# INFLUENCE OF MANUFACTURING VARIABLES ON THE IMPACT RESISTANCE OF RESIN-TREATED WOOD

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# INFLUENCE OF MANUFACTURING VARIABLES ON THE IMPACT RESISTANCE OF RESIN-TREATED WOOD[1]

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## Introduction

Investigations of the impact resistance of resin-treated wood conducted at the Forest Products Laboratory and at the Materiel Center of the Army Air Forces at Wright Field show a relationship between notched toughness values and Izod values. The investigations also show that face-notching gives higher impact values than does edge-notching by both notched toughness methods and Izod methods.

Previous studies of the notched toughness of resin-treated compressed wood (compreg) (1, 2, 3) have shown that this property is more sensitive to manufacturing variables than any of the strength properties thus far tested. This report shows how work values as determined on specimens tested in the Forest Products Laboratory toughness machine and in the Izod impact machine vary (in the order of decreasing importance) with (1) the specific gravity to which the product is compressed, (2) drying conditions of the treated veneer, (3) type of resin used, (4) resin content, (5) the curing temperature and time in the press, (6) presence of plasticizers and other chemicals (7) moisture content prior to pressing, and (8) moisture content at time of testing.

## Preparation of Specimens and Testing Procedure

Test specimens were cut from panels made from 1/16-inch rotary-cut yellow birch veneer (except in the case of the data of fig. 6). All panels were assembled with the grain of the plies in one direction and bonded with one phenolic resin (Bakelite XC7381) to eliminate the bonding variable. Panels were made of both untreated and resin-treated veneer and dried, cured, and compressed under varying conditions. For these tests more than 200 panels were made and more than 4,000 specimens were tested.

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[1]This is one of a series of reports prepared by the Forest Products Laboratory relating to the use of wood in aircraft. Results here reported are preliminary and may be revised as additional data become available.

All the toughness measurements were made with the Forest Products Laboratory toughness machine (4) using a 4-inch span. The specimens for these tests were 1/2 inch square in cross section and 5 inches long in the fiber direction. A standard Izod notch (5), in the case of the notched specimens, was cut across the specimens at right angles to the fibers at the center of the specimen either on a face (parallel to the surface of the plies) or on an edge. As most of the tests were made with face-notched material, the notch will be considered to be in this position unless it is designated otherwise.

Some Izod tests were made by the Materiel Center of the Army Air Forces at Wright Field, (6, 7) for correlation purposes on the specimens furnished by the Forest Products Laboratory. Four sets of ten matched specimens of four materials were prepared, two sets for notched toughness tests and two for Izod tests. One set of toughness specimens and one set of Izod specimens were notched at the Laboratory. The other two sets were similarly notched at Wright Field. Notched toughness tests were made at the Laboratory on half the specimens from both sources of notching. Correspondingly, Izod tests were made at Wright Field. Table 1 gives the results of these tests. In all cases the notches cut independently at the two locations gave nearly identical results, indicating that any slight notch differences are not responsible for the differences between the notched toughness and Izod values obtained.

## Relationship Between Notched Toughness Values and Izod Values

Figure 1 shows that notched toughness and Izod values for normal wood are substantially equal. For compressed wood and compreg, however, Izod values are only about 60 and 67 percent of the notched toughness values for face-notched and edge-notched specimens, respectively.

Accordingly, to convert notched toughness values in inch-pounds to equivalent Izod values in foot-pounds per inch of notch, the notched toughness values must be divided by the following factors:

normal wood, $\frac{12}{2} = 6$

face-notched compreg and compressed wood, $\frac{12}{2 \times 0.60} = 10$

edge-notched compreg and compressed wood $\frac{12}{2 \times 0.67} = 9$

These relationships, of course, apply only to specimens of the size and form used in these tests.

The agreement between the average Izod values and the adjusted notched toughness values is shown in table 1. Table 1 also gives the maximum variation between the duplicate values for each test. Neither of the test methods seems to have an advantage over the other in regard to

reproducibility of results. By either method the reproducibility of results seems to be somewhat greater for uncompressed wood than for compressed wood.

Table 2 gives notched toughness and Izod values for a number of matched specimens of normal wood and compreg that were face- and edge-notched.

The correlation between the adjusted notched toughness values and the Izod values given in these two tables appears to be sufficiently accurate to make possible comparisons of results obtained by the two methods of testing.

## Relationship Between Face Impact Values and Edge Impact Values

Table 2 also shows that face-notching gives higher impact values than edge-notching by both the notched toughness and Izod methods. Tables 2 and 3 show that the face impact values for normal rotary-cut laminated wood are but slightly higher than the edge impact values while the edge impact values for compreg range from about one-half to three-fourths of the face impact values.

## Manufacturing Variables Affecting the Impact Resistance of Resin-treated Wood

A large part of the summaries to follow are shown by the data of Table 3 in which the specimens are classified as high, medium, or low, notch-sensitivity materials. In the case of the high notch-sensitivity material that is only partially compressed, the notch has caused a 60 percent decrease in the toughness. In the case of the low notch-sensitivity material that received only a surface treatment with resin, the notch has caused a 34.3 percent decrease in the toughness. When the notched toughness values are corrected for the decrease in thickness due to the depth of the notch (0.1-inch notch in 0.5-inch material) on the basis of the toughness varying directly as the thickness (8), these decreases are reduced to 50 percent and 18 percent, respectively. On the basis of the toughness varying directly as the square of the thickness, the decreases are reduced to 37.5 percent and 0.0 percent, respectively.

Table 4 shows that the notched toughness values are unaffected by any slight difference that may exist between molded and cut faces on which the notch is cut. This is in agreement with previously reported findings (3).

