

Formula H: Lead - Zinc - Calcium Carbonate (1900-1940)

Composition	Weight (grams)
Basic Carbonate White Lead	1814.4
Zinc Oxide	1134.0
Calcium Carbonate	1360.8
Magnesium Silicate	453.6
Raw Linseed Oil	771.1
Bodied Linseed Oil	816.5
Cobalt Tallate, 6%	5.4
Manganese Tallate, 6%	3.64
Lead Tallate, 24%	10.88
Mineral Spirits	50.0
Weight Per Gallon	6420.32

Formula J: Lead - Zinc - Clay Paint (1900-1930)

Composition	Weight (grams)
Basic Carbonate White Lead	1814.4
Zinc Oxide	1134.0
Clay	1134.0
Magnesium Silicate	226.8
Raw Linseed Oil	771.1
Bodied Linseed Oil	816.5
Cobalt Tallate, 6%	5.4
Manganese Tallate, 6%	3.6
Lead Tallate, 24%	10.88
Mineral Spirits	200.0
Weight Per Gallon	6116.68

Formula K: Lithopone - Leaded Zinc Paint (1915-1940)

Composition	Weight (grams)
Leaded Zinc Oxide, 18%	1814.4
Lithopone	1814.4
Magnesium Silicate	907.2
Raw Linseed Oil	1496.9
Bodied Linseed Oil	508.0
Cobalt Tallate, 6%	6.8
Manganese Tallate, 6%	4.5
Lead Tallate, 24%	13.6
Mineral Spirits	25.0
Weight Per Gallon	6590.8

Formula L: Interior Lithopone - Lead Sulfate - Zinc Paint (1915-1940)

Composition	Weight (grams)
Sublimed Lead	113.4
Zinc Oxide	3175.2
Lithopone	1202.0
Celite	45.4
Linseed Oil Raw	1633.0
Turpentine	824.0
Cobalt Tallate, 6%	5.4
Manganese Tallate, 6%	3.6
Lead Tallate, 24%	10.9
Weight Per Gallon	7012.9

Formula M: Red Lead - Iron Oxide Paint (1940-1970)

Composition	Weight (grams)
China Clay	116.1
Red Lead, 97%	1814.4
Iron Oxide, 85%	453.6
Magnesium Silicate	907.2
Mica, 325 Mesh	226.8
Medium Oil Alkyd, 50% Non Volatile	2515.0
Cobalt Tallate, 6%	9.07
Lead Tallate, 24%	22.68
Weight Per Gallon	6064.85

Formula N: Non Leaded Interior Semi-Gloss (1938-1960)

Composition	Weight (grams)
Titanium Calcium Pigment	2653.5
Bodied Linseed Oil	265.3
Raw Linseed Oil	172.5
Interior Varnish, 45% Non Volatile	1612.0
Lead Tallate, 24%	3.63
Cobalt Tallate, 6%	1.36
Weight Per Gallon	4708.29

Table II. COLOR PIGMENT ADDITIVES

Color	Tinting Pigment	Weight (grams) * of Tinting Pigment
Dark Yellow	Chrome Yellow	36.8
Light Yellow	Chrome Yellow	9.2
Dark Green	Dark Chrome Green	8.8
Dark Orange	Chrome Orange	73.2
Light Orange	Chrome Orange	6.19
Dark Brown	Iron Oxide	50.0
Light Brown	Iron Oxide	10.0

*Added to 500g aliquots of each paint base listed in Table I.

4.2. Calibration and Evaluation Standards

4.2.1. General

Difficulties are frequently encountered in the analysis of lead in paints as a result of the many elements present in the mixed pigments used in paint formulations. Pigments may contain several elements that span major chemical groups, as is indicated in Table III, Metals Commonly Included in Paint As Shown by Chemical Groups.

The magnitude of the lead detection problem is increased by the accumulation of non-leaded layers of paint covering the leaded layers. Paint samples taken from housing where leaded paint was found are characterized in Table IV, Accumulation of Leaded Paint as a Function of Building Age. In general, the leaded layers are found in the oldest few coats of paint.

