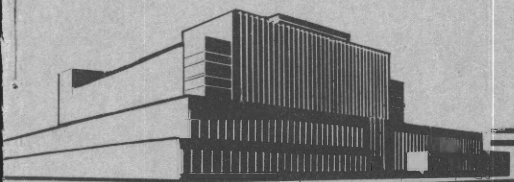
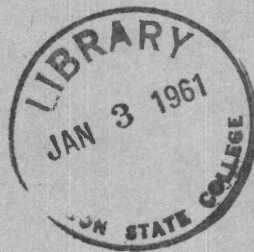


AN ATTEMPT TO HASTEN TEST-FENCE STUDIES OF PAINT FAILURES CAUSED BY TOO-FREQUENT REPAINTING

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UNITED STATES DEPARTMENT OF AGRICULTURE
FOREST SERVICE

In Cooperation with the University of Wisconsin

AN ATTEMPT TO HASTEN TEST-FENCE STUDIES OF PAINT FAILURES
CAUSED BY TOO-FREQUENT REPAINTING

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Previous publications (2, 3)³ revealed a critical film thickness for coatings of house paint beyond which they behave abnormally. The abnormality usually appears first as cross-grain cracking that leads eventually to a coarse pattern of scaling. Such paint failures from excessive film thickness are often seen on older houses that are repainted too frequently but are rarely seen on new houses painted for the first time. The customary methods of evaluating paints by exposure on test fences seldom yield information about critical film thickness because the test panels are seldom repainted after the first paint coating wears out. The unusual tests by the Forest Products Laboratory previously reported involved numerous repaintings and tedious observations over a period of 15 years, from 1936 to 1951. The fact that the literature records no comparable study of critical film thickness probably is due chiefly to the exceedingly long time required.

Critical film thickness, however, is important because it governs, in conjunction with the rate of erosion during weathering, the program of paint maintenance that can be adopted with safety. It would be helpful, for example, if the critical film thickness could be determined quickly for the water-thinned emulsion paints, many brands of which began to reach the market in 1959. The emulsion paints differ so seriously from the older oil paints that they cannot be assumed to have similar properties.

Past experience with artificial weathering devices, such as the Weatherometer, offered little prospect of revealing reliably such developments as cross-grain cracking. It seemed possible, however, that critical film thickness could be determined within the time span of customary paint exposure tests, 5 to 6 years, by applying each paint to new wood at the outset in coatings of various thicknesses from the normal thickness of 5 mils to a clearly excessive thickness, such as 20 mils. Since it is impracticable to apply more than 2 mils of paint in any one coat, the proposed program required the application of many coats of paint to produce the coatings of excessive thickness. The present study was started late in 1952 to learn whether such accelerated technique of building thick coatings reveals the abnormalities obtained when houses are repainted too often.

¹D. F. Laughnan, technologist, formerly with the Forest Products Laboratory, collaborated with the author in planning this study and was responsible for the experimental work up to the time for final evaluation.

²Maintained at Madison, Wis., in cooperation with the University of Wisconsin.

³Underlined numbers in parentheses refer to Literature Cited at the end of this report.

The Test Procedure

The test procedure followed closely that of the earlier tests made from 1936 to 1951 (2). Ten 6-foot units of test fence, the south side of which is shown in figure 1, were required. Each unit held four test panels. On the first five units counting from right to left, each test panel contained four boards of drop siding, two of Douglas-fir, and two of southern yellow pine. On the other five units each test panel contained four boards of bevel siding, two of western redcedar, and two of eastern white pine. All tests were repeated on the north side of the fence. For each of 20 paints there were one drop siding and one bevel siding panel facing south and one drop siding and one bevel siding panel facing north. Each test panel was subdivided into four test areas by drawing vertical lines approximately 18 inches apart. Paint was applied in a sufficient number of coats to make the total coating thickness approximately 5 mils on the left-hand test area of a panel, 10 mils on the next test area, 15 mils on the third test area, and 20 mils on the fourth or right-hand test area.

The paints tested are listed in table 1 with their compositions indicated by symbols that are explained in Appendix A. Paints Nos. 1 to 16 were made from their raw materials at the Forest Products Laboratory. Paints Nos. 17 to 20 were commercial products on the market in 1953. Paints Nos. 1, 3, 5, 10, and 15 were similar although not identical to paints Nos. 1, 4, 8, 9, and 2, respectively, in the earlier tests of 1936 to 1951. Marked changes in commercial practice occurred in the interval between the two series of tests. Accordingly there were some paints in the present tests of a kind not made commercially in 1936. Also the emulsion paints available in 1959 were not on the market in 1952.

All paints were applied according to the self-priming practice; that is, the paint used for finish coats was used also for the priming coat. For the purpose of this study, it was considered advisable to follow the procedure used for most of the paints in the earlier studies. Self-priming is still widely practiced even though the preferred practice now calls for use of special house-paint primers.

Thickness Calculated from Spreading Rate

A record was kept of the spreading rate at which each coat of paint was applied. From the spreading rate and the volumetric composition of the paint, the approximate dry film thickness obtained from each coat was computed by the method previously published (1). Enough coats were applied to attain the desired total thickness of coating on each test area. Spreading rates were kept within limits that would be practicable in painting houses. Table 1 lists the number of coats found necessary with each paint for each of the four coating thicknesses desired. Three coats sufficed for the 5-mil thickness except for paints Nos. 16 and 20, which required four and five coats, respectively. For the 20-mil thickness the number of coats ranged from 7 for paint No. 12 to 19 for paint No. 20.

The coating thickness actually attained was reasonably close to the desired thickness. On the test areas to receive coatings 5 mils thick, the thickness attained differed from the desired thickness by 0.09 mil on the average, with 68 of 80 test areas within 0.1 mil. On the areas to receive coatings 10, 15, or 20 mils thick, the difference between the thickness attained and that desired averaged 0.18 mil, with 196 of 240 test areas within 0.2 mil.

