Figure 1. Harmful Effect on Durability of White Lead Paint of Priming with Aluminum in Red Lead Paint (after 47 Months at Fargo)

Redwood

White pine

Douglas fir

Yellow pine

Conventionally primed — Primed with aluminum powder in red lead paint

Special Priming Paints for Wood

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At a conference on wood painting practice held at the Forest Products Laboratory in September, 1929, the undesirable variation in durability of coatings of house paint on softwoods of different species was discussed. An earlier experimental study (*2*) had shown that the variation between woods can be reduced to some extent by priming wood with aluminum paint before applying ordinary house paints. The conferees were therefore of the opinion that other special priming paints that might be expected to have a similar effect should be tried, and they suggested a number of priming paints for that purpose.

Four softwoods were chosen for the new primer test—redwood, northern white pine, Douglas fir, and longleaf southern yellow pine. Redwood and northern white pine represent woods on which paint lasts longest; Douglas fir and southern yellow pine are stronger and heavier woods on which paints fail earlier by crumbling or flaking from the bands of summerwood (*1*). The lumber was cut into boards of 0.5 × 6 inch (1.27 × 14 cm.) bevel siding, 6 feet (1.83 meters) long. Each test panel consisted of four such boards, one board of each species, making a panel 18 × 72 inches (45.7 × 183 cm.) in area. Cleats on the backs of the panels held the boards together during painting and shipment to the exposure stations where the boards were finally nailed to the framework of the test fences. The backs and edges of the panels were painted with exterior aluminum paint.

Each panel was marked off by vertical lines into three test areas, each 18 × 24 inches (45.7 × 61 cm.) in size. The left-hand and right-hand areas received special priming paints whose efficacy was to be tested. The middle area was primed conventionally with the white paint used for finishing coats over the entire panel. Thus each special primer was applied beside a neighboring area of the same boards conventionally primed. This procedure very largely eliminated uncertainties due to variation in durability of paint on different boards of the same wood (*5*).

Two white paints were used as finishing coats for these experiments, pure white lead paint and a lead and zinc paint. The white lead paint was mixed from soft paste white lead consisting of 85 per cent by weight basic-carbonate white lead and 15 per cent linseed oil as follows:

	Conventional Priming Coat (for Middle Area Only)	Second Coat (for Entire Panel)	Third Coat (for Entire Panel)
Paste white lead, lb. (kg.)	108 (49)	108 (49)	108 (49)
Raw linseed oil, gal. (liters)	3 (11.3)	0.5 (1.89)	2.5 (9.46)
Turpentine, gal. (liters)	2 (7.54)	1.5 (5.65)	0.125 (0.48)
Liquid paint drier, pint (liter)	1 (0.48)	1 (0.48)	1 (0.48)

The lead and zinc paint was a prepared paint of the following composition:

Pigment, 64% by weight of the paint, composed of:	
Basic-carbonate white lead, % by weight	60
Lead-free zinc oxide, % by weight	30
Magnesium silicate, % by weight	10
Liquid, 36% by weight of the paint, composed of:	
Raw linseed oil, % by weight	89
Turpentine, % by weight	5.5
Liquid paint drier, % by weight	5.5

For the priming coat this paint was thinned with 1 quart of turpentine and 1 pint of raw linseed oil per gallon of paint. For second coat it was thinned with 1 pint of turpentine per gallon of paint. For the finish coat it was applied without addition.

Composition of Special Priming Paints

The special priming paints tested may be divided into seven groups as follows:

1. Very durable, granular, colored pigments (tinting colors) added to the conventional priming-coat mixtures of the white finishing paints (*11*).
2. The granular, colored pigments of group 1 made into priming paints with long-oil spar varnish vehicle. The long-oil spar varnish was a commercial "80-gallon" varnish made as a vehicle for exterior aluminum paint.
3. Leafing pigments in long-oil spar varnish (*7, 8*).
4. Mixtures of leafing and granular pigments in linseed oil vehicle (*8, 10*).
5. Conventional priming-coat mixtures of white paint mixed with long-oil spar varnish (*12*).
6. Clear liquids.
7. Unusual volatile thinners.

FIGURE 2. BENEFICIAL EFFECT ON DURABILITY OF WHITE LEAD PAINT OF ADDING ALUMINUM POWDER TO PRIMING COAT OF WHITE LEAD PAINT (AFTER 47 MONTHS AT FARGO)

Twenty special priming paints were subjected to practical exposure tests at Madison, Wis., Fargo, N. Dak., Fresno, Calif., Sayville, N. Y., and Washington, D. C. The special priming paints were compared directly with conventional priming under white finishing paint, applied on neighboring areas of the same boards. Two white finishing paints were used—pure white lead paint and a lead and zinc paint. Ten of the special primers proved beneficial in the sense that they retarded disintegration of coatings over the bands of summerwood in southern yellow pine and Douglas fir and made the durability of the coatings on those woods more nearly equal to that on redwood and northern white pine. The best of the special primers tested were those containing "leafing" pigments, aluminum powder, or flake graphite, in long-oil spar varnish.

For convenience in discussion and tabulation each special primer tested is given a reference number and a title which appear together with the composition in the following list:

1a. LAMPBLACK IN WHITE PAINT. Two pounds (0.91 kg.) of commercial lampblack–linseed oil tinting color were added to one gallon (3.79 liters) of priming-coat mixture of white lead paint for use under finishing coats of white lead paint or to one gallon of priming-coat mixture of lead and zinc paint for use under finishing coats of lead and zinc paint.

