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by Harry E. Ashton

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RÉSUMÉ

Cette étude traite des méthodes empiriques utilisées pour mettre au point des techniques destinées à évaluer la performance des matériaux, et des principes à suivre pour mettre au point des essais accélérés plus fiables. Les produits de finition transparents pour le bois servent à illustrer l'utilisation des mesures des propriétés de base. L'étude examine également les raisons qui permettent d'associer les propriétés retenues à la performance des matériaux et la relation entre la composition du revêtement et les propriétés. Finalement, on donne une équation qui permet de prévoir la durabilité en fonction des propriétés de base. Cette équation est comparée aux indices de durabilité mesurés à la suite d'expositions à l'extérieur.

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CLEAR FINISHES FOR WOOD—AN EXAMPLE OF ONE APPROACH TO PREDICTING PERFORMANCE

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Empirical approaches used in developing methods for evaluating the performance of materials are discussed. Principles required to develop more reliable accelerated tests are outlined. An application of the use of basic property measurements is illustrated with clear finishes for wood. The reasons for relating the selected properties to performance and the relation of coating composition to the properties are reviewed. Finally, an equation to predict durability from basic properties is developed and compared with durability ratings from exterior exposures.

INTRODUCTION

Evaluation of materials for performance or durability is still a subject of research and debate in spite of the work that has been carried out in this field over the past half century. One cause of this slow progress appears to be the empirical approach followed by many workers, including the author in his early studies. The general procedure seems to have been to presuppose which are the important exposure factors in a given service and to try to incorporate as many of them as possible in a test chamber in which specimens are placed until failure of some kind occurs. The initial development of the apparatus or method was usually followed by juggling the proportions of the time allotted to each factor with the objective of obtaining failures more representative of those occurring in nature.

This approach accounts for the many different accelerated weathering cycles described in the earlier literature[1] and for some of the complex cycles that are difficult to automate but still in use for testing some materials[2] or by some countries for evaluating coatings[3]. When the sophistication of the equipment used to accelerate the factors to the levels assumed to be necessary becomes quite high and the conditions are such that the test is specifically designed to relate to a particular end use, the title of "simulated service test" is bestowed on it. This, however, does not change the fact that the test is basically empirical.

Reducing the time to failure, regardless of its nature, is another objective of juggling factors. Instead of varying the proportions, the customary procedure has been to accelerate markedly one or two factors that are believed to have the greatest effect and, perhaps coincidentally that are easy to increase in intensity. Weather factors, however, are synergistic, so that increasing one but not all may lead to unexpected results. A well-known example of synergism is photo-oxidation, in which the rate of oxidation of a polymer is much greater when both radiation, especially ultraviolet, and oxygen are present than when either degradation agent acts alone. Consequently, increasing radiation dose or type because it is easy to accomplish, while leaving oxygen content at the normal atmospheric level because it is costly to increase it, may have an effect on the photo-oxidation process. Granted, over-acceleration of one or two factors allows results to be obtained in a shorter time, but the results may be less reliable unless studies have been made to establish the validity of the procedure. Unfortunately, it cannot be assumed that because this type of acceleration is found to be acceptable for one material it will be valid for all. Judging by some of the results obtained at DBR/NRCC it may be necessary to carry out such studies for a wide range of materials because the response to accelerated tests, even of materials intended for the same end use, may vary markedly if they differ in composition.

An illustration of this latter effect is provided by an investigation of changes in the mechanical properties of two types of clear finsh for exterior wood caused by natural and accelerated weathering.[4] Figure 23.1 shows that in the latter exposure the phenolic varnishes reached in less than 12 days peak tensile strengths considerably higher than the corresponding values resulting from natural weathering. Conversely, 30 days in the same twin enclosed carbon-arch machine were too short to cause the tensile strength of alkyds to increase to the levels reached in 10 to 14 months of natural weathering. This reversal of behavior is attributed to the higher absorption by the paraphenylphenolic resin of the near UV peaks that are present in the carbon arc radiation. Presumably, if the intensity of the radiation were increased, for example by removing the glass filters, the difference would be greater still.

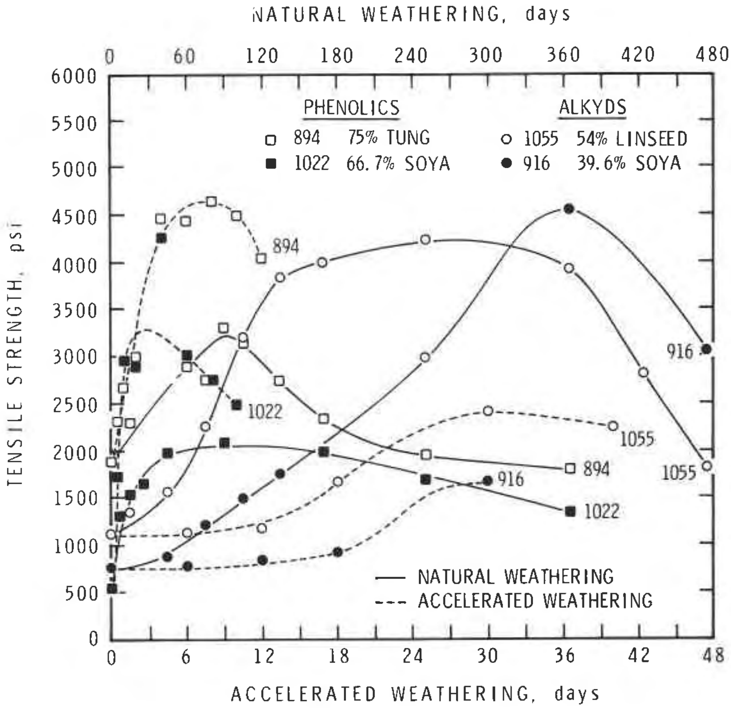

FIGURE 23.1. Changes in tensile strength during natural and accelerated weathering.

Because of the unreliability of tests involving marked acceleration of factors, one of the principles established by the Building Materials Section for the development of evaluation methods is that acceleration of degradative factors must be reasonably related to service conditions to obtain meaningful results. Continuity of exposure to maximum levels of the appropriate factors reduces testing time, although not to the same extend as do excessive levels, but the results are more reliable. This means that conditions to which a material is exposed in practice must be measured to provide a valid basis for the test. The more the test conditions depart from natural levels, the more restricted will be the applicability of the test.

Of even greater importance is the precept that the most effective way to develop a reliable accelerated test is first to obtain an understanding of the fundamental processes involved in the degradation of a material. In the experience of the Building Materials Section, covering subjects from plastics to the freeze-thaw resistance of concrete, the most progress has been made in improving performance as well as evaluation when this route has been taken.

The third proposition is that in developing evaluation methods it is preferable to incorporate as few properties as possible in a single test. If the attribute of interest, e.g., scratch hardness, is controlled by several basic properties, in this case cohesion, adhesion and intrinsic hardness, it is usually impossible to obtain good interlaboratory agreement on numerical results, even when within-laboratory precision is good. Although the developer might claim that a mixed-properties test was intended for use only in his own laboratory, it is inevitable that such tests will be reported in the literature and incorporated in specifications. Then some standardizing organization may spend several years just to find that no matter what refinements are made the test is good for interlaboratory comparisons only if ranking is used.

The opposite approach is to measure separately the basic properties of the materials of interest and then to establish which contribute most to good service life. The properties found to be essential to performance are used with the known performance of the materials to calculate a regression equation that will predict performance. Regression equations were popular 20 to 25 years ago but fell into disfavor because too many variables were often used and too much attention was paid to low correlation coefficients. An application in the coatings field of this last technique, but with more emphasis on selecting properties, is the subject of this paper.

