LUMBER

SECTION
100

General Criteria

100-G-1

Scope

Lumber used in architectural woodwork is divided into two groups:

• Hardwoods: Lumber obtained from angiosperms, usually deciduous trees (broadleaf trees). There are more angiosperms on earth than any other plant group, over 200,000 species. About 900 of those species are commonly available for lumber or veneer throughout the world.

• Softwoods: Lumber obtained from gymnosperms, about 600 of which are coniferous trees such as pine, spruce, and fir. The gymnosperms are among the largest and oldest living plants.

Note: The above groups have NO relationship to the density or "hardness" within or between various species. Some softwoods are harder than some hardwoods, and hardness varies greatly between species within each group.

Quality Standards Illustrated (QSI) lumber grades will always be referenced when specifying architectural woodwork. Selection of the QSI Grade for the finished product (Premium, Custom or Economy) will define *both* materials and workmanship for that product. Lumber grades defined by the lumber manufacturers' associations allow some defects which the architectural woodworker must remove (cut out) or otherwise work around (by gluing, etc.).

The selection of the proper wood species for an architectural design can be the end result of a number of contributing factors and conditions. Intended use, costs, hardness, and relative stability are among many important considerations.

The architect and designer may make his selection from a large variety of foreign and domestic species, now commercially available. The unique quality that wood imparts to design is that each species has its own distinguishing characteristics. Once the species is chosen, its effectiveness may vary according to the manner in which it is sawn, sliced as veneer, treated, and finished.

This section is designed to counsel the architect and designer in the comparisons, considerations, and species which should be evaluated before decisions are made and specifications are written. This section will help you correlate, and tabulate the information needed. An informed choice will reward the owner with the best possible performance by a natural building material.

Wood as a Plant

The trunk and its branches: The cross section of a tree shows the following well-defined features in succession from the outside to the center: (1) bark and cambium layer; (2) wood, which in most species is clearly differentiated into sapwood and heartwood; and (3) pith, the small central core. The pith and bark, of course, are excluded from finished lumber.

Most branches originate at the pith, and their bases are intergrown with the wood of the trunk as long as they are alive. These living branch bases constitute intergrown or tight knots. After the branches die, their bases continue to be surrounded by the wood of the growing trunk and therefore loose or encased knots are formed. After the dead branches fall off, the stubs become overgrown, and subsequently clear wood is formed.

All growth in thickness takes place in the cambium layer by cell division. No growth in either diameter or length takes place in wood already formed; new growth is purely the addition of new cells, not the further development of existing cells.

Annual Rings

Most species grown in temperate climates produce well-defined annual growth rings, which are formed by the difference in density and color between wood formed early and late in the growing season. The inner part of the growth ring formed first is called "spring wood," and the outer part formed later in the growing season is called "summer wood."

Spring wood is characterized by cells having relatively large cavities and thin walls. Summer wood cells have smaller cavities and thicker walls, and consequently are more dense than spring wood. The growth rings, when exposed by conventional methods of sawing, provide the grain or characteristic pattern of the wood. The distinguishing features of the various species are thereby enhanced by the differences in growth ring formation.

Some tropical species, on the other hand, experience year long even growth which may result in less obvious growth rings.

Softwoods and Hardwoods

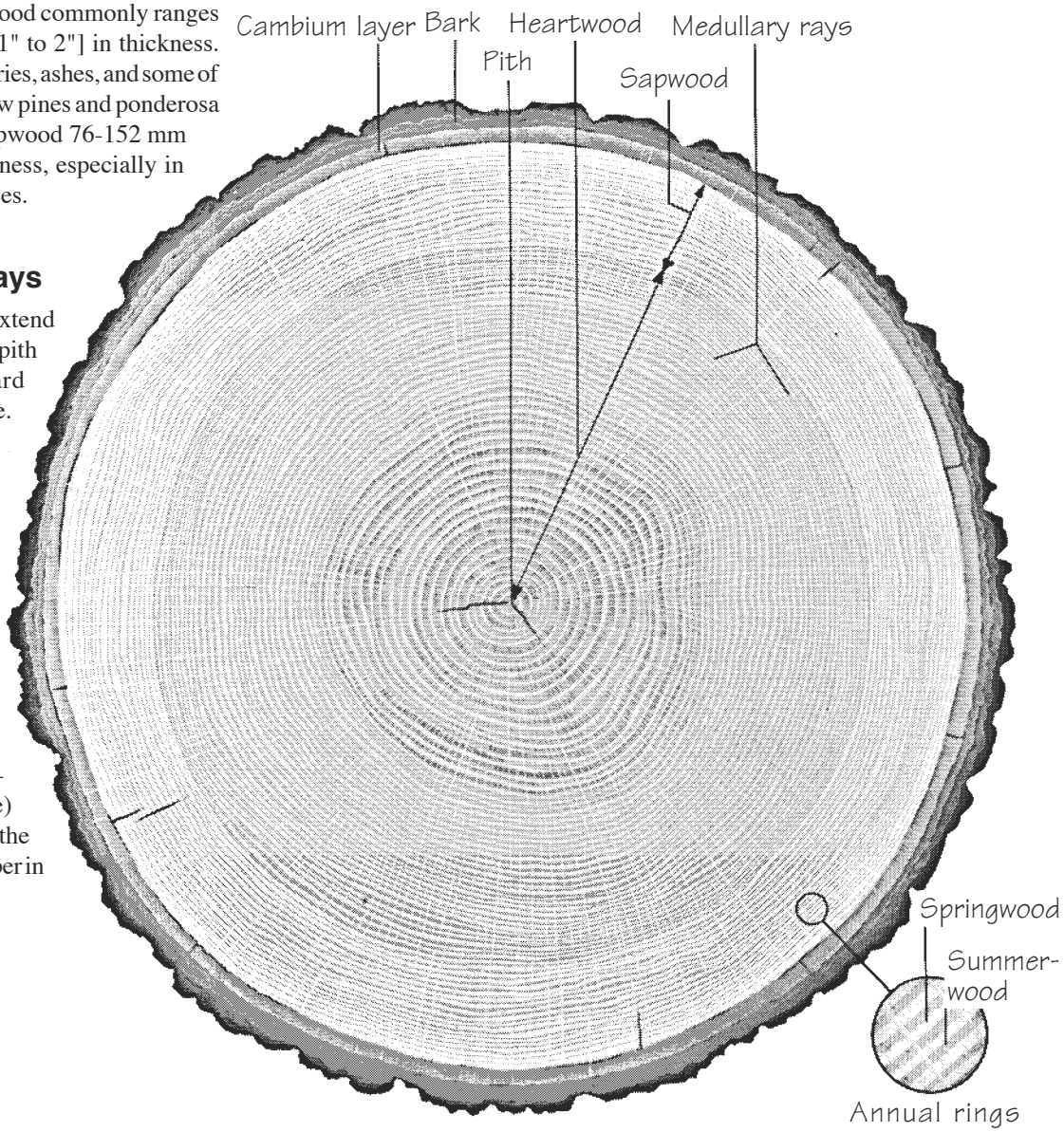
Native species of trees and the wood produced by these trees are divided into two botanical classes: hardwoods, which have broad leaves; and softwoods, which have needle-like or scale-like leaves. This botanical classification is sometimes confusing, because there is no direct correlation between calling a species a hardwood or softwood and the hardness or softness of the wood itself. Generally, hardwoods are more dense than softwoods, but some hardwoods are softer than many softwoods. If hardness is a desired characteristic, refer to the Comparative Table of Wood Species later in this book.

Heartwood

Heartwood consists of inactive cells formed by changes in the living cells of the inner sapwood rings, presumably after their use for sap conduction and other life processes of the tree have largely ceased. The cell cavities of heartwood may also contain deposits of various materials that frequently provide a much darker color. Not all heartwood, however, is darker. The infiltrations of material deposited in the cells of heartwood usually make lumber cut therefrom more durable when exposed to weather. All wood, with the possible exception of the heartwood of redwood and western red cedar, should be preservative-treated when used for exterior applications.

Sapwood

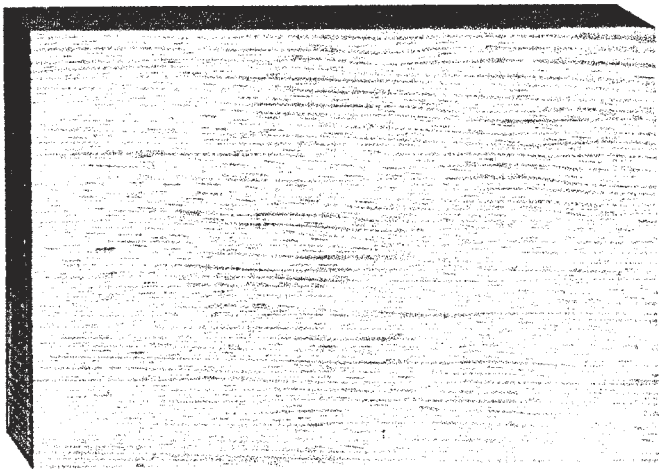
Sapwood contains living cells and performs an active role in the life processes of the tree. It is located next to the cambium and functions in sap conduction and storage of food. Sapwood commonly ranges from 25-50 mm [1" to 2"] in thickness. The maples, hickories, ashes, and some of the southern yellow pines and ponderosa pine may have sapwood 76-152 mm [3" to 6"] in thickness, especially in second growth trees.



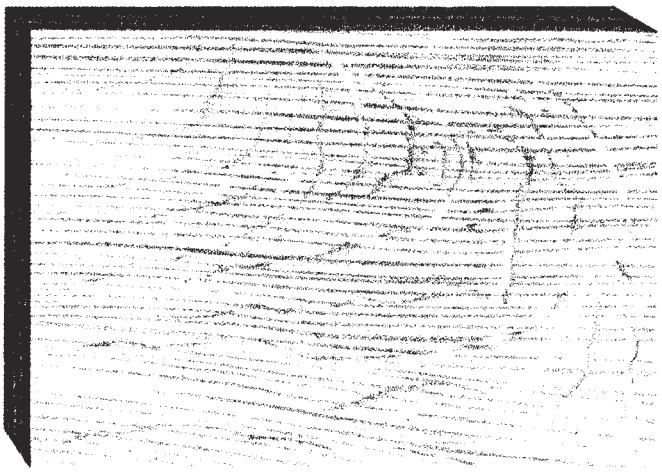
Medullary Rays

Medullary rays extend radially from the pith of the log toward the circumference. The rays serve primarily to store food and transport it horizontally. They vary in height from a few cells in some species to four or more inches in the oaks, and produce the fleck (sometimes called flake) effect common to the quarter-sawn lumber in these species.

Plainsawn Lumber



Riftsawn Lumber



Quartersawn Lumber

Comparative Table of Wood Species

In order to simplify species selection, the Comparative Table of Wood Species has been prepared showing pertinent characteristics of some species of domestic and foreign woods used by the architectural woodwork industry. The table can quickly confirm or deny the wisdom of a species selection by the architect or designer or conversely lead to a proper selection after studying the characteristics.

