FIGHTING RUST WITH SUBLIMED BLUE LEAD

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FIGURE 1

A typical piece of galena ore as mined by the Eagle-Picher Lead Company that contains approximately 80 per cent lead and 11 per cent sulphur in combination to form lead sulphide, the balance being zinc sulphide and other constituents. This ore smelted in special furnaces produces fumes which are collected and ground with oil and marketed by the Eagle-Picher Lead Company as Picher Sublimed Blue Lead, and described in Chapter 3.

Fighting Rust With Sublimed Blue Lead

AN ASSEMBLY OF FACTS CONCERNING THE PROPERTIES AND USES OF SUBLIMED BLUE LEAD

THE EAGLE-PICHER LEAD COMPANY
CHICAGO
1923

FOREWORD

Since the remarkable rust-inhibitive and weather-protective properties of Sublimed Blue Lead are so little known outside of the paint manufacturing industry, it occurred to us that architects and all engineers who are in charge of the erection or maintenance of steel structures should have use for a concise presentation of the principal data covering the properties of Sublimed Blue Lead, together with directions for its use.

Accordingly we have prepared the present publication, it being clearly understood that it is merely an assembly of reliable data for use by engineers who specify paint and painting as an *incidental* part of their work, and who require only such information as has a practical bearing on the results obtained.

We have tried to confine ourselves to things of interest to the user and to anticipate his questions. How well we have succeeded can only be told by our readers, and we trust they will favor us with their criticisms.

THE EAGLE-PICHER LEAD COMPANY.

TABLE OF CONTENTS.

FIGHTING RUST WITH SUBLIMED BLUE LEAD

CHAPTER I

CORROSION OF IRON AND STEEL

Corrosion is the relentless enemy of iron and steel. It operates unceasingly, transforming commercial metal into the oxides of iron of a character similar to natural ores, thus undoing the work that was performed by man when he reduced the iron ore to metal suitable for his purposes.

In this great battle between man and corrosion, corrosion has been the winner up to the present time. The best that man has been able to do is to prolong the fight; corrosion has always won in the end.

This remarkable success of corrosion in achieving the destruction of the utility of iron and its alloys is due principally to properties peculiar to iron itself.

Affinity of Iron for Oxygen

To begin with, iron has such a strong affinity for certain other elements, especially oxygen, that it is never found in nature as a pure metal. In fact, pure iron is one of the rarest sights in the world. It may be purified artificially in the laboratory, but it must be kept sealed and free from contact with other elements; otherwise it instantly absorbs impurities in the presence of air and moisture and reverts to oxides that possess none of the characteristics which make iron so valuable to man.

To give stability and to impart those characteristics most desirable in different kinds of engineering work, iron is alloyed with small amounts of various substances and put through suitable processes of heat treatment and mechanical working.

These processes of converting iron ores into commercial forms of iron and steel suitable for all kinds of construction work, do not, however, eliminate corrosion. The great chemical activity of the iron still remains and in the presence of air and moisture the metal, unless protected, is rapidly disintegrated by corrosion and becomes a heap of dust, worthless unless resmelted and worked through the various metallurgical processes by which it was originally transformed into commercial metal.

Iron and Steel Industry

To realize the magnitude of the iron and steel industry and the importance of these metals to the very existence of our present-day material prosperity is to appreciate the seriousness and the importance of the corrosion problem.

Altogether the United States produces annually approximately 36,000,000 tons* of finished steel, 76 per cent of which is used by ten principal in-

*E. C. Kreutzberg, Iron Trade Review, 1-5-22.

dustries. As shown in the Table I, building leads the list with more than 5,000,000 tons. This includes all structural shapes, plates, concrete reinforcing rods, ornamental iron work, fire escapes, elevators, safes, vaults, window sash, plumber supplies, heating and ventilating equipment, and equipment employed in the manufacture of building materials, such as cement, brick and tile.

TABLE I

FINISHED STEEL OUTPUT

Estimates in net tons

Groups	Normal Annual Requirements	Per Cent Entire Normal Output
Building	5,100,000	14 23
Export	4,815,000	13.43
Automotive	3,540,000	9.82
Car and Locomotive	3,350,000	9.34
Railroad, construction, maintenance and repairs	2,795,000	7.79
Oil, gas and water	2,780,000	7.75
Machinery and hand tool	1.600,000	4.46
Agricultural	1,290,000	3.59
Food container	1,120,000	3.12
Shipbuilding	950,000	2.65
All other requirements	8,500,000	23.71
Totals	35,840,000	99.89

Practically every pound of this enormous production, except steel rails, is protected from the ravages of corrosion by covering the surface with some rust-resisting material.

The cost of this protection is the first tax of corrosion upon the finished steel. General practice is to coat sheet metal, wire and small parts with

FIGURE 2

It has been estimated by experts on corrosion of iron and steel that approximately one million tons a year of steel are being destroyed at the present time by corrosion. This steel if made into structural members would supply enough to build forty Woolworth buildings.

metals, such as zinc, tin or lead. About 60 per cent of all zinc produced in this country is used for galvanizing iron and steel. The larger shapes, such as structural steel, framework of machinery, castings, etc., are protected by painting. Many exposed surfaces are protected by nickel, copper and brass plating, and machined surfaces are usually protected by oil and grease.

In spite of all the protective measures the losses due to corrosion are enormous—over a million tons a year! If this loss were all made into structural shapes it would be sufficient to build forty Woolworth buildings! Surely this is one of the world's big problems!

Indeed, some of the best scientific thought and effort in recent times have been directed to the solution of this problem, and though we have come a long way there is as yet not even a universally accepted theory as to the actual process of corrosion.

Corrosion Theory

If corrosion is to be combated successfully, there must be developed a working theory that is sound. So far we have only a number of hypotheses. Of all the various hypotheses (and there have been many) that have been advanced, the electrolytic has received the largest measure of support. Lately, Friend's colloidal hypothesis, which was advanced to meet some of the objections that were urged against the electrolytic hypothesis, has shared honors with its older competitor.

As far as assistance in formulating protective and preventive measures is concerned, it makes little difference which hypothesis is used as the theory. For our part we shall not presume to choose, but will limit ourselves to a brief statement of each, merely giving such data as might be required rather than ask the reader to refer to another book.

Electrolytic Corrosion Hypothesis*

Due to physical and chemical differences at various points on the surface of any iron or steel, differences of potential always exist, and whenever moisture is present to connect these points of different potentials electrically and act as an electrolyte,

*For those who wish to go into details of corrosion, the following bibliography compiled by the Research Department of The Eagle-Picher Lead Company will be of use.

ELECTROLYSIS AND CORROSION
A. S. Cushman
Proc. A. S. T. M., VIII, 238

SOME EXPOSURE TESTS OF STRUCTURAL STEEL COATINGS
C. M. Chapman
Proc. A. S. T. M., X, 401

FURTHER RESULTS OF THE WESTINGHOUSE, CHURCH, KERR & CO. PAINT TESTS
A. S. Chapman
Proc. A. S. T. M., XI, 628

THE INHIBITIVE POWER OF CERTAIN PIGMENTS ON THE CORROSION OF IRON AND STEEL
A. S. Chapman
Proc. A. S. T. M., VIII, 605

THE MECHANISM OF CORROSION
J. Newton Friend, J. Lloyd Bentley and Walter West
Engineering, 93, 714; Engineer, 113, 527

PAINT AND VARNISH COATINGS AS ACCELERATORS IN THE CORROSION OF METALS
W. H. Walker and W. K. Lewis
J. Ind. Eng. Chem., 1, 754

TESTS FOR BOND AND ELECTROLYTIC CORROSION OF PAINTED REINFORCING STEEL
H. A. Gardner
Eng. News, 73, 136-7 (1913)

PAINT VEHICLES AS PROTECTIVE AGENTS AGAINST CORROSION
M. Toch
J. Ind. Eng. Chem., 7, 51-4 (1915)
J. Soc. Chem. Ind., 34, 592-5 (1915)

POWERFUL INFLUENCE OF BASIC PIGMENTS IN PROTECTING METALS FROM CORROSION
H. A. Gardner
Eng. Record, 68, 93-4

electricity will flow from parts of positive potential to parts of negative potential.

When electricity leaves a metal and enters a liquid (electrolyte) it corrodes the metal by removing particles which then dissolve in the liquid.

In the case of iron, the metallic iron enters the solution where it unites with oxygen and is precipitated out as oxide or rust.

Without oxygen the process could not continue because the electrolyte would quickly saturate with iron and the difference in potential would disappear, a phenomenon known as polarization. The oxygen by precipitating the iron out of the solution depolarizes the system and enables corrosion to continue indefinitely.

PRESERVATION OF IRON
J. N. Friend, Carnegie Scholarship Report
Iron and Steel Institute, May, 1913, 100-168
THE PRESERVATION OF IRON AND STEEL
A. S. Cushman
U. S. Dept. of Agr., Office of Public Roads, Bulletin 35
PRESERVATION OF IRON AND STEEL
A. S. Cushman
Engineering, 87, 710-42
PAINTS FOR METALLIC STRUCTURES
A. S. Cushman
International Association for Testing Materials, 2, (10) XXIV
DOES PAINT KEEP IRON FROM RUSTING?
Erik Liebreich and Fritz Spitzer
Z. Elektrochem., 18, 94-9
CAN IRON RUST BE PREVENTED BY COATINGS?
E. Liebreich
Orig. Com. 8th Intern. Congr. Appl. Chem., 12, 143-154
METAL PROTECTIVE PAINTS
H. A. Gardner
Trans. Amer. Electrochem. Soc., 39, 223
RUST AND RUST PREVENTIVES
L. Hecht
J. Gasbel, 57, 113-5
THE RUSTING OF IRON; ITS CAUSE AND ITS PREVENTION BY PAINTING
George Pfleiderer
Z. Ver. dent Ing., 57, 221-5
THE FORMATION OF RUST UNDER PROTECTIVE PAINTS
E. Liebreich and F. Spitzer
Z. Elektrochem., 19, 295-301
THE FORMATION OF RUST UNDER PROTECTIVE PAINTS
George Pfleiderer
Z. Elektrochem., 19, 507-10

Colloidal Corrosion Hypothesis

According to J. Newton Friend*, iron in the presence of moisture and oxygen oxidizes into ferrous hydroxide which he claims is in the colloidal state;** in which state substances are extra active chemically. Hence, the ferrous hydroxide immediately takes up more oxygen, becoming ferric hydroxide, still remaining in the colloidal state. The colloidal ferric hydroxide now extracts more iron from the original metal and the process begins all over again.