### Specific Gravity

Table 4 also shows that there is an increase in the notched toughness with an increase in the specific gravity of the product resulting from different degrees of compression. The specific gravity determinations of

normal wood were on the basis of the air-dry weight and the air-dry volume at the time of test. The specific gravities of untreated compressed wood and compreg were determined on the basis of pressed dry weight per unit of volume at the time of test.

The increase in notched toughness as specific gravity increases is also shown in figures 2 and 3 for different resins and different concentrations of resin. The increase in notched toughness with an increase in specific gravity is greatest at the higher specific gravities. The effect of specific gravity on the notched toughness is so great that it should always be taken into account when comparing the effects of other variables.

## Drying Conditions

The data of table 5 plotted in figure 4 shows the effect of different drying conditions on the notched toughness of compreg. Drying of the treated veneer on stickers in a kiln for 16 hours at 120° F., followed by 4 hours at 170° F.; or 3 hours at 175° F. does not tend to reduce the notched toughness values. Previous data (3) indicate that 18 hours of drying at 130° F. has no detrimental effect upon the notched toughness. Drying for 4 hours at 170° F. subsequent to a mild drying at lower temperatures such as 6 days at 80° F.; or 16 hours at 120° F. does not reduce the notched toughness of the product. In contrast, drying for 5 hours or more at 170° F., or for shorter periods at higher temperatures definitely decreases the notched toughness.

## Resin Type

In general, wood treated with alcohol-soluble phenolic resins has a greater impact resistance than wood treated with water-soluble phenolic resins (fig. 2). The water-soluble phenolic resin, Compregnite, however, gave notched toughness values as high as one of the alcohol-soluble resins. In earlier tests (3) Compregnite was shown to give the highest notched toughness values of the series of water-soluble resins tested.

## Resin Content

The resin content of the wood greatly affects the notched toughness values. Figure 3 shows that untreated wood gives considerably higher values than wood containing 15 percent resin on the basis of the dry weight of the untreated wood. The wood containing 15 percent resin, in turn, gives significantly higher values than does wood containing 30 percent resin.

## Water Absorption

Figure 5 shows the water absorption in 24 hours by a 3 by 1 by 3/8-inch specimen (1 inch in the fiber direction) plotted against the specific gravity for the resin-treated specimens of figure 2. The order of decreasing water absorption is nearly the same as the order of increasing notched

toughness. Both from a water absorption and an impact resistance basis it is preferable that the wood be compressed to a high specific gravity. Wood treated with 25 percent of any of the resins tested and compressed to a specific gravity of 1.30 or greater will meet both the water absorption and Izod requirements set forth in the Army Air Forces Specification No. 15065, provided the veneer, when treated with one of the water-soluble resins is dried and cured under the mild conditions indicated in table 5.

Curing Temperature and Time in the Press

Table 6 gives the effect of curing conditions on the notched toughness. Increasing the temperature or time of cure decreases the notched toughness to some extent, but this decrease is not so marked as that caused by some of the other variables. In general, curing for more than 30 minutes at 300° F. or higher should be avoided to obtain products with optimum impact resistance.

Presence of Plasticizers and Other Chemicals

Table 7 shows the effect of adding various amounts of a plasticizer (Bakelite 1363-126) to the resin solution. Under drastic drying conditions the plasticizer seems to improve the notched toughness of the compreg, but under mild drying conditions the plasticizer seems to have little or no effect.

The effect of adding diammonium acid phosphate to the treating resin as a fire retardant (28 percent Bakelite BR15100 and 3 percent diammonium acid phosphate, both on the basis of the dry weight of the untreated wood) is shown in figure 6. The phosphate seems to lower the notched toughness slightly.

Moisture Content Prior to Pressing

The effect of preconditioning the veneer to different moisture contents is shown in table 8. There is practically no difference between the notched toughness values of specimens made from veneer at 6 percent and at 12 percent moisture content. The severity of drying rather than the moisture content attained in drying affects the impact values.

If the panels had been made under the same pressure, the higher moisture content material would have given higher specific gravities, which, in turn, would have increased the notched toughness. Thus it might appear desirable to leave appreciable amounts of moisture in the veneer prior to pressing. This is not the case, however. If the moisture content of the veneer at the time of pressing exceeds 2 to 4 percent (2, 3), especially when thick panels are made, surface checking will occur when the compreg panels are exposed for prolonged periods of time to low relative humidities.

Moisture Content at Time of Testing

Figure 7 shows the relationship between the notched toughness of uncompressed laminated birch and the moisture content for specimens dried under three conditions prior to testing. Prior to assembly, part of the veneer was conditioned at 30 percent relative humidity and part at 65 percent relative humidity; that is, to approximately 6 and 12 percent moisture content, respectively. The specimens made from air-dry veneer have slightly higher notched toughness values than the heat-dried specimens. The moisture content at the time of testing has a small effect upon the notched toughness, for the drier specimens give slightly higher notched toughness values.

Figure 8 gives similar data for untreated and resin-treated compressed wood. The notched toughness is virtually unaffected by preconditioning the specimens at different relative humidities prior to testing.

## Conclusions

It has been shown that notched toughness values in inch-pounds for specimens of the size and form used in these tests can be converted to Izod values in foot-pounds per inch of notch in the case of normal wood by dividing by the theoretical conversion factor 6 and in the case of compressed wood and compreg by dividing by the empirical conversion factor 10.

Face impact values obtained on face-notched specimens in all cases are greater than the edge impact values obtained on edge-notched specimens, both by the notched toughness and Izod methods. The difference between the values for the two directions is least for low notch-sensitivity normal wood and greatest for compreg made under conditions which give high notch-sensitivity.