“Cost" has been broken into both *Lumber* and *Plywood* headings, with data divided into Low, Moderate, High, and Very High [V. High]. (Important: Market conditions cause these relationships to vary. Current ratios are likely to be different.) The reason for cost variations in the two products is obvious when we consider the physical differences. Generally, the prices of veneered products reflect the relatively high labor and equipment cost and relatively low material cost in their manufacture. On the other hand, the price of lumber in most species reflects cost factors that are exactly the opposite. In spite of their physical differences, the two products are always compatible, and both are essential to complete design freedom in contemporary buildings.

End use determines the importance of *Hardness* in selecting a species for each particular type of application. Counters, door frames, wall treatments in high-traffic areas, etc., are obvious uses of wood products where hardness and resistance to abrasion must be considered. In many other applications these factors, relatively speaking, are not of great importance.

Dimensional Stability— The dimensional stability table is helpful in selecting woods for use where humidity conditions may vary widely and where design or fabrication of a wood product does not allow free movement or the use of plywood. The column figures indicate extreme conditions and show the maximum amount of movement possible in a 305 mm [12"] wide piece of unfinished wood where its moisture content increases or decreases from 10% to 5%. The possible change in dimension demonstrates that unfinished interior woodwork must be carefully protected prior to finishing by keeping it in rooms where relative humidity is between 25% and 55%. The column also shows the variation between species, and between flat grain and edge grain where such cuts are available commercially.

Careful analysis of the table will make it possible for an architect, designer or specification writers (who may have only a limited knowledge of architectural wood species) to make an informed selection. It is our intent that this tool will enhance understanding between the manufacturer of the woodwork you have designed and your profession, thereby enabling the building industry to better service the client.

This table was originally compiled with Imperial measure and will not be converted to metric for this edition.

Comparative Table of Wood Species

Species	Costs (1)		Practical Size Limits (2)			Hardness	Dimensional Stability (3)
	Lumber	Plywood	Thickness	Width	Length		
Ash	Moderate	Moderate	2-1/2"	5-1/2""	12'	Hard	10/64"
Basswood	Low	no data	2-1/2"	5-1/2"	10'	Soft	10/64"
Beech	Low	no data	1-1/2"	5-1/2"	12'	Hard	14/64"
Birch, Yellow - natural	Moderate	Moderate	1-1/2"	5-1/2"	12'	Hard	12/64"
Birch, Yellow - select red	Moderate	Moderate	1-1/2"	4-1/2"	11'	Hard	12/64"
Birch, Yellow - select white	Moderate	Moderate	1-1/2"	4"	11'	Hard	12/64"
Butternut	High	V. High	1-1/2"	4-1/2"	8'	Soft	8/64"
Cedar, Western Red	High	Moderate	3-1/4"	11"	16'	Soft	10/64"
Cherry, American Black	High	High	2-1/2"	4"	7'	Hard	9/64"
Chestnut - wormy	High	no data	3/4"	5-1/2"	10'	Medium	9/64"
Cypress, Yellow	Low	no data	2-1/2"	7-1/2"	16'	Medium	8/64"
Fir, Douglas - flat grain	High	Moderate	3-1/4"	11"	16'	Medium	10/64"
Fir, Douglas - vertical grain	High	no data	1-1/2"	11"	16'	Medium	6/64"
Hickory	Low	Moderate	1-1/2"	4-1/2"	12'	Very Hard	11/64"
Mahogany, African-plain sawn	High	High	2-1/2"	9"	15'	Medium	7/64"
Mahogany, African-quarter sawn	V. High	V. High	2-1/2"	5-1/2"	15'	Medium	5/64"
Mahogany, Genuine (American)	High	V. High	2-1/2"	11"	15'	Medium	6/64"
Maple, Hard - natural	Moderate	Moderate	3-1/2"	7-1/2"	12'	Very Hard	12/64"
Maple, Hard - select white	Moderate	High	2-1/2"	5-1/2"	12'	Very Hard	12/64"
Maple, Soft - natural	Moderate	no data	3-1/2"	7-1/2"	12'	Medium	9/64"
Oak, English Brown	V. High	V. High	1-1/2"	4-1/2"	8'	Hard	no data
Oak, Red - plain sawn	Moderate	Moderate	2-1/2"	7-1/4"	12'	Hard	11/64"
Oak, Red - rift sawn	High	High	1-1/16"	3-1/2"	8'	Hard	7/64"
Oak, Red - quarter sawn	High	High	1-1/16"	5-1/2"	8'	Hard	7/64"
Oak, White - plain sawn	Low	High	1-1/2"	5-1/2"	10'	Hard	11/64"
Oak, White - rift sawn	High	High	3/4"	3"	8'	Hard	7/64"
Oak, White - quarter sawn	High	High	3/4"	4"	8'	Hard	7/64"
Pecan	Low	Moderate	1-1/2"	4-1/2"	12'	Hard	11/64"
Pine, Eastern or Northern White	Moderate	no data	1-1/2"	9-1/2"	14'	Soft	8/64"
Pine, Idaho	Moderate	no data	1-1/2"	9-1/2"	16'	Soft	8/64"
Pine, Ponderosa	Moderate	Moderate	1-1/2"	9-1/2"	16'	Soft	8/64"
Pine, Sugar	Moderate	no data	3-1/4"	11"	16'	Soft	7/64"
Pine, Southern Yellow	Low	no data	1-1/2"	7-1/2"	16'	Medium	10/64"
Poplar, Yellow	Low	no data	2-1/2"	7-1/2"	12'	Medium	9/64"
Redwood, flat grain heartwood	Moderate	no data	2-1/2"	11"	16'	Soft	6/64"
Redwood, vert. grain heartwood	Moderate	no data	2-1/2"	11"	16'	Soft	3/64"
Teak	V. High	V. High	1-1/2"	5-1/2"	8'	Hard	6/64"
Walnut, American Black	Moderate	High	2-1/2"	4"	6'	Hard	10/64"
Walnut, Nogal	Moderate	no data	3/4"	9-1/2"	9'	Medium	12/64"
Zebrawood, African - quarter sawn	V. High	V. High	1-1/2""	7"	14'	Hard	7/64"

(1) Market conditions will cause these relationships to vary. These are raw costs without consideration of labor.
(2) Maximum practical sizes without lamination/gluing. Only 10% of any order is required to be at maximum sizes.
(3) These figures represent possible width change in a 12" board when moisture content is reduced from 10% to 5%. Figures taken are for plain sawn unless indicated otherwise in the species column.

Ash, White (Fraxinus americana)

While White Ash has always enjoyed widespread use for industrial products where hardness, shock resistance, stability and strength were important, its acceptance for architectural woodwork is increasing. It is open grained and has a strong and pronounced grain pattern. The heartwood is light tan or brown and its sapwood creamy white. Color contrast between the two is minor and its blond effect makes it particularly appealing when a light or near natural finish is desired. Finished with darker tones it presents a very forthright, honest, and virile effect. Its cost is moderate and it is readily available in lumber form. In veneered form some size limitation may be experienced but it can be easily produced on special order.

Birch, Yellow - “Natural" (Betula alleghaniensis)

Birch, Yellow - “Select Red" (heartwood) (Betula alleghaniensis)

Birch, Yellow - “Select White" (sapwood) (Betula alleghaniensis)

Yellow Birch has been and continues to be one of the prominent wood species used for architectural woodwork. This is due not only to its attractive appearance but also to its general availability both as lumber and as veneered products, its adaptability to either paint or transparent finish, and its abrasion resistance. The heartwood of the tree varies in color from medium to dark brown or reddish brown while its sapwood, which comprises a better than average portion of the tree, is near white. Despite its wide usage some confusion exists as to the common terms used to describe Birch lumber and/or veneer. Virtually all commercially used Birch is cut from the Yellow Birch tree, not from the White Birch tree, which botanically is a distinct species. The term “Natural" or “Unselected" Birch means that the lumber or veneer may contain both the sapwood, or white portion, as well as the heartwood, or dark portion, of the tree in unrestricted amounts. The term “Select Red" Birch describes the lumber or veneer produced from the heartwood portion of the tree, and the term “Select White" Birch describes the lumber or veneer produced from the sapwood portion of the tree. To obtain “Red" or “White" Birch exclusively requires selective cutting with corresponding cost premium as well as considerable restriction on the width and length availability in lumber form. Birch, in veneer form, is readily available in all “selections" and is usually rotary cut. While some sliced veneer is produced which simulates the same grain effect as lumber, its availability and cost reflect the same cutting restrictions that are incurred in producing the “select" forms of Birch lumber.

Cherry, American Black (Prunus serotina)

Wild Black American Cherry is a fine and especially stable close grained cabinet and veneer wood. Its heartwood color ranges from light to medium reddish brown. Its sapwood, which is a light creamy color, is usually selectively eliminated from the veneer and lumber. In some respects it resembles Red Birch, but has a more uniform grain and is further characterized by the presence of small dark gum spots which, when sound, are not considered as defects but add to its interest. Cherry is available in moderate supply as lumber and architectural paneling and is usually plain sawn or sliced. Exceptionally rich appearance is achieved with transparent finishes which, together with its fine machining characteristics, justifies its identity with Early American cabinetry and furniture manufacturing, thus adding to its prestige as one of our most desirable native woods.

Cypress, Yellow (Taxodium distichum)

While Cypress is still prevalent throughout the south, distinction should be made between the type now generally available and what was once known as “Tidewater Red Cypress." The latter, once the “premium" wood for exterior applications, is now virtually extinct and subject to limited usage. The currently available Cypress lumber, while similar in appearance, does not contain the heartwood of inherently high decay resistance once associated with the species, and in lumber form contains a high percentage of sapwood. Thus, like most softwoods, preservative treatment is imperative if used on the exterior. While this does not preclude its exterior application, it is perhaps more generally utilized for paneling where its strong, bold grain is best displayed.

Fir, Douglas (Flat Grain) (Pseudotsuga taxifolla)

Douglas-Fir is a large, fast-growing species and is native to the northwest. It accounts for much of the lumber produced in North America. While the preponderance of its production is developed for structural and construction type products, some of its upper grades are used for stock millwork and specialized woodwork. Its heartwood is reddish tan while its sapwood is creamy yellow. Since its growth rings are conspicuous, a rather bold grain pattern develops when either plain sawn for lumber or rotary cut as is common in plywood. Some lumber and veneer is cut edge or vertical grain, producing a superior form of the product since the tendency to “grain-raise" is greatly reduced.

Mahogany, African (plain sawn) (Khaya ivorensis)

This, one of the true mahoganies, is perhaps the most widely used of the several Mahogany species. This is due to its excellent cutting and working characteristics and versatility. While its use has been largely for interior purposes, its innate stability and moderate decay resistance justifies its consideration for selected and demanding exterior applications. It has a very pleasing open grain, with its heartwood ranging in color from light to medium dark reddish brown. In lumber form it is more readily available as plain sawn and selectively so as quartersawn. In veneer form the quarter or “ribbon striped" cut predominates, but plain sliced, as well as many of the exotic “figure" cuts, can be produced on special order.

