Candidate Wood-base Standard Reference Materials For Fire Testing-Red Oak
Abstract

A need is presented for wood-base materials suitable as Standard Reference Materials (SRM's) for nationwide fire testing. Need is based on increasing trend toward large-scale fire testing and use of non-characterized wood materials indiscriminately as a performance reference for other building materials. Research objectives are outlined and studies needed toward the ultimate goal of recommending a procedural guide for selection and processing of wood-base materials for fire testing to ASTM Subcommittee D07.12 on Fire Performance of Wood and Wood-Base Products. This paper presents results of first study which examined red oak as a candidate material from standpoint of present usage, forest resource, growth variability, and fire performance variability in the 8-foot tunnel furnace. The effort toward red oak as an SRM is abandoned primarily due to anticipated decreased usage. A recommendation is made that a reconstituted wood product be investigated as a potential SRM and the 8-foot furnace (ASTM E 286) be used as the reference standard test method for its evaluation.

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Conversion of Units

1 bd ft (1 ft by 1 ft by 1 in.) = 0.00236 m³
1 Btu/min = 17.57250 watts
1 ft = 0.305 m
1 in. = 25.4 mm
1 lb = 0.454 Kg
1° F = 0.556°C
T(°F) = 1.8T(°C) + 32
Candidate Wood-base Standard Reference Materials For Fire Testing-Red Oak

By CARLTON A. HOLMES, Technologist and MARTIN CHUDNOFF, Technologist

Introduction

The fire problem in the United States is enormous in terms of personal injuries and deaths, and in direct and indirect loss of property and services. Increased government attention and public concern, together with advent of many new building products, have brought about a considerable increase in fire research activities and literature. Wood performance is often the reference. But a cursory examination of such fire research literature referencing wood usually shows little or no characterization or identification of the wood product tested. Often only the generic, common (or uncommon) name is used. Performance of wood, plywood, fiberboard, hardboard, particleboard, or cabinet birch is compared with other materials without giving such minimum information as species name, density, moisture content, or even dimensions. It is well known at least in the wood industry that wood species generally vary considerably in their physical, chemical, and mechanical properties. Experience has shown that wood species also have considerable variability in fire performance. This degree of variability may be less, but still present, within a species.

A procedure is needed for the selection and processing of wood-base materials suitable as standard reference materials (SRM) for nationwide fire testing. The general procedure might be applicable to any solid wood product to determine the physical and fire performance properties of interest. If successful, a recommended procedural guide for selection and processing of a wood-base product as an SRM for fire testing would be submitted to ASTM Subcommittee D07.12 on Fire Performance of Wood and Wood-Base Products.

Red oak was selected as the first candidate material upon which to base the development of such a procedure, because of its important use as the calibration standard for the ASTM E 84 25-foot furnace. This test method is used for rating building material surface flammability hazard for code purposes. Strip flooring has been used for this calibration standard for over 30 years because of its uniformity of grade and heretofore wide availability.

In the course of this study on material availability and of the fire performance variability of red oak flooring, information was obtained which altered the approach needed to achieve the ultimate objective. In ASTM Committee E-5 on Fire Standards, the chairman of the Task Group on the Standardization and Updating of ASTM Standard E-84 reported that the task group is working on means of calibrating the 25-foot furnace...
without the use of red oak as a calibration standard (1). Success in this effort would considerably reduce the current supply requirement for red oak strip flooring used for fire testing.

it is expected there would be only minimal, if any, use of red oak strip flooring in the anticipated increase of large (room) scale fire testing of wall and ceiling finish.

The need for red oak for the above uses is questionable at this time. Some useful information has been obtained, however, and is reported in this paper. This includes evaluations of existing test data on red oak in the FPL 8-foot furnace (ASTM E 286) and the red oak resource. These evaluations will be useful both for continued use of red oak as a standard in certain fire tests and for insights into the supply and performance requirements of other wood-base materials as reference standards in fire testing.

Use of Wood as a Reference Material in Fire Testing

Wood as a Reference in Building Codes
Flame spread index limitations on the use of building materials, evident in all building codes, are based on the flame spread performance of Select grade red oak flooring in the ASTM E 84-79 (3) procedure using a 25-foot furnace. The BOCA Basic Building Code (7) states that the products of combustion from approved light-transmitting plastic materials shall be no more toxic than those of untreated wood when burned under similar conditions. The 1976 issue of the Uniform Building Code contains the same limitation, but it has been deleted in the 1979 edition (9).