Clear coatings for exterior wood have long had an attraction for users but have been a disappointment in use in many locations. Based on DBR exposure tests of recommended materials, the cut-and-try method has not led to any great improvement in performance, at least in the Canadian climate. Consequently, basic property studies were undertaken to see whether they would provide better progress. The properties selected, because of their evident connection with weather resistance and because suitable methods existed for their measurement, were water absorption, water vapor permeability, tensile strength and elongation at break. The selection of the essential properties, their incorporation in regression equations to predict clear finish durability and comparison of the predicted performance with actual durability when applied on wood are reported.

EXPERIMENTAL

Materials

The compositions of the clear alkyd resin solutions and phenolic varnishes, which have been the major types used in these studies, are shown in Tables 23.1 and 23.2. The preparation of the free films

TABLE 23.1

Composition of Clear Alkyds

NRP Formula no.	Oil content		% Phthalic content		Solution characteristics	
	Type	Percent of solids	Isomer	Percent of solids	Percent solids	G-H Viscosity
912	Soya	59.4[a]	Ortho	25	50	A-B
913	Soya	62.5[a]	Ortho	24	50	A-B
914	Soya	56[a]	Ortho	30	50	D-F
915	Soya	48[a]	Ortho	35	42	E
916	Soya	39.6[a]	Ortho	39	40	G-H
1055[b]	Linseed	54	Ortho	35	50	A-B
1056[b]	Soya	56.5	Ortho	31	50	A-B
E1	Safflower	70	Ortho	17	60	A_1
E2	Safflower	83	Iso	9	60	A_1
E3	Linseed-Soya	85	Iso	13	60	A_1
E4	Soya	75	Iso	18	50	C-D
E5	Soya	72	Iso	20	50	C-D
E6	Soya	67	Iso	28	50	C-D

[a]Percent oil content calculated from reported fatty acid content. Other commercial alkyds are reported as oil content.

[b]Prepared in laboratory.

TABLE 23.2

Composition of Para-Phenylphenolic Vanishes

NRP Formula no.	Oil content			% Volatile content		Varnish properties	
	Type	Approx. length	Percent of solids	Aromatic solvent	Mineral spirits	Percent solids	G-H Viscosity
1020	Tung	15	58.3	85.3	14.7	51	A-B
893	Tung	20	66.7	33.3	66.7	50	C
894	Tung	30	75	10.0	90.0	50	D
901	Tung	40	80	–	100.0	50	B-C
1021	Linseed	15	58.3	49.4	50.6	49.5	D
902	Linseed	20	66.7	30.6	69.4	51	B-C
903	Linseed	30	75	20.2	79.8	49.5	D
905	Linseed	40	80	10.0	90.0	50	C-D
1022	Soya	20	66.7	28.6	71.4	50	B
1023	Soya	40	80	34.7	65.3	50	C-D
1024	DH Castor	20	66.7	33.3	66.7	50	C
1025	DH Castor	40	80	2.6	97.4	49	E

needed for measuring the basic properties of the finishes has been reported.[5] The tin foil-mercury amalgamation method was used because it does not affect the water-related properties and the foil supports the coating films during natural and artificial weathering.

Methods

Water absorption was measured using the quartz spring balance, which has the sensitivity required to determine the small amounts of water absorbed by clear finishes. In addition to providing information about the effect of temperature, this technique permits a study of the effect of relative humidity on absorption that is not possible with the simple but imprecise immersion method.

Permeability was determined using the Payne cup with slight modifications. The method followed is basically the dry cup procedure of ASTM E 96, but at various levels of temperature or of relative humidity (RH) to study their individual effects on permeation.

Mechanical properties were measured on a tensile testing machine using free films subjected to various periods of natural or accelerated weathering.[4] The latter took place in a twin carbon-arc weathering machine operating on the cycle of 12 hours light without water and 12 hours without light but with high humidity to avoid damage by the usual water spray. Natural weathering of the free films and of coated western red cedar panels was carried out in Ottawa. The results of the panel exposures have been described in the literature[6,7] and at symposia.

BASIC PROPERTY MEASUREMENTS

Absorption

Water absorption is considered to be an important property of exterior coatings because they frequently are in contact with water in the form of rain or humidity. Absorption, which occurs at active sites, is affected by temperature only to a limited extent because activation of absorption sites is not markedly temperature dependent. An increase in relative humidity, however, has a much greater effect due to the interference of water with hydrogen bonding between polymer molecules and the plasticizing action of water on the molecules, both of which lead to greater accessibility of sites.

Phenolic varnishes that contain a high proportion of oil absorb more water, especially at higher humidities, than those with low oil contents because of the condensed structure of the phenolic resin. Figure 23.2 also shows that varnishes made with tung oil absorb less water than those made with slower drying oils, but the differences are small at oil contents lower than 70%.

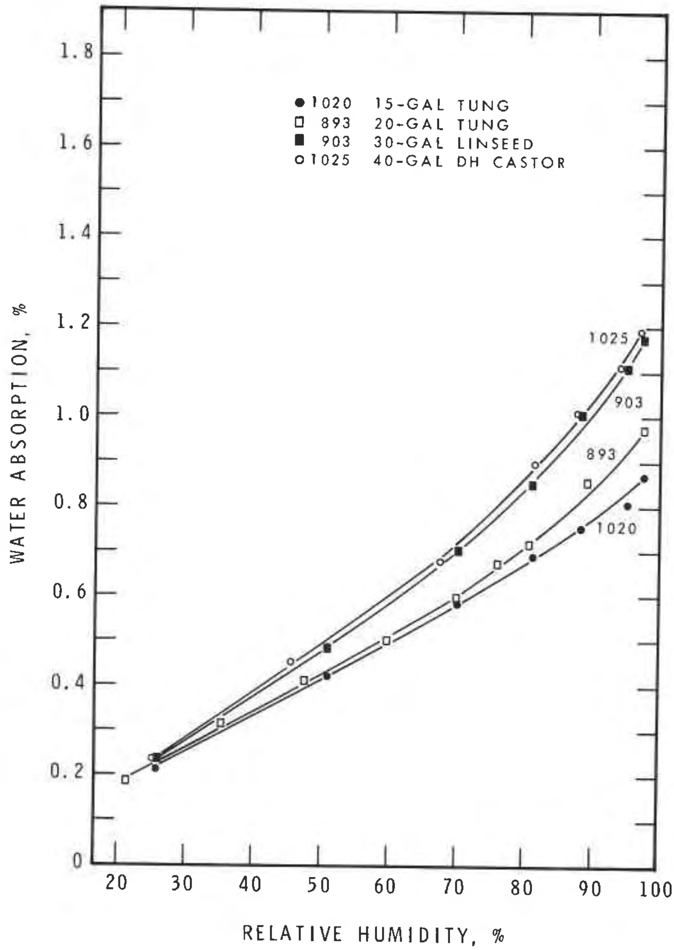

FIGURE 23.2. Relative humidity versus water absorption of phenolic varnishes.