Mahogany, Genuine or American (Swietenia macrophylla)

This mahogany species is commonly known as “Honduras Mahogany," but actually encompasses all of this species that grow throughout Mexico, Brazil, Peru, and Central America. Its traditional identity with fine cabinetry and furniture justifies its position as one of the finest woods for this purpose. Its stability, workability, warm appearance, and firm grain make it a favorite of all woodworking craftsmen. It is a semi-open grain wood, with its heartwood color ranging from light tan to a rich golden brown depending to some extent on the country of its origin. Its outstanding stability and decay resistance expands its potential to include exterior applications for “monumental" projects. It is most generally available as plain sawn lumber and plain sliced veneer with different veneer cuts available on special order.

Maple, Hard - “Natural" (Acer saccharum)

Maple, Hard - “Select White" (Sapwood) (Acer saccharum)

Hard Maple is very similar in general characteristics to Yellow Birch. It is heavy, hard, strong, and resistant to shock and abrasion. The heartwood of the tree is reddish brown and its sapwood is near white with a slight reddish-brown tinge. Another natural characteristic is the prevalence of dark mineral streaks (predominantly in the heartwood), which can be minimized in the sapwood by selective cutting. Like Birch, common usage of descriptive terms does occasion some confusion. The term “Natural" or “Unselected" Maple indicates that the lumber or veneer may contain both the white sapwood and the darker heartwood. The term “White" Maple means that the lumber or veneer is selected and separated from the pieces containing the dark heartwood. Unlike Birch, the heartwood is so low in content that no comparable selection is available. Maple’s close identity with furniture and specialized industrial use overshadows its potential for architectural woodwork. Its modest cost, and pleasing, mild grain pattern warrants its consideration, especially on items subject to hard usage.

English Brown Oak (Quercus robur)

The English Brown Oak, or Pollard Oak is a tree which varies in height from 18-40 m [60'-130'] depending on soil conditions. It varies in color from a light tan to a deep brown with occasional black spots. It produces burls and swirls which are very brittle and fragile, but beautiful work can be obtained with their use. English Brown Oak is considered one of the finest woods in use today.

English Brown Oak is obtained from trees which have had their tops cut out before reaching maturity. This pruning leads to the production of a number of new branches around the cut, and if these are subsequently lopped off, more new branches are formed.

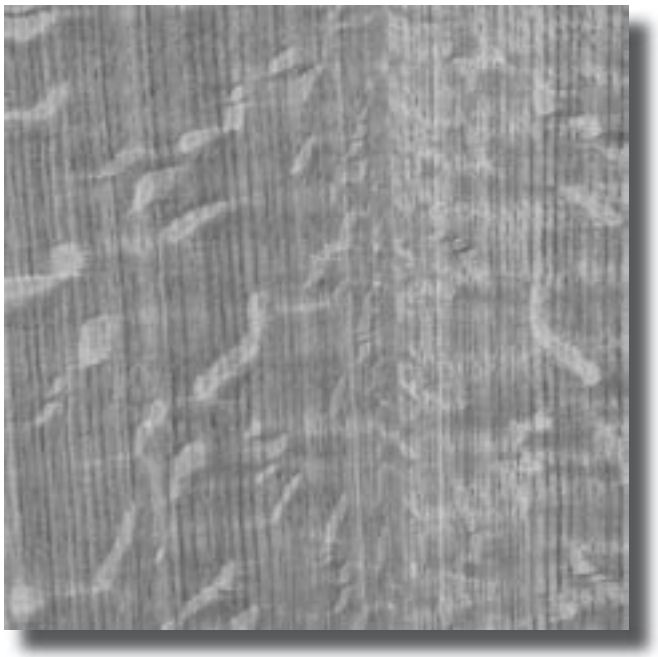
This wood is difficult to season and to work, tending to warp and twist in drying and to tear in working. The best figure is obtained from trees which have been cut over regularly every few years, the branches never being left sufficiently long for the production of large knots. The constant exposure of freshly cut surfaces promotes attack from parasites, the result being that a considerable portion of these trees became decayed sooner or later. This had made the timber relatively scarce and costly.

Oak, Red (plain sawn) (Quercus rubra)

Oak, Red (rift sawn) (Quercus rubra)

Red Oak is one of the most abundant of our domestic hardwoods. Its moderate cost, strength, wearability, and appealing grain characteristics make its use widespread. It is open grained and in its plain sawn or sliced form expresses a very strong “cathedral" type grain pattern. The heartwood is reddish tan to brown and very uniform in color. Its sapwood is lighter in color and minimal in volume, making its elimination by selective cutting very easy. Red Oak is also available in rift sawn or sliced form, which produces a very uniform straight-grained effect. Less frequently it is quarter sawn or sliced, still producing a straight grain but with the fleck (sometimes called flake) of the medullary ray accented. Some sacrifice in width and length availability occurs when producing either rift or quarter sawn lumber.

Oak, White (plain sawn) (Quercus alba)



Oak, White (quarter sawn) (Quercus alba)

White Oak, like Red Oak, is perhaps one of the best-known hardwoods in the world, and its use for architectural woodwork is widespread. It is hard and strong. Its heartwood has good weathering characteristics, making its use for selected exterior applications appropriate. It is open grained and in its plain sawn form is highly figured. The heartwood varies considerably in color from light grayish tan to brown, making the maintenance of color consistency difficult. Its sapwood is much lighter in color, is fairly prevalent, and its elimination

is accomplished by selective ripping. White Oak is often rift sawn or sliced, producing a very straight-grained effect or frequently quarter sawn or sliced, producing straight grain, but with the fleck (sometimes called flake) of the medullary ray greatly pronounced. The special cuts mentioned are more readily attained in veneer form since the solid lumber cutting techniques greatly restrict its width and length potential.

Pine, Ponderosa (Pinus ponderosa)

Ponderosa Pine is said to be the softwood species most commonly used for exterior and interior woodwork components. Its heartwood is tannish pink, while its sapwood is a lighter creamy pink. Its supply is extensive; found in commercial quantities in every state west of the Great Plains. Ponderosa pine grows in pure stands and is abundant in mixed stands. Also, like most Pines, the proportion of sapwood is high and its heartwood has only a moderate natural decay resistance. Fortunately, its receptivity to preservative treatment is high, and since all Pines should be so treated when used on the exterior, it can be used interchangeably with them.

Pine, Southern Yellow (Short Leaf) (Pinus echinata)

Southern Yellow Pine, commonly called Short Leaf Pine, is commercially important in Arkansas, Virginia, Missouri, Louisiana, Mississippi, Texas, and South and North Carolina, and is found in varying abundance from New York and south central Pennsylvania, south and westerly to eastern Texas and Oklahoma.

The yellowish wood is noticeably grained, moderately hard, strong, and stiff. A cubic foot of air-dried Southern Yellow Pine weighs 36 to 39 pounds. It is used extensively in house building, including framing, ceiling, weather boarding, panels, window and door frames, casing, and carved work. The grains shows well in natural finish or when stained. Frames of overstuffed furniture, chairs, desks, agricultural machinery, wood pulp, mine props, barrels, and crates are also made of this pine.

Poplar, Yellow (Liriodendron tulipfera)

Yellow Poplar, sometimes incorrectly called “Whitewood," is an extremely versatile and moderately priced hardwood that is well adapted to general interior woodwork usage. It is even textured, close grained, stable, of medium hardness, and has an inconspicuous grain pattern. The heartwood is pale greenish yellow while the sapwood is white. Occasional dark purple streaks also occur. The tight, close grain results in outstanding paintability, while its modest figure and even texture permits staining to simulate more expensive hardwood. Due to its indistinct grain figure, Poplar is seldom used for decorative veneered products. Its white sapwood is not appropriate for use in exterior applications.

Redwood, Flat Grain (Heartwood) (Sequoia sempervirens)

Redwood is the product of one of nature’s most impressive accomplishments. The enormous size and unique inherent characteristics of this tree produce a material ideally suited for exterior applications. Its heartwood color is a fairly uniform brownish red, while its very limited sapwood is lemon colored. In its plain sawn form medium “cathedral" type figure develops, while in the vertical grain a longitudinal striped figure results. Its availability in “all heartwood" form with its outstanding natural resistance to decay accounts for its wide usage for exterior purposes. It is considered a very stable wood and its paint retention qualities are excellent. Redwood’s principal identity with painted exterior application should not preclude its consideration for either exterior or interior use with transparent finish. Its pleasing and uniform color lends itself to a variety of such finishes suggesting the warmth and honesty of wood in its natural state. The enormous size of the trees yields lumber of unusually character-free widths and lengths.

Teak (Tectona grandis)

Teak is one of the most versatile and valuable woods and has attained great prestige value. The figure variations are extensive and it is available in both lumber and veneered products. Adding to its appeal is its distinctive tawny yellow to green to dark brown color, often with light and dark accent streaks. It is perhaps most appealing in plain sawn or sliced cuts. While it has unique stability and weathering properties, making it ideal for exterior applications, its high cost usually limits its use to decorative interior woodwork, most often in veneer form. Its great beauty and interest dictate it being finished in its near “natural state."

American Black Walnut (Juglans nigra)

American Black Walnut is perhaps our most highly prized domestic wood species. Its grain pattern variations are extensive and in veneered form produces, in addition to its normal plain sliced cut, quartered or “pencil striped" as well as specialty cuts such as crotches, swirls, burls, and others. Its heartwood color varies from gray brown to dark purplish brown. The sapwood, which is very prevalent in solid lumber, is cream colored and its complete elimination by selective cutting is very costly. Fortunately, if this natural effect is felt to be undesirable, its appearance can be neutralized by sap staining in the finishing process. The growth conditions of Walnut result in significant width and length limitations in its lumber form. Its potential is best expressed in veneered products.

Zebrawood, African (quarter sawn) (Brachystegea fleuryana)

The Zebrawood tree is an equatorial tree of medium size, obtaining a height of about 20 m [65'] with a diameter of about 1 m [3']. The sapwood is pale in color and distinct from the heartwood, which is of a creamy yellow color veined or striped with very dark brown or black. The striped effect is seen at its best when the wood is quarter sawn.

The wood is reported to be easy to saw but somewhat difficult to work with other tools. It is claimed that there is little tendency for the wood to "work" after seasoning. It has been used for a number of years for cabinet work, fine joinery, fancy turnings, and veneers. By careful selection of veneered material, the skilled craftsman can obtain very beautiful effects in paneled work. In large panels, a very striking and attractive result may be obtained when using Zebrawood.

Other Species

There are many other species, both domestic and imported, used in fine woodworking. Nearly all are ecologically sound and appropriate for use. Using fine hardwoods for architecture gives value to the species, encouraging improved forest management techniques and the continuation of the species. As of March 2001, there are only four tree species listed on the Convention on International Trade in Endangered Species (CITES) Appendix I restricted table: Brazilian Rosewood, Monkey Puzzle Tree, Guatemalan Fir, and Alerce. Contact your local woodwork manufacturer for up-to-date information or visit www.cites.org.

Use of Reclaimed Timber

Interest in timber salvaged or reclaimed from old logs cut from old growth forests has increased recently.

Logs harvested over 100 years ago and transported by water often sank en-route to mills. The resulting "lost underwater forest" lay on the bottoms of rivers and lakes until recently as proper environmental and mechanical procedures for retrieving them have been developed.

Reclaimed submerged materials are utilized in all aspects of construction of fine furniture, architectural woodwork and musical instruments. Submerged lumber is generally processed in both solid lumber, plain sliced and rotary veneer.

