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THE NATIONAL BUREAU OF STANDARDS
UNITED STATES DEPARTMENT OF COMMERCE
WASHINGTON, D. C.



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ALUMINUM PAINTS

This is chiefly a digest of a paper "Some Observations on Aluminum Paints" prepared by P. E. Walker and E. F. Hickson, and published by permission of the Director, Bureau of Standards, Department of Commerce, Washington, D. C. in "Chemical and Metallurgical Engineering", Vol. 31, No. 18, November 3, 1924. The paper and this digest discuss various tests made by the Bureau to determine how and when aluminum paints may be used satisfactorily.

The following TIBM's contain additional information relative to paint pigments, oil paints, and water paints:

- TIBM - 30 "Paint Pigments - White"
- TIBM - 31 "Paint Pigments - Black, Red, and Lakes"
- TIBM - 32 "Paint Pigments - Yellow, Brown, Blue, Green, and Bronze"
- TIBM - 33 "Federal Specification Paint Pigments and Mixing Formulas"
- TIBM - 34 "Federal Specification Ready-Mixed Paints, Semipaste Paints and Mixing Formulas"
- TIBM - 35 "Preparation of Paints from Paste and Dry Pigments"
- TIBM - 36 "Preparation of Paints from Semipaste Paints, Thinning Ready-Mixed Paints, and Preparation of Water Paints"

Paint is "a mixture of pigment with vehicle intended to be spread in thin coats on surfaces for decoration or protection, or both."¹

¹Quoted from "Standard Definitions of Terms Relating to Paint Specifications", American Society for Testing Materials, A. S. T. M. Standards (1933), pp. 735-739.

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Federal Specifications are specifications adopted by the Federal Specifications Executive Committee and approved by the Director of Procurement, Treasury Department, for use of all departments and establishments of the Government.¹

Durability of Aluminum Paint

To determine the durability of aluminum paints as compared with red lead linseed oil paint, the Bureau of Standards began a series of exposure tests on six metal panels in November 1920. The aluminum paints used were prepared by hand, stirring 15 and 30 percent aluminum powder (by weight of paint) in boiled linseed oil and spar varnish.

Formulas used in preparing the paints, manner of application and exposure, and results of tests are given in Table I (page 3).

Aluminum Paint Mixing Formulas

Tests conducted by the Bureau and subsequent experiences indicate that, while an aluminum paint having a vehicle composed entirely of boiled linseed oil applied on metal panels in a horizontal position was more durable on an outside exposure than paints containing an equal quantity of aluminum powder in a vehicle composed of two-thirds boiled linseed oil and one-third spar varnish, some aluminum paints frequently showed tendencies to run and sag when applied to vertical surfaces.

Aluminum paints produced from formulas given in Table II (page 4) were found to be suitable for painting vertical surfaces. Paints made from formulas given in Table III (page 4) proved to be unsatisfactory when applied to smooth, vertical iron plates, although they possessed suitable brushing consistencies.

¹Copies of all Federal Specifications mentioned in this digest may be obtained from Superintendent of Documents, Government Printing Office, Washington, D. C. (Price 5 cents each).

TABLE I

Results of Exposure Tests Comparing Aluminum and Red Lead Paints¹

Paint			: Number:		Condition of Paint after
Type	Ingredients	Amount	Coats	of	
Aluminum	Aluminum Powder ²	3 1/3 lbs.	1	1	Practically gone.
	Boiled Linseed Oil ³	1 gal.	2	2	Good condition.
	:	:	3	3	Excellent condition.
Red Lead	Dry Red Lead ⁴	20 lbs.	1	1	Practically gone.
	Raw Linseed Oil ⁵	5 pts.	2	2	Faded (nearly white) and
	Turpentine ⁶	2 gills	:	:	chalking, but in good con-
	Drier ⁷	2 gills	:	:	dition.
	:	:	3	3	Faded (nearly white) and
Aluminum	Aluminum Powder ²	3 1/2 lbs.	1	1	Practically gone.
	Boiled Linseed Oil ³	2/3 gal.	2	2	Rust streaks showed through,
	Spar Varnish ⁸	1/3 gal.	:	:	fair condition, needed re-
	:	:	3	3	painting.
Red Lead	Dry Red Lead ⁴	20 lbs.	1	1	Practically gone.
	Raw Linseed Oil ⁵	5 pts.	2	2	Chalking and faded, but in
	Turpentine ⁶	2 gills	:	:	good condition.
	Drier ⁷	2 gills	3	3	Chalking and faded, but in
	:	:	:	:	excellent condition.
Aluminum	Aluminum Powder ²	1 1/3 lbs.	1	1	Gone.
	Spar Varnish ⁸	1 gal.	2	2	Considerable rust; poor
	:	:	3	3	condition.
	:	:	:	:	Rust streaks showing; fair
Red Lead	Dry Red Lead ⁴	20 lbs.	1	1	Practically gone, but better
	Raw Linseed Oil ⁵	5 pts.	:	:	than the aluminum paint.
	Turpentine ⁶	2 gills	2	2	Chalking and fading, but
	Drier ⁷	2 gills	:	:	in good condition.
	:	:	3	3	Chalking and fading, but in
	:	:	:	:	excellent condition.