Alkyds absorb twice as much water as phenolics at 50% RH and almost triple the amount above 90% RH. Absorption by alkyds is more affected by moisture and temperature than is that by phenolics. Within the alkyd class there are also differences in absorption due to composition. Contrary to what happens with phenolics, absorption does not consistently decrease with decreasing oil content but reaches a minimum with medium-long oil resins (Figure 23.3). This might be the result of a closer approach to stoichiometric proportions. At shorter oil lengths an excess of polyol is used to obtain low acid numbers without gelling the resin, and at high oil contents there is, of course, more oil or fatty acids, both of which are less resistant to water than the polyol phthalate portion of the resin. Consequently, water absorption of alkyds is not linearly related to oil content. Isophthalic acids absorb less water than ortho alkyds of comparable or even lower oil content.

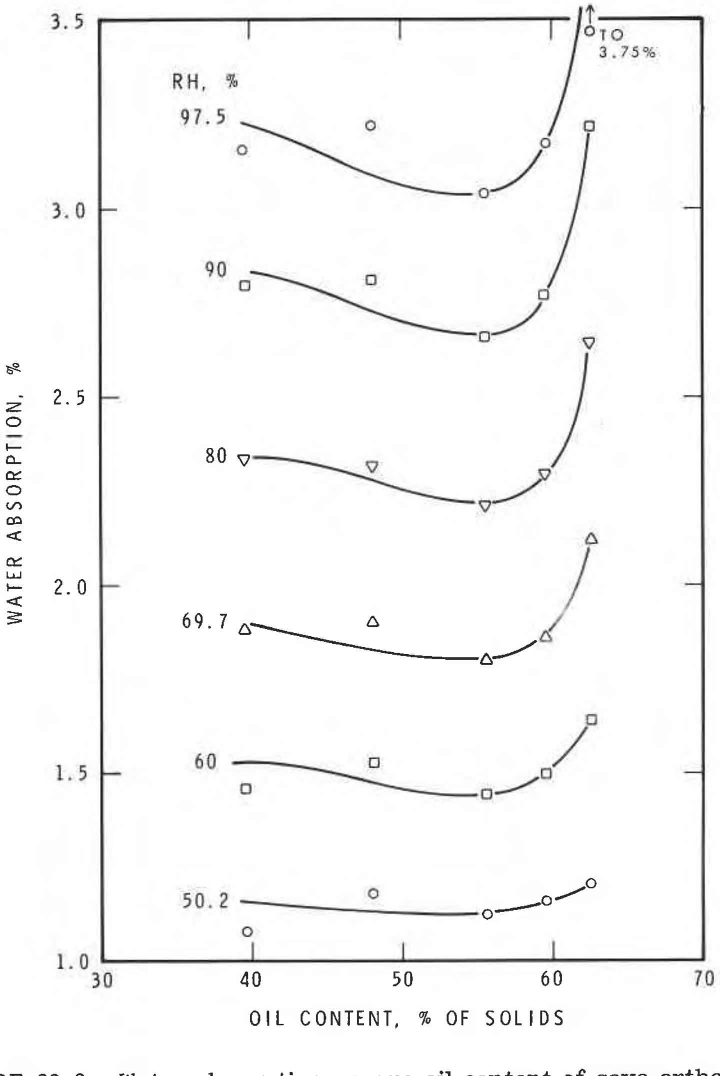

FIGURE 23.3. Water absorption versus oil content of soya ortho alkyds.

Permeability

Because the protection provided to a substrate by a coating is governed to a large extent by the coating's resistance to transmission of various agents, water vapor permeability was also selected for study. With clear finishes on exterior wood, water penetrating to the substrate can affect not only the durability of the system but also its appearance if the wood contains strongly colored, water-soluble extractives, as do Western red cedar and California redwood. Concentration of these materials from transmitted water travelling along the grain leads to objectionable staining, even when 99% of the coating film is in good condition (Figure 23.4).

Water also contributes to the erosion of the wood surface in the spring wood bands by removing lignin and other constituents made water soluble by ultraviolet irradiation.[8] This may explain why failure of clear finishes occurs first over the spring wood while pigmented coatings, which significantly reduce the amount of radiation reaching the wood surface, fail first over the summer wood.

With phenolic varnishes, under a given set of conditions, increasing oil content increases water penetration more than it does absorption. Increasing the relative humidity or temperature also has a greater

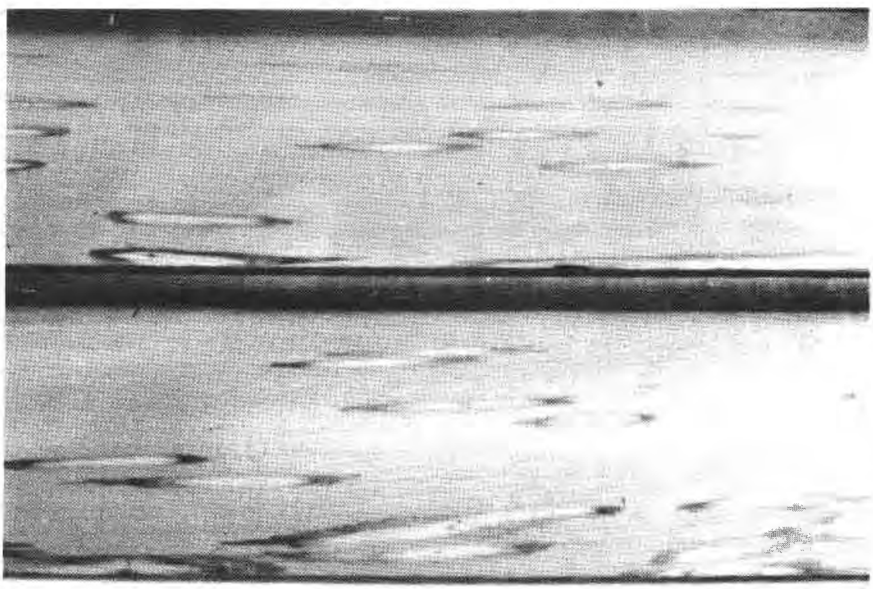

FIGURE 23.4. Concentration of cedar extractives under a clear acrylic lacquer.

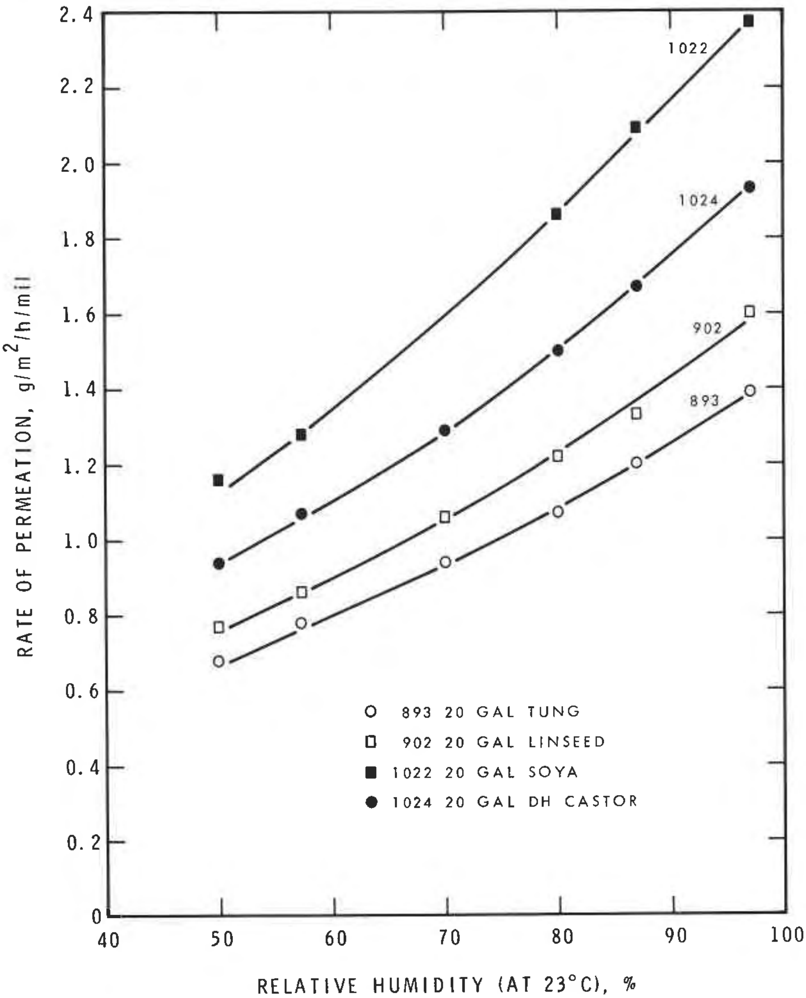

FIGURE 23.5. Relative humidity versus permeation rate through phenolics with different oil types.