1b. IRON OXIDE IN WHITE PAINT. Five pounds (2.27 kg.) of commercial Indian red–linseed oil tinting color were added to one gallon of priming-coat mixture of white lead paint or of lead and zinc paint.

1c. LEAD CHROMATE IN WHITE PAINT. Five pounds of commercial American vermilion (basic lead chromate)–linseed oil tinting color were added to one gallon of priming-coat mixture of white lead paint or of lead and zinc paint.

2a. LAMPBLACK IN VARNISH. This primer was composed of:

Lampblack–Japan tinting color	14 lb. (6.35 kg.)
Long-oil spar varnish	1 gal. (3.79 liters)
Turpentine	0.875 gal. (3.1 liters)

2b. IRON OXIDE IN VARNISH. The composition of this primer was:

Indian red–linseed oil tinting color	29.6 lb. (13.4 kg.)
Long-oil spar varnish	1 gal. (3.79 liters)
Turpentine	0.75 gal. (2.84 liters)

2c. LEAD CHROMATE IN VARNISH. This primer was composed of:

American vermilion (basic lead chromate)–linseed oil tinting color	29.6 lb. (13.4 kg.)
Long-oil spar varnish	1 gal. (3.79 liters)
Turpentine	0.625 gal. (2.36 liters)

3a. GRAPHITE IN VARNISH. One pound (0.45 kg.) of dry flake graphite was stirred into one gallon (3.79 liters) of long-oil spar varnish just before the paint was to be applied.

3b. ALUMINUM IN VARNISH. One and three-fourths pounds (0.79 kg.) of aluminum powder, standard varnish grade, were stirred into one gallon of long-oil spar varnish just before the paint was to be applied.

4a. GRAPHITE IN WHITE PAINT. Two pounds (0.91 kg.) of dry flake graphite were added to one gallon (3.79 liters) of priming-coat mixture of white lead paint for use under finishing coats of white lead paint or to one gallon of priming-coat mixture of lead and zinc paint for use under finishing coats of lead and zinc paint.

4b. ALUMINUM IN WHITE LEAD PAINT. One and three-fourths pound (0.79 kg.) of dry aluminum powder, standard varnish grade, were stirred into one gallon of priming-coat mixture of white lead paint for use under finishing coats of either white lead or lead and zinc paint.

4c. ALUMINUM IN RED LEAD PAINT. This primer was composed of:

Paste red lead (93% pigment by weight)	100 lb. (45 kg.)
Raw linseed oil	1.75 gal. (6.62 liters)
Turpentine	1.75 gal. (6.62 liters)
Liquid paint drier	1 pint (0.47 liter)
Aluminum powder	8 lb. (3.63 kg.)

4d. TRIMETAL. This primer was composed of:

Paste red lead	100 lb. (45 kg.)
Zinc dust	16 lb. (7.26 kg.)
Aluminum powder	8 lb. (3.63 kg.)
Raw linseed oil	4 gal. (15.1 liters)
Boiled linseed oil	1 gal. (3.79 liters)
Turpentine	1 gal. (3.79 liters)
Liquid paint drier	1 pint (0.47 liter)

5. VARNISH ADDED TO WHITE PAINT. The conventional priming-coat mixtures of white lead paint and of lead and zinc paint were each mixed with an equal volume of the long-oil spar varnish.

6a. RAW LINSEED OIL. Raw linseed oil to which one thirty-second volume of liquid paint drier was added.

6b. BODIED LINSEED OIL. Varnish makers' linseed oil was heated at 300° C. (572° F.) for 2.75 hours, one thirty-second volume of liquid paint drier added, and the heating continued for 15 minutes longer. While cooling, the viscous oil was thinned with turpentine until the nonvolatile content of the mixture was 54 per cent by weight and the viscosity approximately that of raw linseed oil.