Need for Wood Reference Materials
Standard wood-base reference materials are needed for nationwide fire testing, particularly for larger-scale fire testing such as room and corridor fire tests, wall tests by ASTM E 119 (4) and the 25-foot flame spread test furnace by ASTM E 84. The use of selected wood materials that have a known fire performance property or properties will give more meaning and credibility to comparative-type test results. Their use also provides a calibration check to determine precision of the test equipment and procedure or method.

Standard Reference Materials
The National Bureau of Standards (NBS), the largest supplier of SRM’s, defines SRM’s as well-characterized and certified materials, produced in quantity: (1) to help develop reference methods of analysis or test, i.e., methods proven to be accurate; and/or (2) to calibrate a measurement system, and/or (3) to assure the long-term adequacy and integrity of the quality control process (8). The only wood-base material presently listed as an SRM by NBS (12) is SRM 1-002b, a hardboard sheet used for checking operation of the radiant panel test equipment, ASTM E-162 (5). Flame spread index for this SRM is certified as 190 and heat evolution factor, Q, 45.4.

The property or properties of interest in an SRM must be determined and certified on the basis of accuracy. Three different routes are used at NBS to do this. In the first, the property is measured by two or more analysts working independently but using the same reference method. A reference method of test is one which has been demonstrated to be accurate such as an ASTM method. If a reference method does not exist, then the measurements are made using two or more different but reliable methods which have high precision although their systematic biases are not fully known. The third route is like the second but a candidate renewal SRM is evaluated by several or many laboratories using a previous issue of an SRM as a check.

A wood-base SRM would have to be provided in large quantity, considering the cost and care necessary in its production and certification and considering the potential volume of usage. NBS usually stores a 6- to 10-year supply.

Candidate Materials
if a wood product is to be used as a standard reference material for fire testing it must have the following characteristics: (1) Adequate supply at a reasonable cost, and (2) uniform fire performance—either naturally nonvariable or variability limits are acceptable.

Based on volume of use in construction, candidate wood-base SRM’s would be particleboard, hardboard, Douglas-fir plywood, southern pine plywood, Douglas-fir lumber and southern pine lumber. Red oak strip flooring may be considered a candidate material based on its present important use for calibration of the 25-foot furnace, although, as indicated elsewhere its use as a flooring is decreasing.

A reconstituted wood product such as particleboard or hardboard should be superior to solid wood as an SRM. A large production lot of candidate SRM would have to be produced at one time. With current fiber or particleboard technology and quality control, it is believed a more uniform product could be produced. Panel-size material would be more suitable than board-size for most fire test applications and be lower in cost to produce and handle.

Red Oak in Fire Testing
The 25-foot furnace of ASTM E 84-79 (3) is calibrated to obtain a flame progression on red oak flooring of 19.5 feet in 5.5 minutes. Flame spread index (FSI) values for all materials tested by this method are based on idealized straight line flame spread distance-time curves. The FSI for red oak is 91.4 by the calculation method employed in the 79a revision of the Standard. Asbestos-cement board establishes the zero FSI.

Smoke development by ASTM E 84 is also referenced in some building codes to set limitations (7, 9, 13). The numerical index for smoke development is based on the performance of materials compared to that of asbestos-cement board and Select Grade red oak flooring arbitrarily established as 0 and 100, respectively.
About seventeen 25-foot furnaces are in operation in the United States and Canada.

ASTM Standard E 286 (6) prescribes use of red oak flooring for calibration of the 8-foot furnace, (specimen size 8 ft by 13.75 in.). The small 2-foot furnace of ASTM D 3806 (2), used primarily for evaluating coatings, uses red oak lumber for establishing the flame spread rating scale. The proposed ASTM Standard Method of test for surface burning characteristics of flooring, floor covering and other materials exposed in a floor-like orientation would use red oak flooring as a standard reference. This test utilizes the 25-foot furnace and the calibration sample (about 24 ft long by 17 in. wide) will be tested on the furnace floor.