Paints were applied indoors and allowed to harden at least overnight, after which the panels were exposed to sunshine outdoors for at least 1 day, usually for several days, before the next coat of paint was applied. The interval between coats varied according to the progress of the work; sometimes it was as much as 2 weeks. Painting began on November 24, 1952, and was completed on April 22, 1953. On any one panel the painting was started simultaneously on all four test areas. Succeeding coats were applied simultaneously until the desired thickness was attained on each test area. Thus the 5-mil coatings were completed first, the 10-, 15-, and 20-mil coatings following later on in order. The panels were mounted on the Madison test fence May 5, 1953.

Thickness Measured Soon After Exposure

About a month after the exposures were started, the thickness of coating was measured on every test area by the method described in a previous report (3). A sample of coated wood was taken with the sampling tool from the approximate center of the face of each board in each test area. The gouges left in the boards by the sampling tool were filled with plastic wood and coated with aluminum paint to prevent local failure of paint near the damaged places during further weather exposure. The samples taken were split, and the coating thickness was measured at 8 to 12 places on each sample with a microscope equipped with a micrometer eyepiece. The average thickness of coating on each test area was then computed and compared with the thickness previously calculated from the spreading rate at which point was applied.

There is more uncertainty in the method of measuring coating thickness by sampling than in the method of calculating from spreading rate, because coatings vary appreciably in thickness despite care in application and the number of samples that can be taken without unduly marring the test area is limited. For an individual area, therefore, the calculated thickness is more reliable than the measured thickness.

The calculated thickness exceeded the measured thickness to the extent shown in table 2. The 20 paints were divided into five groups of paints of similar behavior, and for each group the average difference between the calculated and the measured thickness, expressed in percent of the calculated thickness, is reported in table 2. The difference occurred chiefly from a shrinkage in the volume of paint while the liquid paint was oxidizing and hardening, while the hardened coatings were awaiting exposure on the test fence, and while soluble products of oxidation were leached from the coatings by rain (4) during the first month or so of weather exposure. Since the area of the coatings was fixed by their adhesion to the wood, the shrinkage in volume took place entirely by shrinkage in thickness. (Loss of linseed oil from priming coats is taken into account reasonably adequately in the method of calculating thickness from spreading rate.)

Table 2 shows that the shrinkage was usually greatest for the nominally 5-mil coatings and decreased as nominal coating thickness increased through 10 and 15 mils to 20 mils. The variation with thickness is readily explained. All of the paint, regardless of coating thickness, was subject to the initial shrinkage during hardening, which for linseed oil paints of 0.30 pigment volume amounts to about 5 percent by the tenth day after application (5). All paint in the nominally 5-mil coatings then stood for nearly 5 months while the thicker coatings were being built up.

Further shrinkage, estimated to occur during this 5-month period, amounted to 2.5 percent for the zincless linseed oil paints and 1.25 percent for zinc-containing linseed oil paints. In the 20-mil coatings, however, only the first one-fourth of the paint

passed through nearly the whole 5-month period, whereas the last one-fourth passed through no more than the last 3 weeks of it. The thicker coatings, therefore, shrank relatively less than the thinner coatings during the painting period. Finally, leaching of water-soluble oxidation products during the first month of exposure on the test fence probably was less nearly complete for the thicker than for the thinner coatings.

The difference between the 20-mil and the 5-mil coatings in percent shrinkage probably would have been less if the 5-mil coatings had been applied contemporaneously with the last rather than the first 5 mils of the 20-mil coatings.

The shrinkage reported in table 2 was greater in paints made at 0.30 pigment volume than in otherwise similar paints made at 0.36 or 0.40 pigment volume. Since shrinkage occurs chiefly in the vehicle rather than in the pigment component of the coatings, shrinkage should decrease as the pigment volume increases.

Coatings of linseed oil paints in which one of the pigments was zinc oxide shrank less than linseed oil paints without zinc oxide. For example, the zincless linseed oil paints of 0.30 pigment volume when nominally 5 mils thick shrank 18 percent, whereas the comparable zinc-containing paints shrank 12 percent. The like effect of zinc oxide was reported previously (5) in tests made in a very different way. In these other tests 4-mil coatings of paints Nos. 1 and 15, the two zincless linseed oil paints, shrank 19.7 and 20.1 percent, respectively, whereas 4-mil coatings of paints No. 6 and a similar zinc-containing paint shrank 12.6 and 11.3 percent, respectively. The procedure of the other tests was much more precise than that of the present work.

In table 2 the shrinkage recorded for alkyd-resin or varnish vehicle paints, none of which contained either white lead or zinc oxide, was usually less than that of any of the linseed oil paints. The low shrinkage of the resinous paints may be attributed to their highly bodied vehicles, which may be considered "preshrunk," rather than to the absence of white lead and zinc oxide. The bodying process engages many of the reactive groups that in unbodied oil paints remain free to participate in cross linking with contraction in volume during the period of hardening after the paint has been applied.

Thickness After 4 Years

When the test fence exposures were 4 years old, each test area was sampled a second time, at a place less than 1 inch distant from the first sample, in order to remeasure the thickness of coating and to reveal the loss of coating thickness from weathering. The loss was computed as the difference between the initial thickness calculated from spreading rate and paint composition and the thickness measured on the 4-year-old samples. The calculated rather than the measured initial thickness was chosen as the starting point, because this was the procedure followed in the tests of 1936 to 1951 (2,3), with which it was desired to compare results.

Table 3 records the average loss in thickness of coatings during weathering for each of the five groups of paints of similar behavior. In each of the four groups of linseed oil paints, the loss on weathering was greater the greater the nominal thickness of the coating. For the fifth group of paints with alkyd-resin or varnish vehicles the trend was to lower loss with greater nominal thickness. In the earlier tests (3), in which the thick coats were built by successive repaintings after 2 or more years of weathering, the losses proved to be practically independent of total thickness. Therefore, the losses

in the present test were recalculated by taking the difference between the measured thicknesses on the samples taken about 1 month after exposure and the samples taken after 4 years of exposure. When so recalculated, the losses were found to be nearly or entirely independent of nominal coating thickness. It may therefore be concluded that the greater losses by the thicker coatings during the 4-year weathering period (table 3) represent a recovery of the lag in shrinkage that was exhibited at the time of the first sampling (table 2), the reasons for which have already been explained. The contrary trend of the alkyd-resin or varnish vehicle paints, which does not appear when the losses are calculated from the differences between the 1-month and 4-year measured thicknesses, remains unexplained.