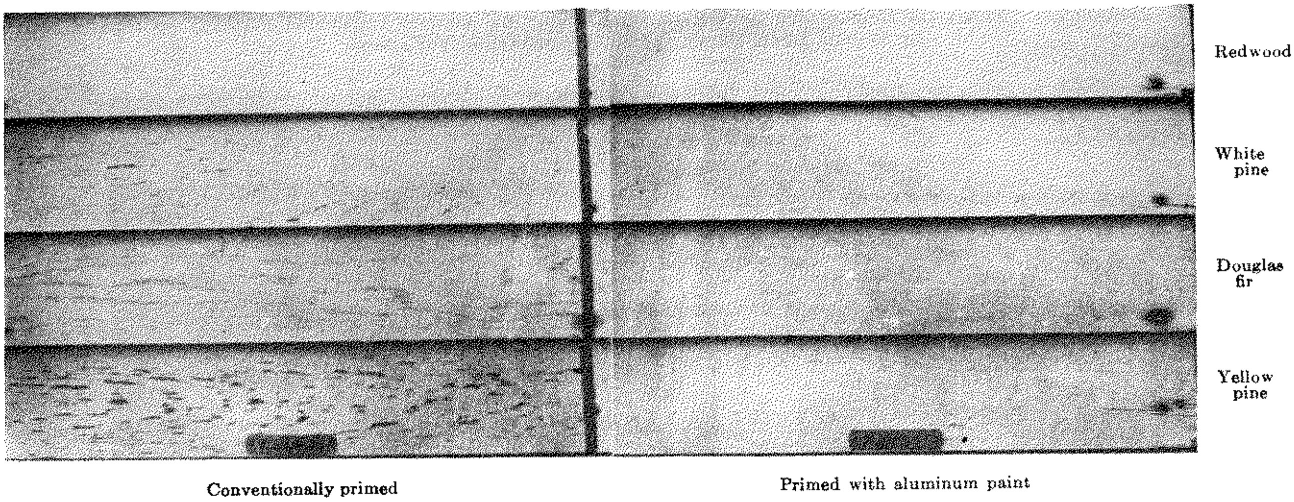


FIGURE 3. BENEFICIAL EFFECT ON DURABILITY OF LEAD AND ZINC PAINT OF PRIMING WITH ALUMINUM PAINT

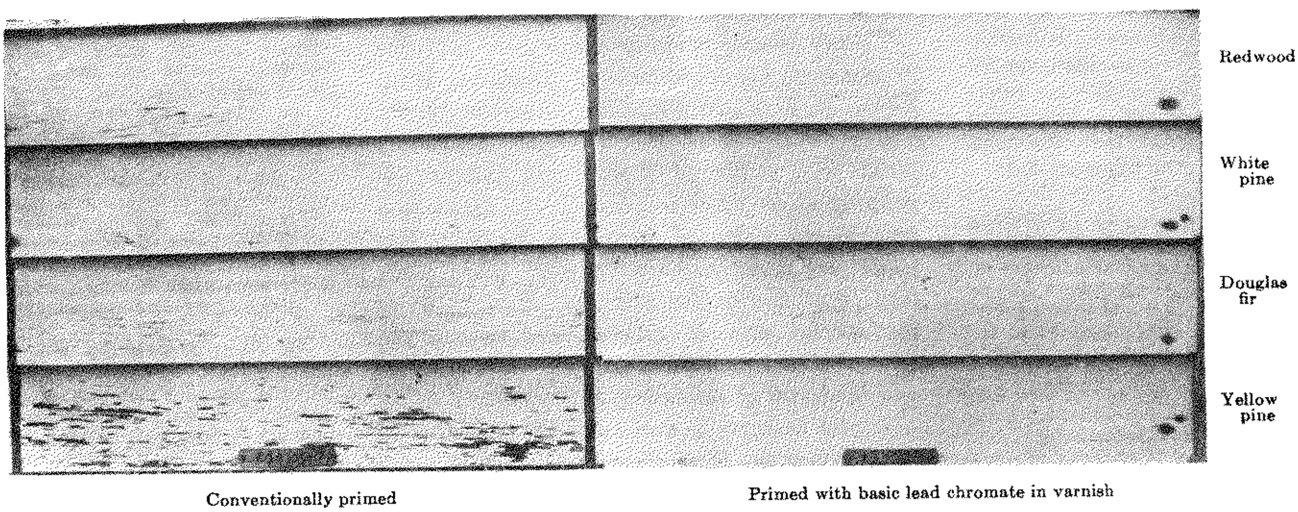


FIGURE 4. BENEFICIAL EFFECT ON DURABILITY OF LEAD AND ZINC PAINT OF PRIMING WITH BASIC LEAD CHROMATE IN VARNISH (AFTER 47 MONTHS AT FARGO)

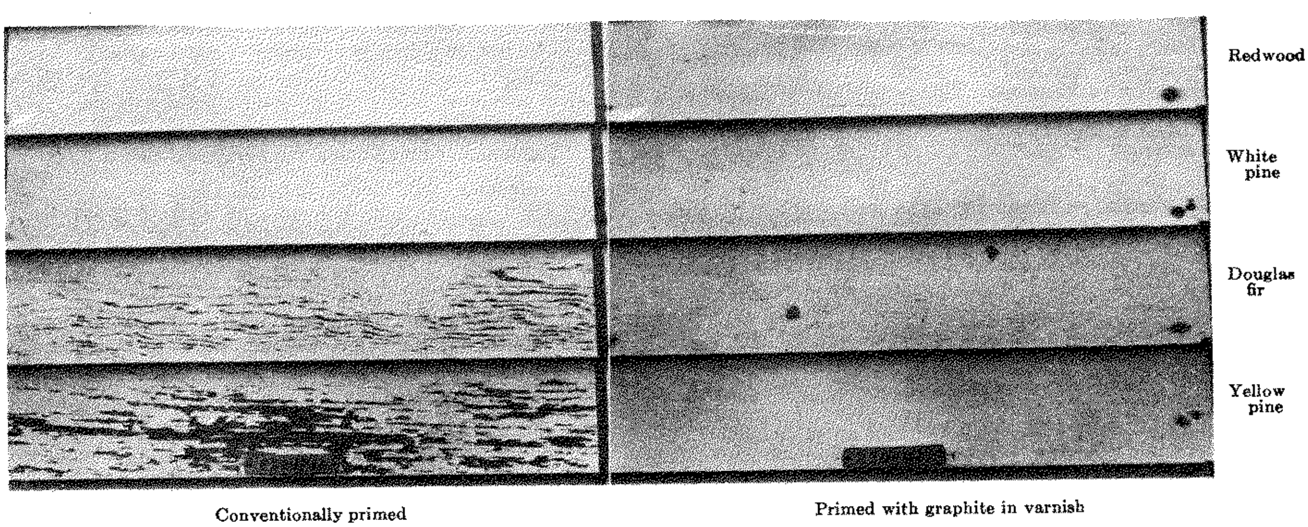


FIGURE 5. BENEFICIAL EFFECT ON DURABILITY OF LEAD AND ZINC PAINT OF PRIMING WITH FLAKE GRAPHITE IN VARNISH (AFTER 47 MONTHS AT FARGO)