The volume of red oak required annually in the United States and Canada for calibration of the three tunnel-type test furnaces is estimated at 5,000 to 10,000 board feet. Use of red oak for other large scale testing would most likely be negligible.

The Red Oak Resource

Inventory data are available for the volume of hardwood sawtimber growing on commercial forest land; volumes are in trees 11 inches and over in diameter at breast height. See “Forest Statistics of the U.S., 1977” table 22 (16). Inventory for the Eastern United States for total hardwoods and red oaks is given in table 1. Net volume of sawtimber for all hardwoods on commercial timberlands in the Eastern United States as of January 1, 1977, was 527 billion board feet. In the North, select red oaks make up about 50 percent of the total red oak volume. In the South, they constitute 20 percent. For the Eastern region (North and South combined), all red oaks have a stumpage of 127 billion board feet or 24 percent of all hardwoods combined. In 1970, the red oak sawtimber inventory was 106 billion board feet. The red oak resource is substantial and is increasing.

Production of Red Oak Lumber

The above is a measurement of the resource “on the hoof.” Total hardwood lumber production for 1976 in the Eastern United States was about 6 billion board feet, of which some 50 percent was in the red and white oaks (table 2), (19). Roughly half of this again would be in the red oaks, as suggested by the forest statistics for 1977 or about 1.5 billion board feet in 1976.

Production of Red Oak Strip Flooring

After World War II, production of oak strip flooring peaked at about 1 billion board feet and then declined rapidly to a low of 200 million board feet in 1972 (last year data available). Current oak strip flooring production is probably down to less than 100 million board feet. There are 20 members of the National Oak Flooring Manufacturers’ Association that process oak strip flooring at mill sites located in the lower Mississippi Valley and in the Southeast (see fig. 1). Production of oak strip flooring has decreased at least tenfold over the past 25 years and production is concentrated in the Southeastern United States.

Red Oak Specific Gravity

In this report, emphasis will be on specific gravity distribution patterns in the red oaks. The possible effect of other wood variables, aside from moisture content on flame spread is not defined.

The specific gravity of various species of red oak are given in table 3. Only black oak (Quercus velutina) and red oak (Quercus borealis syn. Quercus rubra) were sampled from more than one site. Species averages range from 0.52 to 0.61. Six of the nine species have average basic specific gravities that ranged from 0.56 to 0.58.

Quercus borealis syn. Quercus rubra was sampled from 6 sites located in 5 states, see figure 2–33 trees. Site averages are given in table 4. Analysis of variance shows no significant differences at the 5 percent level. The specific gravity distribution pattern is given in figure 3. Single tree averages range from 0.45 to 0.64, with a grand average of 0.566 and a standard deviation of 0.039.

Figure 1.—Mill sites of members of the National Oak Flooring Manufacturers’ Association. (M 149 530)

Figure 2.—The range of northern red oak (Quercus rubra, L.) and sample locations for two different property evaluations. (M 149 531)
R. R. Maeglin sampled 240 Quercus rubra trees—see figure 2 for locations—and reported on their specific gravity values. These ranged from 0.46 to 0.66 with a mean value of 0.56 (fig. 4), almost identical to Technical Bulletin No. 479 (11) distribution. It should be noted that the Technical Bulletin 479 trees were probably old growth as compared to Maeglin’s second-growth trees. Maeglin’s trees had ring counts of 7 to 17 rings per inch, whereas, the average ring count by site measured on the compression parallel-to-grain test specimens used for the Bulletin 479 study ranged from 7.1 to 11.5.

Benson H. Paul reported on specific gravity and growth-rate in second-growth red oak trees in the Appalachian region of West Virginia, Kentucky, and North and South Carolina (74). Sample locations are given in figure 5. A comparison of specific gravity values reported by Paul to those in Technical Bulletin 479 is given in table 5.

Second growth tends to be somewhat denser than the old growth. Bottom-land growth versus mountain growth may be an overriding influence. Within the growth-rate limits of 8 to 17 rings per inch measured by Paul, there was no apparent influence on density. Except for three locations, Maeglin finds the growth-rate, specific gravity relationship in red oak tenuous. Based on 993 compression parallel-to-grain test specimens of red oak (Quercus rubra) that have specific gravity, ring-count data recorded (Tech. Bull. 479), the coefficient of determination ($r^2$) was 0.213. From all of the preceding, growth rate has little influence on density in red oak.

