TECHNICAL NOTE NUMBER 181
FOREST PRODUCTS LABORATORY UNITED STATES FOREST SERVICE
MADISON, WISCONSIN REVISED JANUARY, 1933

COATINGS FOR MINIMIZING CHANGES IN THE MOISTURE CONTENT OF WOOD

Shrinking and swelling and stresses in wood that cause warping, checking, and weathering are brought about by changes in the moisture content. Such changes occur whenever wood is exposed to varying atmospheric conditions. Effective protection against fluctuating atmospheric conditions is furnished by coatings of various moisture retardant finishes provided that the coating is applied to all surfaces of wood through which moisture might gain access. No coating is entirely moisture-proof, however, and there is as yet no way of keeping moisture out of wood that is exposed to dampness constantly or for prolonged periods.

Tests of the moisture-excluding ability of coatings of many kinds have been made at the Forest Products Laboratory. (The method of test is described and more complete data are given in U. S. Department of Agriculture Circular No. 128 obtainable from the Superintendent of Documents, Washington, D. C., for 10 cents.) Table 1 lists coatings suitable for interior use only. The coatings in Table 2 may be used for exterior as well as interior work; some are more durable than others. Ordinarily moisture-excluding ability is only one of several properties that must be considered in selecting a coating for a given use.

The data are for coatings only a few weeks old and not yet exposed to the weather. The effectiveness of many coatings improves slightly with age. Good exterior coatings either retain their maximum effectiveness for a considerable time or lose effectiveness slowly. As long as the original appearance and integrity of the coating are retained most of the effectiveness remains.

Paint that is faded or chalking (removable as a fine powder on rubbing) remains effective if vigorous rubbing removes the chalk and discloses a glossy film underneath. Deep chalking, checking, or cracking indicates serious impairment of the effectiveness.

The numerical values for percentage effectiveness are to be considered in a relative rather than an absolute sense because percentage effectiveness varies materially with the conditions under which exposure to moisture takes place. Coatings are much more effective, for example, against a brief exposure to water in liquid form than they are against one or two weeks of exposure to moisture-saturated air. The values for effective coatings (60% or over) are reliable in the sense that they can be reproduced closely on repeating the test; values for ineffective coatings (less than 20%) must be regarded as rough approximations only. The percentages shown are based on average amounts of moisture absorbed per unit surface area by newly coated and by uncoated wood panels subjected to a relative humidity of 95 to 100% for 14 days. Interior coatings were tested on birch panels only, exterior coatings on white pine, redwood, Douglas fir, and southern yellow pine.

The data obtained lead to the following generalizations:

1. To retard the exchange of moisture between wood and air a substantial coating that is relatively impervious to moisture is necessary. Merely "plugging the wood pores" is not sufficient.
2. The first coat (primer) applied to bare wood rarely forms a substantial coating in the above sense.
3. Linseed oil alone is low in effectiveness even when a substantial coating has been achieved. The effectiveness of drying oils is greatly increased by incorporating resins with them (making varnishes), or by adding pigments (making paints). The more resin or pigment incorporated, within practical limits, the greater the effectiveness. As a rule paints are more

effective than varnishes, and enamels (pigments added to varnish) more so than either.

4. Aluminum powder as a pigment makes especially effective and durable coatings. It can be used with many liquids, but for exteriors the liquid itself should be suitable for exterior use. Aluminum paints may be used as complete coatings or as primers for coatings of other paints.

5. Asphalt and pitch paints are highly effective, inexpensive, and reasonably durable if well made, but they are dark in color and can rarely be painted over satisfactorily with light colored paints.

6. Nitrocellulose wood lacquers are considered suitable for interior use only and do not prove so effective as interior varnishes, though more effective than some exterior varnishes.

Table 1.--MOISTURE-EXCLUDING EFFECTIVENESS OF COATINGS SUITABLE FOR INTERIOR USE ONLY

	Percentage effectiveness†
1.--Three coats of spar varnish coated with vaseline*	98
2.--Aluminum-leaf process, cellulose lacquer base	94
3.--Three coats of aluminum powder in gloss oil (quick drying)	92
4.--Three coats of aluminum powder in shellac	92
5.--Heavy coating of paraffin	91
6.--Three coats of rubbing varnish	89
7.--Three coats of shellac	87
8.--Three coats of enamel (cellulose lacquer vehicle)	76
9.--Three coats of cellulose lacquer	73
10.--Sheet pyralin $\frac{5}{1000}$ inch thick glued to wood	68
11.--Three coats of gloss oil bronzing liquid	12
12.--Three coats of furniture wax	8

†Perfect protection would be represented by 100 per cent effectiveness; the complete lack of protection in the case of uncoated wood, by zero.

*For storage purposes only. Vaseline coating not suitable for exposure to wear.

Table 2.--MOISTURE-EXCLUDING EFFECTIVENESS OF COATINGS SUITAELE FOR EXTERIOR OR INTERIOR USE

Coating No.	Description	Percentage effectiveness† for 1 coat	2 coats	3 coats
1.	--Aluminum powder in asphalt or pitch paint vehicle	--	--	98
2.	--Aluminum powder in No. 16 vehicle	39	88	95
3.	--Extra fine aluminum powder in No. 16 vehicle	78	92	94
4.	--Aluminum powder in "alkyd" type synthetic vehicle	15	81	93
5.	--White lead in a vehicle similar to No. 16	62	86	91
6.	--One coat of No. 2 plus two coats of No. 17	39	86	91
7.	--White lead in No. 19 vehicle	24	85	91
8.	--Aluminum powder in No. 23 vehicle	9	61	90
9.	--Asphalt or pitch paint	--	--	90
10.	--Aluminum powder in bodied linseed oil vehicle	26	84	89
11.	--One coat of No. 8 plus two coats of No. 17	9	62	86
12	--White lead in No. 23 vehicle	7	62	83
13.	--Aluminum in linseed oil	14	57	77
14.	--Aluminum and red lead in linseed oil	7	65	75
15.	--Linseed oil house paint containing zinc oxide and other white pigments with or without tinting colors	30	69	73
*16.	--Phenol-aldehyde synthetic resin, 50-gallon varnish	5	49	73
17.	--Linseed oil house paint containing no zinc oxide, such as common "lead and oil"	20	57	70
18.	--Red lead in linseed oil	15	56	67
*19.	--Ester gum resin, 33-gallon spar varnish	6	37	65
20.	--Graphite in linseed oil	4	58	64
21.	--Red linseed oil barn paint, pigment 98 per cent pure iron oxide	25	53	56
22.	--Red linseed oil barn paint, pigment Venetian red containing 40 per cent iron oxide	1	25	45
*23.	--Ester gum resin, 75- gallon long-oil spar varnish	3	14	35
*24.	--Linseed oil containing paint drier	3	5	21

†Perfect protection would be represented by 100 per cent effectiveness; the complete lack of protection in the case of uncoated wood, by zero.

*Transparent coatings through which the grain of the wood will show.