The uniqueness of the harvesting procedures, the high quality of the material and unusual aesthetic qualities are a few of desirable traits associated with this special material.

Some of the characteristics unique only to reclaimed submerged timber are:

- Greater density due to tighter growth rings than currently harvested stock;
- Beautiful variance of color gained from the transfer of mineral absorption found naturally in bottom sediments and water;
- Substantial increase of ease in milling due to sap replacement;
- Superior tonal qualities;
- A more pristine appearance;
- Aspects of Historical importance as well as environmental consciousness is added to any project;
- Complete use of the harvested resource.

Check availability and differences in aesthetic qualities before selecting.

Engineered Products

Structural Composite Lumber (SCL) — A man-made composite that utilizes grain oriented wood strands from a variety of tree species, providing an alternative to dimension lumber. The material is engineered for strength and stability. While SCL is not really "lumber," it is marketed as a lumber substitute. SCL can be specified as core, stile backers, and core for stiles and rails, so long as all other criteria of these Standarda are met in relation to its use.

100-G-2

Factors Influencing Lumber Selection

1. Æsthetics: 100-G-3
2. Availability: 100-G-4
3. Size Limitations: 100-G-5
4. Cost: 100-G-6
5. Strength, Hardness, Density: 100-G-7
6. Dimensional Stability: 100-G-8
7. Adaptability for Exterior Use: 100-G-9
8. Fire Rating: 100-G-10

Hardwoods and softwoods are raw materials. They cannot be "graded" using the QSI terms Premium, Custom, or Economy Grade.

Note: Only Grades of workmanship and finished product are defined by the Quality Standards Illustrated (QSI) Grade designations: Premium, Custom or Economy. Hardwoods, softwoods and wood veneers are raw materials. Raw material grades, or properties, are defined by independently formulated grading rules. The grades of material defined and utilized in the QSI are Grade I, II and III, for hardwood and softwood lumber and Grades AA, A and B, for veneer face products. For the most part, the QSI requires that the grade of material corresponds to the QSI Grade of workmanship/product specified; i.e. Premium Grade must utilize Grade I and Grade AA. However, you may wish to define a higher, or lower, grade of material for aesthetic, or structural reasons. Opaque finishes usually use a lower material grade.

100-G-3

Æsthetic Characteristics

One of the qualities which contributes to the widespread use of wood is the option offered for æsthetic selection. It varies between species, between two logs of the same species, and between two boards from the same log. Æsthetic considerations in specifying wood are influenced by the following characteristics:

A. **Color** - The basic hue of the species, which may be further enhanced by the finishing process employed.

Sapwood and heartwood - The color of wood within a tree varies between the "sapwood" (the outer layers of the tree that continue to transport sap), which is usually lighter in color than the "heartwood" (the inner layers in which the cells have become filled with natural deposits). If desired, sapwood may be stained in the finishing process to blend with the heartwood. This difference in color is so pronounced in certain species that the sapwood is marketed under a different nomenclature from the heartwood. Some examples are:

Select White Birch - sapwood of Yellow or Paper Birch
Select Red Birch - heartwood of Yellow Birch
Natural Birch - both sapwood and heartwood of any Birch
Select White Ash - sapwood of White or Green Ash
Select Brown Ash - heartwood of Black Ash
Natural Ash - both sapwood and heartwood of any Ash
Select White Maple - sapwood of the Sugar Maple

B. **Grain** - The appearance produced by the arrangement of wood fibers and pores of the species. Open grain woods are said to be ring-porous and usually show a distinct grain pattern. Close grain woods are said to be diffuse-porous with even grain.

Note: Open Grain and Close Grain

The size and distribution of the cellular structure of the wood influences the appearance and uniformity. Open grain hardwoods, such as Elm, Oak, Ash, and Chestnut are *ring-porous* species. These species have distinct figure and grain patterns. Close grain hardwoods, such as Cherry, Maple, Birch, and Yellow Poplar, are *diffuse-porous* species. Most North American diffuse-porous woods have small, dense pores resulting in less distinct figure and grain. Some tropical diffuse-porous species (e.g., Mahogany) have rather large pores.

C. **Figure** - Various species produce different grain patterns (figures), which influence the selection process. There will be variations of grain patterns within any selected species. The architectural woodworker cannot select solid lumber cuttings within a species by grain and color in the same manner in which veneers may be selected.

D. **Methods of Sawing -** The sawing method, and the selection of boards after sawing the log will produce the following types of lumber:

Plain Sawn

Plain sawing, the most common type of lumber sawing, yields broad grain, the widest boards and least waste. The annular rings are typically 30 degrees or less to the face of the board.

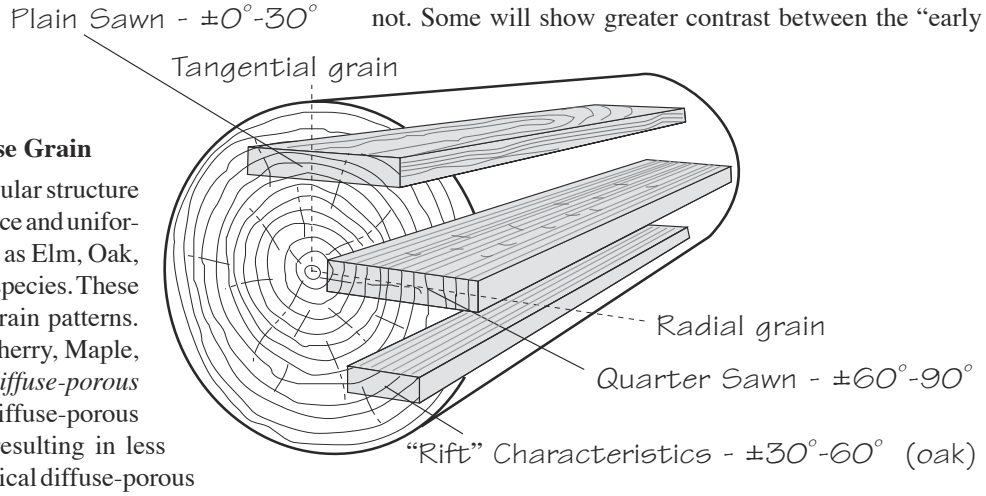
Quarter Sawn

Most often cut as Rift-and-Quartered, and then sorted for appearance, quarter sawn lumber is available in certain species, yields a straight grain, narrow boards, and fleck (sometimes called flake) or figure which runs across the grain in some species (notably the oaks). Dimensional stability across the grain is the best. The annular rings run approximately 60 to 90 degrees to the face of the board, with the optimum being 90 degrees. Quartered lumber is generally more expensive than plain sawn.

Rift Sawn

Rift sawing produces small flecks caused by cutting through the wood rays. Only certain species produce these flecks, primarily Red and White Oak. Rift cutting reduces yield and increases cost. The annular rings run about 30 to 60 degrees to the face of the board, with the optimum being 45 degrees.

E. **Finishing Characteristics -** The many species of wood vary considerably in their receptivity to the multitude of finishing processes on the market. Some woods, because of their open pores, will accept fillers while tighter grained woods will not. Some will show greater contrast between the "early wood" and the "late wood" when stained than others. Design professionals should take into consideration the finish that will be applied when selecting a particular species. Consult with an AWI/AWMAC woodworker about finishing prior to selection or specification. Providing large samples of the desired finish to woodworkers during the design phase and bidding process will assure the designer of obtaining an acceptable final product, while enabling the woodworker to be aware of exactly what is required.



100-G-4

Availability

The supply of lumber is in constant flux throughout the world. It is affected by many factors such as current demand, export regulations of the country of origin, natural forces of weather, fire, disease, political situations, etc. Consult an AWI/AWMAC woodworker before specifying uncommon species, as well as large quantities of a species, thickness, width, or long length.

100-G-5

Size Limitations

Certain trees (species) naturally grow larger, thus producing longer and wider lumber. Other trees are smaller and produce narrow and shorter boards. The architectural woodworker must work with the available lumber, which must be considered when selecting any species.

100-G-6

Cost

The cost of lumber, as with other commodities, is influenced by supply and demand, both of which are constantly changing. For current comparative costs consult an AWI/AWMAC woodworker.

100-G-7

Strength, Hardness, Density

Always a consideration is the ability of the selected lumber species to sustain stress; resist indentation, abuse, and wear; and to carry its anticipated load in applications such as shelving and structural members. The Wood Handbook, published by the U.S. Forest Products Society contains comprehensive data on the mechanical properties of wood.

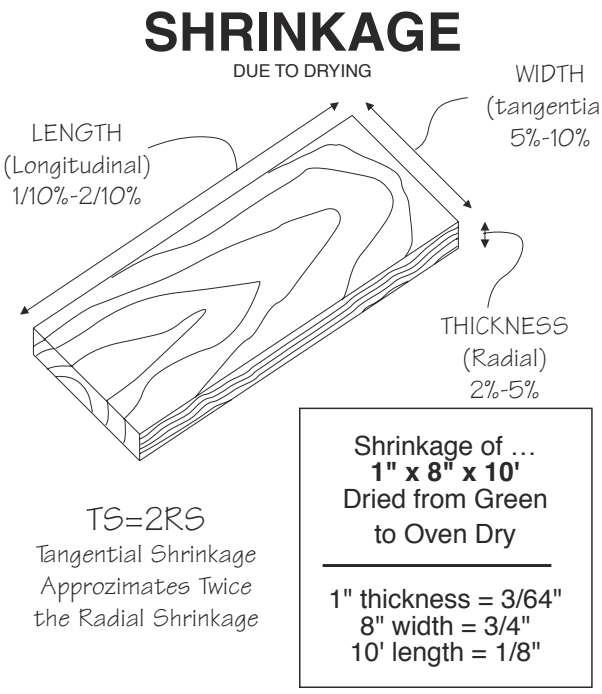
100-G-8

Dimensional Stability, Relative Humidity, and Moisture Content

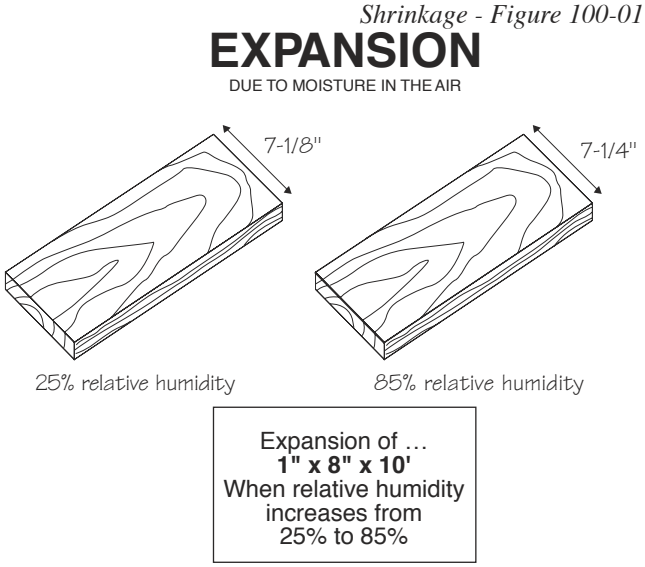
All woods are affected significantly by moisture and to a lesser degree by heat. Lumber swells and shrinks primarily in two directions: thickness and width. There is insignificant change in length. The changes in dimension due to moisture vary with different species, thus influencing the selection of lumber to use and the design elements.

