RED LEAD

in

Corrosion Resistant Paints

Published by
NATIONAL LEAD COMPANY

FOREWORD

As a guide to those responsible for formulating and specifying paints for structural uses and work we have set forth on this booklet the various characteristics of red lead, its function in paint, and formulas for a representative group of general purpose and specific-uses paint primers. It is hoped that the data will assist both the paint manufacturer and the consumer in selecting the best paint for a lasting and durable job.

The engineers of our technical staff are available at any time to those with paint formulations problems. Independent inquiries regarding the formulation of red lead pigmented paints may be had by contacting any one of our offices.

CHAPTER I

Properties and Advantages of RED LEAD

THE essential properties and functions of a metal protective primer that will provide maximum protection are: (1) the inclusion of a constituent which inhibits and stifles corrosion by preventing the reactions causing corrosion; (2) the formation of a continuous film to exclude from the metal the environment which can cause corrosion; (3) the maintenance of flexibility in the film so that it can conform with the stresses set up by temperature changes; and (4) the retention of good bonding properties so that adhesion of the paint film will be maintained, not only initially but for a maximum period of time.

Red lead, used either as a single pigment or combined with other paint pigments, possesses properties which enable it to fulfil the requirements of each one of these specifications. It ranks high as an inhibitor pigment and it also imparts additional qualities to a paint which promote adhesion, toughness, and elasticity in the paint film. In fact, red lead's durability and long service under difficult conditions has become a generally accepted standard of performance for metal protective paints the world over.

Red Lead — An Inhibitor Pigment

Authorities agree that, for the priming coat or coats, a paint should be rust inhibitive if it is to give satisfactory performance.

There have been many tests conducted, both in the field and in the laboratory, to show very definitely and conclusively that red lead is an inhibitive pigment and its presence, therefore, imparts important protective qualities to a paint for metal.

One of the more recent tests of red lead's inhibitiveness is reported by A. H. Stuart.* As a part of his testing, Dr. Stuart wanted to determine whether the red lead itself was responsible for rust inhibition. To do this he immersed a steel rod in a thin paste of red lead and water for one hour. The rod was then removed, thoroughly washed to remove *all* pigment, and tested *along with an untreated rod.* The treated rod, although all trace of red lead had been removed, showed decidedly greater resistance to rusting, as measured electrically, than did the untreated rod. Also the protective action, while it steadily diminished, had not entirely disappeared after forty hours. This is shown graphically in Figure 1.

Dr. Stuart's interpretation of this result is that red lead forms a thin film of oxide on the metal surface, thus creating a passive state. His conclusion, after this and other tests, is that red lead definitely maintains a passive state on a metal surface subject to rusting and that therefore "the faith in red lead as a primer rests on sure foundations."

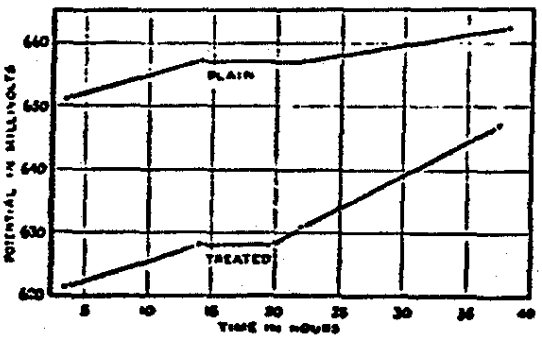


FIGURE 1

Graph showing results of test by A. H. Stuart. In the electrical potential measurement method which he used, a lower point on the scale indicates a less anodic condition of the metal and therefore greater resistance to rusting. It will be noticed that the treated rod was definitely less anodic than the untreated one. Also, while the protective action slowly diminished it was still present at the end of the test period.

*Jan. 1939 Journal of Paint Manufacture

Two members of the Bell Telephone Laboratories, H. E. Haring and R. B. Gibney, have conducted a series of laboratory experiments which seem to confirm this theory of passivity and support their expressed belief that the action of red lead in the priming coat is essentially chemical.

Experiments conducted by K. G. Lewis* also show this inhibitive effect of red lead on metal surfaces. Lewis used the scratch-coat method in which he painted metal with red lead and linseed oil, and when the film was dry made a standard scratch through it exposing the bare metal. A drop of sodium chloride solution placed on this scratch and protected against evaporation caused no corrosion, rusting or softening of the paint film in the case of red lead.

The reasons for the creation of a passive state on red leaded metal surfaces is attributed by some to its basic or alkaline nature. This is on the theory that when steel is attacked, the iron goes into solution at the anodic areas, and the rate of solution is inversely proportional to the alkalinity of the medium in immediate contact with the metal.

It is further held by other authorities that corrosion is prevented if a protective layer of oxide is formed in direct contact with the metal surface. This takes place when the ferrous ions formed at the anodic areas are quickly oxidized to the ferric state. Certainly the presence of an active oxidizing agent, such as red lead, will promote the formation of this protective oxide shield and arrest the process of corrosion.

Red lead is doubly fortunate in that it possesses in such degree both of these chemical properties which authorities agree are responsible for preventing metal corrosion. As has been stated by Dr. Ulick R. Evans,** of Cambridge (England) University, "An inhibitive pigment should be included in the lowest (priming) coat of paint so as to keep the metal passive . . ."

Red Lead Soaps – Their Effect on the Paint Film

When red lead is mixed with most of the paint vehicles in common use, some organic compounds of lead are formed. This reaction has been demonstrated by many independent investigators and is now a generally accepted fact.

*[illegible]

**U. R. Evans, Metallic Corrosion, Passivity and Protection (Edward Arnold & Co., 1937), p. 306

The products of this phenomenon are commonly referred to as lead "soaps" and there has been a great deal of experimentation and research relating to both the formation of these metallic soaps and their effect upon the life and character of the paint film.