The notched toughness of compreg is highly dependent upon the manufacturing variables. The variable which has the greatest effect upon the notched toughness is the specific gravity of the product. Increasing the specific gravity from 1.1 to 1.3, in general doubles the notched toughness of compreg. The next important variable is the drying of the treated veneer. Drying the veneer under mild drying conditions gives a product with appreciably higher notched toughness than is obtained by drying the veneer under drastic drying conditions. The nature of the resins seems to be the third most important variable. Compreg panels made with alcohol-soluble resins have higher notched toughness than panels made with water-soluble resins. The resin concentration is an equally important variable. The higher the resin content of compreg at a constant specific gravity the lower will be the notched toughness. The conditions under which the compreg is pressed have a somewhat smaller effect upon the notched toughness. Overcure tends to reduce the notched toughness. It seems advisable, when high impact resistance is sought, to cure so that the center of the specimen is held for not more than 30 minutes at a temperature not more

than 300° F. when the veneer is treated with the resins tested. The moisture content to which the specimens are conditioned prior to test has such a small effect upon the notched toughness that preconditioning of the specimens before test is unnecessary. Variations in the moisture content of the veneer at the time of pressing, up to 12 percent moisture content, have a negligible effect on the notched toughness. Adding plasticizers to the treating resin improves the notched toughness only under drastic drying and curing conditions. Phosphate salts added to the resin as fire retardants decrease the notched toughness to a slight extent.

Compreg can be made with water-soluble resins that will meet the Army Air Forces Specification No. 15065 for Izod toughness by keeping the resin content (on the basis of the dry weight of the untreated wood) below 30 percent, by drying the treated veneer under such mild conditions as 16 hours at 130° F., and by curing in a press so that the center of the panel is held no higher than 300° F. for no longer than 30 minutes under a pressure that will give a product with a specific gravity of 1.3 or greater.

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Table 1.--Notched impact resistance of matched laminated birch specimens notched and tested at either the Forest Products Laboratory or at the Materiel Center of the Army Air Forces, Wright Field

| Material | Specific gravity of specimens | Notched by[1] | Izod values[2] | | | Notched toughness values[3] | | |
|---|---|---|---|---|---|---|---|---|
| | | | In.-lb. | Ft.-lb. per in. of notch | Maximum variation percent | In.-lb. | Ft.-lb. per in. of notch | Maximum variation percent |
| Untreated, uncompressed wood | 0.77 | FPL | 84.1 | 14.0 | 29.8 | 90.9 | [4]15.1 | 18.1 |
| | | WF | 83.5 | 13.9 | 15.6 | 86.0 | [4]14.3 | 19.1 |
| Untreated, compressed wood | 1.30 | FPL | 55.2 | 9.20 | 45.3 | 97.0 | [5] 9.7 | 24.8 |
| | | WF | 55.0 | 9.17 | 30.9 | 103.2 | [5]10.3 | 64.0 |
| High impact compreg | 1.35 | FPL | 38.3 | 6.58 | 54.9 | 68.0 | [5] 6.8 | 56.9 |
| | | WF | 39.8 | 6.63 | 55.3 | 62.0 | [5] 6.2 | 34.0 |
| Low impact compreg | 1.23 | FPL | 16.4 | 2.73 | 54.8 | 20.5 | [5] 2.1 | 59.0 |
| | | WF | 15.9 | 2.65 | 37.7 | 20.4 | [5] 2.1 | 34.7 |
| Averages | | FPL | | | 46.4 | | | 37.2 |
| | | WF | | | 34.9 | | | 37.9 |

[1]FPL -- Forest Products Laboratory; WF -- Materiel Center, Wright Field.

[2]Izod values determined at Wright Field; values are average of 10 tests.

[3]Notched toughness values determined at Forest Products Laboratory; values are average of 10 tests.

[4]Calculated from inch-pound values by dividing by theoretical conversion factor 6.

[5]Calculated from inch-pound values by dividing by empirical conversion factor 10.

Table 2.--Comparison of standard Izod tests[1] with Forest Products Laboratory notched toughness tests on matched birch specimens

| Material | Face notching (flatwise) | | Edge notching (edgewise) | |
|---|---|---|---|---|
| | Notched toughness | Izod value | Notched toughness | Izod value |
| | In.-lb. | In.-lb. | In.-lb. | In.-lb. |
| Untreated, uncompressed | 62.2 | 47.6 | 54.5 | 56.6 |
| Do | 85.0 | 85.5 | 85.5 | 78.9 |
| Do | 47.3 | 62.7 | 46.5 | 56.6 |
| Do | 73.6 | 85.7 | 68.6 | 81.8 |
| Do | 62.5 | 62.2 | 55.0 | 54.6 |
| Do | 88.5 | 83.8 | -- | -- |
| Average, impact | 69.8 | 71.2 | 62.0 | 65.7 |
| Average, percent of face notching value | 100.0 | 100.0 | 88.8 | 92.2 |
| Conversion factor for ft.-lb. per inch of notch | 6 | 6 | 6 | 6 |
| Adjusted toughness, ft.-lb. per inch of notch | 11.6 | 11.8 | 10.3 | 10.9 |
| Treated, compressed | 50.0 | 25.8 | 30.5 | 21.5 |
| Do | 67.2 | 36.6 | 40.9 | 25.6 |
| Do | 42.1 | 26.3 | 25.9 | 21.8 |
| Do | 23.3 | 19.5 | 17.0 | 14.8 |
| Do | 34.9 | 24.0 | 21.2 | 15.0 |
| Do | 84.8 | 49.9 | 52.3 | 37.7 |
| Do | 75.6 | 45.7 | 57.6 | 35.3 |
| Do | 65.0 | 39.1 | -- | -- |
| Do | 20.3 | 16.2 | -- | -- |
| Average, impact | 56.3 | 33.8 | 35.1 | 24.5 |
| Average, percent of face notching value | 100.0 | 100.0 | 62.4 | 72.5 |
| Conversion factor for ft.-lb. per inch of notch | 10 | 6 | 9 | 6 |
| Adjusted toughness, ft.-lb. per inch of notch | 5.6 | 5.6 | 3.9 | 4.1 |
| Untreated, compressed | 100.0 | 55.0 | -- | -- |

[1] Izod tests made by the Materiel Center of the Army Air Forces, Wright Field.