Red Oak Strip Flooring Costs
In selecting or developing an SRM, cost should have some consideration. From the current “Hardwood Market Report,” (10) oak strip flooring prices were as follows:

<table>
<thead>
<tr>
<th>Grade</th>
<th>Mill price adjusted Memphis, Tenn. (as of Mar. 8, 1980)</th>
<th>Dol/1000 bm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clear</td>
<td>665 - 710</td>
<td></td>
</tr>
<tr>
<td>Select</td>
<td>655 - 675</td>
<td></td>
</tr>
<tr>
<td>No. 1 Common</td>
<td>555 - 600</td>
<td></td>
</tr>
</tbody>
</table>

It would be expected that the cost of material from a certified lot of red oak SRM would be considerably higher than the above mill prices. This would make tests which use a large footage of red oak such as the 25-foot furnace and large-scale tests costly.

Relevance of ASTM Standard E 286 and the Red Oak Calibration Reference

The 8-Foot Furnace
ASTM E 286, Standard Test Method for Surface Flammability of Building Materials Using an 8-Foot (2.44 m) Tunnel Furnace, was selected as a possible reference test method for measuring the flame spread property of any candidate SRM (6, 17, 18). This method, developed at the FPL in the early 1950’s, is designated in the standard for use in research and development and not to be used to develop a basis of ratings for building code use. However, it has proven to have considerable merit in research studies on untreated and fire-retardant-treated wood products. As a reference test method, the 8-foot furnace would be used to evaluate potential SRM candidates. A single candidate needs to be selected by using a test method that has good precision and adequate sensitivity. The final candidate material shown to have low variability in the 8-foot furnace testing would then undergo certification testing by a selected method or methods such as ASTM E-84.

About 1,700 tests have been conducted in the furnace at the FPL following the current standard. A computer file of the data from about 1,000 of these tests has been established. An indication of its precision was determined from the results of 48 tests conducted since May 1956 on Douglas-fir plywood, exterior grade, 3/8-inch thick:

<table>
<thead>
<tr>
<th></th>
<th>Flame spread index</th>
<th>Heating rate Btu/min</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>115.8</td>
<td>3,487</td>
</tr>
<tr>
<td>Standard deviation</td>
<td>5.49</td>
<td>36</td>
</tr>
<tr>
<td>Variance (N-1 weighting)</td>
<td>29.56</td>
<td>1,261</td>
</tr>
<tr>
<td>Coefficient of variation, percent</td>
<td>4.74</td>
<td>1.0</td>
</tr>
</tbody>
</table>

The coefficient of variation of 4.7 percent for FSI indicates quite good precision considering that the results included operator and specimen variability as well as that inherent in the test itself.

ASTM E 286 prescribes that calibration of the 8-foot furnace be accomplished with plain-sawed, Select Grade red oak flooring with a density range from 37 to 42 pounds per cubic foot. The flooring is to be nailed to a backing of plywood 0.25-inch thick. The heating rate of the gas supplied to the main burner is adjusted so that the time required for the flames to travel the length of the red oak specimen is 19.0 ± 1.0 minutes. As indicated earlier, a flame spread index value of 100 is arbitrarily assigned to this calibration and comparison standard. In subsequent tests, this heating rate is

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Figure 3.—Basic specific gravity distribution of red oak 
(*Quercus rubra, L.* as reported in Bulletin 479 (11) 
(Louisiana, Arkansas, Indiana, Tennessee, and 
New Hampshire–33 trees) in comparison to the 
density requirements of ASTM E 286.

![Graph showing basic specific gravity distribution of red oak.]

Figure 4.—Basic specific gravity distribution of red oak 
(*Quercus rubra, L.*) by Maeglin (Missouri, North 
Carolina, West Virginia, Indiana, New York, 
Michigan, and Wisconsin–240 trees) in com-
parison to density requirements of ASTM E 286.

![Graph showing basic specific gravity distribution of red oak.]

maintained the same until a periodic calibration check 
indicates the flame travel time is not within the re-
quired 18- to 20-minute period. Readjustment of the gas 
supply heating rate and recalibration with red oak is 
than carried out to establish a new standard test time 
period.