The ferric hydroxide is said to act as a catalytic agent (one which transfers by contact molecules from one substance to another) taking up iron on the one hand and oxygen on the other, alternately reducing to ferrous hydroxide and then oxidizing to ferric hydroxide until the processes of converting iron into rust is entirely complete.

Moisture and Oxygen

While there are certain definite differences between the two hypotheses above set forth, the two agree absolutely on the necessity of the moisture and oxygen for the continuation of the process of corrosion; hence, one sure way of killing corrosion is to exclude oxygen and moisture; easily

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*New Theory of Corrosion of Iron, Journal of the Chemical Society of London, Vol. 119—page 932, 1921.

**Colloidal state in this instance signifies minute particles (less than 0.00001 millimeter in diameter) dispersed in a liquid medium; particles too small to precipitate without coagulation and too large to pass through a membrane as they would if in true solution.

stated, but practically impossible of perfect accomplishment.

Action of Basic Substances

Another important point where both agree is in the action of basic, or alkaline substances upon the process of corrosion. The basicity of any substance is measured by the amount of a given acid required to neutralize it.

Bases will inhibit corrosion by neutralizing the potential differences between the various parts of the surface, and thus eliminate the possibility of electrolytic action at areas on the iron that are naturally electro-positive. Since a basic coating neutralizes the electro-positive areas on the iron, it must prevent corrosion.

Looking at the subject from the colloidal viewpoint, basic substances are found to arrest the catalytic action of the ferric hydroxide by neutralizing the electric charges that made the action possible and changing the hydroxide from a colloidal to an amorphous state, in which it ceases to promote corrosion.

Prevention of Corrosion

No matter to which hypothesis we may subscribe, the preventive measures that suggest themselves are the same, namely:

1. Inhibitive electro-chemical or colloidal reactions.
2. Exclusion of moisture and oxygen.

In painting practice, all three of these principles should be employed; first, since we have no practical way of assuring a perfectly dry surface at the time the painting is done; and second, since the paint coating cannot be absolutely impervious to moisture, it is necessary to employ as paint a basic substance which will inhibit any corrosion that may be incipient on the surface at the time of painting, or become so later due to the penetration of moisture; therefore the first requirement of rust-resisting paint is that it have proper basicity.

While it is essential to neutralize the corrosive action by the use of a basic coating, it is also necessary to maintain such coating intact for a long period of time if a commercial result is to be obtained. To remain intact such coating must withstand all normal atmospheric conditions of moisture and temperature. It must withstand such chemical action as the atmosphere in the particular locality will inflict upon it. It must resist such mechanical actions as are present under any given service conditions.

Rust-Proofing

To sum up the requirements in two thoughts, the rust-proofing paint must be:

1. Rust inhibitive.
2. Weather resistive.

It must be chemically constituted to prevent corrosion and mechanically constituted to hold its own against the wear and tear of service conditions.

Rust-Proofing Paint

Paint consists in general of a pigment and a vehicle, and one is just as important as the other in determining the service qualities of the resulting paint. The union between the pigment and the vehicle may be mechanical, chemical, or both. However, whether the pigment is linked with the vehicle by chemical or mechanical means, there are certain conditions which the paint must fulfill.

H. A. Gardner, a well-known authority on paints, painting and rust-proofing with paint, recently stated the conditions which should be fulfilled by a rust-proofing paint, as follows:

> "1. The paint employed must be prepared in such a manner as to be easy of application by brush or spray gun and must form, when dry, a coherent layer, possessing maximum power of resistance.
>
> "2. It should be prepared from pure linseed oil, and contain none but pigments ground as finely as possible. The major portion of the pigments should be of a basic or chromate nature.
>
> "3. The paint should dry sufficiently in 12 hours to withstand any rainfall to which it may be exposed.
>
> "4. The grinding should be carried so far that 99 per cent of the paste may be washed through a 325-mesh screen with a solvent. The paint shall dry with a smooth surface, and should not run down or sag when applied to perpendicular surfaces.
>
> "5. The adhesion to the metal must be perfect and the dried paint must be elastic."

FIGURE 3

Young's Million Dollar Pier, Atlantic City. At the end of five years there were only 23 out of 300 panels of the Atlantic City test fence that warranted further observation, and these were transferred to the ocean end of Young's Million Dollar Pier where they were exposed during the sixth year, just before the final rating was made. (See page 21.)

CHAPTER II

RATING OF RUST-PROOFING PAINTS BY THE AMERICAN SOCIETY FOR TESTING MATERIALS

In order to obtain reliable information as to the respective rust-proofing values of various commercial paints, the American Society for Testing Materials in co-operation with the Paint Manufacturers' Association of the United States staged an outdoor test in Atlantic City. This locality was chosen as especially unfavorable to paint protection, and therefore one which would yield results in the shortest time.

Preparation of Specimens

Specimens to be tested were applied to 300 steel plates which were erected as panels of a fence.

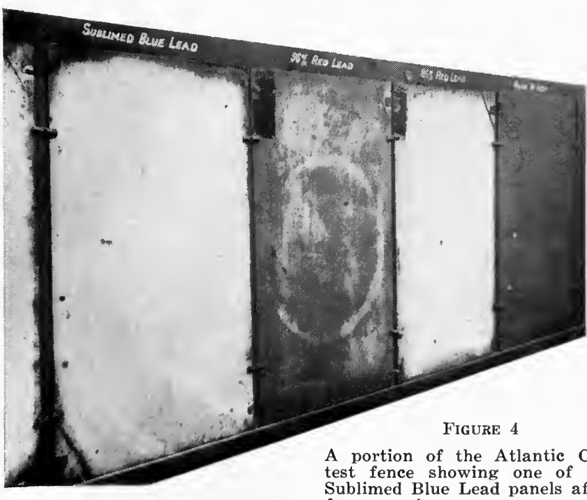


FIGURE 4

A portion of the Atlantic City test fence showing one of the Sublimed Blue Lead panels after four years' exposure.

Each panel was carefully insulated to avoid any possibility of electrolysis from external stray currents. Before painting the plates were carefully cleaned and dried; three coats were applied, with ample time between coats to dry. Special pains were taken to cover the edges as this was considered a weak point where corrosion might start. In short, every precaution was exercised to give each sample the best possible attention as far as skillful application of the paint was concerned.

Committee Reports

Some of the paints failed from the start, but no official report was made until two years had elapsed, when a committee was chosen to examine the fence and report. Each member of the committee made his own individual report based on his own observations and the official report was compiled from these.

In judging the condition of the paint, chalking, checking, cracking, scaling, peeling, color and condition for repainting were all considered. Separate ratings were given for condition as to corrosion and condition as to weather protection. The final rating was a grand average of all points. The perfect paint received a rating of ten.

Inspections were made at intervals of one year for four years, when the number of paints remaining in condition for rating was so small that the test was concluded and the final report turned in. The full account of these tests and the results were given in the Proceedings of the American Society for Testing Materials, Volume IX, 1909, pp. 203,

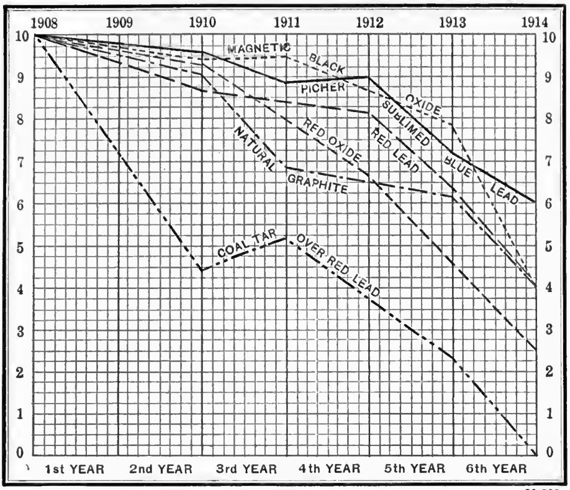


FIGURE 5

In order to make possible a comparison of the performance of Picher Sublimed Blue Lead with other commercial pigments commonly used for painting steel, the above chart of ratings was plotted year by year over the complete test period. The ratings here given are the averages of all those given by the different members of the Committee. The Chairman of the Committee who served through the entire period rated Sublimed Blue Lead as follows:

Third year 9.5
Fourth year 9.0
Fifth year 8.5

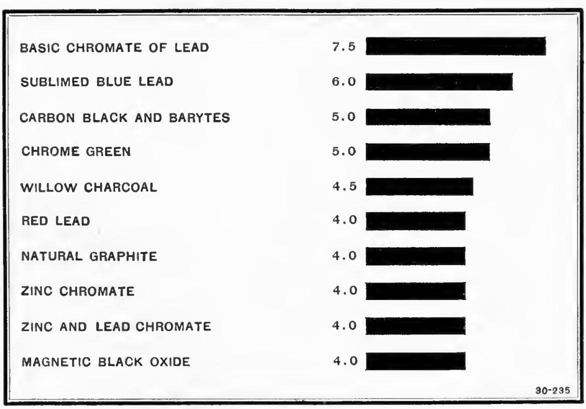


FIGURE 6

The above ten pigments received the highest rating as given at the last inspection of the surviving panels from the Atlantic City test fence which were exposed on Young's Pier.

204; Volume X, 1910, pp. 79-86; Volume XI, 1911, pp. 192-194; Volume XIII, 1913, pp. 369-371; Volume XIV, 1914, Part I, pp. 259, 260.

After five years' exposure on the fence most of the specimens had reached the limit of their usefulness, so much so that all but twenty-three were abandoned. The twenty-three worthy of further study were transferred to the ocean-end of Young's Million Dollar Pier where they were exposed for one year before the final report.