The loss in thickness of the zincless linseed oil paints materially exceeded the loss of zinc-containing linseed oil paints, and the loss of paints of 0.30 pigment volume exceeded the loss of paints of higher pigment volume (table 3). Both of these trends agree with the findings in the earlier tests (3), in which the losses were somewhat greater for coatings facing south than for those facing north. That was the case also in the present tests, although the differences for zinc-containing linseed oil paints and the alkyd-resin or varnish vehicle paints were very slight.

The annual loss in coating thickness of zincless linseed oil paints of 0.29 pigment volume in the earlier tests (3) was approximately 0.6 mil. The annual loss for zincless linseed oil paints of 0.30 pigment volume at 5-mil nominal thickness was 0.7 mil (table 3). For zinc-containing linseed oil paints of 0.29 pigment volume in the earlier tests, the annual loss was approximately 0.4 mil compared with a little more than 0.3 mil for the 5-mil coatings of comparable paints in the present tests. The agreement is considered satisfactory, especially when the difference in procedure in the two series of tests is considered. (The 5-mil coatings in the present tests afford the best basis for comparison, because they do not involve the uncertainty from building thick coatings without adequate weathering between successive increments.)

Abnormal Cracking of Thick Coatings

The exposure tests were continued for a total of 6-1/2 years, until the fall of 1959. Only partial success was achieved in reproducing the cross-grain cracking found with all paints in the earlier tests of 1936 to 1951 when the coatings were repainted often enough to exceed their critical thickness. If the present accelerated technique gave the same results as the earlier slow technique, all 16 of the linseed oil paints should have developed distinct cross-grain cracking at the 10-, 15-, and 20-mil nominal thicknesses. For the three alkyd-resin and one varnish vehicle paints, prior comparable test data are lacking.

Five linseed oil paints of the present study, paints Nos. 3, 4, 10, 11, and 19, in coatings nominally 10, 15, or 20 mils thick did in fact become cracked across the grain in a pattern entirely similar to that found for thick coatings of similar paints in the earlier tests. There was no sign of cross-grain cracking in the 5-mil coatings. The cross-grain cracks were most numerous at the 20-mil thickness, less so at 15-mil thickness, and least so, sometimes absent, at the 10-mil thickness. Figure 2 shows the cracking of the 5-mil and 20-mil coatings of paint No. 10. For these five paints, therefore, the accelerated technique was reasonably successful, although it probably led to overestimates of the critical thickness at which cross-grain cracking occurs in practical paint maintenance.

Another four of the present linseed oil paints, Nos. 5, 6, 8, and 18, developed a conspicuous form of cracking in coatings nominally 10, 15, or 20 mils thick that was absent in the nominally 5-mil coatings. The abnormal cracking of these paints crossed the grain of the paint at least in large part, but at an angle far short of the 90° angle characteristic of true cross-grain cracking. Such form of abnormal cracking was more marked at 20-mil nominal thickness than at 15-mil thickness, still less marked or absent at 10-mil thickness, and never evident at 5-mil thickness. Figure 3 shows the cracking of the 5-mil and 20-mil coatings of paint No. 5. For all four of these paints, the accelerated technique revealed deficiencies at excessive coating thickness but in patterns that were unrepresentative of practical service.

The seven remaining linseed oil paints, Nos. 1, 2, 7, 9, 15, 16, and 17, checked or cracked according to their normal pattern regardless of the thickness of coating. In those of the seven that contained zinc oxide, however, the cracks tended to become longer and more conspicuous the thicker the coating, as is shown in figure 4 for paint No. 9. In the titanium-lead paints, Nos. 15 and 16, the checking pattern was distinctly coarser in mesh and the checks apparently deeper the thicker the coating (fig. 5). In white lead paints, Nos. 1 and 2, the checking pattern remained very nearly independent of coating thickness (fig. 6). Thus, for five of the seven paints the accelerated technique revealed deficiencies at excessive coating thickness in a coarsening of the normal pattern of checking or cracking. For white lead paints, the accelerated technique failed to disclose any abnormality in thick coatings.

Abnormal Disintegration of Thick Coatings

The one varnish vehicle and three alkyd-resin paints had no checking or cracking pattern apart from cracking that lead almost immediately to curling and then flaking or scaling. Such disintegration appeared first and progressed farther the thinner the coating. With the 5-mil coatings, the disintegration took the form of flaking; that is, relatively small chips of coating came loose and fell from the bands of summerwood, leaving coating still clinging to the adjacent springwood. As the thickness of coating increased, however, the cracks became larger, the curling more pronounced, and the disintegration changed more and more to scaling, in which relatively large chips of coating come loose without regard for distinctions between summerwood and springwood. Figure 7 shows the change from flaking to scaling for paint No. 14. For the alkyd-resin and varnish vehicle paints, the accelerated technique revealed no abnormalities of thick coatings except the shift from flaking to scaling disintegration as the coating increased in thickness.

The linseed oil paints that contained zinc oxide tended to disintegrate increasingly by scaling rather than by flaking when the thickness of coating increased from 10 to 20 mils, much as did the alkyd-resin paints. The chips of paint dislodged by scaling of the zinc-containing linseed oil paints, however, were never so large as some of the chips of alkyd-resin paints. Earlier and more numerous cracks in the linseed oil paints served to limit the maximum size of chips that could be formed later on. The zincless linseed oil paints, Nos. 1, 2, 15, and 16, disintegrated by crumbling (fig. 6) without flaking or scaling, regardless of the thickness of coating.