FIGURE 2

Lead soap formations in the early stages of their particle growth.

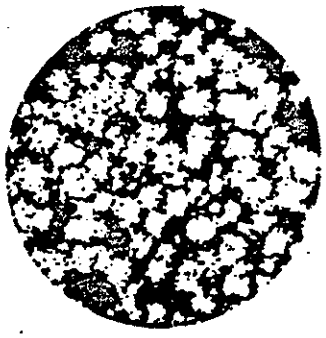


FIGURE 3

This photo, taken under polarized light, more clearly shows the character of lead soaps. Note particularly the fibrous structure.

FIGURE 4

An example of a soap produced with another base pigment. Note the solid, crystalline-like structure of this soap in contrast to the fibrous and rod-like lead soaps.

Not all paint pigments are capable of forming metallic soaps but lead pigments form them readily. The lead soaps are also distinctive in their form and in their effect.

In general, lead soaps form as a series of projections radiating out from a central core. This is shown in the photomicrographs, Figures 2 and 3. There are other metallic soaps that are more solid and crystalline and lack the elasticity and integral strength of the fiber-like spherulites in the lead paints. Such an example is shown in Figure 4.

Furthermore, it has been shown that the development of soap formations continues in the red lead paint film after the surface coating has dried. This continuous growth has even been photographed in a motion picture. Of course, the growth of soap crystals is a slow process and a picture which takes but a few seconds to show on the screen must be made over a period of many weeks.

Lead Soaps Contribute to Impermeability of Paint Film

The formation and presence of lead soap compounds in a paint film is not merely a chemical curiosity. The reaction has a very definite practical effect on the life and performance of the paint.

The composition of the soaps gives a clue to one of the reasons that red lead is an efficient guard against such corrosive factors as air and moisture. Among the products formed with linseed oil are lead linoleate, lead stearate, complex compounds of lead monoxide (litharge) with triglycerides, and basic lead soaps. All of these are highly water-resistant and unquestionably contribute to low moisture permeability. Confirmation of this is contained in a paper* by *Manfred Ragg*, a German investigator. He characterizes paint films containing red lead "as brick walls, built of comparatively large, impermeable bricks which are bound together with a water-tight mortar." Further evidence is contributed by a moisture permeability test quoted by Burns and Schuh.** The red lead paint film outranked all other pigments tested, fifteen in all, in resistance to moisture passage through the coating.

Add Toughness and Elasticity

Examination of the shape and character of lead soaps shows that they contribute also to the toughness and elasticity of the paint film.

It is very evident from a photomicrograph (*See Figure 5*) how the particles intertwine and mechanically reinforce the paint film. This type of particle growth is somewhat analogous to fibers in cloth. Individually the cloth fibers have little strength but once they are woven together their mechanical strength is increased many thousand times.

*Thomassen, The Electrochemical Society, 1935

**Burns & Schuh, Protective Coatings for Metals (Reinhold Publishing Corp.) 1939, p. 282

It is also a characteristic of lead soaps that they allow movement all along the projecting fingers. This is very beneficial to the life of the paint, as once the elastic limit of both the dried oil film and the soap particles is exceeded, the soap particles will give in this manner. This action effectively prevents the ruptures to which a hard, unyielding paint film is subject.

FIGURE 5

This photograph of more fully developed lead soap formations clearly indicates the mechanical reinforcement they give to the paint film.

Adhesion

Those who have carefully studied lead soap formations and their chemical components also believe that they are in great part responsible for the unique adhesiveness of red lead paint.

Of course, the inhibitive action of red lead also contributes to the tight bond between metal and paint. The fact that red lead has the ability to render the metal passive prevents rusting under the paint film which might expand and break the bond between the paint and the metal surface.

Durability of Red Lead

The wide acceptance of red lead as a protective pigment for metal rests on a sure foundation, namely, actual performance in service under all conditions plus numerous tests that have been conducted in all parts of the world.

Among the more important of these tests is the one conducted by a joint committee of The British Iron and Steel Federation and The Iron and Steel Institute.

This sponsorship is entirely unbiased and the tests, which now extend over a period of about ten years, are reported upon annually.

The 1941 published report makes the following definite recommendation: "Use a corrosion-inhibiting priming paint, such as red lead. Follow this with good weather-resisting finishing coats, such as oxide of iron or white lead paints." The report further goes on to explain: "The Committee's tests have shown that the most effective of these (inhibitive) primers for general use is red lead."

For many years similar exposure tests have been conducted under the direction of the Cambridge (England) Laboratory. In these Cambridge tests, many of the effective combinations involved the presence of red lead in the lowest coat. Commenting on them, another paint authority, Dr. Ulick R. Evans,* of King's College, Cambridge University, claims that "The Cambridge outdoor tests support the view that the lowest coat should contain an inhibitor—preferably red lead."

Among the independent authorities who have carefully investigated metal paints of all kinds are R. M. Burns, Assistant Chemical Director of the Bell Telephone Laboratories and A. E. Schuh, Director of Research for the U. S. Pipe and Foundry Co. In a recent book,** on which they collaborated, it is stated "Of all the pigments that have been used in primers on ferrous metals, red lead has the best over-all record. It has been in constant use for well over a century, and in all carefully conducted paint studies has always ranked very high. It is not meant to imply that there is no other priming pigment better than red lead, for unquestionably several other pigments have in specific instances given superior protection. However, it is the one priming pigment which has consistently shown up well both in tests and in actual practice."