Prevention of dimensional problems in architectural woodwork products as a result of uncontrolled relative humidity is possible. Wood products perform, as they have for centuries, with complete satisfaction when correctly designed and used. Problems directly or indirectly attributed to dimensional change of the wood are usually, in fact, the result of faulty design or improper humidity conditions during site storage, installation, or use.

The following examples were originally created in Imperial measure and are not converted for this edition.

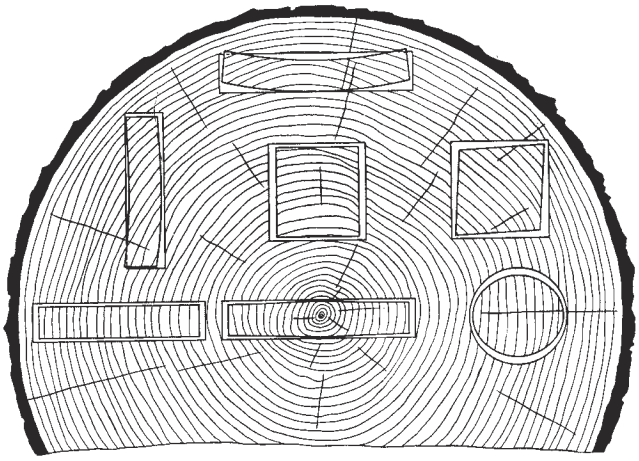


Shrinkage - Figure 100-01



Expansion - Figure 100-02

Wood is a hygroscopic material, and under normal conditions all wood products contain some moisture. Wood readily exchanges this moisture with the water vapor in the surrounding atmosphere according to the relative humidity. In high humidity, wood picks up moisture and swells. In low humidity, wood releases moisture and shrinks. As normal minor changes in humidity occur, the resulting dimensional response in properly designed construction will be insignificant. To avoid problems, it is recommended that relative humidity be maintained within the range of 25% and 55%. Uncontrolled extremes - below 20% or above 80% relative humidity - are likely to cause problems. Together with proper design, fabrication, and installation, humidity control is the important factor in preventing dimensional change problems. The book *Understanding Wood* by Bruce Hoadley contains excellent data of wood and moisture.



Distortion - Figure 100-03

Wood is anisotropic in its shrinkage characteristics. It shrinks most in the direction of the annual rings when it loses moisture from the cell walls. This illustration from the *USDA Wood Handbook* shows the typical distortion of cuts from various parts of a log.

Moisture can also cause iron stain (oxidation) in wood, also referred to as blue/black stain. Iron stain is a natural reaction of acids with iron, oxygen, and moisture (either high relative humidity or direct moisture) in wood. Control of moisture is a simple way to protect wood products from iron stain.

100-G-9

Adaptability for Exterior Use

Years of performance have shown certain species to be more durable for exterior applications. Heartwood shall be furnished when these species are designated for external use, excluding the sapwood. The following is a list of species generally considered acceptable for exterior use, from the Wood Handbook (USDA):

Eastern and Western Red Cedar	Oak, white
Cherry, black	Teak, old growth
Douglas-Fir	Redwood, heartwood
Mahogany, Genuine	Locust, black
Chestnut	Spanish Cedar

Baldcypress (Taxodium distichum) has a long tradition as a species resistant to decay, but beware! There are at least nine other species of four different genus which are marketed under the common name *cypress*. Only the heartwood of T. distichum, often marketed at Tidewater or Red Cypress, is decay resistant. Sinker Cypress, that is old trees which have been brought up from below water in which they have been submerged for some time and properly cured and dried, is also resistant. None of this cypress will come from new cutting, but as salvaged wood.

100-G-10

Fire-Retardant Wood

The natural fire-retardant qualities and acceptability of treatments varies among the species. Where items of architectural woodwork are required to have a flame spread classification to meet applicable building and safety codes, the choice of lumber species must be a consideration. Most treated species are structural softwoods. Following are some references to assist in making these choices. Additional data on various species may be available from the U.S. Department of Agriculture Forest Service, Fire Safety of Wood Products Work Unit — (608) 231-9269.

Flame Spread Classification: This is the generally accepted measurement for fire rating of materials. It compares the rate of flame spread on a particular species with the rate of flame spread on untreated Oak. Most authorities accept the following classes for flame spread:

Class I or A	0-25
Class II or B	26-75
Class III or C	76-200

Built-up Construction to Improve Fire Rating: In lieu of solid lumber, it is often advisable, where a fire rating is required, to build up members by using treated cores clad with untreated veneers not thicker than 1 mm [$^{1}/_{28}$"]. Some existing building codes, except where locally amended, provide that facing materials 1 mm [$^{1}/_{28}$"] or thinner finished dimension are not considered in determining the flame spread rating of the woodwork. See Section 200, Panel Products.

In localities where basic model building codes have been amended, it is the responsibility of the specifier to determine whether the application of the facing material specified will meet the code.

Fire-Retardant Treatments (FRT): Some species may be treated with chemicals to reduce flammability and retard the spread of flame over the surface. This usually involves impregnating the wood, under pressure, with salts suspended in a liquid. The treated wood must be redried prior to fabrication. FRT wood may exude chemicals in relative humidity above 85%, damaging finishes and corroding metals in contact with the FRT surface. Consult with an AWI/AWMAC woodworker about the resulting appearance and availability of treated woods prior to specification.

Hardwoods currently being treated (Flame spread less than 25) include 4/4 Red Oak, and 4/4 to 8/4 Poplar. These woods can be machined after treatment, although machining may void the label classification. Fire retardant treatment *does affect* the color and finishing characteristics of the wood.

According to the traditional model codes in the USA and subject to local code modifications, untreated wood and wood products can usually be used in up to 10% of the combined surface area of the walls and ceiling. Cabinetry, furniture, and fixtures are rarely fire rated, and can be built of combustible materials.

The National Building Code of Canada (1995), states: 3.1.5.7.1) *Combustible millwork including interior trim, doors and door frames, aprons, and backing, handrails, shelves, cabinets and counters is permitted in a building required to be of noncombustible construction.*

Code requirements are reviewed and updated regularly. The design authority shall check document publication dates and local amendments to national codes, and shall inform the woodworker of requirements.

Important

Face veneers are not fire-retardant treated, and combining untreated veneers with treated lumber can result in color and finishing contrasts.

Finishing of Fire-Retardant Treated Lumber: Fire retardant treatments may affect the finishes intended to be used on the wood, particularly if transparent finishes are planned. The compatibility of any finishes should be tested before they are applied.

Intumescent Coatings for Wood: It is possible to reduce flammability by using intumescent coatings in either opaque or transparent finishes. These are formulated to expand or foam when exposed to high heat, and create an insulating effect, which reduces the speed of flame spread. Improvements are continually being made on these coatings. Consequently, the specifier must ascertain whether they will be permitted under the code governing the project. The relative durability of the finish and the effect of the coating on the desired color of the finished product vary from manufacturer to manufacturer. In general, the coatings are less durable, softer, and more hygroscopic than standard finishes.

100-G-11
Preservative Treatments

Modern technology has developed methods of treating certain species to extend their life when exposed to the elements. Some lumber species used for exterior architectural woodwork may be treated with an industry tested and accepted formulation. One such formulation is a liquid containing 3-iodo-2-propynyl butyl carbamate (IPBC) as its active ingredient, which must be used according to manufacturer's directions.

The Window & Door Manufacturers Association (WDMA), though the treatments and coatings committee, has reviewed information from third party testing laboratories which indicates that the a number of formulations at the stated in-use concentration meet the requirements of WDMA I.S.4, current edition. The formulations are acceptable for use under the WDMA Hallmark Water-Repellent Non-Pressure Preservative Treatment Certification Program and are adopted to meet all requirements of the AWI and AWMAC.

Contact WDMA or visit their website at www.wdma.org.

Wood Species (a)	Flame Spread Index (b)	Smoke Developed Index (b)	Source (c)
ASTM E 84 flame-spread indexes for various wood species of 19 mm thick [3/4"] solid lumber as reported in the literature.			
Birch, Yellow	105-110	no data	UL
Cedar, Western Red	70	213	HPVA
Cedar, Alaska (Pacific Coast yellow)	78	90	CWC
Cottonwood	115	no data	UL
Baldcypress (Cypress)	145-150	no data	UL
Fir, Douglas	70-100	no data	UL
Fir, Pacific silver	69	58	CWC
Sweetgum (Gum, red)	140-155	no data	UL
Hemlock. western (West Coast)	60-75	no data	UL
Maple, Sugar (maple flooring)	104	no data	CWC
Oak, Red	100	100	UL
Oak, White	100	100	UL
Pine, red	142	229	CWC
Pine, Eastern White	85	122	CWC
Pine, Western White	75	no data	UL
Pine, Northern White	120-215	no data	UL
Pine, Ponderosa	105-230	no data	UL
Pine, Southern Yellow	130-195	no data	UL
Pine, Lodgepole	93	210	CWC
Poplar, Yellow	170-185	no data	UL
Redwood	70	no data	UL
Spruce, Eastern (Northern, White)	65	no data	UL, CWC
Spruce, Sitka (Western, Sitka)	100, 74	no data, 74	UL, CWC
Walnut, Black	130-140	no data	UL
No reliable data is available on other species at the time of this printing.			
(a)-In cases where the name given in the source did not conform to the official nomenclature of the Forest Service, the probably official nomenclature name is given and the name given by the source is given in parenthesis. (b)-Data area as reported in the literature (dash where data do not exist). (c)-CWC, Canadian Wood Council (CWC 1996); HPVA, Hardwood Plywood & Veneer Association (Tests); UL, Underwriters Laboratories, Inc. (UL 527, 1971) from the Wood Handbook, Forest Products Society, 1999 - FPS catalog no. 7269			

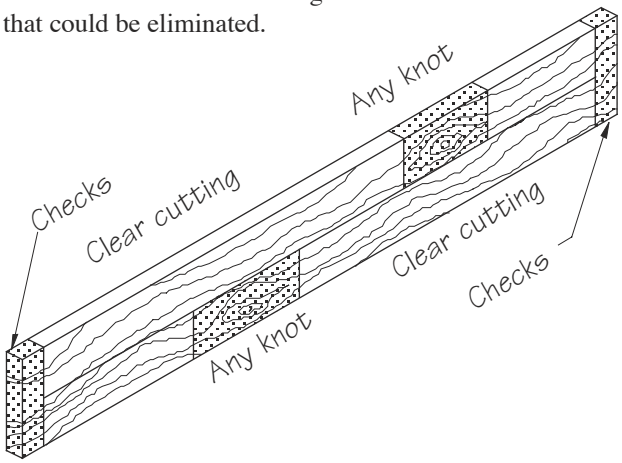
Technical Criteria

100-T-1

QSI Lumber Grades

The tables that follow establish standards of quality for QSI Lumber Grades I, II, and III.

NOTE: These Grades do not relate to the various published lumber association grading rules. Such saw mill grades are not based upon the use of the whole board, but rather the percentage of the board that can be realized by cutting out the defects. For architectural woodwork purposes, the appearance of the piece in the final end product is what is important, and not whether it was cut from a larger board that contained defects that could be eliminated.