effect on the permeability of the longer oil varnishes. Permeability of tung oil varnishes is lower and less affected by RH (Figure 23.5) and temperature than that of linseed varnishes which, in turn, are superior to those containing slower drying oils.

Alkyds are more permeable than phenolics to water vapor. In contrast to absorption, decreasing oil content of alkyds leads to a consistent decrease in permeation (Figure 23.6). The effect of oil type is

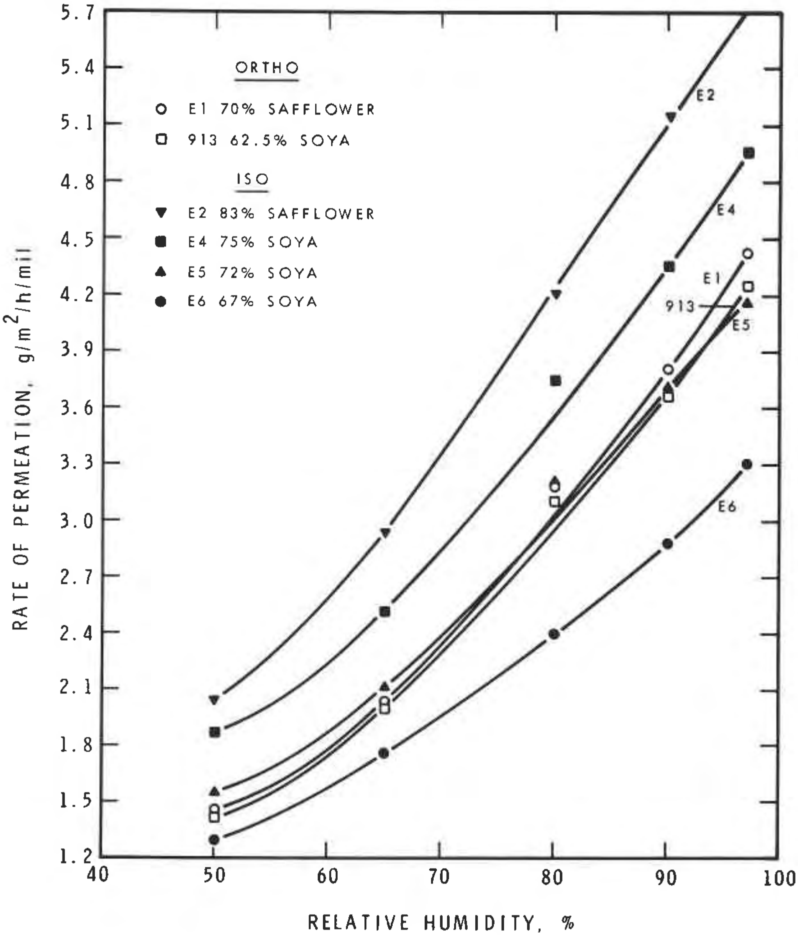

FIGURE 23.6. Relative humidity versus water permeation for alkyds.

also evident in this figure where the safflower ortho alkyd has almost the same permeability as the soya ortho alkyd of lower oil content. As with absorption, isophthalic alkyds are more resistant to water transmission than ortho alkyds. Permeation rates through alkyds are more affected by temperature than are those of phenolics. Increasing permeation with increasing temperature is more marked with ortho than iso alkyds, and with soya than linseed and safflower alkyds.

Tensile Strength

The inclusion of tensile strength in the study was based on the reasoning that coatings with high strength should be more able to resist imposed stresses without cracking. Stresses result from two factors: shrinkage caused by initial drying[9] and by chemical changes brought about by weathering; dimensional movements of the wood substrate caused by frequent changes in relative humidity. Flexibility, however, is also necessary because the movements of the wood substrate are anisotropic and tend to be concentrated at certain localities such as the interface between the summer wood of one year and the spring wood of the following year. If a coating has high strength but poor flexibility it is usually brittle and considered to be unsuitable for use on exterior wood.

The tensile strength of phenolic varnish films exposed to accelerated weathering increases rapidly and then decreases somewhat more slowly.[4] The peak in tensile strength of varnishes containing less oil is higher and occurs a few days earlier than is the case with longer oil varnishes.

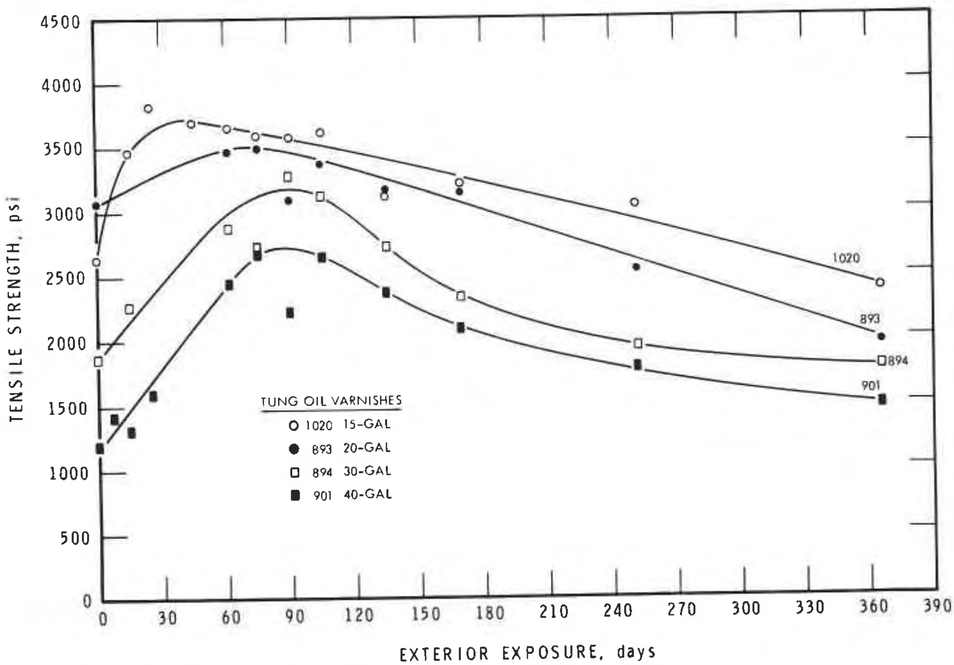

FIGURE 23.7. Effect of natural weathering on tensile strength of tung phenolics.

Tung oil varnishes exhibit moderately higher strengths than linseed varnishes of comparable oil contents, while those made with the slower drying oils have considerably lower strength. These differences are the result of differing densities of crosslinks that form during oxidative polymerization. In natural weathering the effect of composition on tensile strength is the same but the maximum is lower and the changes occur more gradually (Figure 23.7).