Paint Research

National Lead Company is fully cognizant of the value of testing all paints under actual service conditions. Not only does this prevent untried recommendations but it also furnishes us with a mass of valuable data to assist our customers *interested in good paint formulation.*

Straight red lead paints as well as red lead in various combinations with other pigments are constantly being tested and checked at our own outdoor testing grounds. These are located in various sections of the country so as to cover the salt air

*U. R. Evans, Metallic Corrosion-Passivity and Protection (Edward Arnold & Co.) 1937, p. 688

**Burns & Schuh, Protective Coatings for Metals (Reinhold Publishing Corp.) 1939, p. 201

exposure of the coasts, the industrial atmosphere around large cities and the relatively pure air of rural locations. They include also marine tests of various types such as exposure to salt water, tidal waters and river water, both clear and industrially polluted. Climatic differences are likewise taken into account, the test locations ranging from Long Island to Florida, from the east coast to the west.

Information gathered at these various test stations is continually being drawn upon for the benefit of those who seek help in solving some difficult exposure problem or who wish to formulate paints to meet special requirements.

Red Lead with Other Pigments

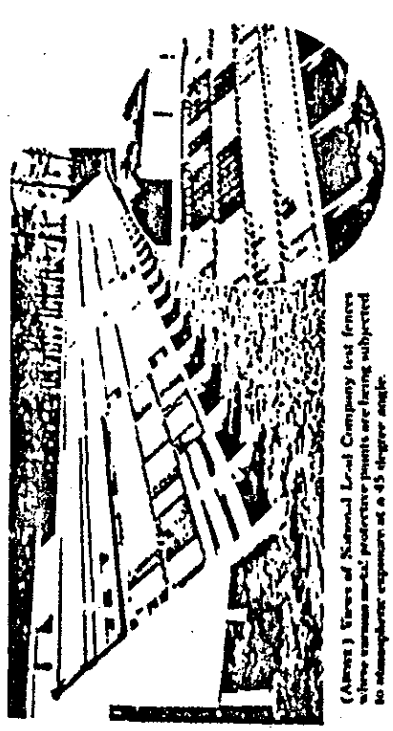
There have been many tests as well as innumerable practical examples to show that the full value of red lead as a protective against rust is realized in straight red lead paints. However, there is also a growing volume of evidence that the strong inhibitive character of red lead and the ability to form useful lead soap compounds increase the protection and length of life of a multi-pigment paint when red lead is included as one of the important components of the pigment phase.

Chapter III contains several formulations from established specifications—Federal, state and commercial—which call for red lead either as a single pigment or combined in various percentages with other pigments. This is an excellent indication of the general acceptance of red lead for the desirable properties that it provides in metal priming paints.

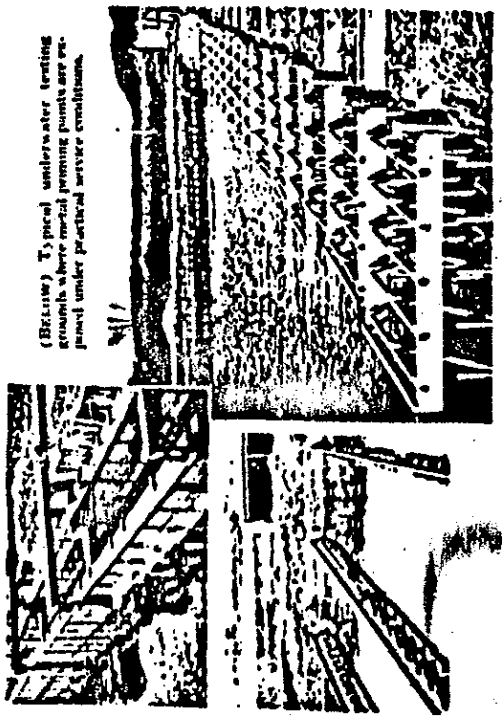
Vehicle Compatibility

The formulation of certain types of paints involves the use of vehicles other than linseed oil. In this respect, although essentially basic, red lead is compatible with practically all types of vehicles commonly used in metal priming paints. For example, varnishes made with alkyd resins, phenolic resins, and modifications of these, as well as various other resins, chlorinated rubber, and different heat treated drying oils, have been successfully used with red lead. Some of the formulas given in Chapter III include a few of the paint vehicles that are specified.

Of course, the choice of vehicle usually depends upon the type of service or exposure for which the paint is intended. Along this line we have compiled data to assist in the formulation of various vehicles with red lead to accomplish specific results. This information is available upon request.



(Above) Views of National Lead Company test fences where corrosion-resistant properties of paints are being subjected to atmospheric exposure at a 45 degree angle.



(Below) Typical underwater testing grounds where metal painting jobs are proved under practical service conditions.

RED LEAD
Types and Properties

TABLE 1

Type Red Lead	% True Red Lead Pb_3O_4	Specific Gravity	Lbs. Per Solid Gallon	Gallons Per Pound	Oil Absorption	Apparent Density (grams)	Fineness (325 Mesh)	Average Part. Size (microns)	% Water Sol. Chlorides (less than)
85% Regular	85 87	9 00	75 0	0133	5 0 7 0	17 21	0 03%	3 0 3 5	0 001
93% Regular	95 96	8 8 8 9	74 0	0135	5 0 7 0	17 21	0 02%	3 0 3 5	0 001
95% Fumed	95 96	8 8 8 9	74 0	0135	7 0 9 0	12 16	0 02%	1 5 2 0	0 001
97% Regular	97 98	8 8 8 9	74 0	0135	5 0 7 0	17 21	0 02%	3 0 3 5	0 001
97% Fumed	97 98	8 8 8 9	74 0	0135	7 0 9 0	12 16	0 02%	1 5 2 0	0 001
98% Regular	98 98.7	8 8 8 9	73 5	0136	5 0 7 0	17 21	0 02%	2 8 3 3	0 001
98% Fumed	98 98 7	8 8 8 9	73 5	0136	7 0 9 0	12 16	0 02%	1 5 2 0	0 001