There were three pairs of zinc-containing linseed oil paints, Nos. 6 and 7, 8 and 9, and 10 and 11, in which both paints of the pair had the same pigmentation but differed in pigment volume. In each pair, the abnormal cracking at excessive coating thickness was somewhat more pronounced for the paint of lower pigment volume than for the

paint of higher pigment volume. Paints 6 and 8, made at 0.30 pigment volume, disintegrated by flaking or scaling slightly more rapidly than their corresponding paints 7 and 8, made at 0.36 pigment volume. Paint 11, made at 0.40 pigment volume, disintegrated more rapidly, however, than its corresponding paint 10 made at 0.36 pigment volume. Among alkyd-resin paints 12, 13, and 14, disintegration was slowest for the 0.30 pigment volume paint and fastest for the 0.40 pigment volume paint. With the zincless linseed oil paints, pairs 1, 2, and 15, 16, the rate of disintegration was practically independent of pigment volume.

All paints disintegrated less rapidly the greater the nominal thickness of the coating. Thus with any paint the most durable painting of new wood is obtained when enough paint is applied to build a coating of the maximum thickness at which the coating weathers in its normal pattern of checking or cracking and ultimately disintegrates by flaking in tiny chips rather than by scaling in large, thick chips. With zincless linseed oil paints, such as white lead and titanium-lead paints, the initial coating thickness could advantageously be at least as great as 10 or 15 mils, but for zinc-containing linseed oil paints or alkyd-resin paints the initial thickness should not exceed 5 mils. In practice, most modern painting of new houses falls far short of 5 mils and therefore is not producing paint jobs of the durability of which the paints are capable. On the other hand, the prevalent undue frequency of repainting soon leads to the abnormalities of excessive coating thickness.

When cross-grain cracking of excessively thick coatings developed in these tests, it usually appeared at least as soon on the test areas facing north as it did on the corresponding areas facing south. Findings were similar in the earlier tests of 1936 to 1951.

Such abnormalities of excessive thickness as cross-grain cracking and coarsening of checking or cracking patterns occurred as soon and as severely on redcedar and white pine as they did on the more exacting woods, Douglas-fir and southern yellow pine. The shift from flaking to scaling as coating thickness increased also appeared without regard for the kind of wood. The same results were found in the earlier tests of 1936 to 1951. In both the earlier and the present tests, coatings thin enough to behave normally disintegrated soonest on southern yellow pine, next on Douglas-fir, still later on white pine, and latest on redcedar. In the earlier tests, excessively thick coatings disintegrated nearly simultaneously on all four woods, but in the present tests the effect of the kind of wood on the order of disintegration remained evident at all coating thicknesses.

Conclusion

The accelerated technique for studying the effects of excessive coating thickness failed to reproduce the full patterns of abnormalities that occur when paint coatings become too thick as a result of too-frequent repainting in practical paint maintenance. Nevertheless, the accelerated technique did succeed in revealing thick-coating abnormalities of one kind or another for all of the paints tested except the two of white lead and linseed oil. The technique therefore affords a useful tool for paint investigations, provided that its limitations are kept in mind. It can be expected to disclose a maximum coating thickness beyond which paint performance becomes abnormal, but it may not disclose the detailed patterns in which the abnormalities will appear in practice.

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1957. Swelling of paint films in water: Part XI, Mixed-pigment paints in linseed oil. Forest Products Journal VII No. 7, 248-252.
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Appendix A: Symbols for Paint Composition

For brevity the composition of paint is indicated by symbols. Capital letters stand for opaque pigments as follows: L, white lead; Z, zinc oxide; T, a mixture of 1 part by volume of titanium dioxide and 3.2 parts by volume of a pigment of low opacity, such as magnesium silicate, calcium carbonate, or calcium sulfate. Subscripts to letters L or Z report the percentage by volume of the indicated pigment in the total pigment portion of the paint. For example, in table 1, the pigment of paint No. 3 contained 37 percent of zinc oxide by volume and 63 percent (100 minus 37) of white lead. When the letter symbols with their subscripts are enclosed in parentheses to which a subscript greater than 100 is attached, it means that the pigment contains less than 3.2 parts of pigment of low opacity for each part of titanium dioxide. The subscript to the parentheses is then a measure of the volume of total pigment that would be necessary to provide the same opacity if the full 3.2 parts of low-opacity pigment per part of titanium dioxide were present. The content of titanium dioxide and low-opacity pigment actually present in paint No. 18, for example, can be calculated as follows: The white lead and zinc oxide together amount to 23 plus 18 or 41 percent of the total pigment. If the titanium dioxide were fully extended with low-opacity pigment, the two together would come to 134 less 41 or 93 percent of the total pigment of which 93 divided by 4.2 or 22.1 percent would be and therefore actually is titanium dioxide. The content of pigment of low opacity is then 100 less 41 less 22.1 or 36.9 percent by volume.

The symbol (e) following the symbols for pigment composition indicates that more than 30 percent by volume of the linseed oil in the paint consists of bodied oil. Symbol (re) means that the paint vehicle contains a resinous component.