In accelerated weathering alkyds have much lower tensile strengths that increase gradually, except for those containing considerable oil. Short oil resins or alkyds based on linseed oil have the highest strength and iso alkyds tend to be somewhat stronger than ortho alkyds of similar or even lower oil content (Figure 23.8). As noted earlier, the main

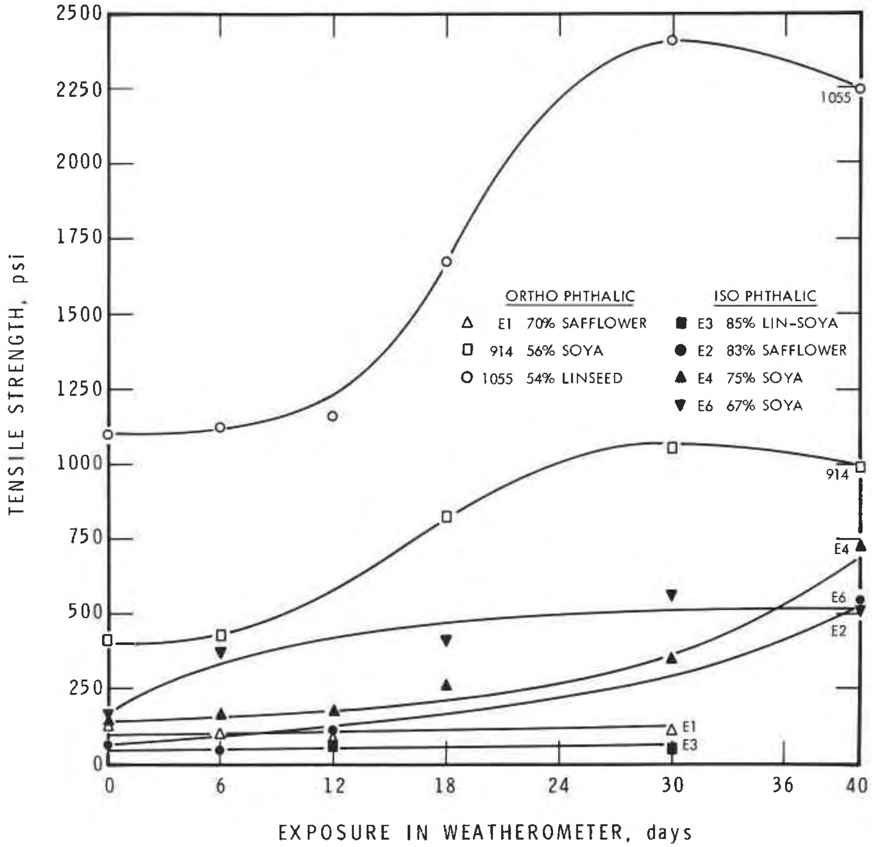

FIGURE 23.8. Effect of accelerated weathering on tensile strength of various alkyds.

difference between artifical and natural weathering of alkyds is that the maximum tensile strength is much higher in the latter. The ranking, however, was basically the same for both exposures.

Extensibility

Flexibility is generally considered to be an essential property of coatings intended for use on substrates that exhibit relatively large dimensional changes. However, tensile strength must also be adequate or the film can easily be stretched to the breaking point. As noted, the dimensional instability of wood is mainly due to its response to relative humidity. To illustrate, if the absolute humidity remains constant, wood shrinks instead of expanding with a rise in temperature because of the decrease in relative humidity. Both mechanical properties of free films were studied to establish whether flexibility is a more important property than tensile strength for exterior wood coatings.

In accelerated weathering, phenolic varnishes of all oil types and contents soon lose their extensibility, with only the long oil soya and dehydrated castor varnishes remaining flexible for more than 8 days. In natural weathering the short oil varnishes, regardless of oil type, become relatively inflexible after 15 days' exposure, while those containing 80% oil have low elongation after 45 days. Because there was little difference in the retention of flexibility during weathering but a marked difference in performance on exterior wood, this property is not considered to be important to the durability of the phenolic-wood system.

The changes in elongation caused by artifical weathering are more distinctive with alkyds than with phenolics because they occur more gradually. The shorter oil alkyds or those containing faster drying oils tend to decrease in flexibility continuously, while the higher oil content alkyds exhibit a peak. Contrary to the usual assumptions, resins containing the most oil (or those made with low molecular weight materials) do not have the greatest extensibility if they have low tensile strength (see E1, E2, and E3, Figures 23.8 and 23.9). In the case of the isophthalic alkyds, the resin with 67% oil retained flexibility much better than the resins containing from 72 to 85% oil. In natural weathering the peak in flexibility is less evident with the medium and long ortho alkyds. The longest ortho and all the iso alkyds reach a peak in extensibility after about 45 days' exposure, with the shortest iso resin again having the best flexibility and flexibility retention. Although clear alkyds are more extensible both initially and after weathering than phenolics, they perform much more poorly on exterior wood. Although this property may be of some value within the alkyd group, therefore, it is of little consequence in the over-all picture.

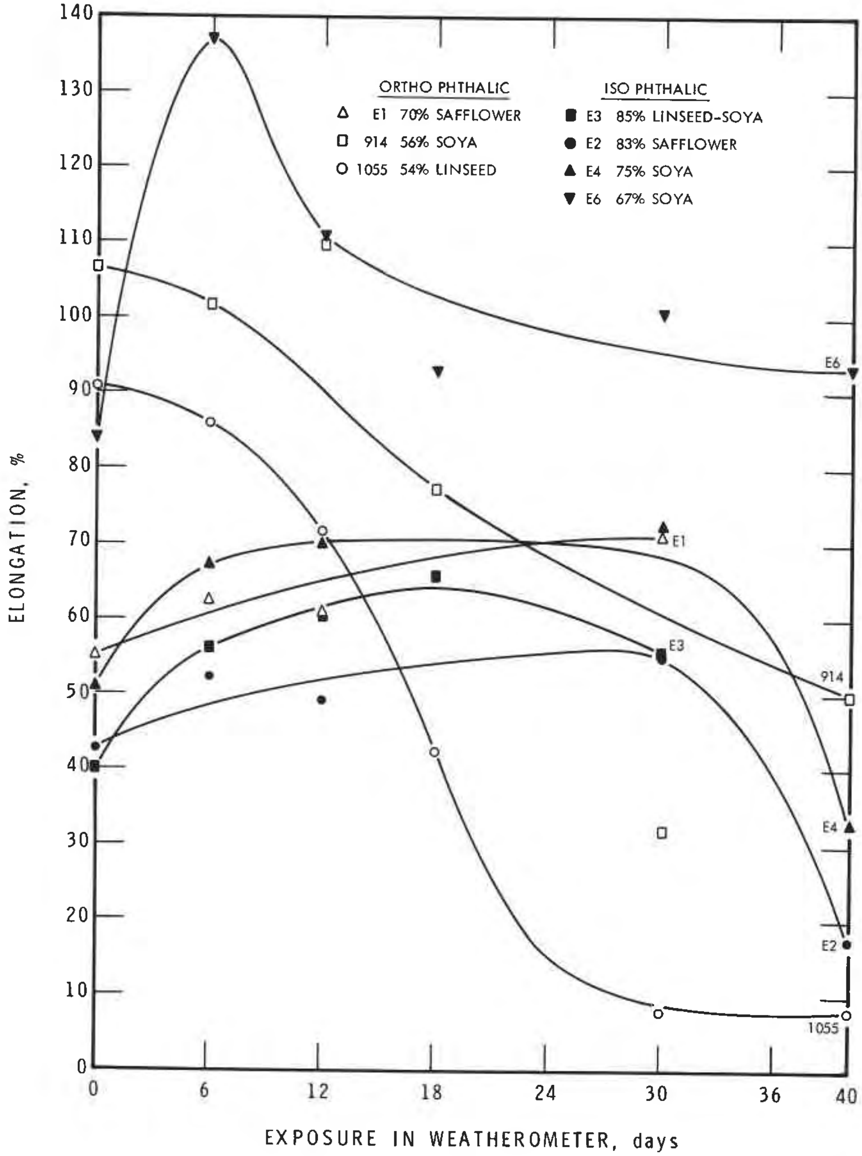

FIGURE 23.9. Effect of accelerated weather on flexibility of various alkyds.