Standard samples reflecting the problems induced by multi-layered coatings were prepared to simulate the difficulties that may be encountered in field analysis of leaded paints.

4.2.2. Preparation of Standards

Chemically pure compounds and assayed pigments listed in Table V, Composition of Components Used in Standard Paints, were incorporated in formulations representative of typical interior and exterior paints. Two base formulations were prepared; a titanium-calcium interior formulation and a titanium-zinc oxide exterior composition (see Formulations - No's. 1 and 2 in Table VI, Standard Paint Formulations). These samples served as lead free coatings and permitted incorporation of such elements as barium, titanium, strontium and other elements which oould possible interfere with the determination of lead (see formulations - No's. 3, 6 and 10 in Table VI).

Samples were also prepared to determine the suitability of various analytical methods for the detection of the minute quantities of those elements included in American Standard Z66.1 - 1964, developed by the American Standards Association, as shown in Table VII, Secondary Standards Containing Elements Specified in American Standard Z66.1 - 1964.

4.2.3. Application and Ageing of Coatings

Since paints are applied to numerous building materials, a variety of substrates were selected for the application of the formulated samples. Substrates, such as plexiglass, gypsum board, plywood and metals were coated with the various formulations. The leaded samples were controlled according to quantity applied as well as the location of the coating relative to substrate (see Tables VIII, Wood Panels Coated with Varying Amounts of Lead Paint Per Unit Area and Table IX, Plexiglass Panels Coated with Varying Amounts of Lead Paint Per Unit Area.)

Free films of several formulations have been obtained by casting selected formulations on a water-impregnable resin paper allowing the coat to dry for forty eight hours. The paper was subsequently soaked in water; causing swelling of the resin and permitting the removal of the coating.

The chemical decomposition of organic coatings is a natural occurrence with ageing and manifests itself in many characteristics, such as yellowing, bleaching, chalking, saponification, embrittlement, etc. In the development of methods for the analysis of aged films, such decomposition was a necessary consideration and required evaluation.

Samples were subjected to accelerated weathering to determine the effects of ageing upon the ability to detect and determine the composition of aged coatings (see Table X, Lead Bearing Samples Exposed to Accelerated Weathering.) Samples were applied to appropriate substrates and exposed in the Twin-Arc Weatherometer. The apparatus operated at $145\,^{\circ}F \pm 5^{\circ}F$ and a cycle time of 120 minutes. The cycle consisted of 102 minutes of U.V. light and 18 minutes of U.V. light and water spray. Each leaded coat was exposed for two hundred hours. The samples have been forwarded to the Analytical Chemistry Department for analyses.

Table III

METALS COMMONLY INCLUDED IN PAINT AS SHOWN BY CHEMICAL GROUPS[1]

Group I:	Silver, Lead, Mercury
Group II:	Bismuth, Copper, Cadmium, Antimony
Group III:	Aluminum, Chrominum, Iron, Nickel, Cobalt, Manganese, Zinc
Group IV:	Barium, Strontium, Calcium
Group V:	Magnesium, Potassium, Sodium

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[1]Similarity based upon behavior of the metal ions when treated with a given reagent.

Table IV

ACCUMULATION OF LEADED PAINT AS A FUNCTION OF BUILDING AGE

	Average Paint Thickness in Mils							
Age of Bldg. (Years)	Baltimore	Chicago	New Haven	Phila-delphia	Washington D.C.	Average Thickness All Cities	Average No. of Coats	Years per Coat*
30	28	-	25	-	22	25	13	2.3
50	28	25	31	-	38	31	16	3.1
60	-	29	-	39	-	34	17	3.5
70	34	-	39	37	42	36	18	3.9

*Assuming 0.002 inch thickness per coat.