NOTE: TEST METHODS USED IN DETERMINING THE PROPERTIES DATA ARE AS FOLLOWS:

True Red Lead	ASTM D 49 37	Fineness (325 Mesh)	ASTM D 185 37
Specific Gravity	ASTM D 153 39	Average Particle Size (microns)	Diameter of particles by surface area
Pounds per Solid Gallon	Calculated from specific gravity		
Gallons per Pound	Calculated from specific gravity	Water Soluble Chlorides	ASTM D 416 39 No. 10 method on water soluble matter specification ASTM D 49 37 No. 10
Oil Absorption	ASTM D 281 31		
Apparent Density	Wt. of 1 cu. in. (loosely packed) National Lead Co. Method		

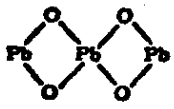
Water Soluble Sulphates are less than 0.01 per cent in all types of red lead. (ASTM D 49-37 No. 13)

CHAPTER II

RED LEAD

Composition–Manufacture–Grades

PURE red lead is an oxide of lead, expressed by the chemical formula Pb_3O_4, and is the lead salt of ortho plumbic acid (plumbous ortho plumbate). This is the structural formula:



which is derived from the reaction:

$$PbO + PbO_2 + PbO \longrightarrow Pb_3O_4$$

Processes Involved

While the chemical reactions remain exactly the same as explained above there are two distinct processes generally employed for making red lead. In the more widely used method the metallic lead is heated in a furnace until converted to litharge. In the other process molten metallic lead is "atomized" by forcing it with

compressed air into the center of a gas flame. This immediately converts it into litharge as a fume which is collected in filter bags. Of course, in each case a furnace is used to convert the litharge to red lead.

There is no difference in the chemical composition or the specific gravity of the two red leads. Comparative properties of the two types and their various grades are listed in Table I on page 12 of this booklet.

Number of Grades

The usual commercial red lead used by the paint industry is of four variations designated as the 85%, 95%, 97% and 98% grades. This refers to the minimum true red lead (Pb_3O_4) content. The remainder is practically all litharge (PbO) since pure commercial red lead contains only a fraction of one per cent of other materials.

It is generally accepted that some litharge content is a desirable factor in red lead paint performance. This is probably due to its basic nature as well as its ability to form relatively insoluble lead soaps.

Red lead with a litharge content of as high as 15% is employed by some because it combines quickly with the vehicle due to the increased reactivity. The film obtained with such a paint also acquires "through" hardness more rapidly than one made with red lead with a higher Pb_3O_4 content. Because the 85% grade red lead combines with the vehicle faster, the paint should be applied the same day as mixed. In fact, such paints are generally mixed by adding the dry pigment to the vehicle on the job.

The 95%, 97% and 98% red leads make paint with good storage properties and for this reason are used almost exclusively for ready-mixed red lead paints. The 95% is generally used in mixed pigment paints and the higher percentages are preferred for straight red lead paints.

CHAPTER III

Formulas and Specifications

RED lead is a part of most Federal Specifications for metal priming paints. It is also included in the Highway Department Specifications of all of the forty-eight states as well as in numerous railway and municipal recommendations. A typical selection has been made from these to include with the formulations in this booklet as a helpful reference. Paints produced in our laboratory according to the suggested formulas fully met our standards of quality and performance and also the requirements of the particular specifications indicated.

It is well recognized that the drawing up of a paint specification is dependent upon such factors as cost, drying time, availability of materials, conditions of exposure, pigment and vehicle compatibility and others. In consequence, it is impossible to set down hard and fast rules. This is why we include this chapter only as a suggestion of what has been done and what can be done with red lead as part of the formulation.

We have much data available from long experience with the paint makers' and users' problems. For those with specific requirements we recommend that they utilize the facilities of the National Lead Company Research Laboratories through one of the branch offices listed in this booklet.

Red Lead Linseed Oil Paints

Red Lead-Mixed Pigment Linseed Oil Paints

Red Lead Varnish Linseed Oil Paints

Red Lead-Mixed Pigment-Linseed Oil Varnish Paints

Red Lead Varnish Paints

Red Lead-Mixed Pigment Varnish Paints

Red Lead—Linseed Oil Paints

Dry and Paste Red Lead

Federal Specification TT-R-191a (Dated July 2, 1938)

This specification covers two types of red lead: Type I, Dry and Type II, Paste in Oil.

There are three commonly used grades of Dry Red Lead: Grade A, 85%; Grade B, 95%; and Grade C, 97%.

There are two grades of Paste Red Lead: Grade B containing 95% red lead and Grade C containing 97% red lead. The composition requirements of pastes made from either grade are:

Pigment	92- 94%
Linseed Oil	6- 8%

Federal Test Formula TT-R-191a:

The Federal Specification for Red Lead TT-R-191a contains formulas for test paints made from either dry or paste red lead, which are frequently used as specifications.

TT-R-191a Dry Red Lead Formula

Dry Red Lead	20 lbs.		100 lbs.
Raw Linseed Oil	5 pts.		3¾ gal.
Turpentine	2 gals.	OR	2½ pts.
Drier	2 gals.		2½ pts.
Approximate Yield	1 gal.		5 gal.

TT-R-191a Paste Red Lead Formula

Paste Red Lead (7.5% Oil)	20 lbs.		100 lbs.
Raw Linseed Oil	1 pts.		1¼ gal.
Turpentine	2 gals.	OR	2½ pts.
Drier	2 gals.		2½ pts.
Approximate Yield	2.5 to 3 gal.		4¾ gal.