Results of ASTM E 286 tests on 1-inch lumber in the 
FPL 8-foot furnace indicate that flame spread index 
(FSI)\(^4\) increases with decrease in wood density (18). 
Figure 6 shows this relationship from individual test 
results on 29 species of hardwoods and softwoods. The 
equation for the regression line is 
y = 165 \( - \) 1.72x,
where y is the flame spread index and x is density in 
pounds per cubic foot. Density was based on weight 
and volume of the wood specimens conditioned at 

\[ y = 165 - 1.72x \]

\(^4\) The flame spread index is a number indicating the comparative flame 
travel rate on the surface of a specimen. The end point is 87 inches in 
the 8-foot furnace. The index for red oak is assigned the value 100. So 
FSI numbers lower or higher than 100 indicate flame travel time to the 
end point slower or faster, respectively than that on red oak.

80° F (26.7° C) and 30 percent relative humidity, or 
about 6 percent equilibrium moisture content (EMC). 
Standard deviation of y about the regression line is 9.1 
and the coefficient of determination is \( r^2 = 56 \) percent. 
A test of the F statistic indicates the regression to be 
significant at the 1 percent level. A casual examination 
of the plotted points showed no significant difference 
between hardwoods and softwood. A similar, within-
pecies, density-flame spread relationship is reported 
in a limited sampling of red oak, figure 7 (17).

Density of Red Oak Used for Furnace Calibration

Earlier work with the 8- foot furnace showed that density 
of red oak affected the time for flames to travel the 
full specimen length, figure 7, (17). The standard, 
therefore, was written to limit selection of red oak 
specimens in the density range of 37 to 42 pounds per 
cubic foot. The standard is not clear regarding the 
moisture content of the oak at the stated density. It is 
assumed that it would be calculated on weight and 
volume at the conditioned moisture content. The EMC 
of wood at the required conditioning atmosphere, 75 ± 
5° F (24 ± 2.8° C) and relative humidity of 35 to 40 per-
cent, is 6.8 to 7.7 percent (15). Specimens to be tested 
in the 8-foot furnace at the FPL are conditioned at 
80° F (26.7° C) and 30 percent relative humidity or 6 
percent EMC. The density of each individual piece or
Figure 6.—Test results on 1-inch lumber of 29 species in the FPL 8-foot furnace of ASTM E 286. Flame spread index decreases with increasing wood density.

Figure 7.—Effect of red oak density on flame travel time is reported in a previous FPL Research Note (17) using limited sampling.

Figure 8.—Density based on weight and volume at 6 and 8 percent moisture content versus basic specific gravity based on ovendry weight and green volume.

Figure 9 shows the scatter diagram and a linear regression line of the relationship between density and flame travel time. The regression equation is \( y = 7.66 + 0.273 \, x \), where \( y \) is the predicted time in minutes for flames to reach 87 inches and \( x \) is the density in pounds per cubic foot with density based on weight and volume at 6 percent EMC. The standard deviation of \( y \) about the regression line is \( s = 0.653 \) minute. The coefficient of determination, \( r^2 \), is 0.502. A test of the calculated F statistic indicates the regression is significant at the 1 percent probability level. We may conclude from this analysis that there is a high probability that 50 percent of the variation in flame travel time on red oak is associated with the specimen density.

Effect of Gas Supply Heating Rate on Flame Travel
Figure 10 shows the effect of gas supply heating rate on flame travel time in the 65 tests on red oak. The plotted points are quite scattered but the existence of a regression line is indicated. The regression equation is \( y = 42.4 - 0.0069 \, x \), where \( y \) is the predicted time in minutes for flames to reach 87 inches and \( x \) is the gas supply heating rate.

Figure 8.—Density based on weight and volume at 6 and 8 percent moisture content versus basic specific gravity based on ovendry weight and green volume.
minutes and $x$ is the heating rate in Btu per minute. Standard deviation of $y$ is $s = 0.857$ minute; $r^2 = 0.141$. The test of the F-statistic indicates significance at the 1 percent level. The heating rate obviously must affect the time of flame travel. If the furnace were an error-free perfect instrument with precise control of the gas supply, the heating rate used would be constant and $r^2$ would be zero. Consequently, the $r^2$ of 14 percent obtained is an indication of some variability in the furnace operation. In the 65 tests conducted, the heating rate varied by only about 3 percent, or $3440 \pm 110$ Btu per minute.