¹The paints were applied by brushing on one side of clean, horizontal steel panels measuring 1/4"x18"x24". The first coat of red lead was applied to the left half of the panel and the first coat of aluminum to the right half. The second coat was applied to the upper two-thirds of the respective area in each case, and the last coat to the upper third. The first coats were applied Oct. 26, 1920, the second coats Oct. 28, 1920, and the third coats on Nov. 1, 1920. The painted panels, after drying in the laboratory, were exposed on Nov. 5, 1920, facing South at an angle of 45°, on the roof of the Chemistry Building, National Bureau of Standards, Washington, D. C.

²Federal Specification TT-A-476 "Aluminum-Powder; (For) Paints (Aluminum-Bronze-Powder)."

³Federal Specification JJJ-O-331 "Oil; Linseed, Boiled."

⁴Federal Specification TT-R-191 "Red Lead; Dry and Paste-In-Oil."

⁵Federal Specification JJJ-O-336 "Oil; Linseed, Raw."

⁶Federal Specification LLL-T-791a "Turpentine; (For) Paint, Type I."

⁷Federal Specification TT-D-651 "Drier; Paint, Liquid."

⁸Federal Specification TT-V-121a "Varnish; Spar, Water-Resisting."

TABLE II

Aluminum Paint Formulas Suitable For Vertical Surfaces¹

No. 1	:	No. 2
2 lbs. Aluminum Powder, polished ²	:	2 lbs. Aluminum Powder, polished ²
1 gal. Vehicle consisting of:	:	1 gal. Mixing Varnish for Aluminum
60 parts Bodied Linseed Oil ³	:	Paint ⁶
6 " Liquid Paint Drier ⁴	:	
34 " Mineral Spirits ⁵	:	
No. 3	:	No. 4
2 lbs. Aluminum Powder, polished ²	:	2 lbs. Aluminum Powder, polished ²
1 gal. "Bronzing Liquid" ⁷	:	1 gal. Vehicle consisting of:
	:	2/3 Mixing Varnish for Aluminum
	:	Paint ⁶
	:	1/3 Boiled Linseed Oil ⁸

TABLE III

Aluminum Paint Formulas Providing Suitable Brushing Consistencies⁹

No. 1	:	No. 2
2 lbs. Aluminum Powder, polished ²	:	2 lbs. Aluminum Powder, polished ²
1 gal. Vehicle consisting of:	:	1 gal. Vehicle consisting of:
90 parts Raw Linseed Oil ¹⁰	:	80 parts Raw Linseed Oil ¹⁰
10 " Liquid Paint Drier ⁴	:	10 " Mixing Varnish for
	:	Aluminum Paint ⁶
	:	10 " Liquid Paint Drier ⁴
No. 3	:	No. 4
2 lbs. Aluminum Powder, polished ²	:	2 lbs. Aluminum Powder, polished ²
1 gal. Vehicle consisting of:	:	1 gal. Boiled Linseed Oil ⁸
1/3 Mixing Varnish for	:	
Aluminum Paint ⁶	:	
2/3 Boiled Linseed Oil ⁸	:	

¹These paints possess good brushing consistencies, which when applied to vertical metal plates gave firm, uniform, smooth films free from running, streaking, or sagging.

²Federal Specification TT-A-476 "Aluminum-Powder; (For) Paints (Aluminum-Bronze-Powder)."

³Raw linseed oil JJJ-O-336 heated to 295°C for three hours.

⁴Federal Specification TT-D-651 "Drier; Paint, Liquid."

⁵Federal Specification TT-T-291 "Thinner; Paint, Volatile Mineral Spirits."

⁶Federal Specification TT-V-81 "Varnish; Mixing (For) Aluminum-Paint."

⁷Commercial sample of a brittle rosin varnish not suitable for out door use.

⁸Federal Specification JJJ-O-331 "Oil; Linseed, Boiled."

⁹These paints possess suitable brushing consistencies, but proved to be unsatisfactory when applied to smooth vertical iron plates.

¹⁰Federal Specification JJJ-O-336 "Oil; Linseed, Raw."