Table 3.--Summary of face and edge impact toughness values for both notched and unnotched specimens of laminated birch.

| Type of specimen | Number of panels[1] | Unnotched | | | | Notched | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Face impact | | Edge impact | | Face impact | | Edge impact | |
| | | In.-lb. | Relative percent | In.-lb. | Relative percent | In.-lb. | Relative percent | In.-lb. | Relative percent |
| **High notch sensitivity:** | | | | | | | | | |
| Treated: water-soluble resin; Dried: normally; Compressed: partially | 7 | 95.8 | 100.0 | 91.5 | 95.6 | 38.3 | 40.0 | 33.0 | 34.4 |
| Treated: water-soluble resin; Dried: excessively; Compressed: completely | 6 | 109.2 | 100.0 | 126.6 | 115.7 | 48.4 | 44.3 | 22.8 | 22.8 |
| Average | | 102.5 | 100.0 | 109.0 | 105.6 | 43.3 | 42.2 | 27.9 | 27.6[2] |
| **Medium notch sensitivity:** | | | | | | | | | |
| Treated: water-soluble resin; Dried: normally; Compressed: completely | 7 | 106.3 | 100.0 | 106.3 | 100.0 | 55.7 | 52.3 | 36.3 | 34.1 |
| Treated: water-soluble resin; Dried: mildly; Compressed: completely | 4 | 127.9 | 100.0 | 129.7 | 101.5 | 65.9 | 51.5 | 32.6 | 25.4 |
| Treated: water-soluble resin with plasticizer; Dried: normally; Compressed: completely | 6 | 137.2 | 100.0 | 132.4 | 96.5 | 54.3 | 39.5 | 28.9 | 21.0 |
| Average | | 123.8 | 100.0 | 122.8 | 99.3 | 58.6 | 47.8 | 32.6 | 26.8[3] |
| **Low notch sensitivity:** | | | | | | | | | |
| Untreated, uncompressed | 10 | 119.7 | 100.0 | 99.8 | 83.5 | 66.8 | 55.8 | 58.3 | 48.7 |
| Surface treated: water-soluble resin; Dried: normally; Compressed: completely | 2 | 141.0 | 100.0 | 122.2 | 86.7 | 92.7 | 65.7 | 68.3 | 48.3 |
| Treated: spirit-soluble resin; Dried: normally; Compressed completely | 7 | 140.0 | 100.0 | 136.0 | 97.3 | 76.1 | 54.5 | 58.8 | 42.0 |
| Average | | 133.6 | 100.0 | 119.3 | 89.2 | 78.5 | 58.7 | 61.8 | 46.3[4] |
| Grand average | | | 100.0 | | 98.0 | | 49.6 | | 33.6[5] |
| Grand average (corrected in thickness for depth of notch) | | | 100.0 | | 98.0 | | 62.0 | | 42.0 |

[1] Each value represents 7 tests per panel.

[2] Assuming value for notched face impact as 100 percent, notched edge impact has a relative value of 65.4 percent.

[3] Assuming value for notched face impact as 100 percent, notched edge impact has a relative value of 55.5 percent.

[4] Assuming value for notched face impact as 100 percent, notched edge impact has a relative value of 78.8 percent.

[5] Assuming value for notched face impact as 100 percent, notched edge impact has a relative value of 67.8 percent.

Table 4.--Impact resistance of specimens notched on a molded face compared to similar specimens notched on a cut face

| Panel number | Average specific gravity | | | | Average |
|---|---|---|---|---|---|
| | 1.05 | 1.13 | 1.26 | 1.36 | |
| | Impact value (in.-lb.) notched on a molded face[1] | | | | |
| 1 | 20.3 | 36.2 | 53.8 | 95.0 | 51.3 |
| 2 | 36.5 | 54.4 | 66.1 | 97.0 | 63.5 |
| 3 | 34.5 | 54.7 | 59.5 | 113.0 | 65.5 |
| 4 | -- | 61.2 | 78.1 | 115.9 | 85.1 |
| 5 | 26.7 | 34.3 | 55.1 | 92.2 | 52.1 |
| 6 | 69.2 | 83.9 | 101.3 | 137.0 | 97.8 |
| Average | 37.4 | 54.1 | 69.0 | 108.6 | 68.5 |
| | Impact value (in.-lb.) notched on a cut face[1] | | | | |
| 1 | 21.3 | 39.5 | 58.1 | 90.1 | 52.2 |
| 2 | 34.2 | 57.7 | 70.9 | 95.4 | 64.5 |
| 3 | 29.2 | 62.7 | 63.4 | 113.3 | 67.1 |
| 4 | -- | 86.3 | 80.4 | 120.2 | 95.6 |
| 5 | 28.7 | 40.3 | 61.7 | 97.7 | 57.1 |
| 6 | 63.8 | 89.6 | 101.6 | 143.2 | 99.5 |
| Average | 35.4 | 62.7 | 72.7 | 110.0 | 71.7 |

[1] Ten specimens tested from each panel.