Federal Paint Test Formula TT-R-191a:

On a percentage and batch weight basis the two preceding formulas are represented by a single formula, which is as follows:

	Formula	Per Cent	Pounds	Gallons
Pigment	Red Lead*	100.0	1900	26.5
Vehicle	Raw Linseed Oil	84.1	475	61.3
	Turpentine	7.8	44	6.1
	Liquid Drier, Federal Spec. TT-D-45 1a, Type I	8.1	46	6.1
			2525	100.0

Pigment	77.6%
Vehicle	22.4%
Wt Gal	25.25 lbs.
PV	30.3

Red Lead Content per Gallon of Paint 19.6 lbs.
Linseed Oil Content per Gallon of Paint - 4.75 lbs.

*To keep the red lead in loose suspension the addition of up to 0.5% of Aluminum Stearate by weight of pigment is recommended.

Red Lead Base: Linseed Oil, Ready-Mixed Paint

Federal Specification TT-P-86 (Dated September 9, 1939)

	Formula	Per Cent	Pounds	Gallons
PIGMENT	RED LEAD, 97% grade*	100.0	1957	26.6
VEHICLE	Raw Linseed Oil	94.3	536	68.5
	Petroleum Spirits and Drier†	5.7	32	4.5
			2525	100.0

Pigment 77.5%
Vehicle 22.5%
Wt. Gal. 25.25 lbs. (25.0 lbs. Specified Minimum)
PV 27.6

Red Lead Content per Gallon of Paint 19.5 lbs.
Linseed Oil Content per Gallon of Paint 5.3 lbs.

TT-P-86 Dry Red Lead Mixing Formula

Dry Red Lead (97% grade)	100	lbs.
Raw Linseed Oil	3½	gals.
Turpentine or Petroleum Spirits	1	pt.
Liquid Drier (TT-D-651a, Type I)	1	pt.
Approximate Yield	4⅛	gals.

TT-P-86 Paste Red Lead Mixing Formula

Paste Red Lead (7.5% Oil)	100	lbs.
Raw Linseed Oil	2¼	gals.
Turpentine or Petroleum Spirits	1	pt.
Liquid Drier (TT-D-651a, Type I)	1	pt.
Approximate Yield	4¼	gals.

*To keep the red lead in loose suspension the addition of up to 0.3% of Aluminum Stearate by weight of pigment is recommended.

†Drier: 0.3% Lead, 0.02% Manganese and 0.01% Cobalt based on oil content.

Red Lead Base: Linseed Oil, Ready-Mixed Paint

Federal Specification TT-P-86, Amendment No. 1 (Dated September 1, 1943)

	Formula	Per Cent	Pounds	Gallons
PIGMENT	RED LEAD, 97% grade	99.7	1876.0	25.4
	Aluminum Stearate	0.3	5.6	.6
VEHICLE	Linseed Replacement Oil*	100.0	544.0	74.0
			2425.6	100.0

Pigment 77.6%
Vehicle 22.4%
Wt. Gal. 24.25 lbs. (24.0 lbs. Specified Minimum)
PV 36.5

Red Lead Content per Gallon of Paint 18.8 lbs.
Linseed Oil Content per Gallon of Paint 3.6 lbs.
3.75 lbs. (Maximum)

Per Cent Volatile in Vehicle 35.0

Consistency at 25 C. : 0.25 , 175 grams (77 K.U.) to 300 grams (95 K.U.)
Stormer Viscometer (Paddle Type Rotor)

TT-P-86, Amendment No. 1, Dry Red Lead Mixing Formulas

Dry Red Lead (97% grade)	100	lbs.
Linseed Replacement Oil (TT-O-371)	4	gals.
Approximate Yield	5½	gals.

TT-P-86, Amendment No. 1, Paste Red Lead Mixing Formulas

Paste Red Lead (7.5% Oil)	100	lbs.
Linseed Replacement Oil (TT-O-371)	2 to 2½	gals.
Turpentine or Petroleum Spirits	2 to 3	pts.
Yield	4½ to 5	gals.

*The specification states that good results have been obtained with a vehicle containing 30% ... alkali refined linseed oil, 20% ... linseed oil [illegible], and 35% thinner and drier. To avoid [illegible] with [illegible] pigments, [illegible] to use linseed replacement oil having a low acid value [illegible] and that the [illegible] linseed oil used should be one [illegible] at low temperature. The complete extracted vehicle should meet the requirements of Federal Specification TT-O-371, Type I, dated May 1, 1942, Linseed Replacement Oil, except that the requirements for appearance, color and viscosity shall be waived.

Red Lead, Ready-Mixed Paint
American Association of State Highway Officials' Specification M72-42 (Issued 1942)

	Formula	Per Cent	Pounds	Gallons
PIGMENT	Dry Red Lead, 95% grade	100	1962	25.6
VEHICLE	Mixture of Raw (M125-42) and Boiled (M126-42) Linseed Oils*	100	569	73.4
			2531	100.0

Pigment	77.5% (77-80% Specified)		
Vehicle	22.5%	Red Lead Content per Gallon of Paint	19.6 lbs.
Wt. Gal	25.3 lbs.	Linseed Oil Content per Gallon of Paint	5.69 lbs.
PV	26.5		

*Specification states Boiled Linseed Oil may constitute up to 30% of total Oil Content

Red Lead (Dry and Paste in Oil) and Paint Made Therefrom
American Association of State Highway Officials' Specification M71-42 (Issued 1942)

Paint made according to the mixing formulas given previously under Federal Specification TT-R-191a (Test Formulas) will meet the requirements of this specification.

Note: The raw linseed oil called for may be replaced with boiled linseed oil to the extent of 50 per cent of the total oil content.