Table V

COMPOSITION OF COMPONENTS USED IN STANDARD PAINTS

Chemically Pure Compounds

1.	Titanium dioxide (TiO_2)	99.90%
2.	Calcium carbonate ($CaCO_3$)	99.90%
3.	Zinc oxide (ZnO)	99.90%
4.	Basic carbonate of white lead ($2PbCO_3 \cdot Pb(OH_2)$)	99.90%
5.	Lead chromate ($PbCrO_4$)	99.90%
6.	Magnesium silicate ($2MgO \cdot 4SiO_2 \cdot H_2O$)	99.90%
7.	Ferric oxide (Fe_2O_3)	98.00%
8.	Barium sulfate ($BaSO_4$)	99.90%
9.	Sodium arsenate ($Na_2HAsO_4 \cdot 7H_2O$)	99.90%
10.	Antimony trioxide (Sb_2O_3)	99.90%
11.	Lead carbonate ($PbCO_3$)	99.90%

Spectrochemically Assayed Pigments

1.	Cadmium Red	
	Cd	68.25%
	Se	20.60%
	S	11.05%
2.	Strontium Yellow	
	Sr	49.00%
	Cr	35.70%
	O	11.1 %

Table VI

STANDARD PAINT FORMULATIONS

#1 Titanium-Calcium Base - Interior

Component	Weight (grams)
TiO_2	1252.00
$CaCO_3$	748.00
Alkyd Solution	2845.30
Cobalt Tallate	16.70
Manganese Tallate	42.00
Pigment	40.80%
Vehicle	59.20%
Total Non-Volatile by Weight of Paint	70.9 %

#2 Titanium-Zinc Oxide Base - Exterior

Component	Weight (grams)
TiO_2	576.0
ZnO	144.0
Alkyd Solution	3725.0
Cobalt Tallate	16.0
Manganese Tallate	39.0
Pigment	16.0 %
Vehicle	84.0 %
Total Non-Volatile by Weight of Paint	66.4 %

#3

To 829.0 grams of base paint #1 (equivalent to 587.8 grams of non-volatile), the following additives were included:

Percent Additives*

Percent Additives*		
1.00 % Pb	as 7.60 g. of $PbCO_3$	
0.01 % Ba	as 0.10 g. of $BaSO_4$	
0.01 % Sb	as 0.07 g. of Sb_2O_3	
0.01 % As	as 0.24 g. of $Na_2HAsO_4 \cdot 7H_2$	
0.01 % Cd	as 0.09 g. of Cadmium Red	
0.003% Se		
0.001% S		
0.01 % Sr	as 0.123g. of Strontium Yellow	
0.008% Cr		
0.01 % Hg	as 2.800g. of Fungicide	

*Percentages computed on percent total non-volatile in paint.

#4

To 974.3 grams of base paint #1 (equivalent to 690.8 g. of non-volatile), the following additives were included:

Percent Additives*

1.0 % Pb	as 8.92 g. of $PbCO_3$
0.03 % Ba	as 0.35 g. of $BaSO_4$
0.03 % Sb	as 0.25 g. of Sb_2O_3
0.03 % AS	as 0.86 g. of $Na_2HAsO_4 \cdot 7H_2O$
0.03 % Cd 0.009% Se 0.005% S	as 0.30 g. of Cadmium Red
0.03 % Sr 0.023% Cr	as 0.42 g. of Strontium Yellow
0.03 % Hg	as 9.85 g. of Fungicide

*Percentages computed on percent total non-volatile in paint.

#5

To 974.3 grams of base paint #1 (equivalent to 690.8 g. of non-volatile), the following additives were included:

<u>Percent Additives*</u>

1.0 % Pb	as	8.93 g.	of $PbCO_3$
0.05 % Ba	as	0.59 g.	of $BaSO_4$
0.05 % Sb	as	0.42 g.	of Sb_2O_3
0.05 % As	as	1.44 g.	of $Na_2HAsO_4 \cdot 7H_2O$
0.05 % Cd, 0.014% Se, 0.008% S	as	0.51 g.	of Cadmium Red
0.05 % Sr, 0.04 % Cr	as	0.71 g.	of Strontium Yellow
0.05 % Hg	as	16.45 g.	of Fungicide

*Percentages computed on percent total non-volatile in paint.