Conclusions and Recommendations

Leafing Properties: Federal Specification TT-A-476 "Aluminum-Powder; (For) Paints (Aluminum-Bronze-Powder)" states "The powder shall have good 'leafing' properties and a paint made by mixing with a suitable vehicle in the proportion of two pounds of aluminum powder to one gallon of vehicle shall give a free flowing, smooth continuous coating." It is reasonable to suppose that this metallic top layer or coating protects the perishable paint vehicle from the sunlight.

As the desirable leafing properties of aluminum powders, mixed in various paint liquids, develop rapidly and gradually diminish in ready-mixed paints, it is recommended that aluminum paint be mixed on the job and only in such quantities as will be used the same day, because mixed aluminum paints kept in closed packages for various lengths of time may produce gases and burst the packages.

Durable Outside Aluminum Paints: An aluminum paint containing from 25 to 30 percent of aluminum powder in a vehicle composed of boiled linseed oil, or a mixture of boiled linseed oil and mixing varnish will prove to be a durable outside paint when applied in three coats. Two coats of these paints will give good service. One coat alone is not recommended.

A paint containing 15 percent aluminum powder in mixing varnish does not equal, for outdoor durability, one containing approximately twice as much powder in a mixed vehicle of mixing varnish and boiled linseed oil. This is also true of one, two, or three-coat work.

Aluminum paint containing boiled linseed oil without any varnish proved to be more durable for outside use, under test conditions, than a paint containing an equal amount of the same aluminum powder in a vehicle of two-thirds boiled linseed oil and one-third mixing varnish.

Recommended Outside Aluminum Paints: For outdoor exposures including vertical surfaces, Formulas Nos. 1, 2, and 4 given in Table II (page 4) are recommended. Paints produced from Formulas Nos. 1 and 4 will probably be more durable than paint made from Formula No. 2 which contains straight aluminum paint mixing varnish. One gallon of average mixing varnish for aluminum paint will weigh about seven and one-half pounds, and with two pounds of aluminum powder, the paint will weigh about 8.6 pounds to the gallon and contain about 21 percent of pigment by weight.

Aluminum paint for outdoor exposure, possessing extreme durability, may be made by using as much as two and one-half pounds of aluminum powder

¹"Leafing is the term used when a continuous brilliant film forms over the entire free surface of a mixture of aluminum powder in a suitable liquid, within one minute after cessation of stirring the mixture."

to one gallon of liquid, provided the paint is still of good brushing consistency without the addition of turpentine or mineral spirits. A gallon of this paint will weigh about 8.9 pounds, and contain about 25 percent of pigment by weight. The present day trend for exterior aluminum paints, is to use two pounds of aluminum powder or paste to one gallon of a synthetic resinous type spar varnish, particularly of the straight phenol-formaldehyde type.

Tests indicate that the use of raw or boiled linseed oil alone, as the liquid in aluminum paints for painting vertical surfaces is not advisable, as such paints, especially those containing raw oil, do not form a continuous film but exhibit marked running, streaking, and sagging tendencies. Although the streaky defect seemed to be lessened slightly by increasing the amount of powder in the oil vehicle, experiments show that even though the powder content be increased to three and one-half pounds to one gallon of boiled linseed oil, the paint still produces a somewhat streaky appearance on vertical surfaces. This same formula, however, gives a very durable paint on outdoor horizontal surfaces.

In using aluminum paint for the protection of exterior steel structures, it is recommended that the first or priming coat on bare steel should be other than aluminum paint. A rust-inhibitive primer such as red lead paint, basic lead chromate or zinc chromate paint, etc., is recommended next to the bare steel. Over this primer the aluminum paint may be applied.

Aluminum Paints For Ordinary Interior Use: For ordinary interior use, one and one-half to two pounds or more of aluminum powder mixed with either one gallon of mixing varnish for aluminum paint, or one gallon of a mixture of two volumes of the mixing varnish and one volume of turpentine or mineral spirits, will give a quick-drying serviceable paint.

Aluminum Paint For Radiators: Two or more pounds of aluminum powder mixed with one gallon of equal volumes of mixing varnish and turpentine will produce a good radiator paint.

Aluminum Paint For Surfaces Subject To Sulphide Fumes: In tests conducted by the Bureau, a paint composed of two to two and one-half pounds of polished aluminum powder in one gallon of mixing varnish for aluminum paint (a commercial sample free from lead, but containing cobalt) showed no discoloration when exposed to sulphide fumes. Substitution of boiled linseed oil, containing 0.12 percent lead, for the mixing varnish in this paint showed appreciable darkening in hydrogen sulphide.

Aluminum Bronze Powder versus Other Metal Powder Pigments: As bronze powder pigments other than aluminum, such as "copper bronze" and "pale gold bronze", have higher specific gravities, about twice as much pigment should be used to make satisfactory brushing paints as is required for aluminum bronze powder.