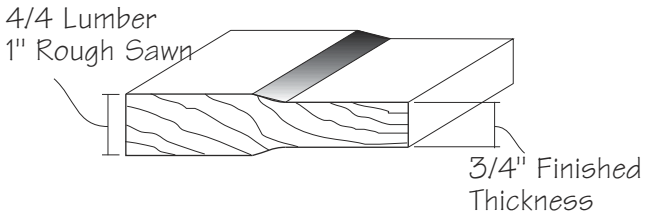
Cutting to Grade - Figure 100-04

The Standards establish the sizes of pieces which must be furnished free and clear of all natural or seasoning characteristics that are considered undesirable and therefore classed as defects.

- The Standards limit the extent of such defects that will be permitted in boards larger than the required size;
- The Standards apply only to those surfaces visible after assembly and installation;
- The Standards do not apply to special varieties of species that display unusual characteristics and that are desirable for æsthetic and design reasons. These include Knotty Pine, Wormy Chestnut, Pecky Cypress, Wattled Walnut, various burls, etc. If their use is contemplated, individual ranges of characteristics and availability should be investigated and specified accordingly;
- No decay is allowed in any Grade;
- All lumber will be furnished plain sawn unless otherwise specified.

100-T-2

Lumber Thickness



Lumber Thickness - Figure 100-05

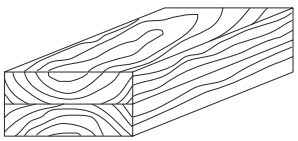
Lumber is rough sawn and marketed in commercial thickness expressed in quarter-inch increments. After sawing, lumber must be dried and machined for end use purposes, producing the following finished thicknesses.

Note: In the absence of either drawing details scaled 1-1/2" = 1'-0" (or larger); or specification; or drawing notations of dressed sizes, the finished thickness noted in the After Machining column-will be furnished.

Economies can be realized by detailing and specifying thicknesses within the finish sizes noted. Not all lumber is available in all thicknesses. (Table based on PS-20 for softwoods.)

Before Machining		**After Machining**
Nominal (Rough) Thickness		QSI Finished Thickness
Millimeters	Quarters	Hardwoods & Softwoods
25 [1"]	4/4	19 [3/4"]
32 [1-1/4"]	5/4	25 [1"]
38 [1-1/2"]	6/4	32 [1-1/4"]
51 [2"]	8/4	38 [1-1/2"]
64 [2-1/2"]	10/4	51 [2"]
76 [3"]	12/4	64 [2-1/2"]
Note: Soft Imperial conversions appear in [brackets] after metric measurements		

Gluing for Thickness



Gluing for Thickness - Figure 100-06

For responsible utilization of natural resources, gluing for thickness is permitted at the option of the woodworker, as follows:

1. Hardwoods may be glued for thicknesses exceeding 27 mm [1-1/16"].
2. Softwoods may be glued for thicknesses exceeding 38 mm [1-1/2"]
3. Adhesives -when intended for exterior use, Type I assemblies must be used. Otherwise, adhesives are at the option of the woodworker.

4. Match for glued pieces intended only for transparent finish:
Grade I - pieces shall be well matched for color and grain.
Grade II - pieces shall be compatible for color and grain.
Grade III - no matching for color or grain required.

100-T-3

Lumber Width

Architectural markets for hardwood and softwood lumber can be entirely different from each other. Softwoods are mainly sold as nominal width boards, derived from Imperial measure, i.e.:

1 x 4 (3/4" x 3-1/2") [19 x 89 mm]

1 x 6 (3/4" x 5-1/2") [19 x 140 mm]

1 x 8 (3/4" x 7-1/4") [19 x 184 mm]

1 x 10 (3/4" x 9-1/4") [19 x 235 mm]

1 x 12 (3/4" x 11-1/4") [19 x 286 mm]

Hardwood lumber, on the other hand, is cut and sold to yield the maximum usable material. Each board is sawn as wide and long as the log and grade allows, then trimmed just enough to make the edges and ends true. This production method satisfies the major hardwood markets; at the same time limiting waste and reducing costs.

NOTE: In the absence of either drawing details scaled 1-1/2" = 1'-0" (or larger); or specification; or drawing notations of dressed sizes, references to the width of members shall be construed to be nominal dimensions, and finished widths noted in parentheses will be furnished.

Gluing for Width

Gluing for Width - Figure 100-07

For responsible utilization of natural resources, gluing for width is permitted at the option of the woodworker as follows:

1. Hardwoods:
Rift sawn White and Red Oak, quarter sawn White and Red Oak, select Red and select White Birch, select White Ash, Cherry, quarter sawn Maple and Walnut may be glued for width exceeding 108 mm [4-1/4"].
All other hardwoods may be glued for width exceeding 152 mm [6"].
2. Softwoods - may be glued for width exceeding 184 mm [7-1/4"].
3. Adhesives - when intended for exterior use, Type I assemblies must be used. Otherwise, adhesives are at the option of the woodworker.

4. Match for glued pieces intended only for transparent finish:
Grade I - pieces shall be well matched for color and grain.
Grade II - pieces shall be compatible for color and grain.
Grade III - no matching for color or grain required.

Note: When gluing for width, the direction of the end grain of the boards shall be alternated for stability and flatness.

Glossary of Natural Characteristics Terms

Bark Pocket: A bark-filled blemish in the board.

Burl: A burl is a swirl or twist in the grain of the wood that usually occurs near a knot but does not contain a knot.

Check: A lengthwise separation of the wood that usually extends across the rings of annual growth and commonly results from stresses set up in wood during seasoning.

Compatible for Color and/or Grain: Although "compatibility" is subjective, this phrase means that lighter than average color members will not be adjacent to darker than average color members. Two adjacent members shall not be widely dissimilar in grain, character, and figure. (The application of finish will change the color of wood and wood products, and not always consistently from piece to piece.)

Honeycomb: A cellular separation that occurs in the interior of a piece of wood, usually along the wood rays.

Mineral Streak: An olive to greenish-black or brown discoloration of undetermined cause in hardwoods.

Pin Knot: A knot which does not exceed 3 mm [1/8"] in average diameter.

Sapwood: The living wood of pale color near the outside of the log.

Shake: A separation along the grain, the greater part of which occurs between the rings of annual growth.

Sound Knot: A knot that is solid across its face, as hard as the surrounding wood, and shows no indication of decay.

Split: A lengthwise separation of the wood, due to the tearing apart of wood cells.

Well matched for Color and/or Grain: Like "compatible" above, this phrase is also subjective. Wood members are selected so that the color of adjacent members is similar and nearly uniform in appearance. The grain figure or other natural character markings shall be similar in character and appearance. Members with only flat grain should not be permitted adjacent to members with only vertical grain. Members with mixed grain are only permitted adjacent to members with similar grain at the adjacent edge.

100-T-4

Maximum Natural Characteristics Allowed

Natural Characteristic	Hardwoods			Softwoods		
QSI Lumber Grade	**I**	**II**	**III**	**I**	**II**	**III**
Bark pocket - not exceeding in length	None	None	3 mm [1/8"]	None	None	None
Burl	Permitted			Permitted		
Checks or splits not exceeding: [1]	1 x 76 mm [1/32" x 3"]	2 x 127 mm [1/16" x 5"]	2 x 152 mm [3/32" x 6"]	1 x 127 mm [1/32" x 5"]	2 x 178 mm [1/16" x 7"]	2 x 254 mm [3/32" x 10"]
Honeycomb	None			None		
Patches - not apparent after finishing beyond: [1]	457 mm [18"]	610 mm [24"]	914 mm [36"]	610 mm [24"]	914 mm [36"]	1219 mm [48"]
Pitch pockets or pitch streaks not exceeding: [1]	None			None	None	3 x 102 mm [1/8" x 4"]
Shake - not exceeding in length	None	None	3 mm [1/8"]	None	3 mm [1/8"]	6 mm [1/4"]
Sound knot - not exceeding in diameter: (loose knots not permitted)	3 mm [1/8"]	6 mm [1/4"]	10 mm [3/8"]	10 mm [3/8"]	16 mm [5/8"]	25 mm [1"]
Worm holes - not exceeding in diameter: [1]	None	2 mm [1/16"]	3 mm [1/8"]	None	2 mm [1/16"]	3 mm [1/8"]
Natural growth variations such as "mineral"[2] in Maple, Birch, or Ash (black spot/streak); "gum" in Cherry (dark brown to black); sap blue/grey in Oak, Poplar, or Maple (light blue or grey stain streaks in sapwood); "mineral stain" in Oak (discoloration over majority of board) and "mineral stains" in softwoods	None (except slight "mineral" in Maple, Birch, or Ash and "gum" in Cherry)	Permitted in 25% of pieces, not exceeding 10% of the surface area of each piece	Permitted without limit	None	Permitted in 35% of pieces, not exceeding 10% of the surface area of each piece	Permitted without limit
Sapwood is not a defect except where it exceeds in a board the percentage shown below for the species listed:						
Cherry	5%	10%	None of these species fall within these grades			
Walnut	5%	10%				
Butternut	5%	10%				
Select Red Birch	0%	0%				
Select Brown Ash	0%	0%				
Clear Heart Redwood				0%	0%	No such grade
Heartwood in any amount is not permitted in the following hardwood species:						
Select White Birch	0%	0%	None of these species fall within these grades			
Select White Maple	0%	0%				
Select White Ash	0%	0%				

[1] To be filled in the finishing process.

[2] "Mineral" is an allowed natural characteristic unless the species mentioned is specified as "Select White…" in the project documents; for example, "Select White Ash" or "Select White Birch" or "Select White Maple."