Ratings

At the start there were nearly one hundred paints; at the end of two years only twelve scored 9 or better; at the end of the test, six years from the start, only two paints scored 6 or better, and Sublimed Blue Lead was one of these! The only paint that rated as good or better than Sublimed Blue Lead was American Vermillion (basic chromate of lead) which obtained a rating of 7.5 against Sublimed Blue Lead of 6. American Vermillion is too expensive to be used unadulterated as a paint for protecting steel; therefore Sublimed Blue Lead in Oil stands at the head of the list of commercial paints for rust-proofing structural steel.

To give an idea of the standing of Sublimed Blue Lead in comparison with pigments that are well known to engineers and architects, the ratings of some of those which made the best showing have been plotted with time in Figure 5. It is interesting to note that while the slope of most of these paints indicates six years as approximately the limit of useful life, Sublimed Blue Lead was declining at a much slower rate than the others.

CHAPTER III

SUBLIMED BLUE LEAD

Sublimed Blue Lead is a fume product derived from lead sulphide ore by smelting in special furnaces. Used as a pigment and mixed with the proper amount of pure linseed oil as vehicle, it makes a rust-proofing paint that fulfills the five basic conditions set forth on page 19.

Sublimed Blue Lead Analysis

Sublimed Blue Lead is a basic sulphate of lead which upon analysis runs approximately as follows:

Lead Sulphate ($PbSO_4$)	45-55 per cent
Lead Oxide (PbO)	30-40 per cent
Lead Sulphide (PbS)	Not over 12 per cent
Lead Sulphite ($PbSO_3$)	Not over 5 per cent
Zinc Oxide (ZnO)	Not over 5 per cent
Carbon and undetermined	Not over 5 per cent

The major components of Sublimed Blue Lead are in chemical combination. A mechanical mixture of the proper amounts of exactly the same ingredients to give the same analysis does not in any way produce Sublimed Blue Lead and does not exhibit the same properties when mixed with pure linseed oil to make paint.

Galena

The raw material used in the manufacture of Sublimed Blue Lead is Galena, lead sulphide ore. Some of the finest deposits in the world are located in the Joplin District of Missouri, where the Eagle-Picher Lead Company operates various mines and manufactures Sublimed Blue Lead.

Manufacture of Sublimed Blue Lead

In making Sublimed Blue Lead, the ore, Galena, which as obtained from the Joplin field shows about 80 per cent lead content and 11 per cent sulphur content, in combination to form lead sulphide, the balance being zinc sulphide and other constituents, is mixed in suitable proportions with bituminous coal and slag and charged into furnaces of the Scotch-hearth type.

These furnaces are designed and operated to produce fumes that come off the surface of the molten charge and are caught by a hood which conducts them to a flue, where they are joined by fumes of other furnaces. They then pass through an enormous cooler made up of a series of loops 40 feet or more in height.

The draft necessary to pull the fumes from the furnaces is produced by a fan which discharges into a collector consisting of a series of long bags held in a vertical position.

These bags act as filters, allowing the gases to pass out and retaining the solid particles of Sublimed Blue Lead in the same way that the bag of a vacuum cleaner retains the dust.

At intervals the bags are automatically shaken and the Sublimed Blue Lead dust falls into hoppers from which it is drawn as required into barrels for shipment.

The principle of operation of a Sublimed Blue Lead plant is illustrated diagramatically in Figure 7.

Dry Sublimed Blue Lead

Sublimed Blue Lead in the dry state as it comes from the smelter is used in the manufacture of paints and rubber. The Eagle-Picher Lead Company sells the dry product to paint manufacturers and to rubber manufacturers. It also grinds the Sublimed Blue Lead with pure raw linseed oil and markets it in paste form ready to mix with oil, drier and thinner for rust-proofing purposes.

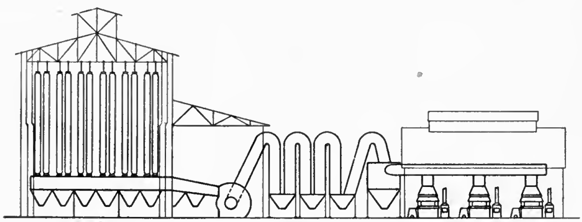


FIGURE 7

Process diagram illustrating the manufacture of Sublimed Blue Lead. Galena Ore mixed with bituminous coal and slag is smelted in special furnaces and the fumes collected by a flue system and passed through a series of goosenecks to cool the gases. The draft for handling the fumes is produced by a fan which exhausts the fume-carrying gases into a system of vertically arranged bags that act as filters to separate the dust from the gases. These bags are shaken automatically at stated periods, the Sublimed Blue Lead following into hoppers from which it is drawn into containers and made ready for shipment.

Linseed Oil

The vehicle is just as important as the pigment in determining the quality of a rust-proofing paint. There has been a long sustained effort on the part of paint technicians to develop other oils that could be substituted for a linseed oil, but up to the present time there is no oil that can be counted on to give the service that can be obtained with pure raw linseed oil.

Boiled linseed oil is specified by many for use with Sublimed Blue Lead because it dries quicker. Raw linseed oil can be given the same drying characteristics by adding suitable drier, and many believe that superior durability is obtained with raw oil.

Linseed oil has been exhaustively studied and engineering specifications for judging its suitability for paint surfaces have been prepared by, and may be obtained from, the American Society for Testing Materials.*

Sublimed Blue Lead in Oil

The grinding of Sublimed Blue Lead powder with oil is a mighty important operation, and unless done in a thorough-going manner, the resulting paste will make inferior paint.

The Eagle-Picher Lead Company produces Sublimed Blue Lead in Oil by the most modern meth-

*Linseed Oil Specifications, 1921, A. S. T. M. Standards, pages 655-658.

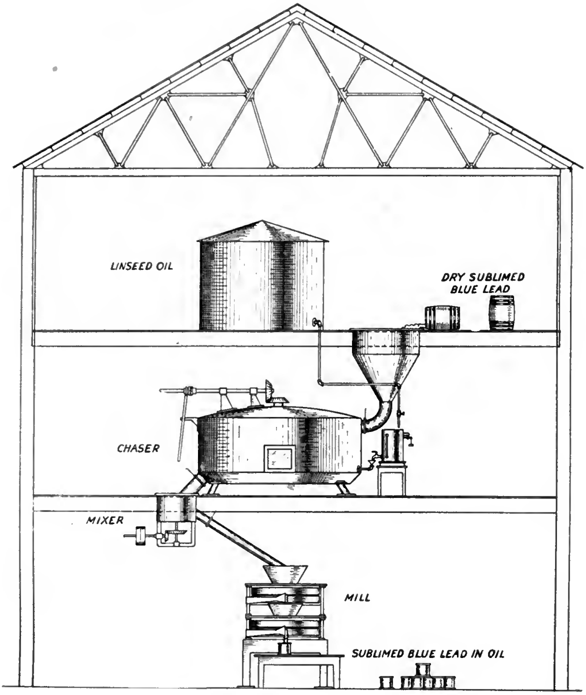


FIGURE 8

Grinding Sublimed Blue Lead with oil. The process of grinding Sublimed Blue Lead in Oil as conducted by the Eagle-Picher Lead Company takes place in two stages; carefully settled pure raw linseed oil and dry pure Picher Sublimed Blue Lead are mixed in accurate proportions of 9 to 1 in a Chilean mill or Chaser, the mill taking one batch at a time. The batch when thoroughly mixed is dumped into a mixer which is merely a tank equipped with an agitator. From here it flows by gravity in a continuous stream to a burrstone mill, going in at the eye and coming out at the periphery. The degree of grinding required is obtained by the use of two mills in series and the final product is delivered directly into containers.

ods. No other raw materials are employed. These two are accurately weighed and mixed in a proportion of nine parts of Sublimed Blue Lead to one part oil by weight, in a Chilean mill, which consists of a large shallow pan, over the bottom surface of which a solid iron roller travels. Steel scrapers follow the roll and turn the mixture from both sides back into the path of the roll, thus aiding in the thorough mixing of the two ingredients. This machine is completely enclosed to avoid dust and prepares a batch at a time. When the mixing of the oil in the pigment is complete, the batch is dumped into a vat or tank equipped with an agitator, and from this mixing tank it flows continuously into the eye of a burrstone mill. From this mill it flows into a second mill, and from there into a cooling tank shaped like a hopper, from which it is pumped by a rotary pump into kegs and other containers as required for shipment.

Physical Properties of Sublimed Blue Lead

Dry Sublimed Blue Lead is a slate gray colored pigment of an almost impalpable fineness. With the exception of lamp black, Sublimed Blue Lead is the finest pigment in use today, the particles being of the order of 0.0002 millimeter (0.2μ) in diameter. An idea of how small this really is may be obtained by comparing this with cement particles. Ordinary dry cement leaves approximately 22 per cent on a 200-mesh screen, while Sublimed Blue Lead will pass completely through a 325-mesh screen. A 200-mesh screen has 40,000 holes per square inch, while a 325-mesh screen has 106,000 holes. The relative size of these screens is shown plainly in Figure 9.

Picher Sublimed Blue Lead in Oil mixed with pure raw linseed oil and not more than 5 per cent by weight of drier will form a coating the modulus of elasticity of which is far above that required by any deformation that can take place by expansion of the metal to which it is applied.

The specific gravity of Sublimed Blue Lead is 6.67, that is, it weighs 6.67 times as much as an equal volume of water. One solid gallon weighs 55.56 pounds and one pound bulks 0.018 gallon.

Paint Characteristics of Sublimed Blue Lead

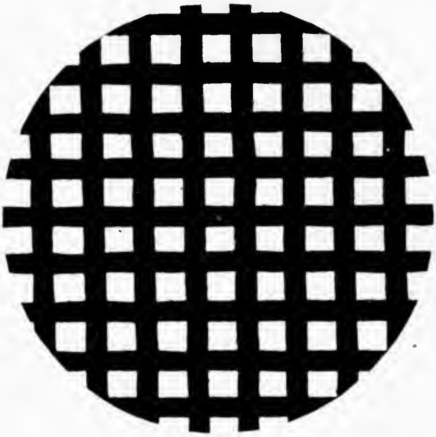
Sublimed Blue Lead paste mixed with proper proportions of pure linseed oil makes a rust-proofing paint, possessing unusually fine qualities.