TABLE I. DURABILITY OBTAINED WITH WHITE LEAD PAINT OVER SPECIAL PRIMERS AND OVER CONVENTIONAL PRIMING WITH WHITE LEAD PAINT

(Reading downward, each group of three primers was tested on one panel at each station so that the three primers of the group were on neighboring areas of the same boards)

		Durability in Months or, if Coating Is Still Serviceable, Rating in Integrity at Last Inspection at:																					
		Fresno on:				Fargo on:				Madison on:				Sayville on:				Washington on:		Composite Rating in Durability at All Stations			
	Primer	RD[a]	WP	DF	SP	RD	WP	DF	SP	RD	WP	DF	SP	RD	WP	DF	SP	RD and WP	DF and SP	RD	WP	DF	SP
1a	Lampblack in white paint	F−	F−	30	30	P+	P+	P+	P+	F−	F−	F−	F−	F	F	33	41	F	F−	49	49	40	42
	Conventional (white lead paint)	F−	F−	29	29	P+	P+	47	39	F−	F−	48	48	F	F	33	41	F	P+	49	49	38	38
4a	Graphite in white paint	F−	F−	33	33	P+	P+	P+	P+	F−	P+	P+	P+	F	41	33	36	F	29	49	47	39	40
1b	Iron oxide in white paint	F−	F−	33	33	F−	47	47	36	F−	48	42	40	F	41	41	41	F	P+	50	45	39	36
	Conventional (white lead paint)	P+	P+	30	28	F−	47	47	35	F−	F−	40	37	F	F	41	36	F	29	49	48	37	33
1c	Lead chromate in white paint	F−	F−	33	33	F−	47	47	36	F−	F−	43	39	F	41	41	41	F	P+	50	47	39	36
4d	Trimetal	47	47	27	16	P+	40	27	27	P+	P+	29	29	F	F	P+	36	F	24	47	45	30	26
	Conventional (white lead paint)	F−	F−	33	24	F−	F−	42	42	P+	P+	40	40	F	F	F	37	F	P+	49	49	39	35
3b	Aluminum in varnish	F−	F−	F−	P+	F−	F−	F−	F−	F−	F−	F−	F−	F	F	F	P+	F	P+	50	50	48	45
4b	Aluminum in white lead paint	P+	P+	P+	P+	F−	F−	P+	P+	F−	F−	F−	F−	F	F	41	41	F	F−	49	49	46	46
	Conventional (white lead paint)	P+	P+	33	33	F−	F−	39	39	F−	F−	P+	37	F	F	41	41	F	P+	49	49	39	36
4c	Aluminum in red lead paint	47	47	30	33	47	F−	38	38	P+	P+	43	18	F	F	36	36	F	29	47	48	35	31
2a	Lampblack in varnish	F	P+	P+	47	F−	F−	47	47	F−	43	43	43	F−	F−	F−	36	F	P+	50	46	44	41
	Conventional (white lead paint)	F	47	33	26	F−	P+	39	39	F−	F−	43	43	F	F−	F−	36	F	F−	50	47	39	36
3a	Graphite in varnish	F	47	F	47	F−	F−	F−	F−	F−	F−	P+	P+	F−	F−	41	41	F	F−	50	48	47	45
2b	Iron oxide in varnish	F−	F−	47	26	47	47	47	47	F−	F−	35	35	F	P+	P+	41	F	F−	48	47	42	37
	Conventional (white lead paint)	47	47	36	26	47	47	38	35	F−	F−	35	35	F	F	F	36	F	F−	47	47	39	33
2c	Lead chromate in varnish	F	F	P+	P+	47	47	47	47	F−	F−	35	42	F	P+	P+	P+	F	F−	49	48	42	42
6a	Raw linseed oil	47	33	29	29	F−	47	32	39	F−	F−	40	30	F	F	F	30	F	F−	48	44	37	33
	Conventional (white lead paint)	47	47	33	29	F−	47	39	40	F−	F−	43	37	F	F	F	33	F	F−	48	47	40	35
6b	Bodied linseed oil	F−	F−	F−	F−	F−	P+	47	40	F−	F−	F−	30	F	F	F	33	F	P+	50	49	47	34
6d	Long-oil spar varnish	47	P+	47	23	P+	P+	39	32	48	48	43	30	F	F	41	41	F	P+	46	47	40	32
	Conventional (white lead paint)	P+	P+	33	29	P+	P+	39	32	F−	F−	43	30	F	F	41	33	F	P+	48	48	38	31
5	Varnish added to white paint	28	28	28	21	P+	P+	35	32	F−	P+	43	30	F	F	41	41	F	P+	44	43	36	31
6c	Oxidized linseed oil	F−	F−	P+	25	F−	F−	47	39	F−	F−	43	43	F	F	41	36	F	P+	49	49	43	35
	Conventional (white lead paint)	47	F−	33	28	F−	F−	42	38	F−	F−	43	37	F	F	41	41	F	P+	48	49	38	35
6e	Nitrocellulose lacquer	F−	F−	F−	47	34	38	29	27	32	32	32	32	F	F	32	34	F	29	41	42	35	34
7a	Butyl alcohol thinner	F−	F−	36	30	32	32	20	20	P+	43	36	32	F−	P+	33	33	F	17	44	42	28	26
	Conventional (white lead paint)	F−	F−	47	30	F−	F−	42	39	F−	F−	43	43	F	F	41	41	F	P+	49	49	41	37
7b	Ethyl lactate thinner	F−	F−	36	30	F−	F−	42	39	F−	F−	43	40	F−	F−	F−	38	F	P+	49	49	40	36

[a] Key to symbols: RD, redwood; WP, northern white pine; DF, Douglas fir; SP, southern yellow pine; F, fair in integrity; P, poor; + and − indicate slightly better or slightly worse than typical of the integrity rating to which the sign is attached.