Red Lead-Linseed Oil Paint for Structural Metal—Heavy Weight

	Formula	Per Cent	Pounds	Gallons
PIGMENT	Dry Red Lead, 97% grade	100.0	2281.0	30.8
VEHICLE	Raw Linseed Oil	94.8	507.0	65.4
	Thinner and Drier*	5.2	28.0	3.8
			2816.0	100.0

Pigment	31.0%		
Vehicle	19.0 %	Dry Red Lead Content per Gallon of Paint	22.8 lbs.
Wt Gal	28.1 lbs.	Linseed Oil Content per Gallon of Paint	5.06 lbs.
PV	32.0		

*0.2% Lead, 0.02% Manganese and 0.01% Cobalt based on oil content.

Red Lead-Linseed Oil Paint—Light Weight

	Formula	Per Cent	Pounds	Gallons
PIGMENT	Dry Red Lead, 97% grade, Fume Type	95.6	1364.0	18.7
	Aluminum Stearate	.4	5.5	.7
VEHICLE	Raw Linseed Oil	38.2	213.7	28.1
	Pale Heat Bodied Linseed Oil (Z1)	20.8	121.6	15.4
	Thinner and Drier*	4.0	23.0	35.1
			1984.8	100.0

Pigment	70.0%		
Vehicle	30.0%	Dry Red Lead Content per Gallon of Paint	13.8 lbs.
Wt Gal	19.5 lbs.	Linseed Oil Content per Gallon of Paint	3.57 lbs.
PV	30.0		

*0.2% Lead, 0.02% Manganese and 0.01% Cobalt based on oil content.

Red Lead—Mixed Pigment—Linseed Oil Paints

Red Lead and Oil, Ready-Mixed Primer

U. S. Maritime Commission Specification No. 52MC20 (Dated April 12, 1943)

	Formula	Per Cent	Pounds	Gallons
PIGMENT	DRY RED LEAD, 97% grade	96.1	1826	24.7
	Magnesium Silicate, 52MC11, Type I	3.6	68	2.9
	Aluminum Stearate	.3	5	.6
VEHICLE	Raw Linseed Oil	95.2	535	69.0
	Petroleum Spirits and Drier*	4.8	27	4.0
			Approximate Yield	101.2

Pigment	77.2%
Vehicle	22.8%
Wt Gal	24.3 lbs.
PV	29

Linseed Oil Content per Gallon of Paint 5.3 lbs.
Consistency - 68-78 KU

*Drier: 0.5% Lead, 0.02% Manganese and 0.01% Cobalt based on oil content.

Red Lead Paint (Extended)

*Southern Railway System Specification No. 48A** (Dated September 27, 1939)

	Formula	Per Cent	Pounds	Gallons
PIGMENT	RED LEAD, 95% Min. Pb_3O_4	75	818	11.05
	Diatomaceous Silica	10	109	5.68
	Magnesium Silicate	15	163	6.85
VEHICLE	Raw Linseed Oil	82	468	60.39
	Thinner and Drier**	18	102	15.69
			1660	99.66

Pigment	65.6%
Vehicle	34.4%
Wt Gal	16.6 lbs.
PV	28.0

Linseed Oil Content per Gallon of Paint 4.68 lbs.

Consistency at 77° F. 60-75 KU for spray and 85-100 KU for brush (Stormer Viscosimeter Fork Type)

*This specification is inactive for the duration. It has been replaced by Specification No. 48B (see page 20) which complies with War Production Board linseed oil limitation order M-332.

**Drier: 0.5% Lead, 0.02% Manganese and 0.01% Cobalt based on oil content.

Red Lead Paint (Extended)

Southern Railway System Specification No. 48B (Dated September 28, 1943)

	Formula	Per Cent	Pounds	Gallons
Pigment*	Red Lead, 95% grade	75.0	738.5	9.98
	Diatomaceous Silica	10.0	98.5	5.13
	Magnesium Silicate	15.0	147.7	6.21
Vehicle	Linseed Oil	65.0	375.9	48.12
	Thinner and Drier**	35.0	202.4	30.56
			1563.0	100.00

Pigment	63%	
Vehicle	37%	Consistency: 105-165 grams for spray and 221-350
Wt Gal	15.6 lbs.	grams for brush by ASTM Method D-562-42-T.
PV	30.7	

Note: In general a vehicle meeting the requirements described for Federal Specification TT-P-86, Amendment 1, September 1, 1943, will also meet the requirements called for in this specification. (See footnote, page 17 of this booklet.)

*The addition of Aluminum Stearate up to 0.3% by weight of pigment is suggested to maintain suspension of the pigment in the vehicle.

**Drier: 0.5% Lead, 0.02% Manganese, 0.01% Cobalt based on oil content.

Exterior Primer for New and Rebuilt Steel Freight Cars

Chicago & Northwestern Railway Company

Specification Standard Paint No. 2

	Formula	Per Cent	Pounds	Gallons
Pigment	Red Lead, 95% grade	45	339	4.6
	Zinc Chromate	16	121	4.2
	Iron Oxide, 70% Fe_2O_3	16	121	3.3
	Magnesium Silicate	23	173	7.3
Vehicle	Heat Treated Oils	60	356	45.2
	Japan Driers	8	47	6.2
	Mineral Spirits	32	190	29.2
			1347	100.0

Pigment	56.0%	
Vehicle	44.0%	Linseed Oil Content per Gallon of Paint 3.56 lbs.
Wt. Gal	13.47 lbs.	Consistency: 190 grams (ASTM Method D-562-42-T)
PV	30	

Red Lead-Mixed Pigment Linseed Oil Metal Paint Primer

	Formula	Per Cent	Pounds	Gallons
Pigment	Red Lead, 95% grade	45.0	529	7.1
	Iron Oxide, 76% Fe_2O_3	27.0	317	9.0
	Magnesium Silicate	27.7	326	13.7
	Aluminum Stearate	.3	3	.4
Vehicle	Raw Linseed Oil	58.4	301	38.6
	Heat Bodied Linseed Oil, 22	8.3	42.7	5.3
	Thinner and Drier*	33.3	171.3	25.7
			1090.0	100.0

Pigment	69.5%	
Vehicle	30.5%	Linseed Oil Content per Gallon of Paint 2.43 lbs.
Wt. Gal	14.9 lbs.	Consistency: 190 grams (ASTM Method D 562-42T)
PV	40	

*Drier: 0.5% Lead, 0.02% Manganese, 0.01% Cobalt based on oil content.