Mixing with Oil

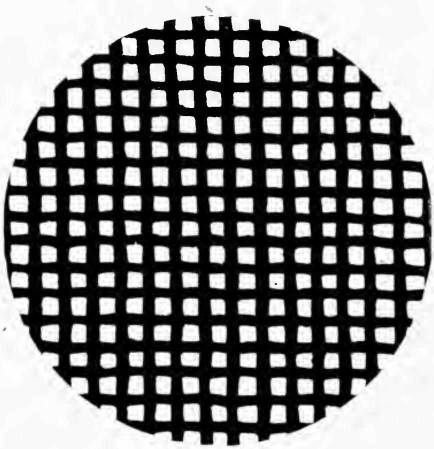
Sublimed Blue Lead mixes perfectly with pure linseed oil and once mixed it remains in suspension. Therefore, Sublimed Blue Lead in oil does not harden or liver in the container and can be kept without deterioration.

Inhibition of Rust

Sublimed Blue Lead in Oil being a basic (material electro-positive toward iron), inhibits rusting.



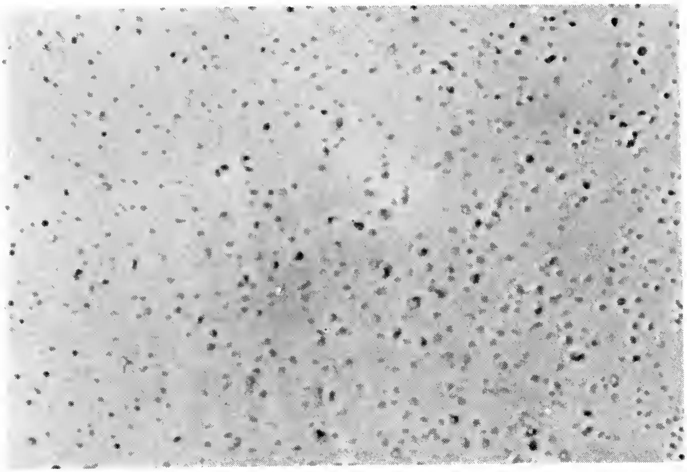
200 mesh screen.



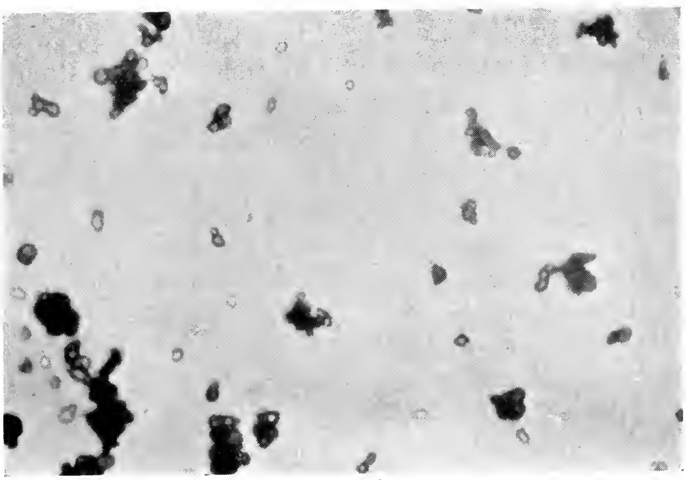
325 mesh screen.

FIGURE 9

As a means of visualizing the fineness of Sublimed Blue Lead, a 200-mesh and a 325-mesh screen are reproduced with a 50 diameter enlargement from photomicrographs. Dry cement leaves approximately 22 per cent residue on the 200-mesh screen, while Sublimed Blue Lead will wash through a 325-mesh screen without any residue.



Sublimed Blue Lead.



Red Lead.

FIGURE 10

Comparison between photomicrographs (2,000 diameter enlargement) of Picher Sublimed Blue Lead and pure red lead, indicating the difference in uniformity of size and shape of the particles, as well as the distribution of the particles in the oil film.

Adhesion

Sublimed Blue Lead in Oil, being composed of uniform and extremely fine particles that remain in suspension in oil, enters into intimate contact with every part of the iron surface, whether rough or smooth, thus assuring perfect adhesion.

Cohesion

Sublimed Blue Lead in Oil, because of its exceedingly small particles evenly distributed in the oil, flows together behind the brush, eliminating brush marks and forming a coating of even thickness that does not sag.

Drying

Sublimed Blue Lead in Oil dries in twelve hours to form a tough and elastic coating that will stand the wear of severe weather conditions and take subsequent coats with perfect adhesion between the two.

Opacity

Sublimed Blue Lead in Oil, due to the uniformity of the coat and the color, has a remarkable hiding power. A gallon of properly mixed Sublimed Blue Lead in oil will cover approximately 800 square feet per gallon on surfaces of average smoothness.

Color

The natural color of Sublimed Blue Lead in Oil is slate gray. It can be mixed with other materials, such as chrome green, chrome yellow, red lead, etc., to obtain a variety of colors without appreciably changing its remarkable rust-proofing qualities.

Temperature

Heat and cold within the range of normal atmospheric conditions do not affect the use of Sublimed Blue Lead in Oil, nor require a change in the formula of its mixture. Once applied, its elasticity, its adhesion and its cohesion cause it to go and come with the metal without damage to its rust-proofing power.

Gases

Sulphur and carbon dioxide present in the atmosphere, especially in industrial centers, do not deteriorate the rust-proofing quality of Blue Lead in oil.

Brushing

Sublimed Blue Lead in Oil, due to its texture and perfect mixture with the oil, spreads easily and uniformly over rough surfaces and smooth. It permits fast work and requires less muscular power on the part of the painter.

Durability

Sublimed Blue Lead in Oil proved its durability at Atlantic City (see page 23).

Repainting

Sublimed Blue Lead when ready for repainting needs simply to be brushed in order to furnish a perfect surface to receive more coats. This was proven at the Atlantic City tests (see page 23).

CHAPTER IV

USE OF SUBLIMED BLUE LEAD

Sublimed Blue Lead in Oil may be employed for rust-proofing wherever iron or steel is used. In short, it fills a need in every industry, including building, railroad, marine, mining, manufacturing, public utility and agriculture.

With the whole world as a field, it is impossible even to consider a specific description of every use of Sublimed Blue Lead. It is proposed here to limit the discussion to general principles that apply to practically all cases.

New Surfaces

Paint must come into intimate and perfect contact with sound metal if it is to perform its rust-proofing functions for any appreciable length of time. Therefore, the first requisite for a satisfactory job of rust-proofing is a dry surface free of rust, dirt and grease.

New metal from hot rolling or heat treating processes is usually covered with mill scale (black oxide of iron) which must be removed before painting. To paint on top of scale is useless, as the scale is sure to come off once the steel is in service where it is subjected to changes in temperature.

Scale is removed by scraping, sandblasting or pickling. The particular process employed is a

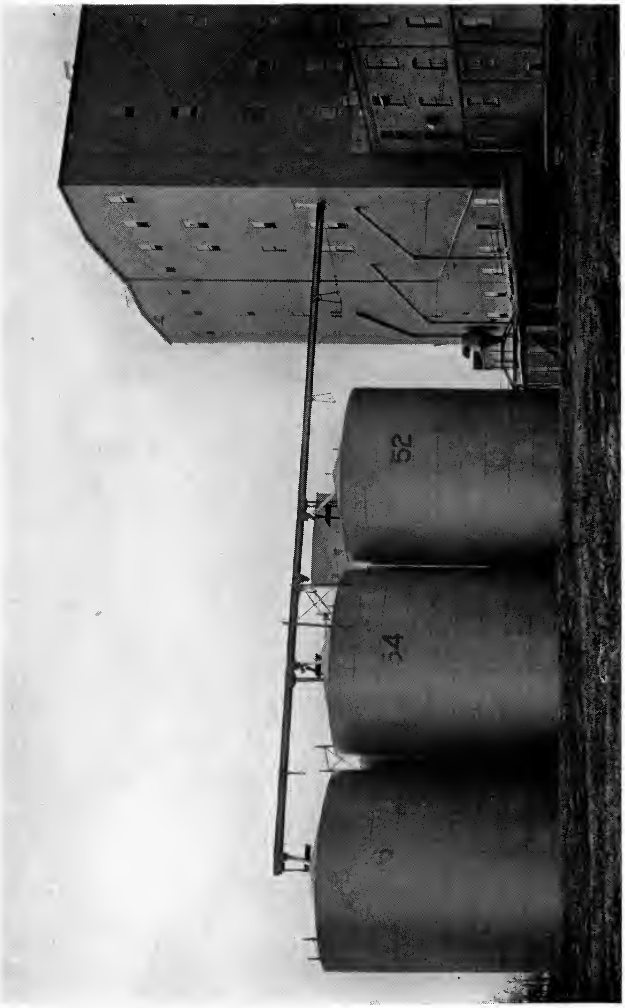


FIGURE 11
Steel seed storage tanks painted with Picher Sublimed Blue Lead in Oil.

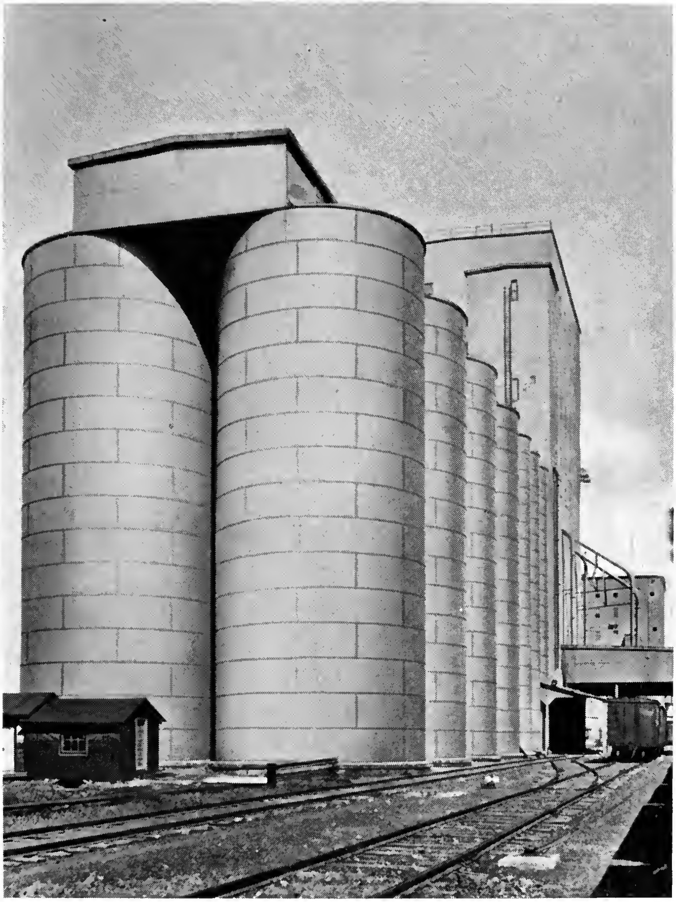


FIGURE 12

Steel seed storage tanks painted with Picher Sublimed Blue Lead in Oil.