The combination of density plus heating rate was examined by analysis of variance for effect on flame travel time. A comparison of the $r^2$s, 0.584 versus 0.502, indicate that the addition of the 2nd variable (heating rate) to the regression equation does not lend any improvement of practical significance. If there were improvement in the control of the heating rate, density alone would explain 58 percent of the variation in the flame travel time on red oak.

Need for Changing the ASTM Standard

The ASTM E 286 standard on the 8-foot tunnel furnace test prescribes a red oak calibration specimen having a density within 37 to 42 pounds per cubic foot, or a basic specific gravity range of 0.50 to 0.56. To better represent the resource, the density range should be changed to 40 to 45 pounds per cubic foot at 6 to 8 percent moisture content (basic specific gravity 0.53 to 0.60) (figs. 3 and 4). In addition, since it has been shown that density of red oak affects the flame travel time, the information developed in this study should be used to correct for density when establishing the standard heating rate for operation of the furnace. Consideration should also be given to calibration of the furnace without use of red oak since its use introduces a density variable.

Conclusions and Recommendations

1. The red oak inventory in the forest is substantial, and about 1.5 billion board feet of red oak lumber is produced annually.

2. A high cost is indicated for use of a red oak SRM that appears not to be warranted for the variability encountered.

3. A need for red oak (flooring) as a standard reference material for use in calibration of the 8- and 25-foot standard test furnaces, or for large-scale fire testing, is not indicated at this time. This does not preclude, however, any future development of a red oak standard reference material to meet potential needs for a wood SRM for use in small-scale tests such as in ignition, smoke development, rate of heat release, and toxicity of combustion products.

4. It is recommended that a reconstituted wood panel product be considered as an alternative to red oak as a wood-base standard reference material for fire testing.

5. It is recommended that the 8-foot furnace be used as the reference standard test method for the initial evaluation of any candidate wood SRM's.

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### Table 1.—Total net volume of hardwood and red oak sawtimber in trees 11 inches and greater in diameter as of January 1, 1977 (16)

<table>
<thead>
<tr>
<th>Region</th>
<th>Total hardwoods</th>
<th>Select red oaks</th>
<th>Other red oaks</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Million bfm</td>
<td>Million bfm</td>
<td>Million bfm</td>
</tr>
<tr>
<td>Northeast</td>
<td>118,759</td>
<td>17,169</td>
<td>10,677</td>
</tr>
<tr>
<td>North Central</td>
<td>142,157</td>
<td>14,093</td>
<td>16,550</td>
</tr>
<tr>
<td>Total North</td>
<td>260,916</td>
<td>31,262</td>
<td>27,227</td>
</tr>
<tr>
<td>Total Red Oaks</td>
<td></td>
<td></td>
<td>58,489</td>
</tr>
<tr>
<td>Southeast</td>
<td>135,484</td>
<td>7,056</td>
<td>24,146</td>
</tr>
<tr>
<td>South Central</td>
<td>130,307</td>
<td>7,728</td>
<td>29,638</td>
</tr>
<tr>
<td>Total South</td>
<td>265,791</td>
<td>14,782</td>
<td>53,784</td>
</tr>
<tr>
<td>Total Red Oaks</td>
<td></td>
<td></td>
<td>66,566</td>
</tr>
<tr>
<td>Total Eastern Regions</td>
<td>526,707</td>
<td>46,044</td>
<td>81,011</td>
</tr>
<tr>
<td>North and South total</td>
<td>127,055</td>
<td></td>
<td></td>
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</table>

### Table 2.—Production of hardwood lumber by region, 1976 (19)

<table>
<thead>
<tr>
<th>Region</th>
<th>Total hardwoods</th>
<th>White and red oak</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Million bfm</td>
<td>Million bfm</td>
</tr>
<tr>
<td>South</td>
<td>3,834</td>
<td>1,938</td>
</tr>
<tr>
<td>Northeast and North Central</td>
<td>2,427</td>
<td>1,032</td>
</tr>
<tr>
<td>East</td>
<td>6,261</td>
<td>2,970</td>
</tr>
</tbody>
</table>
Table 3.–Basic specific gravity of red oaks