Red Lead—Varnish—Linseed Oil Paints

Red Lead-Varnish Linseed Oil General Purpose Primer

	Formula	Per Cent	Pounds	Gallons
PIGMENT	Red Lead, 97% grade; ½ Fume, ½ Regular Types	99.6	1570	21.2
	Aluminum Stearate	.4	6	.7
VEHICLE	Raw Linseed Oil	6.0	35	4.5
	Pale Heat Bodied Linseed Oil Y Viscosity; Acid No. 8 Max.	27.0	157	19.7
	Spar Varnish*	42.0	245	32.6
	Thinner and Drier**	25.0	145	21.3
			2158	100.0

Pigment	73.0%
Vehicle	27.0%
Wt Gal	21.6 lbs.
PV	36.2

Linseed Oil Content (Free and Combined) per Gallon of Paint 2.67 lbs.
Per Cent Volatile in Vehicle by Weight 45.2%
Consistency: 190 grams (ASTM Method D 562-42T)

*Varnish used should comply with Federal Specification TT-V-121a dated May 7, 1935, or with R-TT-V-121a dated February 10, 1943, and should be so guaranteed that it will be compatible with red lead.
**Drier: 0.5% Lead and 0.05% Cobalt based on oil content.

Red Lead—Mixed Pigment—Linseed Oil—Varnish Paints

Red Lead-Iron Oxide Primer

Corps of Engineers Specification T-1601 (Dated September 14, 1942)

	Formula	Per Cent	Pounds	Gallons
PIGMENT	Red Lead, 95% Pb_3O_4	75.0	1345	18.2
	Iron Oxide, 75% Fe_2O_3	25.0	448	12.4
VEHICLE	Alkyd Res in Solution; (50% Solids) 34% phthalic anhydride on non-volatile	32.0	167	21.0
	Raw Linseed Oil	50.0	260	33.8
	Thinner and Drier*	18.0	94	12.9
			2314	100.0

Pigment	77.5% (77.0% Minimum Specified)
Vehicle	22.5%
Wt. Gal	23.1 lbs.
PV	41.8

Per Cent Volatile in Vehicle by Weight 34.0%
Glyceryl-Phthalate on Nonvolatile Vehicle 11.0% (10.5% Minimum Specified)
Consistency: 190 grams (ASTM Method D 562-42T)

*Drier: 0.5% Lead, 0.05% Cobalt based on oil content.

U. S. Maritime Commission Specification 52MC18 (Dated March 3, 1943)

	Formula	Per Cent	Pounds	Gallons
Pigment	Red Lead, 97% grade	71.8	818	11.0
	Basic Carbonate White Lead	7.5	86	1.5
	Indian Red (Federal Spec. TT-I-511, Type 1)	4.4	50	1.2
	Magnesium Silicate, 52MC11	16.3	186	7.8
Vehicle	Raw Linseed Oil	27.4	160	20.6
	Pale Heat Bodied Linseed Oil (4.0-5.0 poises)	21.8	127	16.0
	Spar Varnish (52MC7)	36.1	211	27.8
	Thinner (52T9, Grade 1), and Drier*	14.7	86	14.1
			1724	100.0

Pigment	66.1%
Vehicle	33.9%
Wt Gal	17.3 lbs.
PV	30

Per Cent Volatile in Vehicle by Weight 30.94
Consistency: 70-85 KU

*Drier: 0.3% Lead, 0.2% Manganese, .001% Cobalt based on oil content.

Red Lead-Mixed Pigment General Purpose Primer

	Formula	Per Cent	Pounds	Gallons
Pigment	Red Lead, 97% grade	70.0	872	11.8
	Zinc Oxide	10.0	125	2.7
	Iron Oxide, 78% Fe_2O_3	10.0	125	2.9
	Magnesium Silicate	7.0	87	3.7
	Diatomaceous Silica	3.0	37	1.9
Vehicle	Raw Linseed Oil	61.0	354	46.1
	Bodied Linseed Oil, 22	6.7	39	4.9
	Spar Varnish (TT-V-121a)	21.2	136	18.1
	Thinner and Drier*	9.1	51	7.9
			1632	100.0

Pigment	68.0%
Vehicle	32.0%
Wt Gal	18.3 lbs.
PV	28.8

Per Cent Volatile in Vehicle 19.8
Consistency: 221 grams (ASTM Method D 562-42T)

*Drier: 0.15% [illegible] .050% Manganese, .005% Cobalt on nonvolatile vehicle.

Red Lead-Zinc Chromate-Phenolic Varnish
Primer for Underwater Exposure
Tennessee Valley Authority Specification C-46 (Dated May 6, 1938)

	Formula	Per Cent	Pounds	Gallons
Pigment	Dry Red Lead, 97% grade, contained in paste red lead which is specified	82.7	973	13.2
	Zinc Chromate	8.4	99	3.4
	Diatomaceous Silica	8.9	105	5.5
Vehicle	Raw Linseed Oil Carried in Paste Red Lead	13.3	79	10.2
	Phenolic Resin Varnish*	84.0	500	65.7
	Pine Oil, Navy Dept. Bur. Ships Spec. 52-0-12	2.7	16	2.0
			1772	100.0

Drier: 0.2% Lead, 0.02% Manganese, 0.01% Cobalt based on total oil content

Pigment	66.4%
Vehicle	33.6%
Wt, Gal	17.7 lbs.
PV	34.7

Per Cent Volatile in Vehicle by Weight 40.56
Consistency: 100 grams (ASTM Method D 562-42T)

*100% phenol formaldehyde condensate resin, 75 gallon, 100% Chinawood Oil, 35% nonvolatile.