6c. OXIDIZED LINSEED OIL. A commercial oxidized linseed oil was thinned with turpentine until the viscosity of the mixture was approximately that of raw linseed oil.

6d. LONG-OIL SPAR VARNISH. This was the varnish used in the primers of groups 2 and 3.

6e. NITROCELLULOSE LACQUER. The composition of this primer was as follows (in per cent by weight):

Nitrocellulose (1/2-sec. viscosity)	3.54
Rezyl 12 (American Cyanamid Co.)	10.66
Rezyl balsam 33 (American Cyanamid Co.)	3.54
Ethyl alcohol	1.42
Ethyl acetate	16.20
Butyl alcohol	8.10
Ethyl lactate	4.04
Toluene	52.2

7a. BUTYL ALCOHOL THINNER. Butyl alcohol was substituted for the turpentine in the conventional priming-coat mixtures of white lead paint and of lead and zinc paint.

7b. ETHYL LACTATE THINNER. Ethyl lactate was substituted for the turpentine in the conventional priming-coat mixtures of white lead paint and of lead and zinc paint.

PAINTING AND EXPOSURE OF THE PANELS

The panels were painted indoors at Madison, Wis. Four days were allowed for drying between coats; during part of this time the panels were taken outdoors for exposure to sunshine. Record was kept of the amount of paint applied in each coat in order to make sure that the coatings were of proper thickness.

Complete sets of panels were exposed in the vertical position facing south during September and October, 1930, at Madison, Wis., Fresno, Calif., Fargo, N. Dak., Sayville, N. Y., and Washington, D. C. The tests at Washington were discontinued after 29 months because the test fence was blown down in a storm. At the other stations the last inspections before this report was written were made when the panels were slightly less than 4 years old. At Fresno the panels were repainted in August, 1934, partly for the purpose of observing the effect of the different forms of failure observed on the ease of repainting satisfactorily.

RESULTS AND DISCUSSION

Although many of the special primers were very dark in color, all but two of them were completely hidden by the two subsequent coatings of white paint and their surfaces were satisfactorily white to begin with. The two exceptions were primers 1c and 2c, which contained American vermilion tinting color. The first supply of this material received contained, in addition to basic lead chromate, a bright red organic pigment ("toner") that promptly bled through the finishing coats of white paint and stained them pink. In the course of a few months the pink color bleached and the coatings became white again. A second supply of American vermilion free from organic toner was found to give no such difficulty.

Complete records were kept of the behavior of the coatings on aging according to the methods of the Forest Products Laboratory (6). For the present discussion interest centers in the effect of the primers on maintenance of the integrity of the coatings, especially with respect to retardation of crumbling or flaking from the bands of summerwood and the relative durability on the four species of wood. Accordingly, Tables I and II present the data for durability with respect to integrity of the coatings of white lead paint and of lead and

TABLE II. DURABILITY OBTAINED WITH LEAD AND ZINC PAINT OVER SPECIAL PRIMERS AND OVER CONVENTIONAL PRIMING WITH LEAD AND ZINC PAINT

(Reading downward, each group of three primers was tested on one panel at each station so that the three primers of the group were on neighboring areas of the same boards)