Table 5.--Effect of drying conditions on the notched toughness

| Panel number (see fig. 5) | Drying conditions: Temperature | Drying conditions: Time | Specific gravity | Notched toughness |
|---|---|---|---|---|
| | ° F. | | | In.-lb. |
| | | Drastic Drying | | |
| 8 | 170 | 9 hours | 1.27 | 35.9 |
| 10 | 170 | 9 " | 1.29 | 29.2 |
| 13 | 170 | 8 " | 1.35 | 55.8 |
| 14 | 170 | 8 " | 1.36 | 58.4 |
| 11 | 150 | 4 " | 1.31 | 50.6 |
| | 170 | 4 " | | |
| 9 | 225 | 90 min. | 1.29 | 40.4 |
| 12 | 150 | 190 " | 1.31 | 38.2 |
| | 300 | 10 " | | |
| | | Mild Drying | | |
| 1 | 120 | 16 hours | 1.29 | 55.8 |
| | 170 | 4 " | | |
| 2 | 170 | 5 " | 1.32 | 61.8 |
| 3 | 80 | 6 days | 1.33 | 63.1 |
| | 170 | 4 hours | | |
| 5 | 130 | 4 " | 1.34 | 64.4 |
| | 150 | 4 " | | |
| 6 | 120 | 16 " | 1.35 | 70.6 |
| 7 | 80 | 6 days | 1.35 | 66.7 |
| 4 | 175 | 3 hours | 1.34 | 67.3 |

Table 6.--Effect of curing conditions on the notched toughness of laminated birch

| Treatment | Number of panels | Curing conditions: Temperature | Curing conditions: Time | Specific gravity | Notched toughness |
|---|---|---|---|---|---|
| | | ° F. | Min. | | In.-lb. |
| Untreated | 2 | 300 | 30 | 0.70 | 73.6 |
| Do | 2 | 300 | 180 | .69 | 60.5 |
| Do | 4 | 300 | 30 | 1.09 | 96.7 |
| Do | 4 | 350 | 30 | 1.10 | 90.3 |
| Resin treated[1] | 2 | 300 | 30 | 1.34 | 58.6 |
| Do | 2 | 300 | 180 | 1.29 | 47.2 |
| Do | 8 | 300 | 30 | 1.35 | 62.7 |
| Do | 8 | 350 | 30 | 1.35 | 60.2 |

[1]35 percent of Bakelite BR15100 on the basis of the dry weight of the untreated wood.

Table 7.--Effect of plasticizer on the notched toughness of resin treated[1] birch compreg

| Plasticizer[2] | Time of drying before pressing[3]: 9 hours at 170° F. | 16 hours at 120° F. + 4 hours at 170° F. | 4 hours at 170° F. | 16 hours at 120° F. |
|---|---|---|---|---|
| Percent | In.-lb. | In.-lb. | In.-lb. | In.-lb. |
| 0 | 32.5 | 55.8 | 62.4 | [4]61.1 |
| 5 | 48.2 | 45.8 | | |
| 10 | 60.1 | 55.5 | | [4]64.8 |
| 15 | 62.6 | 55.6 | | |

[1]40 percent Bakelite BR15100 on the basis of the dry weight of the untreated wood.

[2]Bakelite 1363-126, percentage based on weight of resin solution.

[3]Panels pressed at 1,250 pounds per square inch for 30 minutes at 300° F.

[4]Average of 16 panels (20 tests per panel).

Table 8.--Effect of moisture content of veneer (prior to pressing) on the notched toughness[1]

| Resin content[2] | Preconditioning[3] relative humidity | Specific gravity | Notched toughness |
|---|---|---|---|
| Percent | Percent | | In.-lb. |
| 0 | 30 | 1.01 | 91.1 |
| 0 | 65 | 1.11 | 90.3 |
| 15 | 30 | 1.20 | 23.3 |
| 15 | 65 | 1.18 | 25.6 |
| 30 | 30 | 1.34 | 61.4 |
| 30 | 65 | 1.35 | 69.7 |
| 45 | 30 | 1.35 | 57.5 |
| 45 | 65 | 1.36 | 61.9 |

[1] Each value is for the average of 10 specimens from each of three different panels cured at 350° F. for 30 minutes.

[2] Resin Bakelite BR15100, resin content on basis of the dry weight of the untreated wood.

[3] 30 percent relative humidity gives 6 percent moisture content; 65 percent relative humidity gives 12 percent moisture content.

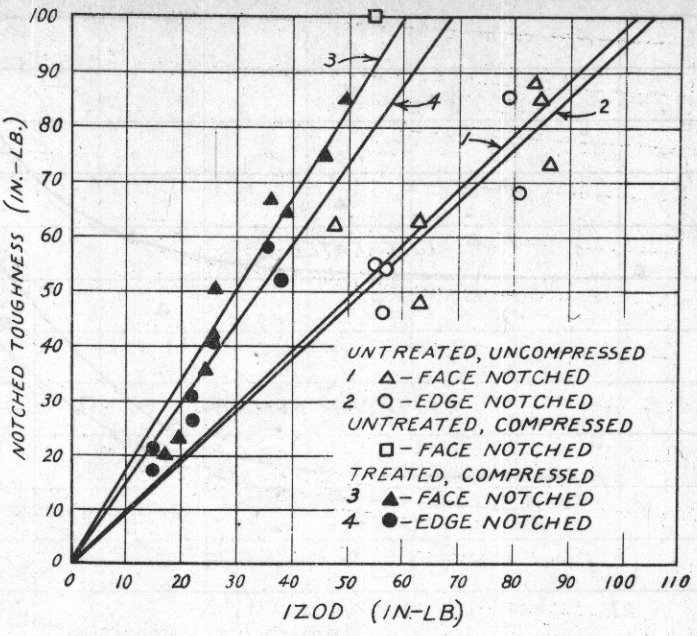


Figure 1.--Relationship between notched toughness and Izod values of normal wood, compressed wood, and compreg.