FIGURE 13

In 1916 this Highway Bridge in South Beloit, Ill., was painted with three coats of Picher Sublimed Blue Lead in Oil. It has not been repainted or touched up since—yet it is in perfect condition.

matter to be decided on the ground, where full knowledge of local conditions is available.

Steel that is punched, drilled or otherwise machined is always smeared with grease and dirt. Brushing and scraping are never completely successful in removing grease and oil. Sandblasting and pickling are both effective in cleaning such surfaces.

From the standpoint of the painter, it makes little difference *how* a surface is cleaned, so long as it is clean and dry at the time the paint is applied, and this is more important for the first coat than for any other as far as rust-proofing is concerned.

Old Surfaces

When painting over old surfaces that have been painted before, the same principles as set forth under New Surfaces also obtain, except that old paint which firmly adheres to the metal may be regarded as good as sound metal upon which to apply new paint.

If the old paint does not adhere well, it should be completely removed by scraping, burning with a torch or sandblasting. In any case, the whole surface should be brushed and cleaned of all loose dust, grease and moisture.

Each successive coat of paint can be no better than the weakest coat beneath it.

FIGURE 14

Twin City Tractors shown in action in the above photographs are all painted with Picher Sublimed Blue Lead applied by spraying.

Galvanized Iron

Galvanizing is seldom so perfect as to afford sheet metal a sure protection from corrosion. Any imperfection in the coating will start intense corrosive action and soon puncture the iron. Therefore, all galvanized sheet metal should be rustproofed with suitable paint.

The natural surface of new galvanized iron is so smooth that paint will not adhere properly to it. To prevent peeling by assuring uniform and perfect adhesion of the paint, the surface can be roughened by brushing it with a weak copper solution. H. A. Gardner* recommends as solution 4 ounces of copper acetate, copper chloride, or copper sulphate dissolved in 1 gallon of water.

An hour or so after the surface is brushed with this solution it may be lightly rubbed off with a dry brush, after which it is ready for a priming coat of Sublimed Blue Lead.

Tin Plate

Tin plating of sheet iron, like galvanizing, can not be relied upon to prevent corrosion, because minute imperfections not only permit but actually intensify the corrosive processes.

The surface of new tin plate is slightly greasy; therefore, in order to prepare it for painting, it must be cleaned dry. This may be done by using benzine or turpentine and a soft cotton rag.

*Gardner International Association of Master Car & Locomotive Painters' Convention, 1915.

Paint Formulas

The mixing of Sublimed Blue Lead paste and linseed oil to make paint is a very simple matter, but strange to say, there are almost as many ideas as to relative quantities of these two substances in the mixture as there are painters who use it. Formulas recommended range all the way from 50 per cent to 70 per cent pigment by weight.

The State standards for highway bridges in Iowa require that Sublimed Blue Lead in Oil paint shall not contain less than 60 per cent pigment in the shop coat and not less than 50 per cent in the field coat. Boiled oil is specified in both cases.

The State standards for bridges and concrete reinforcing rods in Illinois require that Sublimed Blue Lead in oil paint shall not take less than 50 per cent nor more than 54 per cent pigment. Boiled oil is specified in all cases.

The Eagle-Picher Research Department recommends 70 per cent pigment to 30 per cent pure raw or boiled linseed oil. If raw linseed oil is used, a suitable quantity of drier (not to exceed 5 per cent) must be added.

Tables giving quantities of oil, pigment and paste involved in mixtures of various proportions are given on pages 62 and 63.

Brushing

To be effective, even on surfaces that are perfectly prepared, rust-proofing paint must be properly and conscientiously applied. The architect or

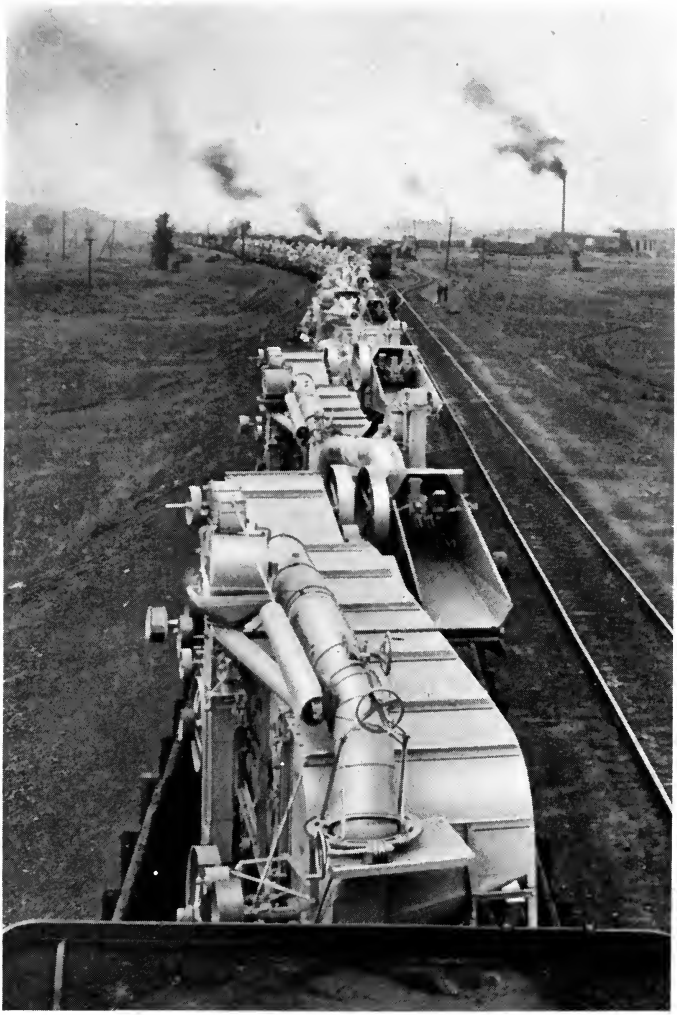


FIGURE 15
Train load of twenty-seven threshing machines, all of which are painted with Picher Sublimed Blue Lead.

engineer writing specifications for painting can do little more than to specify the size and kind of brushes, and require thorough and proper brushing. A competent paint contractor is the surest if not the only way to assure proper application of the paint to the surfaces to be protected. Supervision is only a rough check. It can never be sufficiently detailed to compensate for the lack of conscientious workmanship.

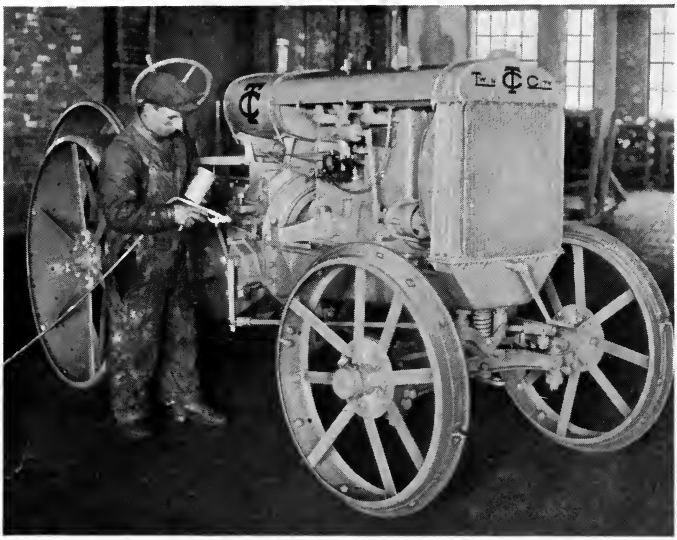


FIGURE 16

Rust-Proofing Twin City Tractors in plant of the Minneapolis Steel & Machinery Co., Minneapolis, Minn. Illustration shows workman applying with Pasche air brush a finishing coat of Picher Sublimed Blue Lead in Oil tinted gray with Eagle Sublimed White Lead. The first coat used on these tractors is Picher Sublimed Blue Lead in Oil, thinned with naphtha, to which 5 per cent of oil has been added.

The kind of brushes used varies with the character of the work. In general, brushes that are too large should be avoided, especially brushes that are wide and flat. For structural steel round brushes are preferred, as they enter corners and other places difficult of access. Then, too, the round brush applies more pressure and requires more strokes than a flat brush—all of which is good for the paint.

Spraying

Sublimed Blue Lead because of its fine particles and its perfect suspension in oil is excellently adapted to application with a spraying device.

The ideal application of spraying is in connection with production work in manufacturing processes, where articles of the same character must be kept moving through the manufacturing process at a given rate. In such cases wonderfully uniform results are obtained with a minimum of labor and space. Spraying is also well suited for painting large areas, such as walls, roofs and ceilings. Time can often be saved where rough surfaces are involved by combining spraying and brushing. The paint is first applied very rapidly with a spray and then brushed out to a uniform film.

In mixing Sublimed Blue Lead for spraying purposes, the same proportion of pigment to oil is used as for brushing, namely, 70 pigment, 30 oil. To this a volatile thinner, such as turpentine, benzine, or gasoline, is added until paint of the proper consistency for application with the spraying apparatus is obtained.

Dipping

Sublimed Blue Lead, having no tendency to settle or harden when mixed properly with oil, makes an excellent paint for dipping.