<table>
<thead>
<tr>
<th>Species</th>
<th>Location</th>
<th>Number of trees</th>
<th>Basic specific gravity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oak, black</td>
<td>Ark., Wis.</td>
<td>8</td>
<td>0.56</td>
</tr>
<tr>
<td><em>Quercus velutina</em></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oak, laurel</td>
<td>La.</td>
<td>5</td>
<td>0.56</td>
</tr>
<tr>
<td><em>Quercus laurifolia</em></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oak, pin</td>
<td>Mass.</td>
<td>5</td>
<td>0.58</td>
</tr>
<tr>
<td><em>Quercus palustris</em></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oak, red</td>
<td>Ark., Ind., La., N.H., Tenn.</td>
<td>33</td>
<td>0.57</td>
</tr>
<tr>
<td><em>Quercus borealis</em>²</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oak, scarlet</td>
<td>Mass.</td>
<td>5</td>
<td>0.60</td>
</tr>
<tr>
<td><em>Quercus coccinea</em></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oak, southern red</td>
<td>La.</td>
<td>4</td>
<td>0.52</td>
</tr>
<tr>
<td><em>Quercus rubra</em>²</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oak, swamp red</td>
<td>La.</td>
<td>3</td>
<td>0.61</td>
</tr>
<tr>
<td><em>Quercus rubra pagodaeifolia</em>²</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oak, water</td>
<td>La.</td>
<td>5</td>
<td>0.56</td>
</tr>
<tr>
<td><em>Quercus nigra</em></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oak, willow</td>
<td>La.</td>
<td>2</td>
<td>0.56</td>
</tr>
<tr>
<td><em>Quercus phellos</em></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

² Select red oaks.

Table 4.–Basic specific gravity of red oak (*Q. rubra*) by sites

<table>
<thead>
<tr>
<th>Location</th>
<th>Number of trees</th>
<th>Basic specific gravity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Richland Parish, La.</td>
<td>5</td>
<td>0.56</td>
</tr>
<tr>
<td>Stone County, Ark.</td>
<td>5</td>
<td>0.57</td>
</tr>
<tr>
<td>Hendricks and Marion Counties, Ind.</td>
<td>5</td>
<td>0.56</td>
</tr>
<tr>
<td>Sevier County, Tenn.</td>
<td>5</td>
<td>0.53</td>
</tr>
<tr>
<td>Grafton County, N. H.</td>
<td>7</td>
<td>0.56</td>
</tr>
<tr>
<td>Stafford County, N. H.</td>
<td>5</td>
<td>0.59</td>
</tr>
<tr>
<td>Total</td>
<td>33</td>
<td>Average 0.57</td>
</tr>
</tbody>
</table>

Table 5.–Comparison of specific gravity values

<table>
<thead>
<tr>
<th>Oak Species</th>
<th>Technical Bulletin 479¹</th>
<th>Technical Bulletin 1286²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Black oak</td>
<td>0.56</td>
<td>0.60</td>
</tr>
<tr>
<td>Northern red oak</td>
<td>0.57</td>
<td>0.58</td>
</tr>
<tr>
<td>Southern red oak</td>
<td>0.52</td>
<td>0.57</td>
</tr>
<tr>
<td>Scarlet oak</td>
<td>0.60</td>
<td>0.58</td>
</tr>
<tr>
<td>Water oak</td>
<td>0.56</td>
<td>0.59</td>
</tr>
<tr>
<td>Average</td>
<td>0.56</td>
<td>0.58</td>
</tr>
</tbody>
</table>

¹ Ref. (11).
² Ref. (14).


A need for wood-base materials suitable as Standard Reference Materials (SRM) for nationwide fire testing is presented. This paper presents results on first study which examined red oak as a candidate material from standpoint of present usage, forest resource, growth variability, and fire performance variability in the 8-foot tunnel furnace. A recommendation is made that a reconstituted wood product be investigated as a potential SRM.

Keywords: SRM, reconstituted wood, 8-foot tunnel furnace, fire performance, fire testing.