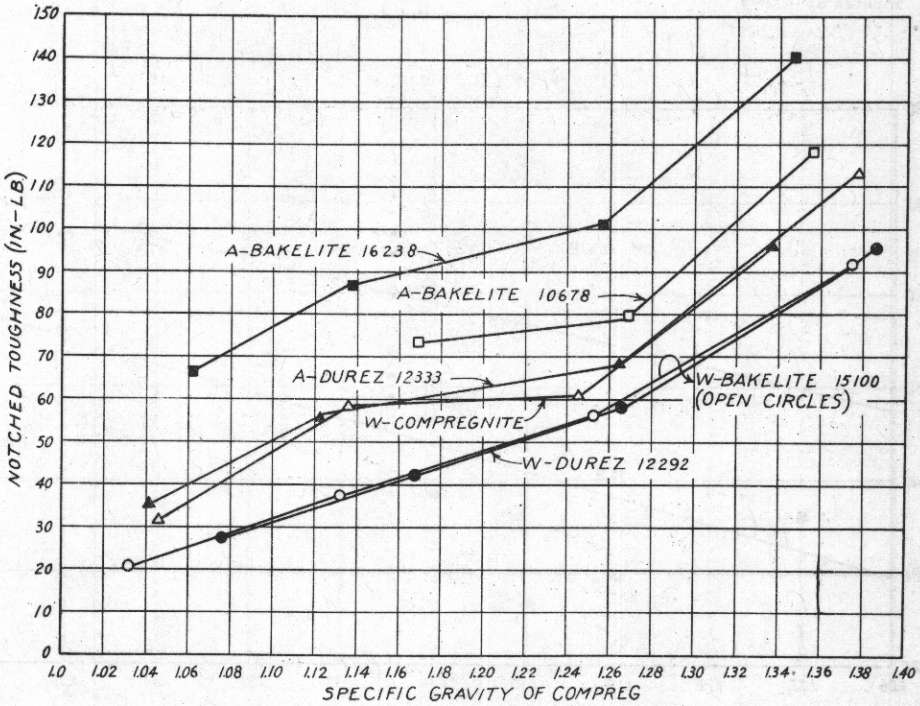


Figure 2.--Relationship between the notched toughness and the specific gravity of compreg when made with three alcohol-soluble resins (A) and three water-soluble resins (W). Resin contents on the basis of the dry weight of the untreated wood are: A - Bakelite BV16238, 28.5 percent; A - Bakelite BV10678, 27.1 percent; A - Durez 12333, 26.3 percent; W - Compregnite (Casein Co. of America), 24.0 percent; W - Bakelite BR15100, 25.2 percent; W - Durez 12292, 28.7 percent. The treated veneer was in all cases dried for 18 hours at 120° F., pressed, and cured under different pressures for 30 minutes at 300° F.

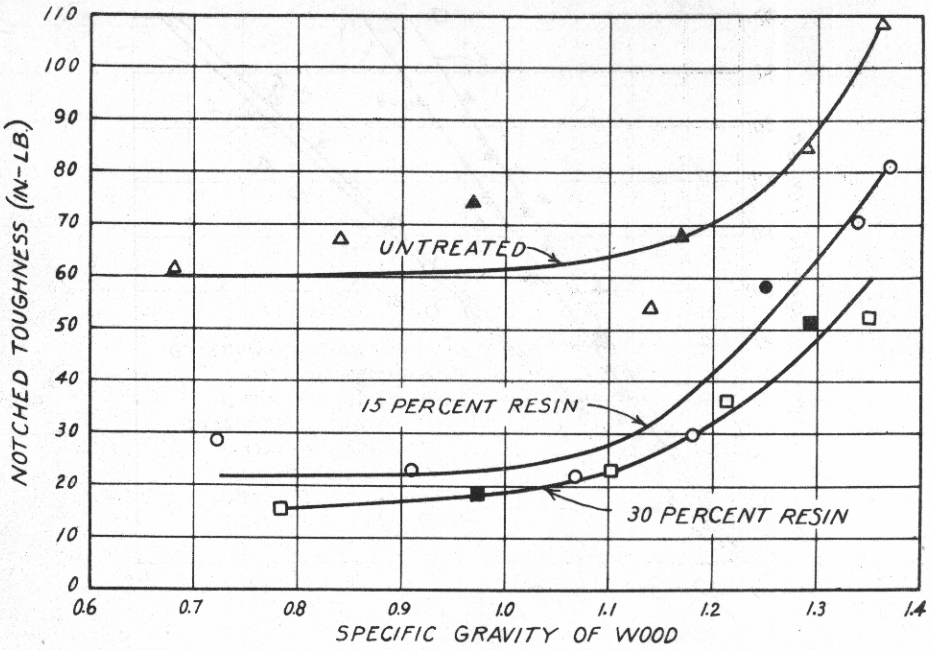


Figure 3.--Relationship between the notched toughness and the specific gravity of wood for different resin contents. Open symbols indicate specimens made by normal procedure of compressing plies while assembling panel. Solid symbols indicate specimens made by precompressing individual plies prior to assembly, thus making possible more uniform compression of all the plies. Bakelite BR15100 resin was used. The resin content in each case was based on the dry weight of the untreated wood. The treated veneer was dried for 18 hours at 130° F. The plies of impreg panels were cured for 15 minutes at 300° F. in a continuous roller drier, after which the plies were assembled and the panels pressed and cured under different pressures for 30 minutes at 300° F.