Dipping is applicable only to shop or factory work. It requires facilities for handling the articles to be dipped, as well as for draining and drying them. There is no practical limit on the size of article that can be dipped except the equipment for handling it.

FIGURE 17
Sublimed Blue Lead in oil mixed with linseed oil and thinned with naphtha is here used for dipping. The perfection of the suspension of Sublimed Blue Lead in linseed oil and the fineness and uniformity of the pigment give a non-settling, non-livering paint especially well suited to dipping applications.

Dipping is not satisfactory for structural steel. In fact, good practice will not tolerate anything but brushing for the shop coat on structural steel.

The formula for dipping paint will vary somewhat with the character of work. The following formula has been successfully used:

100 lb. of Sublimed Blue Lead in Oil.
7 gal. of raw pure linseed oil.
2 pt. of drier.
6 pt. of benzine or naphtha.

Number of Coats

A number of thin coats, each one thoroughly dry before the next is applied, make the most durable job.

However, since the time and labor factors are of such importance in most operations, practice has finally settled down to the use of three coats as standard for general rust-proofing work.

The first coat on steel work is applied in the fabricating shop and is called the "shop coat." The second and third coats are applied on the job at the time of erection and are called "field coats."

In order to facilitate inspection by enabling an inspector to tell at a glance what coat or coats have been applied, it is usual to specify a definite color for each coat.

Colors

The natural color of Sublimed Blue Lead in Oil is slate gray, a very agreeable color for outdoor

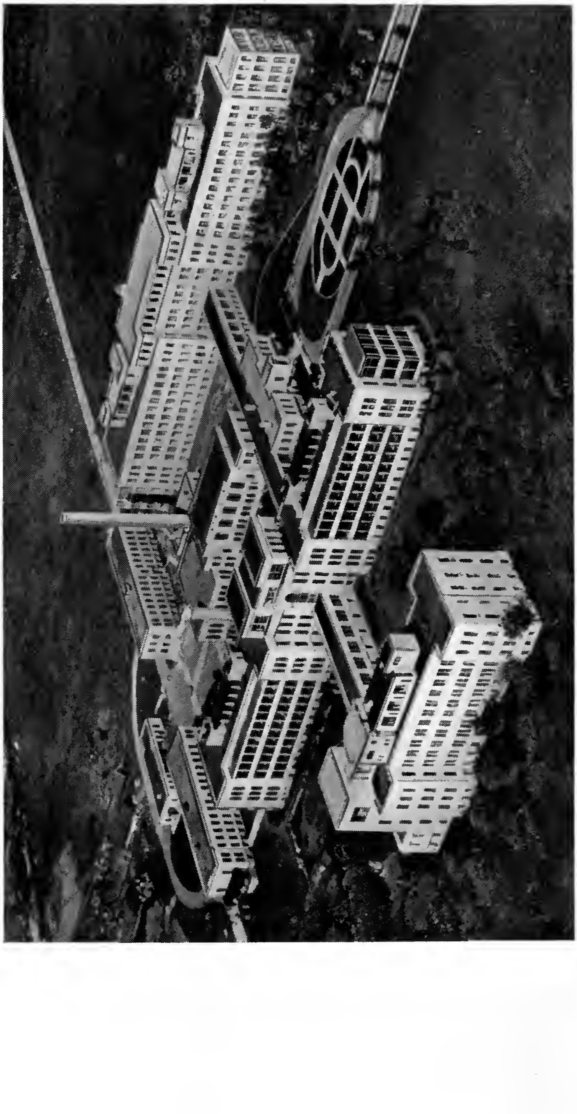


FIGURE 18
City Hospital in Buffalo, N. Y. Architects, F. J. and W. A. Kidd. All the steel work in these buildings was painted with Picher Sublimed Blue Lead according to specifications.

structures, and one which blends well with natural surroundings.

When other colors are desired, pigments, such as American Vermillion, Red Lead, Chrome Yellow, may be added to the Sublimed Blue Lead. Such pigment should be in paste form and when mixed with Sublimed Blue Lead paste and linseed oil the proportion, 70 pigment to 30 oil, should be maintained.

FIGURE 19

This corrugated steel building was painted in 1914 with Picher Sublimed Blue Lead in Oil. It is still in good condition and has protected the metal from corrosion. The building in the upper illustration, which is part of the same plant, was painted in 1921, seven years after the painting of the main shop buildings, and is proof that the owners, Shoemaker-Satterthwait Bridge Company, Pottstown, Pa., were satisfied with the performance of Sublimed Blue Lead in Oil.

Pure Sublimed Blue Lead in Oil.

50 per cent Sublimed Blue Lead in Oil and 50 per cent Commercial Chrome Yellow.

80 per cent Sublimed Blue Lead in Oil and 20 per cent Commercial Chrome Yellow.

95 per cent Sublimed Blue Lead in Oil and 5 per cent Commercial Chrome Yellow.

50 per cent Sublimed Blue Lead in Oil and 50 per cent Commercial Chrome Green.

50 per cent Sublimed Blue Lead in Oil and 50 per cent Red Lead.

50 per cent Sublimed Blue Lead in Oil and 50 per cent Eagle White Lead.

CHAPTER V

SUGGESTED PAINTING SPECIFICATIONS FOR STRUCTURAL STEEL WORK

1. *GENERAL.* All paint and materials for painting shall be of the quality herein specified. Paints or pastes which have hardened on standing or which have thickened or otherwise deteriorated will not be acceptable, and the use of dry pigment mixed with the vehicle by the contractor will not be permitted. Pastes shall be ground to a uniform and smooth consistency. When it is specified that the paint shall be tinted, the tinting material shall be thoroughly and uniformly incorporated with the paint to produce a uniform shade.

2. *PREPARATION OF NEW METAL SURFACES.* All surfaces to be painted shall be cleaned thoroughly, removing all rust, dirt, mill scale, grease and other foreign matter, using scrapers, chisels or sandblast to accomplish the specified result. Bright steel should be exposed in all cases. If sandblasting is used, the first coat of paint must follow immediately.

3. *PREPARATION OF OLD METAL SURFACES.* All dirt, loose scale, dead paint and rust shall be removed entirely. All bare spots shall be chipped, sanded or wire-brushed to expose clean metal and then shall be covered with paint specified hereinafter.

4. *THE PAINT.* The paint used shall consist of Sublimed Blue Lead in Oil paste mixed with pure raw linseed oil in the following proportions:

> 100 lb. of Sublimed Blue Lead in Oil, 4 gal. of pure raw linseed oil thinned with not more than 2 pt. of turpentine and not more than 2 pt. of a good drier.

5. The Sublimed Blue Lead shall be a chemical combination of lead sulphate and lead oxide, and certain other ingredients, which upon analysis will conform to the following specifications:

Lead Sulphate ($PbSO_4$)	45-55 per cent
Lead Oxide (PbO)	30-40 per cent
Lead Sulphide (PbS)	Not over 12 per cent
Lead Sulphite ($PbSO_3$)	Not over 5 per cent
Zinc Oxide (ZnO)	Not over 5 per cent
Carbon and undetermined	Not over 5 per cent

6. The vehicle shall be raw linseed oil from North American seed and shall conform to the following requirements:*

	Maximum	Minimum
Specific Gravity at $\frac{15.5°}{15.5°}$ C.	0.936	0.932
or		
Specific Gravity at $\frac{25°}{25°}$ C.	0.931	0.927
Acid Number	6.00	....
Saponification Number	195.	189.
Unsaponifiable matter, per cent	1.50	....
Refractive Index at 25° C.	1.4805	1.4790
Iodine Number (Hanus)	....	180.

*Linseed Oil Specifications, 1921, A. S. T. M. Standards, pages 655-658.

7. *COLORS.* In order to distinguish between the successive coats, the paint shall be mixed as follows:

8. First coat shall be in accordance with the formula set forth in paragraph 4.

9. The second coat shall consist of paint mixed in the proportions of 95 lb. Sublimed Blue Lead in oil, 5 lb. chrome yellow in oil, with 4 gal. of raw linseed oil thinned with not more than 2 pt. of turpentine and not more than 2 pt. of a good drier.

10. The third coat shall consist of paint mixed in the proportions of 50 lb. Sublimed Blue Lead in oil with 50 lb. red lead in oil with 4 gal. of raw linseed oil thinned with not more than 2 pt. of turpentine and not more than 2 pt. of good drier.

(Note.—If other colors are desired than those here recommended, formulas such as shown on page 53 may be substituted.)

11. *APPLICATION OF PAINT.*

Ordinary Surfaces. All surfaces of (state whether structural steel, cast iron, etc.) shall be given one shop coat of paint and two field coats.

12. All surfaces shall be covered thoroughly, using pound brushes. Make sure that all rivet or bolt heads and all similar surfaces are given the same number of coats as specified for the remaining surfaces.

13. All places that will be inaccessible after erection shall be painted before erection.

14. *APPLICATION OF PAINT.*

GALVANIZED SURFACES. All galvanized metal surfaces shall have brushed over them before paint is to be applied, a coat of copper acetate in the proportions of four ounces to one gallon of water. This coating shall be allowed to dry for one hour, after which it shall be brushed with a stiff brush before the first coat may be applied.

15. *APPLICATION OF PAINT.*

TINNED SURFACES. All tinned metal surfaces shall be cleaned by rubbing with a soft cotton rag moistened with benzine or turpentine, after which the first coat may be applied.

CHAPTER VI

ESTIMATES, DATA AND TABLES

Paint Per Square Foot

Sublimed Blue Lead mixed with pure linseed oil in the proportions of 70 per cent pigment to 30 per cent vehicle and applied to a fairly smooth, clean surface by brushing will cover approximately 800 square feet per gallon, hiding a white surface. The quantity of paint required when applied with a spray or by dipping will depend so much upon the actual local conditions and the character of the surfaces painted that it is impossible to give spreading rates more closely than the one that has been determined for brushing.