		Durability in Months or, if Coating Is Still Serviceable, Rating in Integrity at Last Inspection at:																		Composite Rating in Durability at All Stations			
		Fresno on:				Fargo on:				Madison on:				Sayville on:				Washington on:					
	Primer	RD[a]	WP	DF	SP	RD	WP	DF	SP	RD	WP	DF	SP	RD	WP	DF	SP	RD and WP	DF and SP	RD	WP	DF	SP
1a	Lampblack in white paint	F−	F−	P+	29	P+	P+	29	47	F−	F−	P+	48	F−	F−	38	38	F−	29	48	48	39	38
	Conventional (lead and zinc paint)	F−	33	33	15	P+	36	24	29	F−	P+	43	30	F	F	P+	36	F−	29	48	41	35	28
4a	Graphite in white paint	F−	F−	47	19	P+	P+	24	47	F−	F−	P+	48	F−	F−	38	38	F−	29	48	48	38	36
1b	Iron oxide in white paint	P+	47	33	28	P+	P+	47	26	F−	F−	40	37	F	F	P+	36	F−	P+	48	47	39	32
	Conventional (lead and zinc paint)	47	47	27	16	P+	32	32	20	F−	43	30	29	F−	36	41	36	F−	29	47	39	32	26
1c	Lead chromate in white paint	P+	47	33	28	P+	P+	47	27	F−	F−	43	43	P+	P+	P+	P+	F−	P+	47	46	38	35
4d	Trimetal	P+	27	27	18	P+	36	40	27	P+	P+	35	35	F	F	41	36	F−	29	47	40	34	29
	Conventional (lead and zinc paint)	40	30	23	15	47	36	40	26	P+	P+	35	35	F−	F−	30	30	F−	26	44	40	31	26
3b	Aluminum in varnish	47	47	47	33	P+	P+	P+	P+	F−	F−	F−	F−	F−	F−	F−	F−	F−	P+	47	47	46	43
4b	Aluminum in white lead paint	F−	F−	47	33	P+	P+	P+	P+	F−	F−	F−	F−	F−	F−	41	41	F−	29	48	48	44	41
	Conventional (lead and zinc paint)	33	33	28	21	P+	P+	40	38	F−	43	43	28	F−	41	41	33	F−	29	44	40	36	30
4c	Aluminum in red lead paint	47	47	30	27	P+	P+	42	42	F−	43	36	36	F−	F−	35	32	F−	29	47	44	34	33
2a	Lampblack in varnish	F−	P+	P+	27	P+	P+	32	32	P+	P+	43	37	F	37	F−	36	F−	29	48	45	40	32
	Conventional (lead and zinc paint)	47	30	31	26	P+	47	32	24	37	48	37	34	F	37	F−	34	F−	25	44	39	34	29
3a	Graphite in varnish	F	F	F	P+	P+	P+	P+	P+	P+	P+	P+	P+	41	41	41	41	F−	29	47	47	45	44
2b	Iron oxide in varnish	P+	P+	P+	P+	P+	P+	47	47	P+	P+	P+	P+	F	F	F	41	F−	P+	47	47	46	46
	Conventional (lead and zinc paint)	33	33	30	27	47	47	47	27	P+	P+	48	35	F	F	F	41	F−	P+	43	43	41	32
2c	Lead chromate in varnish	P+	P+	P+	P+	47	47	47	47	P+	P+	P+	P+	F	F	F	F	F−	P+	47	47	46	46
6a	Raw linseed oil	F−	33	21	15	P+	47	39	32	F−	43	43	30	F−	41	41	41	F−	P+	48	40	35	30
	Conventional (lead and zinc paint)	F−	28	21	17	P+	47	39	32	F−	43	43	30	F	41	41	41	F−	29	48	39	35	30
6b	Bodied linseed oil	15	15	15	15	15	15	15	15	21	21	21	21	18	18	18	18	17	17	17	17	17	17
6d	Long-oil spar varnish	47	47	33	33	47	47	47	24	32	32	32	32	18	18	18	18	F−	24	36	36	31	26
	Conventional (lead and zinc paint)	33	33	21	21	47	47	47	20	P+	P+	48	28	F−	F−	34	34	F−	24	43	43	35	25
5	Varnish added to white paint	21	33	21	21	47	47	47	40	48	36	48	36	41	41	41	41	F−	29	38	38	37	33
6c	Oxidized linseed oil	47	47	30	27	20	20	20	20	48	48	24	24	41	41	30	30	F−	24	38	38	26	25
	Conventional (lead and zinc paint)	33	33	26	21	47	47	47	20	P+	P+	38	30	F	F	41	33	F−	29	32	43	36	27
6e	Nitrocellulose lacquer	47	47	39	33	26	47	38	26	42	42	30	28	27	27	27	27	F−	24	35	40	32	28
7a	Butyl alcohol thinner	47	24	24	24	47	47	40	40	48	48	43	43	F	F	41	36	F−	P+	45	41	36	35
	Conventional (lead and zinc paint)	47	27	27	21	47	47	40	40	48	48	37	37	F	41	41	30	F−	P+	45	40	35	32
7b	Ethyl lactate thinner	42	26	26	16	47	47	40	40	32	32	32	32	F	41	41	30	F−	29	41	36	36	29

[a] Key to symbols: RD, redwood; WP, northern white pine; DF, Douglas fir; SP, southern yellow pine; F, fair in integrity; P, poor; + and − indicate slightly better or slightly worse than typical of the integrity rating to which the sign is attached.

zinc paint, respectively. Pertinent observations concerning the effect of some primers on maintenance of appearance are given in the course of the discussion. The effect of special primers on maintenance of protection is being studied in another series of experiments (*3*).

In Tables I and II the durability of the coating over each special primer is recorded immediately above or below the durability on the neighboring area of the same boards primed conventionally with the white paint. The difference in durability over the specially primed area and the conventionally primed area very largely measures the value of the special primer from the point of view of this discussion. By way of summarizing the results with each primer, a composite rating for all stations is calculated and recorded in the final columns of Tables I and II. This composite rating is the average durability, in months, based on the assumption that those coatings that were still serviceable at the last inspection would remain so for 9 months longer if last rated "fair," 6 months longer if last rated "fair minus," and 3 months longer if last rated "poor plus." The composite ratings are merely an arbitrary arithmetical convenience for concise presentation.

Table III presents the average gain or loss in durability effected by the special primers. This is the difference between the composite rating for durability over the primer and over the neighboring area of the same boards conventionally primed, as recorded in Table I or II. In Table III the primers are listed in the order of merit, taking both kinds of finishing paint into consideration. The first ten primers listed were, on the whole, better than conventional priming and the last ten listed were worse than conventional priming. In general, the order of merit of the special primers is much the same for the white lead paint and for the lead and zinc paint, but there are a few marked exceptions. Bodied linseed oil and oxidized linseed oil were fairly good primers for white lead paint but very bad ones for lead and zinc paint. Trimetal and aluminum in red lead paint slightly improved the durability of lead and zinc paint but materially reduced that of white lead paint. The extent to which the durability was improved by successful primers was materially greater in the case of lead and zinc paint than it was in that of white lead paint.

On redwood and white pine none of the primers increased the average durability of white lead paint very much, but on Douglas fir and southern yellow pine the better primers increased the average durability by as much as 10 months. The average durability of lead and zinc paint was increased by the better primers by 3 or 4 months on redwood, 4 to 8 months on northern white pine, and as much as 15 or 17 months on Douglas fir and southern yellow pine. The tendency, therefore, was for greater uniformity in durability over the different woods when the better primers were used than when the conventional primer was used. Even the best of the primers, however, failed to make paint last fully as long on Douglas fir and southern yellow pine as it did on redwood and northern white pine.