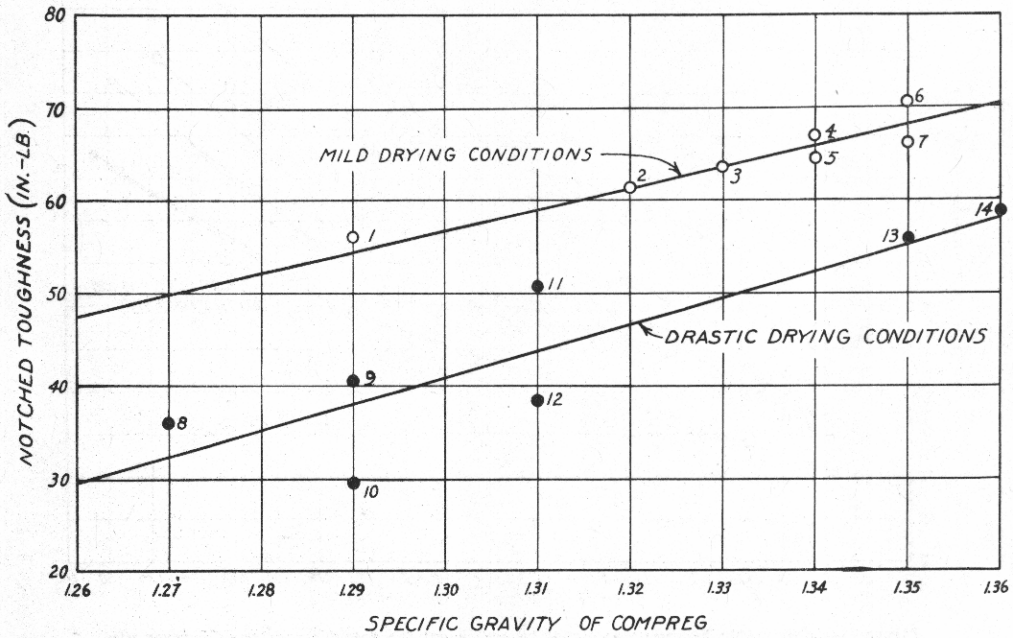


Figure 4.--Relationship between the notched toughness and the specific gravity of compreg made under different drying conditions with 40 to 50 percent of Bakelite BR15100 resin on the basis of the dry weight of the untreated wood and cured under a pressure of 1,250 pounds per square inch for 30 minutes at 300° F. The drying conditions used for each of the numbered symbols are given in table 5.

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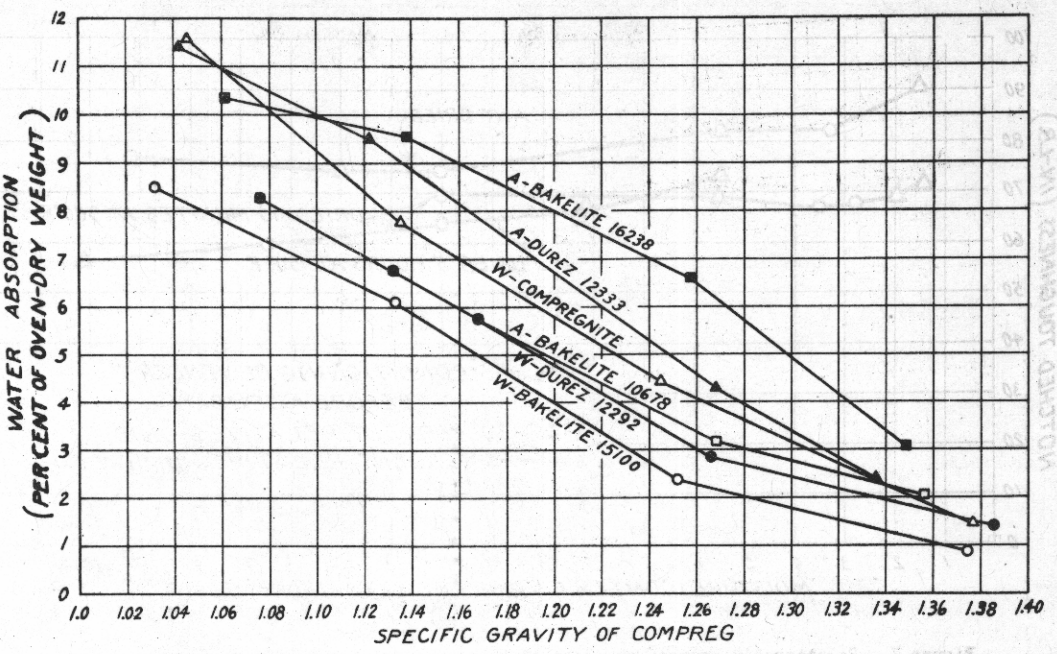


Figure 5.--Relationship between the water absorption of compreg (Army Air Forces Specification No. 15065) and the specific gravity for the specimens of figure 2 (see fig. 2 for description). Specimens 3 by 1 by 3/8 inches (1 inch in fiber direction) were soaked in water for 24 hours. A and W designations are the same as in figure 2.

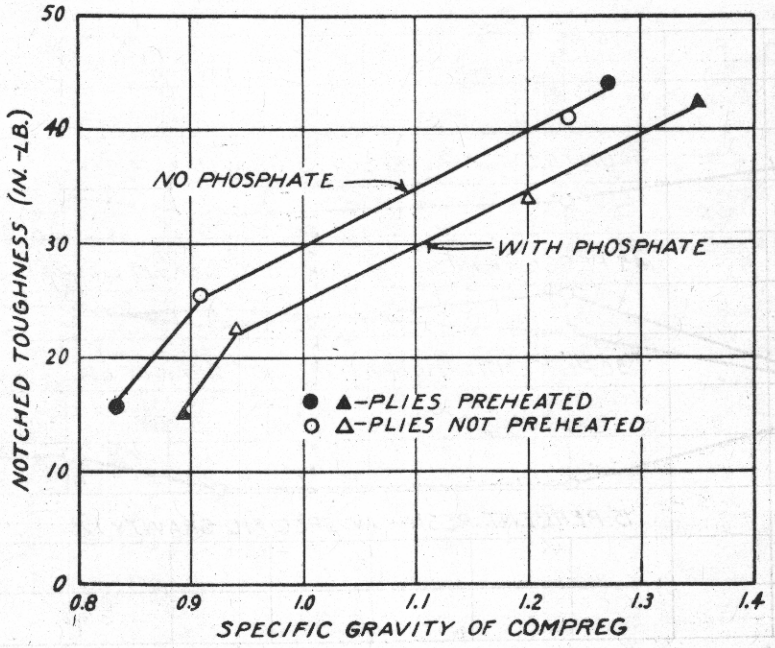


Figure 6.--Relationship between notched toughness and the specific gravity of compreg made from 1/8-inch, rotary-cut, cottonwood veneer with and without diammonium acid phosphate added to the treating solution. All panels contained 28 percent of Bakelite BR15100 resin and the phosphate-treated samples contain 3 percent of the salt, both on the basis of the dry weight of the untreated wood. Solid symbols indicate specimens preheated to 220° F. for 10 minutes before pressing. All panels were cured under different pressures for 30 minutes at 300° F.