EFFECT OF BASIC PROPERTIES ON PERFORMANCE ON EXTERIOR WOOD

Not all of the finishes studied have been exposed on exterior cedar panels because some were added as a result of the exposure tests. Therefore, not all the basic property measurements could be used in establishing the relation with test fence performance. To simplify the treatment of water absorption and water vapor permeability results, the values obtained at 80% RH were selected because differences among coatings are more evident at higher humidities, and because at this relative humidity sufficient water is present for surface reactions to occur.[10] With tensile properties it was necessary to estimate values from the curves rather than use the actual value at a given time because it might not be representative of the general trend owing to the large scatter in tensile results evident in Figures 23.7 to 23.9.

In the exposure studies the phenolic varnishes containing 67 and 75% tung oil and 67% linseed oil were most durable.[6] This appears to be related, at least in part, to their low water vapor permeability, low water absorption and high peak tensile strength. To establish on a quantitative basis which properties are important to durability, correlation coefficients were calculated using results from all the phenolics that had been exposed on wood.

The correlation coefficient, r, can vary from +1, when there is a positive, perfect functional relation between two variables, to -1 when the perfect relation is negative. If r = 0 there is no relation, while intermediate values indicate that the variables are correlated, and the closer r is to +1 or -1 the more nearly the correlation approaches a strictly functional relation. As noted earlier, low correlation coefficients have sometimes been used unjustifiably to claim an association between variables. However, even a high value of r does not automatically ensure that values of the dependent variable can be reliably predicted from values of the independent variable.[11] In some cases, more common in sociological studies, the variable believed to be independent is really dependent upon another factor that is controlling both dependent variables, which naturally are highly associated. Also, as shown in Figure 23.10, it is possible to have regression equations with equal r and F values, but one will predict the dependent variable values more closely. When both variables are in the same units, the slope of the regression line should approach 1. In this work, therefore, r and S were both used to establish which are the important properties, while the regression factor values, per se, received little attention.

Calculation of the regression between permeability and durability of phenolics showed that the two properties are linearly related, even though two of the durability ratings were only estimated from

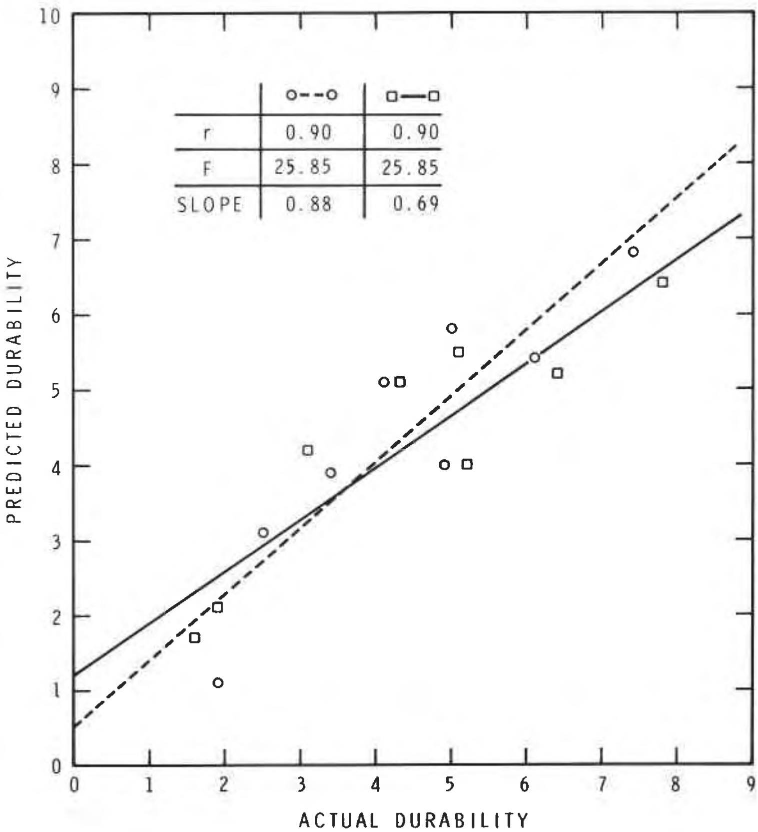

FIGURE 23.10. Correlation coefficients and predictability.

similar varnishes exposed in an earlier series (Figure 23.11). The water absorption—durability regression line for phenolics shown in Figure 23.12 is almost parallel to the durability axis because of the narrow range of absorption results. The correlation coefficients for permeability, absorption and tensile strength with respect to durability are -0.88, -0.58, and +0.89, showing that low permeability and high tensile strength correlate well with durability. When durability ratings were calculated using the regression equations, however, the slopes for both permeability and tensile strength were below 0.8, as shown in Table 23.3. Thus, neither of the individual properties predicts durability very well, in spite of the high correlation coefficients.

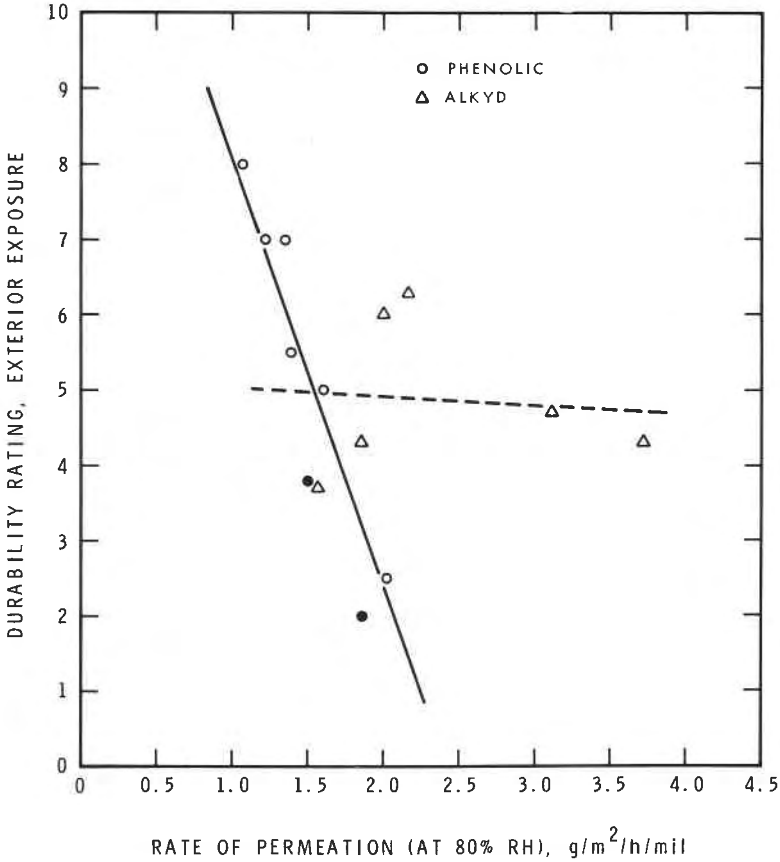

FIGURE 23.11. Permeability versus durability.