Table 1.--The paints tested and the number of coats required to obtain the desired film thickness

Paint			Number of coats required to obtain the film thickness indicated				
No.:	Pigment composition ¹	Pigment: volume	Total non-volatile				
:	:	:	:	5 mils:	10 mils:	15 mils:	20 mils
:	:	:	Gal./gal.	:	:	:	:
1 :	L	: 0.30	: 0.870	: 3	: 6	: 8	: 10
2 :	L	: <u>2</u> .36	: .750	: 3	: 6	: 8	: 10
3 :	LZ37	: .30	: .870	: 3	: 6	: 8	: 11
4 :	TL50Z30	: .30	: .870	: 3	: 5	: 7	: 9
5 :	(TL30Z25) 103	: .30	: .870	: 3	: 5	: 7	: 9
6 :	(TL20Z20) 105	: .30	: .870	: 3	: 5	: 7	: 10
7 :	(TL20Z20) 105	: <u>2</u> .36	: .738	: 3	: 6	: 8	: 10
8 :	(TL10Z10) 106	: .30	: .870	: 3	: 5	: 8	: 10
9 :	(TL10Z10) 106	: <u>2</u> .36	: .738	: 3	: 6	: 8	: 11
10 :	(TZ20) 104(e)	: <u>2</u> .36	: .738	: 3	: 5	: 7	: 8
11 :	(TZ20) 104(e)	: <u>2</u> .40	: .675	: 3	: 6	: 8	: 10
12 :	³ T94(re)	: .30	: .850	: 3	: 4	: 6	: 7
13 :	³ T94(re)	: .36	: .750	: 3	: 5	: 7	: 9
14 :	³ T94(re)	: .40	: .727	: 3	: 5	: 7	: 8
15 :	TL40	: .30	: .870	: 3	: 6	: 8	: 10
16 :	TL40(e)	: <u>2</u> .40	: .675	: 4	: 7	: 10	: 12
17 :	Brand A, TL7Z23(e)	: <u>4</u> .35	: .798	: 3	: 6	: 8	: 10
18 :	Brand B, (TL23Z18) 134	: .31	: .825	: 3	: 6	: 8	: 10
19 :	Brand C, (TZ16) 122	: <u>4</u> .38	: .807	: 3	: 5	: 7	: 8
20 :	Brand D, ⁵ T139(re)	: <u>4</u> .31	: .383	: 5	: 10	: 15	: 19

¹For the significance of the symbols, see Appendix A.

²Part of the linseed oil was heat-bodied to viscosity Z3 (46 poises).

³The vehicle was a long-oil alkyd vehicle widely used for making stain- and blister-resistant paints.

⁴An undisclosed portion of the linseed oil was bodied linseed oil.

⁵The vehicle contained some copal resin and tung oil as well as bodied linseed oil. The paint was sold as a "low-luster, breather-type paint" said to be resistant to blistering.

Table 2.--The extent to which the calculated thickness of coatings, T_c , exceeded the measured thickness, T_m , expresses as percent of the calculated thickness

Description of paint groups on which average results based	Difference $T_c - T_m$ expressed in percent of T_c for coatings of nominal thickness			
	5 mils	10 mils	15 mils	20 mils
	Percent	Percent	Percent	Percent
Linseed oil paints containing white:	:	:	:	:
lead but no zinc oxide and with	:	:	:	:
pigment volume 0.30	:	:	:	:
(Paints Nos. 1 and 15)	18	19	16	12
Linseed oil paints containing white:	:	:	:	:
lead but no zinc oxide and with	:	:	:	:
pigment volume 0.36 or 0.40	:	:	:	:
(Paints Nos. 2 and 16)	18	16	13	9
Linseed oil paints containing zinc	:	:	:	:
oxide and with pigment volume	:	:	:	:
0.30 or 0.31 (Paints Nos. 3, 4,	:	:	:	:
5, 6, 8, and 18)	12	12	9	6
Linseed oil paints containing zinc	:	:	:	:
oxide and with pigment volume	:	:	:	:
0.35 to 0.40 (Paints Nos. 7, 9,	:	:	:	:
10, 11, 17, and 19)	10	7	5	5
Alkyd-resin or varnish vehicle	:	:	:	:
paints containing neither white	:	:	:	:
lead nor zinc oxide (Paints Nos.	:	:	:	:
12, 13, 14, and 20)	10	5	3	2

Table 3.--Loss in thickness of coatings during 4 years of weathering,
computed as the difference between the initial thickness
calculated from spreading rates and the thickness measured
on samples taken 4 years after exposure of the panels

Description of paint groups on which average results based	Loss in thickness of coatings of initial nominal thickness			
	5 mils	10 mils	15 mils	20 mils
	<u>Mils</u>	<u>Mils</u>	<u>Mils</u>	<u>Mils</u>
Linseed oil paints containing white: lead but no zinc oxide and with pigment volume 0.30 (Paints Nos. 1 and 15)	2.8	4.2	4.6	4.7
Linseed oil paints containing white: lead but no zinc oxide and with pigment volume 0.36 or 0.40 (Paints Nos. 2 and 16)	2.1	3.0	3.5	3.1
Linseed oil paints containing zinc oxide and with pigment volume 0.30 or 0.31 (Paints Nos. 3, 4, 5, 6, 8, and 18)	1.3	1.5	1.6	1.7
Linseed oil paints containing zinc oxide and with pigment volume 0.35 to 0.40 (Paints Nos. 7, 9, 10, 11, 17, and 19)	1.2	1.3	1.4	1.5
Alkyd-resin or varnish vehicle paints containing neither white lead nor zinc oxide (Paints Nos. 12, 13, 14, and 20)	1.4	1.1	.9	.8