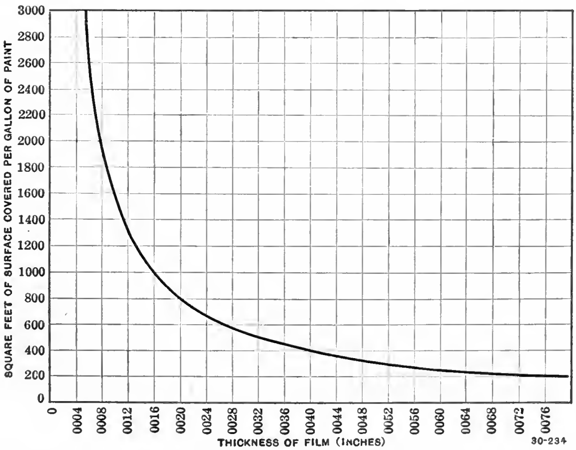


FIGURE 20

Relation between spreading rate of paint in square feet per gallon and thickness of paint film.

When the number of square feet over which a gallon has been spread is known, the thickness of the film can be determined from the diagram in Figure 20.

Painting Calculations

In making calculations for painting with Sublimed Blue Lead, the quantities of oil and Sublimed Blue Lead paste are determined by the following factors:

1. Ratio of pigment to vehicle.
2. Surface to be covered.
3. Character of surface.

Once the ratio of pigment to vehicle has been decided, the number of gallons of oil and the number of pounds of Sublimed Blue Lead paste required to make the paint can be determined from Table I.

TABLE I

PAINT QUANTITIES

Ratio		Pounds Paste 1 Gallon Oil	Gallon Oil 1 Gallon Paint
Pigment	Vehicle		
25	75	2.99	0.951
30	70	3.89	0.937
35	65	4.94	0.920
40	60	6.21	0.899
45	55	7.76	0.874
50	50	9.71	0.842
55	45	12.21	0.812
60	40	15.54	0.747
65	35	20.18	0.672
70	30	27.20	0.558

Example: Assume 1800 sq. ft. to be painted with one coat of Sublimed Blue Lead in Oil mixed in the proportion of 70 per cent pigment to 30 per cent vehicle by weight. One gallon will cover 800 sq. ft.* —1800 sq. ft. would require 2.25 gal. According to Table I in the fourth column, there will be 0.558 gal. of oil required for each gallon of paint, or 2.25 × 0.558 = 1.25 gal. of oil for the job. Referring to the third column, it is found that for every gallon of oil there is required 27.2 lb. of Sublimed Blue Lead paste, or 1.25 × 27.2 = 34.0 lb. of Sublimed Blue Lead for the job.

*See page 70.

FIGURE 21
These gas holders have demonstrated the suitability of Picher Sublimed Blue Lead in Oil for protection of steel work in this class of service.

TABLE II

Number of Pounds of Sublimed Blue Lead Necessary to Mix with a Given Quantity of Linseed Oil for Painting Consistency About 70% Pigment and 30% Oil

Oil Gallons	Pounds Sublimed Blue Lead—Dry	Pounds Sublimed Blue Lead in Oil	Oil Gallons	Pounds Sublimed Blue Lead—Dry	Pounds Sublimed Blue Lead in Oil
1	18.1	27.2	26	470.6	707.2
2	36.2	54.4	27	488.7	734.4
3	54.3	81.6	28	506.8	761.6
4	72.4	108.8	29	524.9	788.8
5	90.5	136.0	30	543.0	816.0
6	108.6	163.2	31	561.1	843.2
7	126.7	190.4	32	579.2	870.4
8	144.8	217.6	33	597.3	897.6
9	162.9	244.8	34	615.4	924.6
10	181.0	272.0	35	633.5	952.0
11	199.1	292.2	36	651.6	979.2
12	217.2	326.4	37	669.7	1006.4
13	235.3	353.6	38	687.8	1033.6
14	253.4	380.8	39	705.9	1060.8
15	271.5	408.0	40	724.0	1088.0
16	289.6	435.2	41	742.1	1115.2
17	307.7	462.4	42	760.2	1142.4
18	325.8	489.6	43	778.3	1169.6
19	343.9	516.8	44	796.4	1196.8
20	362.0	544.0	45	814.5	1224.0
21	380.1	571.2	46	832.6	1251.2
22	398.2	598.4	47	850.7	1278.4
23	416.3	625.6	48	868.8	1305.6
24	434.4	652.8	49	886.9	1332.8
25	452.5	680.0	50	905.0	1360.0

TABLE III

Quantity of Sublimed Blue Lead in Oil and Linseed Oil Necessary to Make a Given Number of Gallons of Paint of the Proportion 70% Pigment to 30% Oil

Gallons of Paint Required	Pounds of Sublimed Blue Lead in Oil Required	Gallons of Raw Linseed Oil	Gallons of Paint Required	Pounds of Sublimed Blue Lead in Oil Required	Gallons of Raw Linseed Oil
1	15.17	.558	26	394.42	14.508
2	30.34	1.116	27	409.59	15.066
3	45.51	1.674	28	424.76	15.624
4	60.68	2.232	29	439.93	16.182
5	75.85	2.790	30	455.10	16.740
6	91.02	3.348	31	470.27	17.298
7	106.19	3.906	32	485.44	17.856
8	121.36	4.464	33	500.61	18.414
9	136.53	5.022	34	515.78	18.972
10	151.70	5.580	35	530.95	19.530
11	166.87	6.138	36	546.12	20.088
12	182.04	6.696	37	561.29	20.646
13	197.21	7.254	38	576.46	21.204
14	212.38	7.812	39	591.63	21.762
15	227.55	8.370	40	606.80	22.320
16	242.72	8.928	41	621.97	22.878
17	257.89	9.486	42	637.14	23.436
18	273.06	10.044	43	652.31	23.994
19	288.23	10.602	44	667.48	24.552
20	303.40	11.160	45	682.65	25.110
21	318.57	11.718	46	697.82	25.668
22	303.74	12.276	47	712.99	26.226
23	348.91	12.834	48	728.16	26.784
24	364.08	13.392	49	743.33	27.342
25	379.25	13.950	50	758.50	27.900

Structural Shapes

To facilitate the estimation of surface areas, factors are given in Tables IV and V, which when multiplied by the length in feet of the steel specified in the tables will give the total square feet to be painted. By dividing these figures by the pounds per foot of the structural shape specified in the table, the square feet per pound will be obtained.

TABLE IV

SURFACE OF STRUCTURAL SHAPES

Shape	Square Feet Surface, Per Foot Length									
	3 in.	4 in.	5 in.	6 in.	8 in.	10 in.	12 in.	15 in.	18 in.	20 in.
	1.3	1.6	1.8	2.2	2.7	3.2	3.7	4.4	5	5.3
	1	1.2	1.4	1.7	2.2	2.6	3	3.7		
	1.4	2.7	2	2.3						

Example: Assume that in a given structure 12,000 lb. of 12-in. I-beams are to be painted with

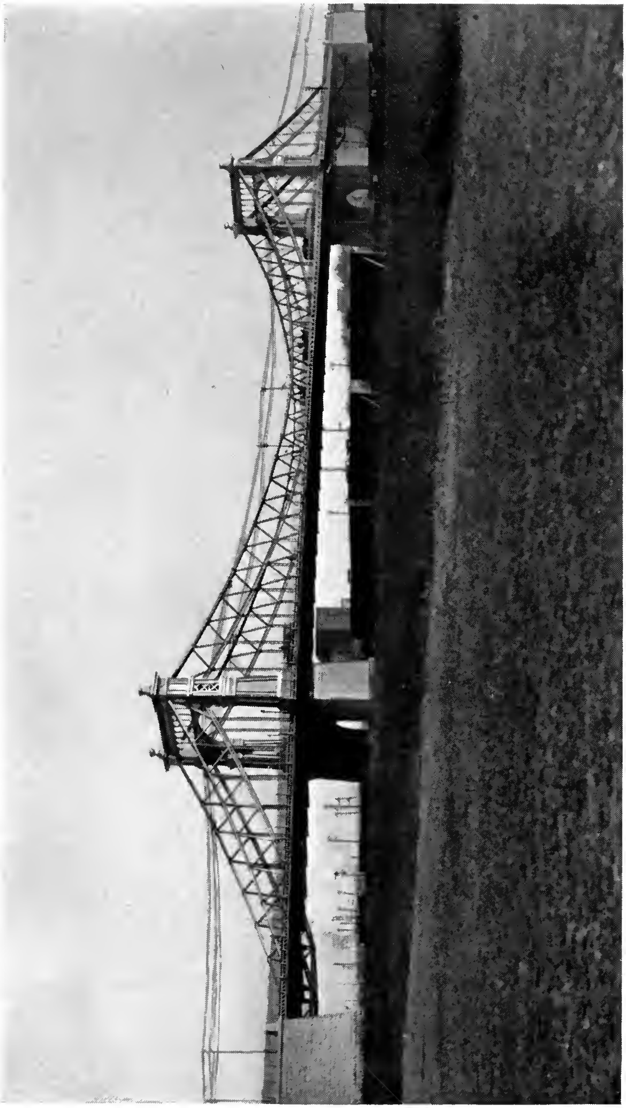


FIGURE 22
Grand Avenue Viaduct, St. Louis, painted with Picher Sublimed Blue Lead in Oil.

one coat of Sublimed Blue Lead in Oil, it being required to determine the number of square feet surface area to be painted. Referring to Table IV, the surface area per lineal foot is given as 3.7 square feet. Referring to a book of structural shapes, such as issued by steel companies, we find that this particular I-beam weighs 35 lb. per foot. Therefore the surface per pound is $3.7 \div 35 = 0.106$ square feet per pound, or $12000 \times 0.106 = 1270$ square feet total.

TABLE V

SURFACE OF ANGLES

Square Feet Surface, Per Foot Length

Inches	1 in.	2 in.	3 in.	4 in.	5 in.	6 in.	8 in.
1	0.33						
2	0.5	0.66	0.83				
3	0.66	0.83	1.0	1.2	1.3	1.5	
4	0.83	1.0	1.2	1.3	1.5	1.7	
5	1.0	1.2	1.3	1.5	1.7	1.8	
6	1.2	1.3	1.5	1.7	1.8	2.0	
8	1.3	1.5	1.7	1.8	2.0	2.2	2.7

TABLE VI

SURFACE OF PLATES

Thickness in Inches	Square Feet Surface per Pound							
	1/8	1/4	3/8	1/2	5/8	3/4	7/8	1
....	0.4	0.2	0.13	0.1	0.8	0.66	0.057	0.05

Cylinders

Interior and exterior surfaces of pipes, tanks and other cylindrical shells can be estimated by multiplying the factors given in Tables VII, VIII and IX by the length in feet of the cylinders.