Variations in Natural Wood Products

Wood is a natural material, with variations in color, texture, and figure. These variations are influenced by the natural growing process and are uncontrollable by the manufacturer. The color of wood within a tree varies between the “sapwood" (the outer layers of the tree that continue to transport sap) which is usually lighter in color, and the “heartwood" (the inner layers in which the cells have become filled with natural deposits). Various species produce different grain patterns (figures), which influence the selection process. There will be variations of grain patterns within any selected species. The manufacturer cannot select solid lumber cuttings within a species by grain and color in the same manner in which veneers may be selected. Therefore, color, texture, and grain variations will occur in the finest architectural woodworking. *One of each allowable natural characteristic is permitted in larger boards per the total exposed area indicated in the last column.*

100-T-5

Limits of Natural Characteristics Permitted

TYPE	SPECIES	GRADE I	
	All Grades supplied Plain Sawn, except when noted Rift or Quartered	No characteristics allowed in boards smaller than	Characteristics allowed in larger members (per indicated additional dimension)
Hardwoods	Natural Ash, Natural Birch, Basswood, Hard & Soft Maple, Poplar, Red Oak, White Oak, Mahogany & Teak	3870 sq. cm [600 sq. in.]	1 per 968 sq. cm [150 sq. in.]
	Select Red Birch, Select White Birch, Select Brown Ash, Select White Ash, Select White Hard Maple	3548 sq. cm [550 sq. in.]	1 per 839 sq. cm [130 sq. in.]
	Rift or Quarter Sawn Red or White Oak, Walnut, Cherry, Butternut	1774 sq. cm [275 sq. in.]	1 per 333 sq. cm [50 sq. in.]
Softwoods	All Heart Redwood	6774 sq. cm [1050 sq. in.]	1 per 1935 sq. cm [300 sq. in.]
	All Other Species	6194 sq. cm [960 sq. in.]	1 per 1935 sq. cm [300 sq. in.]
TYPE	**SPECIES**	**GRADE II**	
Hardwoods	Natural Ash, Natural Birch, Basswood, Hard & Soft Maple, Poplar, Red Oak, White Oak, Mahogany & Teak	2968 sq. cm [460 sq. in.]	1 per 968 sq. cm [150 sq. in.]
	Select Red Birch, Select White Birch, Select Brown Ash, Select White Ash, Select White Hard Maple	2581 sq. cm [400 sq. in.]	1 per 839 sq. cm [130 sq. in.]
	Rift or Quarter Sawn Red or White Oak, Walnut, Cherry, Butternut	1290 sq. cm [200 sq. in.]	1 per 333 sq. cm [50 sq. in.]
Softwoods	All Heart Redwood	3870 sq. cm [600 sq. in.]	1 per 1935 sq. cm [300 sq. in.]
	All Other Species	4129 sq. cm [640 sq. in.]	1 per 1935 sq. cm [300 sq. in.]
TYPE	**SPECIES**	**GRADE III**	
Hardwoods	Natural Ash, Natural Birch, Basswood, Hard & Soft Maple, Poplar, Red Oak, White Oak, Mahogany & Teak	1 per 1935 sq. cm [300 sq. in.]	1 per 903 sq. cm [140 sq. in.]
	Select Red Birch, Select White Birch, Select Brown Ash, Select White Ash, Select White Hard Maple	No such Grade this species	No such Grade this species
	Rift or Quarter Sawn Red or White Oak, Walnut, Cherry, Butternut	No such Grade this species	No such Grade this species
Softwoods	All Heart Redwood	No such Grade this species	No such Grade this species
	All Other Species	2258 sq. cm [350 sq. in.]	1 per 1935 sq. cm [300 sq. in.]
Species Not Listed: Consult your AWI/AWMAC woodwork manufacturer. The natural characteristics of species not listed above shall be as agreed to between buyer and seller during the design, species selection and specification process.			

100-T-6

Veneered Construction

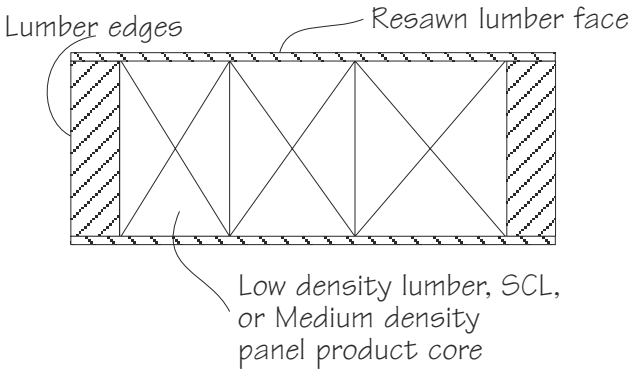
To secure wide and thick members in species with limited cutting potential, an acceptable technique is to apply thin lumber or veneer over the faces and edges of a compatible density lumber, structural composite lumber (SCL), or medium density panel product core.

Veneered construction shall be permitted utilizing resawn lumber or commercially available veneers (Type I assembly for exterior work), and with matching as follows:

Grade I - For transparent finish - veneers shall be well matched for color and grain on all exposed faces and edges.

Grade II - For transparent finish - veneers shall be compatible for color on exposed faces and edges.

Grade III - For transparent or opaque finish, no selection for grain or color required.



Veneered Construction - Figure 100-08

100-T-7

Lumber Lengths

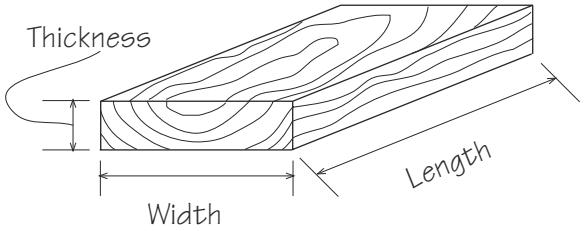
The availability of long lengths is dependent upon the species. Unless specified otherwise, the number of boards of the maximum practical length shown need not exceed 10% of the boards furnished. Specifier should check availability of large quantities of long lengths with an AWI/AWMAC woodworker prior to specification.

	SPECIES	MAXIMUM PRACTICAL LENGTHS AVAILABLE
TYPE	All solid lumber supplied Plain sawn, except when noted Rift or Quartered	
Hardwoods	Natural Ash, Natural Birch, Basswood, Hard & Soft Maple, Poplar, Red Oak, White Oak, & Mahogany	3300 mm [11' - 0"]
	Select Red Birch, Select White Birch, Select Brown Ash, Select White Ash, Select White Hard Maple	3000 mm [9' - 10"]
	Teak, Rift & Quarter Sawn Red or White Oak	2700 mm [8' - 10"] *
	Walnut, Cherry, Butternut	2300 mm [7' - 10"]
Softwoods	All Heart Redwood	6000 mm [19' - 8"]
	All other species	4700 mm [15' - 8"]
* Rift cut lumber is generally only available in Oak. Acceptable rift cut lumber is narrower and shorter than any other cut. Rift cut lumber should not be specified when large dimensions are required.		

100-T-8

Dimension Conventions

Lumber is generally dimensioned in the following conventional order: Thickness, followed by Width (across the grain direction), followed by Length (with the grain direction). Example: 19 mm [$^{3}/_{4}$"] (thick) x 162 mm [6-$^{3}/_{8}$"] (wide) x 2286 mm [90"] (long).



Dimensions - Figure 100-09

100-T-9

Fire-Retardant Treatment

The natural fire-retardant qualities and acceptability of treatments varies among the species, and most are structural softwoods. Where certain items of architectural woodwork are required to have a flame spread classification to meet applicable building and safety codes, the choice of lumber species is restricted to those accepting treatment using currently available technology.

Flame Spread Classification: This is the generally accepted measurement for fire rating of materials. It compares the rate of flame spread on a particular species with the rate of flame spread on untreated Oak.

Most traditional authorities accept the following classes for flame spread:

Class I or A	0-25
Class II or B	26-75
Class III or C	76-200

Furniture and fixtures are generally not regulated by fire code requirements and are not fabricated from treated wood.

100-T-10

Preservative Treatment for Exterior Woodwork

Modern technology has developed methods of treating certain species to extend their life when exposed to the elements. All lumber species used for exterior architectural woodwork, except species listed as “Resistant or very resistant" in the following tables (although it is desirable for those species) shall be treated with an industry-tested and accepted formulation listed by the Window and Door Manufacturers Association (WDMA) in the current edition of WDMA I.S. 4. See the Hallmark Certification section of www.wdma.com for the latest information.

Some domestic woods by heartwood decay resistance			Some imported woods by heartwood decay resistance		
Resistant or very resistant	**Moderately resistant**	**Slightly or nonresistant**	**Resistant or very resistant**	**Moderately resistant**	**Slightly or nonresistant**
Baldcypress, old growth (1)	Baldcypress, young growth (1)	Alder, red	Goncalo alves *	Avodire	Jelutong
Cedars	Douglas-fir	Ashes	Ipe (Iapacho) *	Benge	Meranti, light red (2)
Cherry, black	Larch, western	Beech	Jarrah *	Bubinga	Meranti, yellow (2)
Redwood, old growth	Redwood, young growth	Birches	Lignumvitae *	Keruing	Meranti, white (2)
Chestnut	Tamarack	Butternut	Mahogany, Genuine (Honduras)	Mahogany, African	Obeche
Cypress, Arizona		Hickories	Purpleheart *	Meranti, dark red (2)	Prana pine
Junipers		Maples	Spanish cedar	Sapele	Ramin
Locust, black *		Most pines (2)	Teak, old growth *	Teak, young growth	Sande
Oak, white (2)		True firs (western and eastern			
Walnut, black		Sycamore			
Yew, Pacific *		Spruces			
		Yellow-poplar			

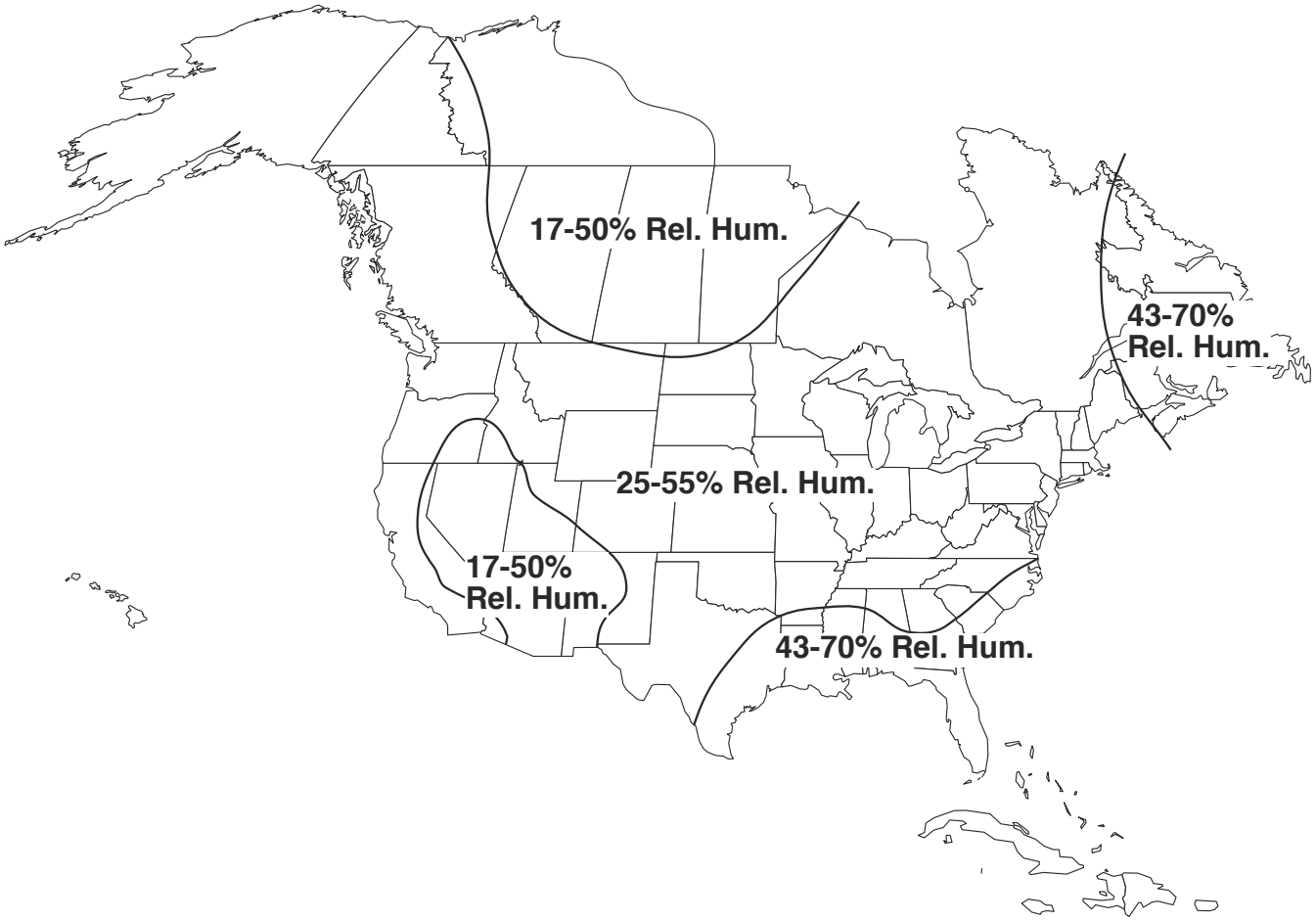
(1) Baldcypress is now largely second growth with a large proportion of sapwood. Substantial quantities of heartwood lumber of this species is not available. (2) More than one species included, some of which may vary in resistance from that indicated. — * Exceptionally high decay resistance.
DATA: 1999 Wood Handbook, Table 3-10, Forest Products Laboratory, No. 7269, (excerpts)

100-T-11

Relative Humidity and Moisture Content

It is the responsibility of the design professional to engineer the space in which fine woodwork (not to mention laminates, fabrics, and wall coverings) is to be installed with humidity controls required to maintain the optimum relative humidity as shown on the following chart. (For additional data on moisture content and relative humidity refer to the Table on the following page.) The map below shows the approximate average moisture content for interior use of finished woodwork recommended for general areas of the United States and Canada.