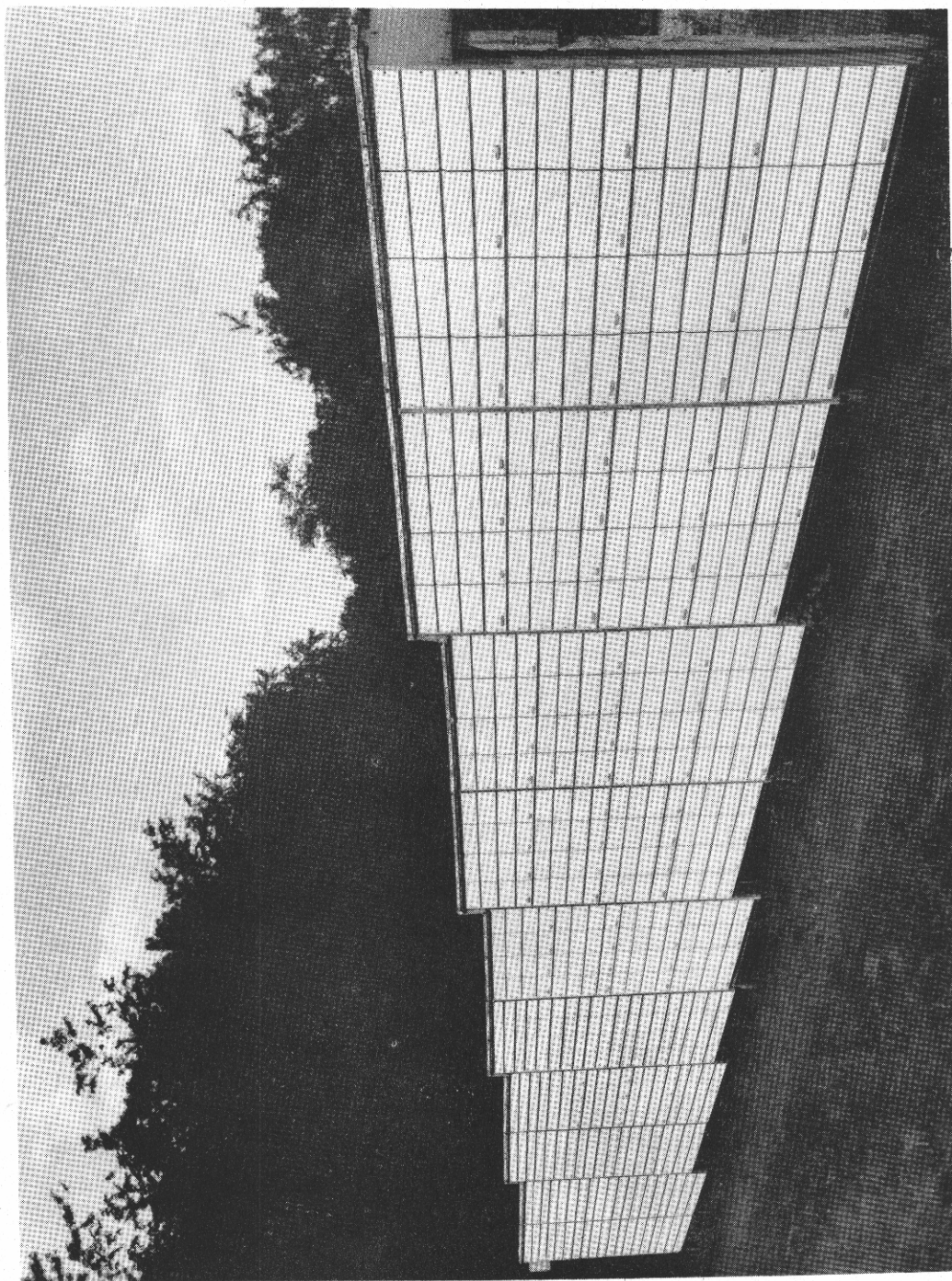


Figure 1.--The south side of the test fence in August 1953. Places where samples were taken to measure coating thickness can be seen. Tests were duplicated on the north side of the fence.

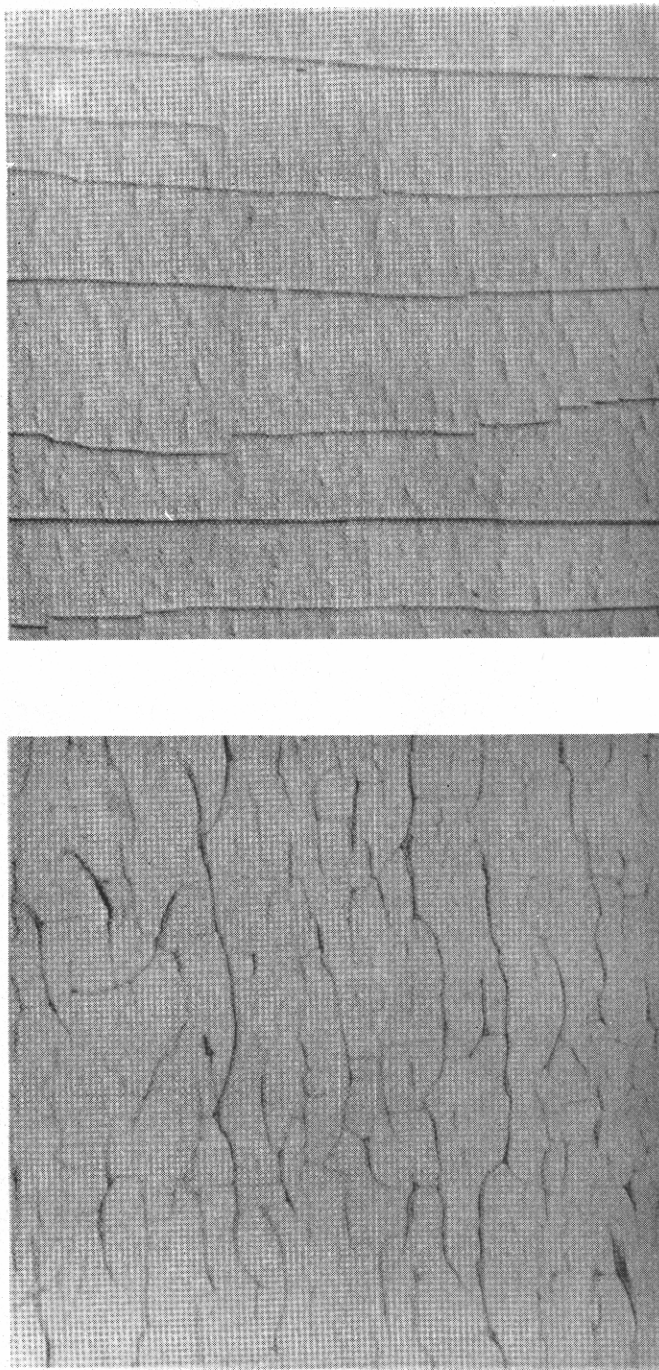


Figure 2.--Cross-grain cracking of nominally 20-mil coating of paint No. 10 (right) and normal cracking of 5-mil coating of the same paint (left). Each area shown is approximately 1 inch square.