#6

To 974.3 grams of base paint #1 (equivalent to 690.8 g. of non-volatile), the following additives were included:

Percent Additives*		
1.0 % Pb	as	8.92 g. of $PbCO_3$
0.06 % Ba	as	0.71 g. of $BaSO_4$
0.06 % Sb	as	0.50 g. of Sb_2O_3
0.06 % As	as	1.73 g. of $Na_2HAsO_4 \cdot 7H_2O$
0.06 % Cd, 0.017% Se, 0.010% S	as	0.61 g. of Cadmium Red
0.06 % Sr, 0.04 % Cr	as	0.85 g. of Strontium Yellow
0.06 % Hg	as	19.15 g. of Fungicide

*Percentages computed on percent total non-volatile in paint.

#7

Component	Weight (grams)
TiO_2	248.23
$CaCO_3$	175.00
ZnO	50.00
Alkyd Vehicle	552.9

To the above components the following impurities were added:

Percent Additives*

Percent	
1.00 % Ba	as 13.65 g. of $BaSO_4$
1.00 % Pb	as 10.32 g. of $PbCO_3$
0.10 % Sr, 0.07 % Cr	as 1.63 g. of Strontium Yellow
0.10 % Cd, 0.03 % Se, 0.02 % S	as 1.17 g. of Cadmium Red

Total non-volatile by weight of paint is 76.0%.

*Percentages computed on percent total non-volatile in paint.

#8

Component	Weight (grams)
TiO_2	206.94
$CaCO_3$	175.00
ZnO	50.00
Alkyd Vehicle Solution	549.75

To the above components the following impurities were added:

Percent Additives*

1.00 % Ba	as 13.65 g. of $BaSO_4$
5.00 % Pb	as 51.61 g. of $PbCO_3$
0.10 % Sr 0.07 % Cr	as 1.63 g. of Strontium Yellow
0.10 % Cd 0.03 % Se 0.02 % S	as 1.17 g. of Cadmium Red

Total non-volatile by weight of paint is 76.2%.

*Percentages computed on percent total non-volatile in paint.

#9

Component	Weight (grams)
$CaCO_3$	175.00
TiO_2	70.60
ZnO	50.00
Alkyd Vehicle Solution	523.05

To the above components the following impurities were added:

Percent Additives*

15.0 % Pb	as 188.00 g. of $PbCrO_4$	
0.10% Sr 0.07% Cr	as 1.63 g. of Strontium Yellow	
0.10% Cd 0.03% Se 0.02% S	as 1.17 g. of Cadmium Red	
1.00% Ba	as 13.65 g. of $BaSO_4$	

Total non-volatile by weight of paint is 78.2%.

*Percentages computed on percent total non-volatile in paint.

#10

To 960.0 grams of base paint #2 (equivalent to 638.0 g. of non-volatile), the following additives were included:

TiO_2	36.38 g.

Percent Additives*

0.92 % Ba as 12.30 g. of $BaSO_4$

10.20 % Pb as 103.60 g. of $PbCO_3$

0.89 % Fe as 10.02 g. of Fe_2O_3

Total non-volatile 83.4%

*Percentages computed on percent total non-volatile in paint.

Table VII

SECONDARY STANDARDS CONTAINING ELEMENTS SPECIFIED IN AMERICAN STANDARD Z66.1-1964

Paint Formulations (See Table VI)	Z66.1-1964 Elements							
	Sb	As	Ba	Cd	Pb	Hg	Se	Sr
#3	0.01%	0.01%	0.01%	0.01%	0.99%	0.01%	0.003%	0.01%
#4	0.03%	0.03%	0.03%	0.03%	0.99%	0.03%	0.009%	0.03%
#5	0.05%	0.05%	0.05%	0.05%	0.99%	0.05%	0.014%	0.05%
%6	0.06%	0.06%	0.06%	0.06%	1.00%	0.06%	0.01%	0.06%