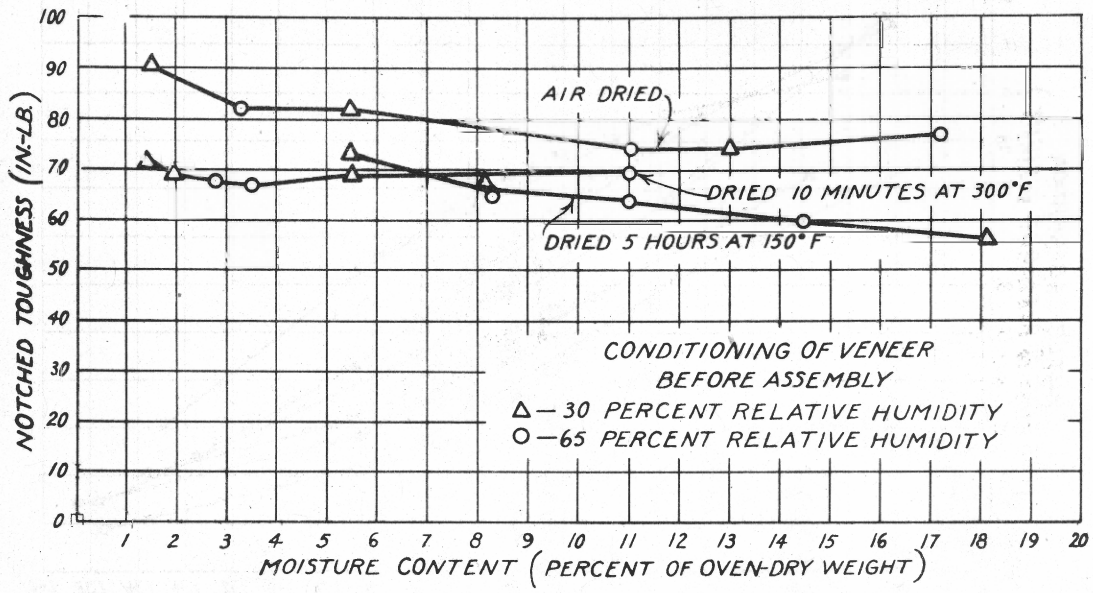


Figure 7.--Relationship between the notched toughness and the moisture content at time of testing of uncompressed laminated birch dried under three different conditions and preconditioned at two different relative humidities.

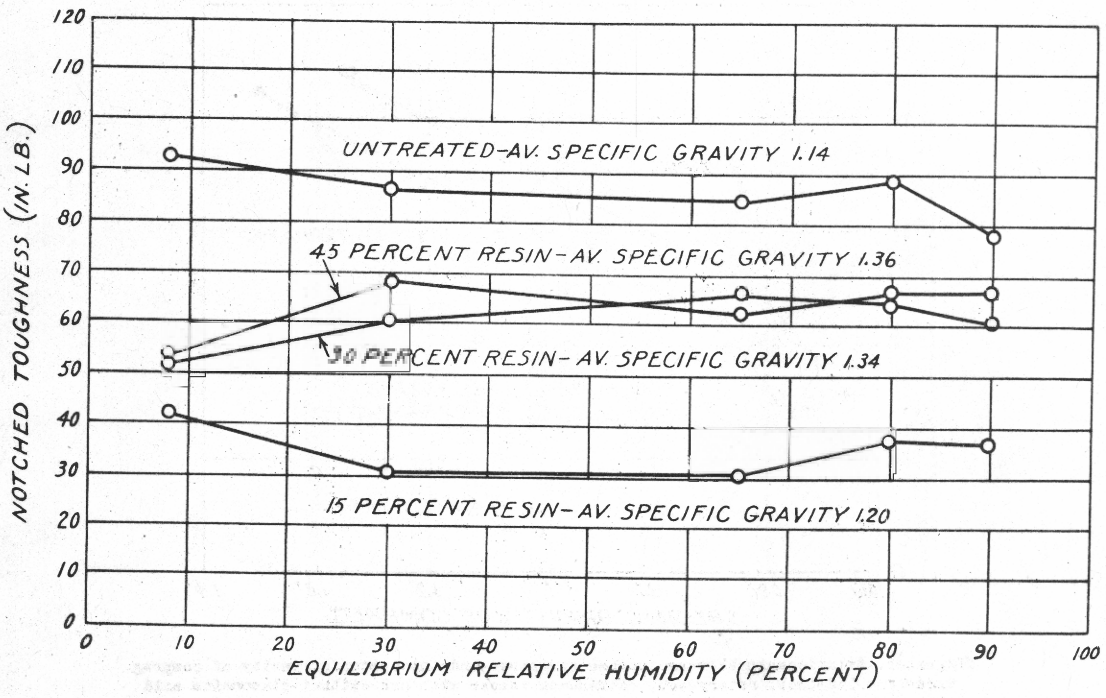


Figure 8.--Relationship between the notched toughness and the relative humidity at which the specimens were conditioned prior to testing. The 8 percent relative humidity values were for samples dried at 150° F. for 2 to 4 days, giving a moisture content of the untreated specimens of 2 percent. The progressively increasing values of notched toughness of the resin-treated materials are due to the increased specific gravities rather than to the increased resin content.