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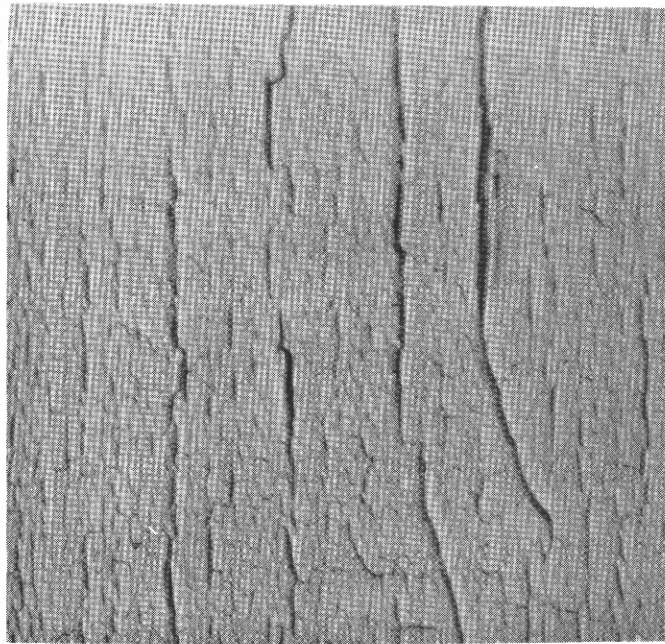
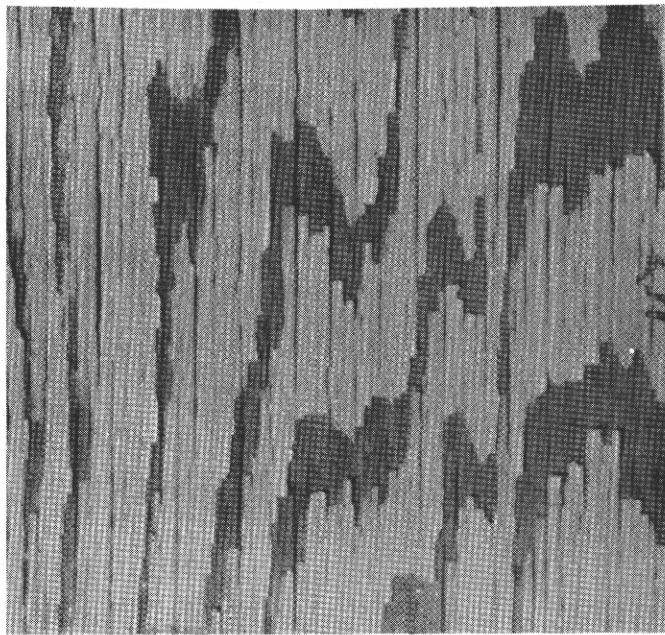


Figure 3.---Cracking often at an angle to the grain of paint No. 5 in nominally 20-mil coating (right) but parallel to the paint grain in nominally 5-mil coating (left). The 5-mil coating is flaking from bands of summerwood in southern yellow pine. Each area shown is approximately 1 inch square.



Figure 4.--Increase in nominal thickness of coating from 5 mils (left-hand area) to 20 mils (right-hand area) does not alter the direction of cracks but the cracks become longer and more conspicuous and curling becomes more marked as the thickness of coating increases. The paint is No. 9.

ZM 116 265

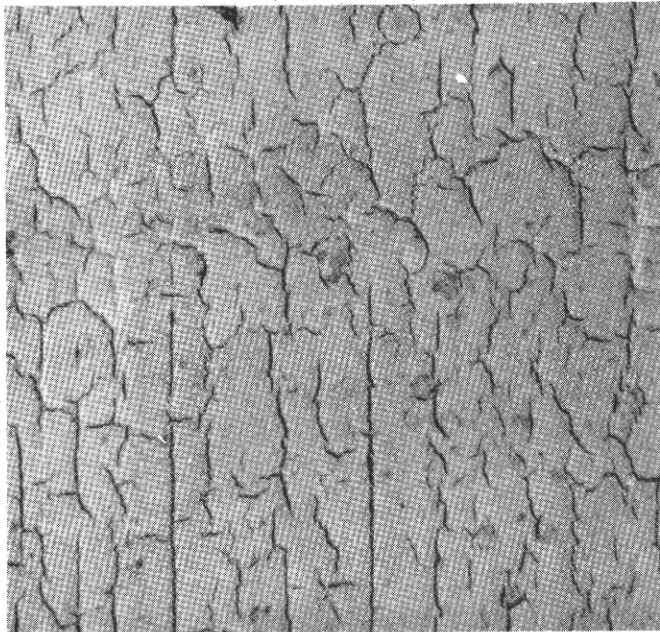
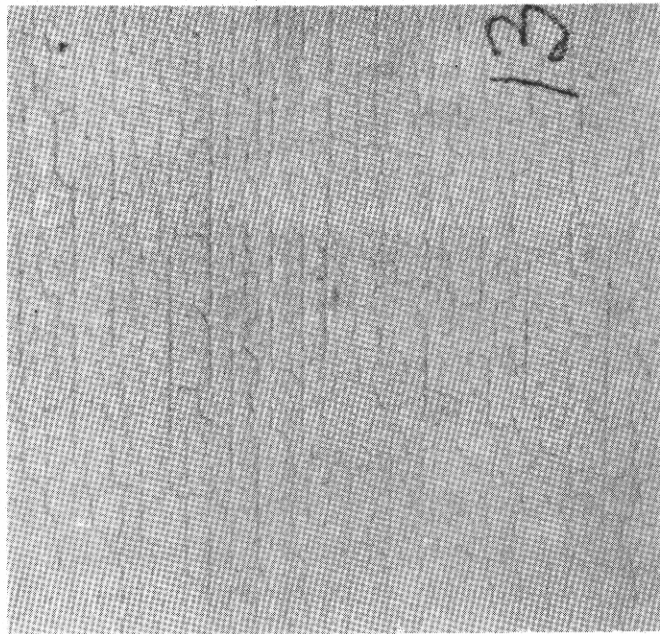


Figure 5.--The checking pattern of paint No. 15 is coarser in mesh and the checks are deeper in the nominally 20-mil coating (right) than in the nominally 10-mil coating (left). Each area shown is approximately 1 inch square.