Red Lead-Iron Oxide Structural Steel Primer

	Formula	Per Cent	Pounds	Gallons
Pigment	Red Lead, 97% grade	75.0	1001	13.5
	Iron Oxide, 78% Fe_2O_3	24.8	331	9.1
	Aluminum Stearate	.2	2.6	.3
Vehicle	Raw Linseed Oil	57.0	326	42.1
	Spar Varnish*	25.0	143	19.1
	Thinner and Drier**	18.0	103	15.9
			1906.6	100.0

Pigment	70.0%
Vehicle	30.0%
Wt Gal	19.0 lbs.
PV	31

Per Cent Volatile in Vehicle 29.0

*Phenolic-Chinawood or Oiticica type Alkyd or combination of two or varnish meeting the requirements of Federal Specification TT-V-121a.
**Drier: 0.2% Lead, 0.02% Manganese and 0.01% Cobalt based on oil content.

Red Lead—Varnish Paints

Quick-Drying (Synthetic) Red Lead

U. S. Maritime Commission Specification MC 52-A-1 Class XXII

(Dated June 6, 1939)

	Formula	Per Cent	Pounds	Gallons
Pigment	Red Lead, 97% grade	99.6	1312	17.7
	Aluminum Stearate*	0.3	4	.5
Vehicle	Alkyd Oxidizing Type Resin (Mineral Spirits Solution—50% Solids), containing a minimum of 34% Phthalic Anhydride in solids	80.0	487	63.2
	Plasticizer	0.1	1.5	.2
	Additional Mineral Spirits	20.0	121	18.4
			1925.5	100.0

Drier: 0.03% Cobalt based on vehicle solids
Antiskinning agent*: 0.1 lb. per 100 gallons paint

Pigment	68.3%
Vehicle	31.7%
Wt Gal	19.25 lbs.
PV	41.0

Phthalic Anhydride on total vehicle 13.6% (13.0% minimum specified)
Consistency: 160 grams (ASTM Method D 562-42T)

*When approved by the Maritime Commission limited amounts of suspending agents, antiskinning agents, etc., may be included to meet the full requirements of the specification. See specification for detailed vehicle information.

Glyceryl Phthalate, Exterior, Marine, Red Lead Paint

U. S. Treasury Department Specification No. 358 (Dated July 8, 1939)

	Formula	Per Cent	Pounds	Gallons
Pigment	Red Lead, 95% grade	100.0	1325	17.9
Vehicle	Alkyd Oxidizing Type Resin (Mineral Spirits Solution—70% Solids), containing a minimum of 27% Phthalic Anhydride in solids	78.5	498	61.5
	Additional Petroleum Thinner	21.5	137	20.6
			1960	100.0

Drier: 0.2% Lead and 0.01% Cobalt on vehicle solids
Antiskinning Agent: 0.1 lb. per 100 gallons of paint

Pigment	67.5%
Vehicle	32.5%
Wt Gal	19.6 lbs.
PV	31.0

Consistency: 166 grams (ASTM Method D 562-42T)

Red Lead—Mixed Pigment—Varnish Paints

Quick-Drying (Synthetic) Red Lead Primer

U. S. Maritime Commission Specification 52MC23 (Dated August 28, 1943)

	Formula	Per Cent	Pounds	Gallons
PIGMENT	Red Lead, 97% grade	87.0	1165	15.7
	Magnesium Silicate	9.0	120	5.0
	Diatomaceous Silica	4.0	54	3.2
VEHICLE	Alkyd Oxidizing Type Resin (Mineral Spirits Solution, 70% Solids), containing a minimum of 23% Phthalic Anhydride on Solids (52MC21)	57.3	324	40.5
	Raw Linseed Oil	7.8	44	5.7
	Aromatic Petroleum Spirits or Dipentene*	5.1	29	4.1
	Petroleum Spirits (52T9) and Drier**	29.8	168	25.4
			1904	99.8

Pigment	70.3%
Vehicle	29.7%
Wt. Gal	19.8 lbs.
PV	44.8

Per Cent Volatile in Vehicle by Weight 52
Consistency: 68-78 KU

*Dipentene (52DS INT) may be substituted for all or part of the Aromatic Petroleum Spirits.
**Drier: 0.2% Lead, 0.01% Cobalt based on vehicle solids.

Red Lead Fast Dry Primer for Surfaces Exposed to Fresh Water and Other General Priming Purposes

	Formula	Per Cent	Pounds	Gallons
PIGMENT	Red Lead, 97% Fume	91.7	1150	15.94
	Diatomaceous Silica	8.0	100	5.21
	Aluminum Stearate	0.3	4	.48
VEHICLE	Phenolic Resin Varnish*	94.0	538	74.40
	Thinner and Drier**	5.2	31	4.77
			1843	100.4

Pigment	= 68%
Vehicle	= 32%
Wt Gal	18.4 lbs.
PV	= 35.3

Per Cent Volatile in Vehicle by Weight 45
Consistency: 190 grams (ASTM Method D 562-42T)

*[illegible] phenol formaldehyde condensation resin, 25 gallons, 100% China-wood oil (30% solids).
**Drier: 0.2% Lead, 0.02% Manganese, 0.002% Cobalt based on oil content.

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