If the two properties, permeability and tensile strength, are jointly correlated versus durability, the values are changed only slightly. On the other hand, combining absorption with either of the preceding properties increases the slope to about 0.84, with the highest multiple correlation coefficient, 0.92, being for permeability and absorption. Combining all three properties has a negligible effect on these values of r and the slope. Thus, of the basic properties measured, the durability of the phenolic varnishes used in this study is controlled by water absorption and permeability (Figure 23.13) and can be predicted quite well from the equation:

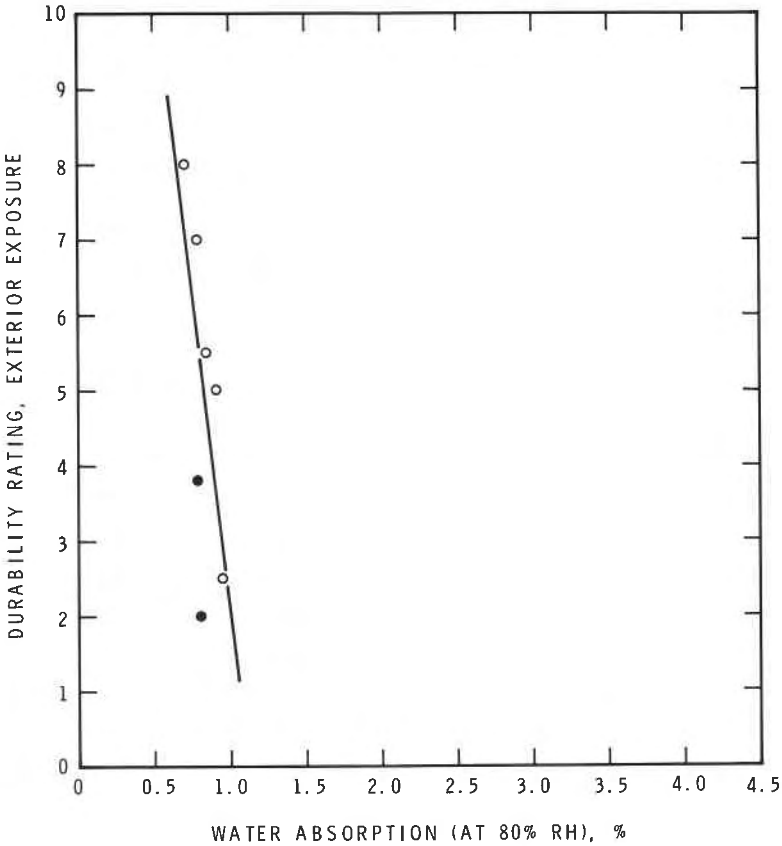

FIGURE 23.12. Absorption versus durability of phenolics.

Durability = -8.06 (Permeability) + 13.68 (Absorption) + 6.11. For a different exposure time the factors in the multiple regression equation would, of course, change but the principle is still valid.

With the alkyds it is more difficult to relate basic properties to durability for two reasons: (1) only a limited number have been exposed on the test fence; (2) durability of alkyds reaches a maximum at intermediate oil contents, whereas permeability increases with increasing oil content (Figure 23.14). There is a stronger relation between durability and absorption, which reaches a minimum at oil contents where durability peaks, but the correlation coefficient is still only -0.4.

TABLE 23.3

Correlations Between Phenolic Varnish Properties and Durability Ratings

Property or properties	Regression equation factors				Correlation coefficient r	F Ratio	Regression slope actual vs predicted durability
	Permeability	Absorption	Tensile strength	Constant			
Permeability	-5.64	—	—	13.7	-0.88	20.3	0.77
Absorption	—	-17.2	—	19.4	-0.58	3.0	0.33
Tensile strength	—	—	0.22	- 4.61	0.89	22.3	0.79
Permeability and Tensile strength	-1.99	—	0.15	1.72	0.89	23.2	0.79
Absorption and Tensile strength	—	5.6	0.26	-10.8	0.90	24.5	0.86
Permeability and absorption	-8.06	13.7	—	6.11	0.92	31.3	0.84
Permeability, absorption and Tensile strength	-6.36	12.5	0.06	1.87	0.92	32.2	0.84

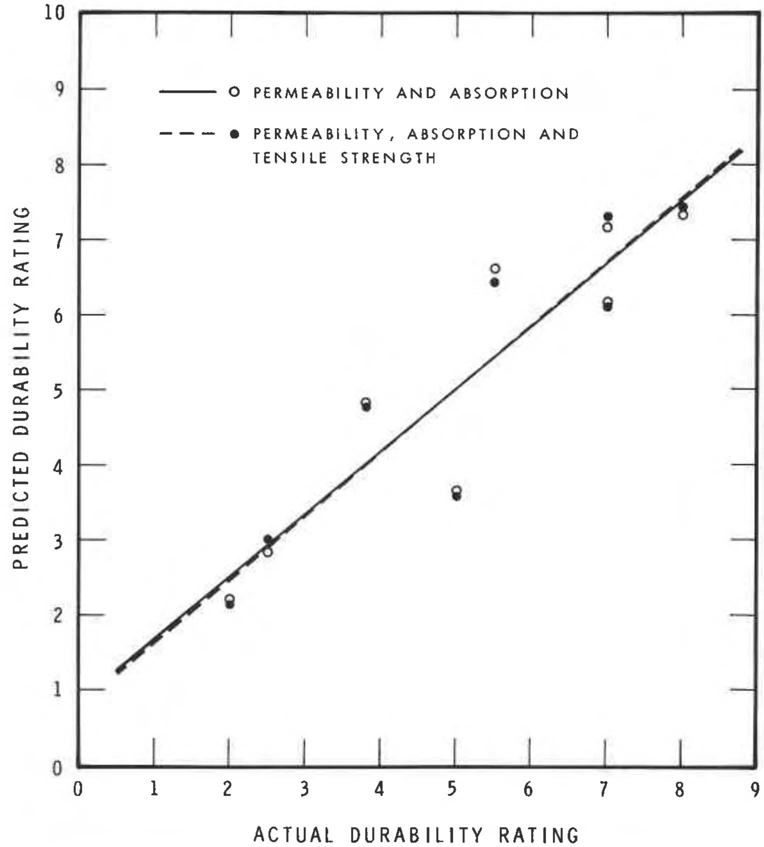

FIGURE 23.13. Phenolic durability predicted from basic properties.