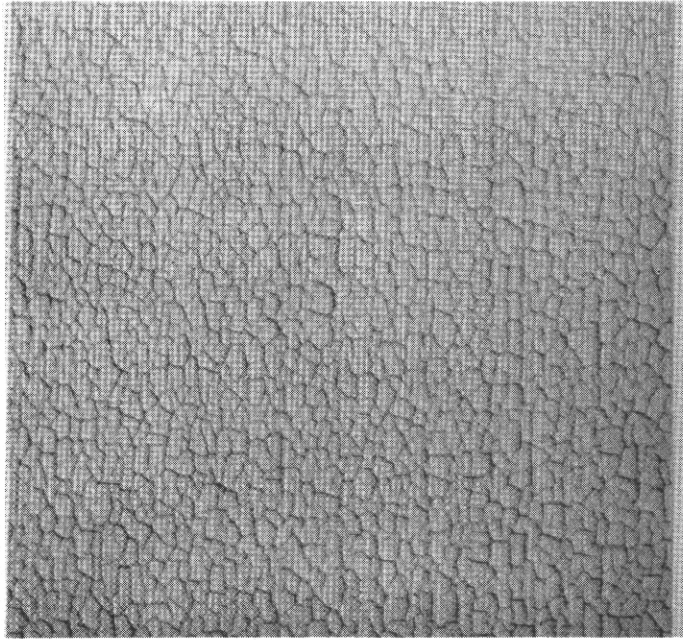
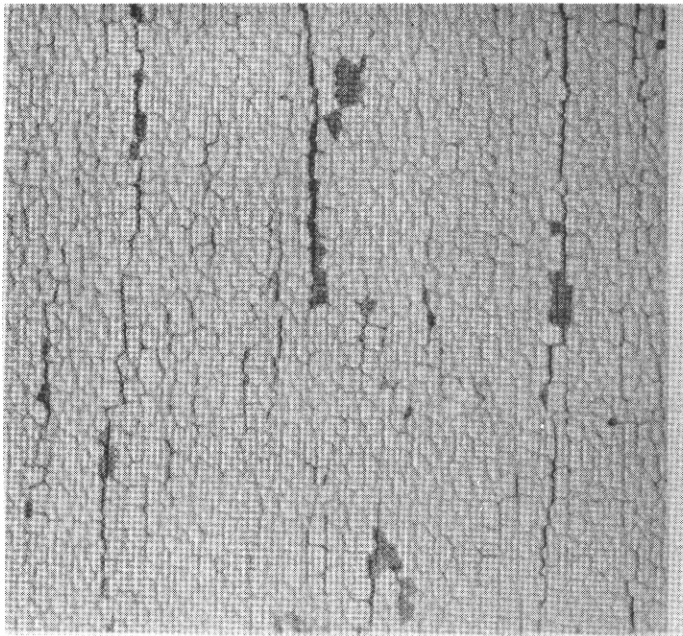


Figure 6.--The checking pattern of paint No. 1 is unaffected by coating thickness, but the nominally 10-mil coating (left) has begun to crumble over bands of summerwood in southern yellow pine. Each area shown is approximately 1 inch square.

ZM 116 699

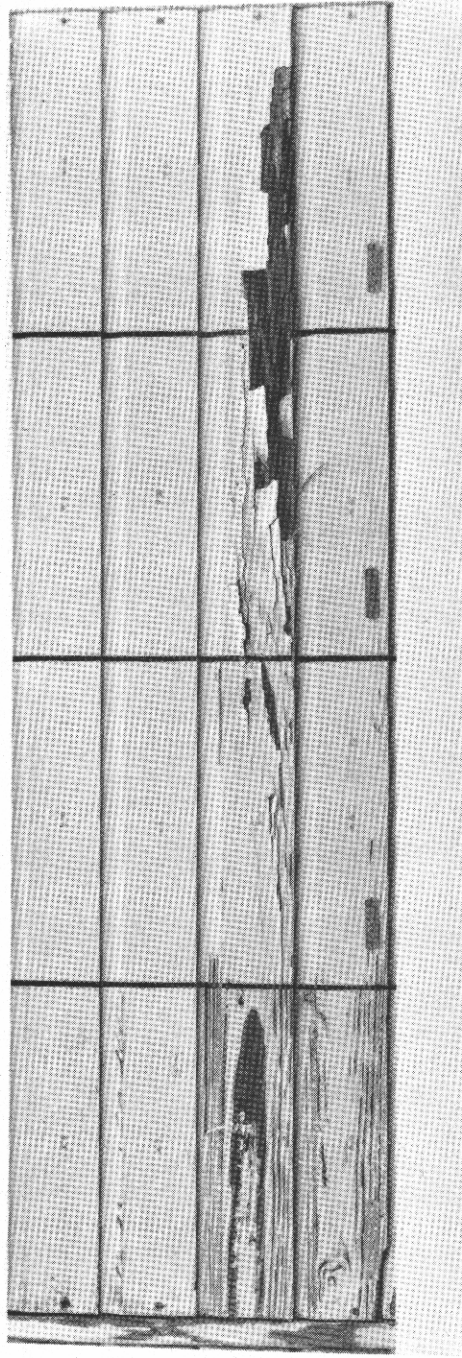


Figure 7. --Disintegration of paint No. 14 by flaking from bands of summerwood in the nominally 5-mil coating (left-hand area) changes as the thickness of coating increases to scaling without regard for springwood or summerwood bands when the coating thickness reaches 20 mils (right-hand area).

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