The best primers tested were those made by adding leafing pigments (aluminum powder or flake graphite) to long-oil spar varnish. The merits of aluminum paint as a special primer have been demonstrated

TABLE III. AVERAGE GAIN OR LOSS IN DURABILITY EFFECTED BY THE SPECIAL PRIMERS

(Differences between the composite ratings in Tables I and II for the durability over the special primers and over neighboring areas of the same boards conventionally primed)

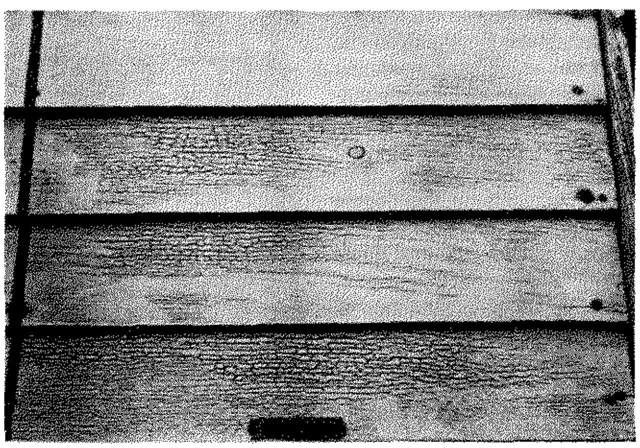
		Average Gain (+) or Loss (−) in Durability in Months for:										
		White lead finish coats on:					Lead-zinc finish coats on:					Both finish coats
	Primer	RD[a]	WP	DF	SP	All four woods	RD	WP	DF	SP	All four woods	All woods
3b	Aluminum in varnish	+1	+1	+ 9	+10	+5.3	+ 3	+ 7	+15	+17	+10.5	+7.9
3a	Graphite in varnish	0	+1	+ 8	+ 9	+4.5	+ 3	+ 8	+11	+15	+ 9.3	+6.9
4b	Aluminum in white lead paint	0	0	+ 7	+10	+4.3	+ 4	+ 8	+ 8	+11	+ 7.8	+6.0
2c	Lead chromate in varnish	+2	+1	+ 3	+ 9	+3.8	+ 4	+ 4	+ 5	+14	+ 6.8	+5.5
2b	Iron oxide in varnish	+1	0	+ 3	+ 4	+2.0	+ 4	+ 4	+ 5	+14	+ 6.8	+4.4
2a	Lampblack in varnish	0	−1	+ 5	+ 5	+2.3	+ 4	+ 6	+ 6	+ 3	+ 4.8	+3.5
1a	Lampblack in white paint	0	0	+ 2	+ 4	+1.5	0	+ 7	+ 4	+10	+ 5.3	+3.4
1c	Lead chromate in white paint	+1	−1	+ 2	+ 3	+1.3	0	+ 7	+ 6	+ 9	+ 5.5	+3.4
1b	Iron oxide in white paint	+1	−3	+ 2	+ 3	+0.8	+ 1	+ 8	+ 7	+ 6	+ 5.5	+3.1
4a	Graphite in white paint	0	−2	+ 1	+ 2	+0.3	0	+ 7	+ 3	+ 8	+ 4.5	+2.4
4c	Aluminum in red lead paint	−2	−1	− 4	− 5	−3.0	+ 3	+ 4	− 2	+ 3	+ 2.0	−0.5
6a	Raw linseed oil	0	−3	− 3	− 2	−2.0	0	+ 1	0	0	+ 0.3	−0.9
5	Varnish added to white paint	−4	−5	− 2	0	−2.8	− 5	− 5	+ 2	+ 8	0	−1.4
7b	Ethyl lactate thinner	0	0	− 1	− 1	−0.5	− 4	− 4	+ 1	− 3	− 2.5	−1.5
4d	Trimetal	−2	−4	− 9	− 9	−6.0	+ 3	+ 3	0	+ 3	+ 2.3	−1.9
6c	Oxidized linseed oil	+1	0	+ 5	0	+1.5	− 5	− 5	−10	− 2	− 5.5	−2.0
6d	Long-oil spar varnish	−2	−1	+ 2	+ 1	0	− 7	− 7	− 4	+ 1	− 4.3	−2.1
7a	Butyl alcohol thinner	−5	−7	−13	−11	−9.0	0	+ 1	+ 1	+ 3	+ 1.3	−3.9
6e	Nitrocellulose lacquer	−7	−7	− 3	− 1	−4.5	− 8	− 3	− 4	+ 1	− 3.5	−4.0
6b	Bodied linseed oil	+2	+2	+ 7	− 1	+2.5	−31	−22	−18	−13	−21.0	−9.2

[a] Key to symbols: RD, redwood; WP, northern white pine; DF, Douglas fir; SP, southern yellow pine.

in previous tests (*4*), but there seems to be very little prior experience with a similar use of flake graphite paint. Although the graphite primer did not prove quite so effective as the aluminum primer in these experiments, the graphite primer was good enough to warrant further study of its possibilities.

The third primer in merit was 4b—aluminum in white lead paint. An earlier test of special primers made by adding aluminum powder to white paints indicated only a slight improvement over conventional priming (*2*), but in the earlier test only about one-sixth as much aluminum powder was added. It appears, therefore, that a substantial proportion of aluminum powder must be added to white lead paint in order to effect the desired improvement in durability. Primer 4a, in which graphite was added to white paint, proved fairly satisfactory but was distinctly inferior to aluminum in white lead. The two remaining primers in which a leafing pigment was mixed with granular pigment paints (aluminum in red lead and trimetal primer) impaired the durability of white lead paint and improved that of lead and zinc paint only slightly. The presence of red lead in these two primers was probably harmful (*2*).