Both high tensile strength and good elongation retention in alkyds seem to be related to durability but, as shown in Table 23.4, a multiple correlation of the two with durability increased r only to 0.75, compared to 0.70 for elongation alone. Because these mechanical properties are generally inversely related, an attempt was made to combine them into a single factor in which one would not tend to cancel the other. This was done for artificial weathering by multiplying the peak tensile strength by the elongation at 30 days (natural weathering results could also be used but the test would not be accelerated). The resulting tensile parameter was used to calculate

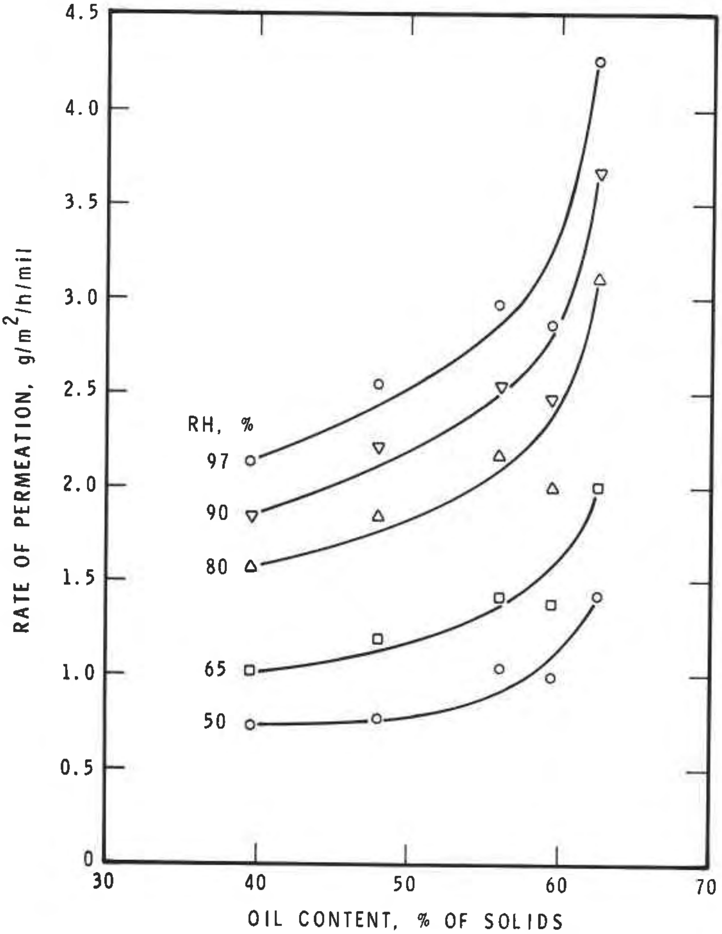

FIGURE 23.14. Water vapor permeation versus oil content of soya ortho alkyds.

multiple regressions with other alkyd properties. In most cases there was little improvement except where it was used with permeability.

At first the multiple regression of permeability and absorption against durability of alkyds had been ignored because the individual correlation coefficients were so low. However, when this combination of properties was found to be of value with phenolics the regression was calculated for alkyds and proved to have the highest coefficient

TABLE 23.4

Correlations between Alkyd Properties and Durability Ratings

	Regression equation factors						
	Permeability	Absorption	Tensile property: PTS, Elong., or Tensile parameter	Constant	Correlation coefficient r	F Ratio	Regression slope actual vs predicted durability
Permeability	0.046	—	—	4.84	0.04	0.01	—
Absorption	—	-2.69	—	11.35	-0.39	0.54	—
Elongation, 30 days accel. weath.	—	—	0.047	2.60	0.70	3.75	0.48
Absorption and Elongation	—	-1.24	0.047	5.67	0.75	3.94	0.57
Tensile strength and Elongation	—	—	0.048 PTS 0.0565 El	1.74	0.75	5.2	0.56
Permeability and Elongation	-0.189	—	0.050	2.92	0.71	4.1	0.51

Permeability and AW Tensile parameter	1.606	—	0.0057 TP	-1.04	0.91	20.4	0.86
Permeability and Absorption	2.66	-10.3	—	23.6	0.939	22.5	0.88
Permeability, Absorption and Elongation	2.845	-11.0	-0.006	2.52	0.94	22.7	0.88
Permeability, Absorption and Peak Tensile strength	3.18	-10.3	0.055	22.0	0.946	25.7	0.90
Permeability, Absorption and Tensile parameter	2.08	0.028	0.006	1.92	0.97	48.4	0.94

and slope for two factors. Addition of either elongation or tensile strength caused merely minor changes in both values; only the multiple regression of the tensile parameter with permeability and absorption increased r and the slope. As shown in Figure 23.15, the water vapor permeability and water absorption properties of clear alkyds can be used to predict their durability by the equation Durability = 2.66 (Permeability) -10.3 (Absorption) +23.6.

Because of their marked difference in properties, a statistically significant regression equation could not be obtained for the combined results of phenolics and alkyds.

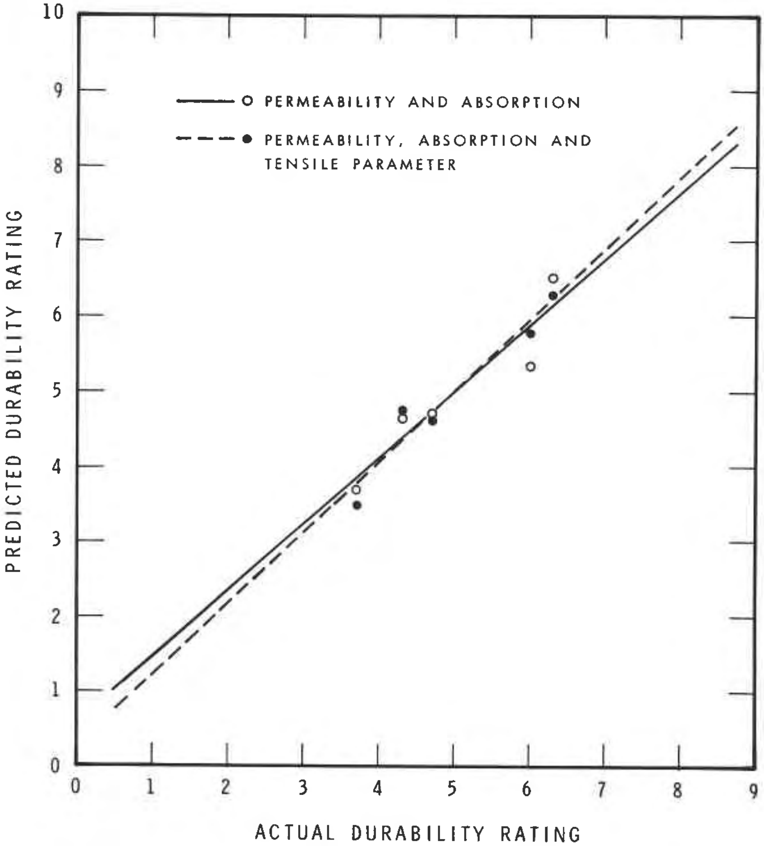

FIGURE 23.15. Alkyd durability predicted from basic properties.

SUMMARY

Durability of phenolic varnishes exposed naturally for two years is related to their water absorption, water vapor permeability and, to a smaller extent, tensile strength while it is unrelated to flexibility. For alkyds the same two properties are related to durability, with a smaller contribution from a tensile parameter that combines elongation after 30 days with the peak tensile strength in accelerated weathering.

The work relating the basic properties of the two classes of material to performance does not, so far, include the effect of ultra-violet light on the durability of wood coated with a clear finish. Nevertheless, the results of the basic property studies have been of help in designing a more satisfactory clear finish.

This work is an example of one of the principal procedures adopted by DBR/NRCC for evaluating materials, i.e., the separate measurement of basic properties in place of incorporating several in a single empirical test. Other principles established for predicting performance are that the degradative agents should not be excessively increased, especially in relation to each other, that a test developed for one material should not be used with another without first establishing that the basis of the test is appropriate for the material, and that an understanding of the processes occurring in the degradation of a material is the surest way to develop a reliable evaluation test.

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