TABLE VII

CIRCUMFERENCE IN FEET OF PIPES

Diameter in Inches	Circumference in Inches	Circumference in Feet
1	3.14	0.26
2	6.28	0.52
3	9.42	0.78
4	12.56	1.05
5	15.71	1.31
6	18.85	1.57
7	21.99	1.83
8	25.13	2.1
9	28.27	2.4
10	31.41	2.6
11	34.56	2.9
12	37.70	3.1
13	40.84	3.4
14	43.98	3.7
15	47.12	3.9
16	50.26	4.3
17	53.41	4.5
18	56.55	4.7
19	59.69	5.
20	62.83	5.2

TABLE VIII

CIRCUMFERENCE IN FEET OF CYLINDRICAL TANKS

Diameter in Inches	Circumference in Inches	Circumference in Feet
30	94.25	7.9
35	110.	9.2
40	126.	10.5
45	141.	11.7
50	157.	13.1
55	173.	14.5
60	188.	15.7
65	204.	17.
70	220.	18.3
75	236.	19.7
80	251.	20.9
85	267.	22.2
90	283.	23.6
95	298.	24.8
100	314	26.2

TABLE IX

CIRCUMFERENCE IN FEET OF CYLINDRICAL RESERVOIRS

Diameter in Feet	Circumference in Feet	Diameter in Feet	Circumference in Feet
10	31.5	35	110.
15	47.	40	126.
20	63.	45	141.
25	78.5	50	157.
30	94.5		

Example: Assume a tank of 80 inches in diameter and 10 feet high to be painted inside and outside with Sublimed Blue Lead in Oil. The area to

FIGURE 23

These mining buildings in Oklahoma painted with Picher Sublimed Blue Lead have demonstrated the suitability of this paint for use in atmospheres heavily charged with sulphur fumes.

be painted is obtained by multiplying the height by the circumference in feet as given in the third column of Table VIII, thus 20.9 × 10 = 209 square feet on one side. For inside and outside it is multiplied by 2, giving 418 square feet total. Since a gallon of Sublimed Blue Lead will cover 800 square feet, one gallon will be practically enough for two coats.

Corrugated Iron

Corrugated surfaces can be estimated by figuring the area as if it were flat and then multiplying by the factor given in Table X.

TABLE X

ACTUAL AREA CORRUGATED SURFACES

Nominal Width Inches	Area Factor	Nominal Width Inches	Area Factor
5	1.16	2	1.08
3	1.08	1¼	1.04
2½	1.08	⅝	1.04

Example: Assume a side of a building 100 feet long and 20 feet high to be covered with corrugated steel having 2½-inch corrugations. The area of this side without corrugations would be 2000 square feet, but on account of the corrugations this area must be multiplied by the factor given in Table X, namely, 1.08, which gives the total area on one side to be painted as 2160 square feet.

Cost of a Gallon of Paint

The cost of Sublimed Blue Lead in Oil when mixed in the proportion of 70 per cent pigment to 30 per cent oil by weight is given in Table XI for a range of prices that more than covers the normal fluctuations in the market. From this table the cost of pure linseed oil per gallon of paint, the cost of Sublimed Blue Lead in oil for a gallon of paint, as well as the cost of the resulting paint, may be instantly read. For instance, with oil selling at $1.25 a gallon and Sublimed Blue Lead at 13c a pound, the cost of the oil for a gallon of paint will be found at the top of the table immediately under the cost per gallon ($0.70). The cost of the Sublimed Blue Lead in Oil per gallon of paint will be found at the left opposite the 13c price ($1.98), and the cost of the paint which is the sum of the cost of the oil and the cost of the Sublimed Blue Lead will be found at the intersection of the column under the $1.25 price and the row opposite the 13c price ($2.68).

TABLE XI

COST OF SUBLIMED BLUE LEAD PAINT PER GALLON*

COST OF LINSEED OIL PER GALLON

Cost of Linseed Oil in dollars, per gallon		0.60	0.65	0.70	0.75	0.80	0.85	0.90	0.95	1.00	1.05	1.10	1.15
Cost of Linseed Oil in dollars, per gallon of paint		0.34	0.37	0.39	0.42	0.45	0.48	0.51	0.53	0.56	0.59	0.62	0.65
Cost of Blue Lead in Oil:													
Per Pound	Per Gallon Paint												
0.08	1.22	1.56	1.59	1.61	1.64	1.67	1.70	1.73	1.75	1.78	1.81	1.84	1.87
0.08½	1.29	1.63	1.66	1.68	1.71	1.74	1.77	1.80	1.82	1.85	1.88	1.91	1.94
0.09	1.37	1.71	1.74	1.76	1.79	1.82	1.85	1.88	1.90	1.93	1.96	1.99	2.02
0.09½	1.45	1.79	1.82	1.84	1.87	1.90	1.93	1.96	1.98	2.01	2.04	2.07	2.10
0.10	1.52	1.86	1.89	1.91	1.94	1.97	2.00	2.03	2.05	2.08	2.11	2.14	2.17
0.10½	1.60	1.94	1.97	1.99	2.02	2.05	2.08	2.11	2.13	2.16	2.19	2.22	2.25
0.11	1.67	2.01	2.04	2.06	2.09	2.12	2.15	2.18	2.20	2.23	2.26	2.29	2.32
0.11½	1.75	2.09	2.12	2.14	2.17	2.20	2.23	2.26	2.28	2.31	2.34	2.37	2.40
0.12	1.82	2.16	2.19	2.21	2.24	2.27	2.30	2.33	2.35	2.38	2.41	2.44	2.47
0.12½	1.90	2.24	2.27	2.29	2.32	2.35	2.38	2.41	2.43	2.46	2.49	2.52	2.55
0.13	1.98	2.32	2.35	2.37	2.40	2.43	2.46	2.49	2.51	2.54	2.57	2.60	2.63
0.13½	2.05	2.39	2.42	2.44	2.47	2.50	2.53	2.56	2.58	2.61	2.64	2.67	2.70
0.14	2.13	2.47	2.50	2.52	2.55	2.58	2.61	2.64	2.66	2.69	2.72	2.75	2.78
0.14½	2.20	2.54	2.57	2.59	2.62	2.65	2.68	2.71	2.73	2.76	2.79	2.82	2.85
0.15	2.28	2.62	2.65	2.67	2.70	2.73	2.76	2.79	2.81	2.84	2.87	2.90	2.93
0.15½	2.36	2.70	2.73	2.75	2.78	2.81	2.84	2.87	2.89	2.92	2.95	2.98	3.01

Cost of Sublimed Blue Lead Paint per Gallon*. Cost of Linseed Oil per Gallon—Cont'd.

Cost of Linseed Oil in dollars, per gallon		1.20	1.25	1.30	1.35	1.40	1.45	1.50	1.55	1.60	1.65	1.70	1.75
Cost of Linseed Oil in dollars, per gallon of paint		0.67	0.70	0.73	0.76	0.79	0.81	0.84	0.87	0.90	0.93	0.95	0.98
Cost of Blue Lead in Oil:													
Per Pound	Per Gallon Paint												
0.08	1.22	1.89	1.92	1.95	1.98	2.01	2.03	2.06	2.09	2.12	2.15	2.17	2.20
0.08½	1.29	1.96	1.99	2.02	2.05	2.08	2.10	2.13	2.16	2.19	2.22	2.24	2.27
0.09	1.37	2.04	2.07	2.10	2.13	2.16	2.18	2.21	2.24	2.27	2.30	2.32	2.35
0.09½	1.45	2.12	2.15	2.18	2.21	2.24	2.26	2.29	2.32	2.35	2.38	2.40	2.43
0.10	1.52	2.19	2.22	2.23	2.28	2.31	2.33	2.36	2.39	2.42	2.45	2.47	2.50
0.10½	1.60	2.27	2.30	2.33	2.36	2.39	2.41	2.44	2.47	2.50	2.53	2.55	2.58
0.11	1.67	2.34	2.37	2.40	2.43	2.46	2.48	2.51	2.54	2.57	2.60	2.62	2.65
0.11½	1.75	2.42	2.45	2.48	2.51	2.54	2.56	2.59	2.62	2.65	2.68	2.70	2.73
0.12	1.82	2.49	2.52	2.55	2.58	2.61	2.63	2.66	2.69	2.72	2.75	2.77	2.80
0.12½	1.90	2.57	2.59	2.62	2.65	2.68	2.71	2.74	2.77	2.80	2.83	2.85	2.88
0.13	1.98	2.65	2.68	2.71	2.74	2.77	2.79	2.82	2.85	2.88	2.91	2.93	2.96
0.13½	2.05	2.72	2.75	2.78	2.81	2.84	2.86	2.89	2.92	2.95	2.98	3.00	3.03
0.14	2.13	2.80	2.83	2.86	2.89	2.92	2.94	2.97	3.00	3.03	3.06	3.08	3.11
0.14½	2.20	2.87	2.90	2.93	2.96	2.99	3.01	3.04	3.07	3.10	3.13	3.15	3.18
0.15	2.28	2.95	2.98	3.01	3.04	3.07	3.09	3.12	3.15	3.18	3.21	3.23	3.26
0.15½	2.36	3.03	3.06	3.09	3.12	3.15	3.17	3.20	3.23	3.26	3.29	3.31	3.34

NOTE:

15.17 = pounds of Sublimed Blue Lead in Oil per gallon of paint.
4.33 = pounds or 0.588 gallon of linseed Oil per gallon of paint.
19.50 = pounds weight of one gallon Sublimed Blue Lead paint (70 per cent pigment and 30 per cent oil).

* To find cost of Blue Lead paint per gallon, follow the line headed by the cost of Blue Lead in Oil per pound across to the column headed by the cost of linseed oil per gallon. For example, if linseed oil is $1.25 per gallon and Blue Lead in Oil is 12½ cents per pound, then the cost is $2.59 per gallon of paint.

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