The fourth, fifth, and sixth primers in order of merit were 2c, 2b, and 2a, in which lead chromate, iron oxide, or lampblack was incorporated in long-oil spar varnish. The beneficial effect of these primers must be attributed largely to the nature of the pigments because primer 5, in which the varnish was added to white paint, impaired the durability on redwood and white pine, though it improved slightly the durability of lead and zinc paint on southern yellow pine.



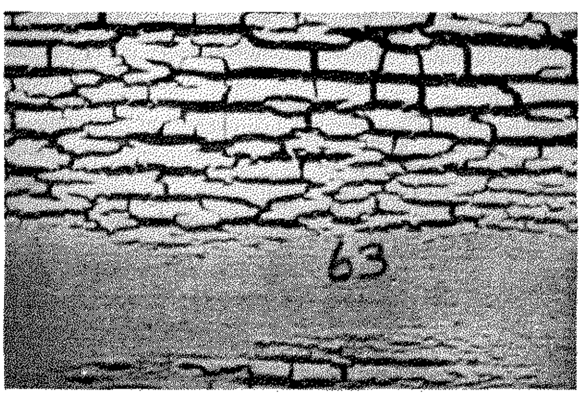


FIGURE 6. CRACKING AND SLIPPING OF LEAD AND ZINC PAINT OVER BODIED LINSEED OIL PRIMER (AFTER 47 MONTHS AT FARGO)

Primers 1a, 1c, and 1b, in which lampblack, lead chromate, or iron oxide was added in substantial proportions to the white priming paints, likewise improved the durability of the coatings, but the effects were not so great as those obtained by priming with the colored pigments in varnish. Presumably the addition of moderate proportions of tinting colors to white paints would prove relatively ineffective.

All of the primers of groups 1, 2, 3, and 4 were dark gray, black, or red. Two substantial coats of white paint of good hiding power are necessary to hide such primers satisfactorily. When finishing paints are thinned unduly or are brushed out into thin coatings, as is often done in house painting at the present time, the color of the primer may show through enough to turn the white paint slightly gray or pink. If two coats of good white paint are applied properly, however, there should be no difficulty on that score unless the white paint is of inferior quality. It was found in these tests that deep checking, which developed during the second year of exposure, was more easily observed over the colored primers than over white paint primers, but careful inspection revealed no essential differences in the checking either in respect to the age at which it developed or the pattern in which it appeared. Although the checking was more easily detected at this stage over the colored primers, it was not more conspicuous to nontechnical observation and did not mar the appearance of the coatings. During the fourth year of exposure when the coatings were chalking deeply and the fissures were opening wider, the effect of the colored primer gradually became noticeable enough to mar the appearance slightly, especially if observed immediately after a rain. Red primers were less desirable at this stage than gray or black ones because pink is more conspicuous than gray. Development of a gray cast toward the end of the life of a coating may not be entirely a disadvantage, however, because it gives warning of the need for repainting before more serious defects set in.

All of the clear liquids tried as primers proved either ineffective or definitely undesirable. Raw linseed oil impaired the durability of white lead paint slightly and left that of lead and zinc paint practically unchanged. Oxidized and bodied linseed oils improved the durability of white lead paint somewhat but impaired that of lead and zinc paint. Long-oil spar varnish decreased the durability of both paints on redwood and white pine, and nitrocellulose lacquer proved generally unsatisfactory. Primers of bodied and oxidized linseed oils and varnish did succeed in retarding the flaking of coatings from the bands of summerwood, but the gain in that respect was offset by a hastening and exaggeration of the development of fissures in the coatings. Checking of white lead paint appeared earlier over these primers and soon became coarser in pattern and more conspicuous than it was over the conventional white lead primer. The lead and zinc paint cracked badly over these primers and developed the defect known as "slipping" (*9*) which was so serious over the bodied oil that the coatings had to be considered failures during the second year of exposure.

Substitution of ethyl lactate for the turpentine in the priming coat of white lead paint had little effect on the durability; its use in lead and zinc priming paint materially impaired the durability. Results with butyl alcohol as thinner were the reverse, in that the durability of white lead paint was materially impaired but that of lead and zinc paint was slightly improved. Both substitute thinners are more highly polar solvents than are customarily used in linseed oil paints. The results suggest that the effect of such solvents on the degree of flocculation of hydrophilic and hydrophobic pigments in paints may have a significant effect on the structure and durability of paint films.

Conclusions

1. Leafing pigments in long-oil spar varnish make the most effective special primers so far discovered from the point of view of retarding the flaking of paint coatings from the bands of summerwood and making the durability of paints on such woods as Douglas fir and southern yellow pine more nearly comparable with the durability on woods such as redwood and white pine. Flake graphite offers possibilities as an alternative to aluminum powder for making special primers of this type.

2. Other special primers that proved reasonably effective in these experiments are made by adding aluminum powder in substantial amount to conventional white lead priming paint, by making paints with such pigments as lead chromate, iron oxide, or lampblack in long-oil spar varnish, or by adding lead chromate, iron oxide, or lampblack tinting colors in substantial amount to conventional priming-coat mixtures of white paint.

3. Special primers containing red lead seem to be unsatisfactory.

4. Clear liquids used as special primers likewise seem to be unsatisfactory.

Acknowledgment

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