Table VIII

WOOD PANELS COATED WITH VARYING AMOUNTS OF LEAD PAINT PER UNIT AREA

Panel #	% Lead in Leaded Coats*	Wt. in g. of Lead Free Coats**		Wt. in g. of Leaded Coats		Total Wt. in g. Lead Free Paint	Total Wt. in g. Leaded Paint	Total Wt. Lead in mg.	Area in cm^2	mg. Pb per cm^2
		1st	2nd	3rd	4th					
1	10%	0.215	0.200	0.300	0.230	0.415	0.530	53.0	77.40	0.68
2	10%	0.485	0.540	0.420	0.510	1.025	0.930	93.0	77.40	1.20
3	10%	0.480	None	0.460	None	0.480	0.460	46.0	77.40	0.59
4	10%	0.115	None	0.300	0.365	0.115	0.665	66.5	77.40	0.86
5	10%	0.610	0.240	0.200	0.285	0.850	0.485	48.5	77.40	0.63
6	10%	0.710	None	0.410	None	0.710	0.410	41.0	77.40	0.53
8	10%	0.620	None	0.565	None	0.620	0.565	56.5	77.40	0.73
9	10%	None	None	0.555	None	None	0.555	55.5	77.40	0.72
10	10%	None	None	0.400	None	None	0.805	80.5	77.40	1.04

*Formulation #10, from Table VI.

**Formulation #1, from Table VI.

Table IX

PLEXIGLASS PANELS COATED WITH VARYING AMOUNTS OF LEAD PAINT PER UNIT AREA

Panel #	% Lead in Leaded Coats*	Wt. in g. of Lead Free Coats**		Wt. in g. of Leaded Coats		Wt. in g. Lead Free 5th (Top) Coat	Total wt. in g. Lead Free Paint	Total wt. in g. Leaded Paint	Total wt. Lead in mg.	Area in cm^2	mg. Pb per cm^2
		1st	2nd	3rd	4th						
20	1%	None	None	2.000	1.675	1.025	1.025	3.675	36.75	70.95	0.52
21	1%	1.025	None	2.597	None	1.125	2.150	2.597	25.97	74.18	0.35
22	1%	0.725	0.825	2.010	1.125	1.010	2.560	3.135	31.35	74.18	0.42
23	1%	0.640	None	2.810	2.305	1.111	1.751	5.115	51.15	74.18	0.69
24	1%	0.920	1.010	1.121	1.779	None	1.930	2.900	29.00	70.95	0.41
25	1%	None	None	2.222	1.288	None	None	3.510	35.10	74.18	0.47
26	1%	1.321	None	1.103	1.550	1.201	2.522	2.653	26.53	70.95	0.37
27	1%	0.986	None	2.042	3.001	0.416	1.402	5.043	50.43	74.18	0.68
28	1%	0.922	0.644	3.444	3.884	None	1.566	7.328	73.28	77.40	0.95
29	1%	0.612	None	0.320	0.108	0.642	1.254	0.428	4.28	75.79	0.06
30	1%	0.200	0.225	0.425	None	None	0.425	0.425	4.25	74.18	0.06

*Formulation #4, from Table VI.
**Formulation #1, from Table VI.

Table X

LEAD BEARING SAMPLES EXPOSED TO ACCELERATED WEATHERING

Panel #	Formu-lations*	Pb $\left(\frac{mg.}{Cm^2}\right)$	g. of Lead Paint Applied	Top Coat	# of Pb Coats	# of Top Coats	g. at Top Coat	% Pb in Non Volatile
31	7	0.23	2.125	Non-Leaded	2	2	0.840	1
32	7	0.20	2.040	None Applied	2	None	None	1
33	8	1.1	1.905	Non-Leaded	2	2	0.900	5
34	8	1.2	2.307	None Applied	2	None	None	5
35	9	3.7	2.125	Non-Leaded	2	2	1.225	15
36	9	3.6	2.285	None Applied	2	None	None	15

*From Table VI.