Geographical Location	Interior Use		Exterior Use
	Optimum Moisture Content (MC) of Wood	Indoor rel. humidity required to hold optimum MC	Optimum Moisture Content (MC) of Wood
Most of the U.S., Ontario and Quebec in Canada	5-10%	25-55%	9-15%
Damp Southern Coastal areas of the U.S., Newfoundland and Canadian Coastal Provinces	8-13%	43-70%	10-15%
Dry Southwestern U.S.	4-9%	17-50%	7-12%
Alberta, Saskatchewan, Manitoba in Canada	4-9%	17-50%	10-15%



Moisture Content Map - Figure 100-10

Dry bulb temperature in degrees Fahrenheit	Wet bulb lowering in degrees Fahrenheit																											
	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
40	83 17.6	75 14.8	68 12.9	60 11.2	52 9.9	45 8.6	37 7.4	29 6.2	22 5.0	15 3.5	8 1.9																	
45	85 18.3	78 15.6	72 13.7	64 12.0	58 10.7	51 9.5	44 8.5	37 7.5	31 6.5	25 5.3	19 4.2	12 2.9	6 1.5															
50	86 19.0	80 16.3	74 14.4	68 12.7	62 11.5	56 10.3	50 9.4	44 8.5	38 7.6	32 6.7	27 5.7	21 4.8	16 3.9	10 2.8	5 1.5													
55	88 19.5	82 16.9	76 15.1	70 13.4	65 12.2	60 11.0	54 10.1	49 9.3	44 8.4	39 7.6	34 6.8	28 6.0	24 5.3	19 4.5	14 3.6	9 2.5	5 1.3											
60	89 19.9	83 17.4	78 15.6	73 13.9	68 12.7	63 11.6	58 10.7	53 9.9	48 9.1	43 8.3	39 7.6	34 6.9	30 6.3	26 5.6	21 4.9	17 4.1	13 3.2	9 2.3	5 1.3	1 0.2								
65	90 20.3	84 17.8	80 16.1	75 14.4	70 13.3	66 12.1	61 11.2	56 10.4	52 9.7	48 8.9	44 8.3	39 7.7	36 7.1	32 6.5	27 5.8	24 5.2	20 4.5	16 3.8	13 3.0	8 2.3	6 1.4	2 0.4						
70	91 20.9	86 18.2	81 16.5	77 14.9	72 13.7	68 12.5	64 11.6	59 10.9	55 10.1	51 9.4	48 8.8	44 8.3	40 7.7	36 7.2	33 6.6	29 6.0	25 5.5	22 5.6	19 4.3	15 3.7	12 2.9	9 2.3	6 1.5	3 0.7				
75	91 21.0	86 18.5	82 16.8	78 15.2	74 14.0	70 12.9	66 12.0	62 11.2	58 10.5	54 9.8	51 9.3	47 8.7	44 8.2	41 7.7	37 7.2	34 6.7	31 6.2	28 5.6	24 5.1	21 4.7	18 4.1	15 3.5	12 2.9	10 2.3	7 1.7	4 0.9	1 0.2	
80	92 21.2	87 18.7	83 17.0	79 15.5	75 14.3	72 13.2	68 12.3	64 11.5	61 10.9	57 10.1	54 9.7	50 9.1	47 8.6	44 8.1	41 7.7	38 7.2	35 6.8	32 6.3	29 5.8	26 5.4	23 5.0	20 4.5	18 4.0	15 3.5	12 3.0	10 2.4	7 1.8	5 1.1
85	92 21.3	88 18.8	84 17.2	80 15.7	76 14.5	73 13.5	70 12.5	66 11.8	63 11.2	59 10.5	56 10.0	53 9.5	50 9.0	47 8.5	44 8.1	41 7.6	38 7.2	36 6.7	33 6.3	30 6.0	28 5.6	25 5.2	23 4.8	20 4.3	18 3.9	15 3.4	13 3.0	11 2.4
90	92 21.3	89 18.9	85 17.3	81 15.9	78 14.7	74 13.7	71 12.8	68 12.0	65 11.4	61 10.7	58 10.2	55 9.7	52 9.3	49 8.8	47 8.4	44 8.0	41 7.6	39 7.2	36 6.8	34 6.5	31 6.1	29 5.7	26 5.3	24 4.9	22 4.6	19 4.2	17 3.8	15 3.3
95	92 21.3	89 19.0	85 17.4	82 16.1	79 14.9	75 13.9	72 12.9	69 12.2	66 11.6	63 11.0	60 10.5	57 10.0	55 9.5	52 9.1	49 8.7	46 8.2	44 7.9	42 7.5	39 7.1	37 6.8	34 6.4	32 6.1	30 5.7	28 5.3	26 5.1	23 4.8	22 4.4	20 4.0
100	93 21.3	89 19.0	86 17.5	83 16.1	80 15.0	77 13.9	73 13.1	70 12.4	68 11.8	65 11.2	62 10.6	59 10.1	56 9.6	54 9.2	51 8.9	49 8.5	46 8.1	44 7.8	41 7.4	39 7.0	37 6.7	35 6.4	33 6.1	30 5.7	28 5.4	26 5.2	24 4.9	22 4.6
110	93 21.4	90 19.0	87 17.5	84 16.2	81 15.1	78 14.1	75 13.3	73 12.6	70 12.0	67 11.4	65 10.8	62 10.4	60 9.9	57 9.5	55 9.2	52 8.8	50 8.4	48 8.1	46 7.7	44 7.5	42 7.2	40 6.8	38 6.6	36 6.3	34 6.0	32 5.7	30 5.4	28 5.2
120	94 21.3	91 19.0	88 17.4	85 16.2	82 15.1	80 14.1	77 13.4	74 12.7	72 12.1	69 11.5	67 11.0	65 10.5	62 10.0	60 9.7	58 9.4	55 9.0	53 8.7	51 8.3	49 7.9	47 7.7	45 7.4	43 7.2	41 6.8	40 6.6	38 6.3	36 6.1	34 5.8	33 5.6
	13% moisture										10% moisture																5% moisture	

Table of equilibrium moisture content values at various temperatures and humidities

The table on the previous page indicates relative humidity must average between 25% and 55% to maintain wood moisture content between 5-10%. This is range best suited for most of the U.S. and Canada. While temperature has an impact on relative humidity, temperature alone has little effect on wood products if the relative humidity is maintained within recommended ranges.

Examples of moisture equilibrium table use

The above table may be used as a guide in determining whether or not the conditions in a construction area are suitable for receiving woodwork. For example: if woodwork with an 8% average moisture content is to be installed and the average temperature in the building will be maintained at 70° F, it can be determined by following the 70° F column horizontally to the right until the lower moisture content figures of 8.3% and 7.7% are reached. Here the upper figures in the same squares show that ideally a relative humidity of between 44% and 40% should be maintained in order to achieve dimensional equilibrium. After the woodwork is painted or finished, moisture changes in the wood are retarded so that maintenance of relative humidity between the practical limits shown on the curve (between 5%-10% m.c.) of the humidity table, i.e., 25%-55% relative humidity, is usually satisfactory.

To use table

Obtain wet and dry bulb readings. Subtract wet bulb reading from dry bulb reading. Find dry bulb on left margin of table and follow across to the column where the value at the top corresponds with the difference between wet and dry readings. At point of intersection, the upper figure in the square gives relative humidity in percent and the lower figure gives equilibrium moisture content of the woodwork.

IMPORTANT PRODUCT ADVISORY

ALL USERS OF ARCHITECTURAL WOODWORK PRODUCTS

DIMENSIONAL CHANGE PROBLEMS IN ARCHITECTURAL WOODWORK

This advisory concerns prevention of dimensional problems in architectural woodwork products as the result of uncontrolled relative humidity. It is further intended as a reminder of the natural dimensional properties of wood and wood-based products such as plywood, particleboard, and high pressure decorative laminate (HPDL) and of the routine and necessary care—and responsibilities—which must be assumed by those involved.

For centuries, wood has served as a successful material for architectural woodwork, and as history has shown wood products perform with complete satisfaction when correctly designed and used. Problems directly or indirectly attributed to dimensional change of the wood are usually, in fact, the result of faulty design, or improper humidity conditions during site storage, installation, or use.

Wood is a hygroscopic material, and under normal use and conditions all wood products contain some moisture. Wood readily exchanges this molecular moisture with the water vapor in the surrounding atmosphere according to the existing relative humidity. In high humidity, wood picks up moisture and swells. In low humidity wood releases moisture and shrinks. As normal minor fluctuations in humidity occur, the resulting dimensional response in properly designed construction will be insignificant. To avoid problems, it is recommended that relative humidity be maintained within the range of 25-55%. Uncontrolled extremes—below 20% or above 80% relative humidity—can likely cause problems.

Oxidation is a reaction of acids in wood (i.e., tannic acid), with iron, oxygen, and moisture, whether this be relative humidity or direct moisture. Control of moisture is a simple way to protect wood products from stains as a result of oxidation.

Together with proper design, fabrication, and installation, humidity control is obviously the important factor in preventing dimensional change problems.

Architectural woodwork products are manufactured as designed from wood that has been kiln dried to an appropriate average moisture content and maintained at this condition up to the time of delivery. Subsequent dimensional change in wood is and always has been an inherent natural property of wood. These changes cannot be the responsibility of the manufacturer or products made from it. Specifically:

- Responsibility for dimensional change problems in wood products resulting from improper design rests with the designer/architect/specifier.
- Responsibility for dimensional change problems in wood products resulting from improper relative humidity exposure during site storage and installation rests with the general contractor.
- Responsibility for dimensional change problems in wood products resulting from humidity extremes after occupancy rests with engineering and maintenance.