wood and sapwood, but the color frequently extends well into the heartwood. It may be solid or in bands separated by heartwood of lighter color. It is not evidence of decay, and is to be regarded as a normal coloration.

In yellow birch the sapwood may vary from almost white to light orange yellow, and the heartwood may vary from very light yellowish brown to dark reddish brown (*2–5*). In general, uniformity of color over extensive areas, particularly in veneer, may be taken as an indication of normality, but frequently discolorations occur, which in rotary-cut veneer show up as narrow bands of color merging gradually into each other and running parallel to the grain. Predominant shades are greenish brown, olive, yellowish brown, and grayish brown. The colors are not brilliant as they are in the heartwood of yellow-poplar. Such discolored veneer is often fuzzy to velvety but the veneer does not seem to be always infected by fungi. Light streaks occur occasionally in the heartwood. These may be "included sapwood." Figure 2–103 shows such a streak.

The heartwood of sweetgum is frequently highly figured and is either walnut brown or gray brown. Such wood is as strong as plain heartwood (*2–9*).

There is a wide variation in the color of yellow-poplar (*2–7*). Good sound heartwood may be a pure yellow-buff or greenish yellow streaked with varying widths of blackish zones or it may vary from pure yellow-buff through many colors, such as yellow, greenish yellow, yellow green, dark green, lavender, purple, purple brown, and red. If the heartwood is white, warm buff, salmon buff, yellowish brown, or brown, decay should be suspected.

2.3219. *Stains and decays references.*

(2–1) Boyce, J. S.
1923. *Decays and Discolorations in Airplane Woods.* U. S. Dept. Agr. Bul. 1128, 52 pp., illus.

(2–2) ———, and Hepting, George H.
1943. *Decay of Wood in Aircraft.* Forest Pathology Special Release No. 12, 4 pp. (Mimeo.)

(2–3) Chapman, A. Dale, and Scheffer, Theodore C.
1940. *Effect of Blue Stain on Specific Gravity and Strength of Southern Pine.* Jour. Agr. Res. 61: 125–134.

(2–4) Forest Pathology, Bureau of Plant Industry
1941. *Cause and Prevention of Blue Stain in Wood.* Forest Products Laboratory Tech. Note 225, 4 pp. Rev. Sept. 1941.

(2–5) Hansbrough, J. R., Waterman, A. M., and Luxford, R. F.
1943. *The Significance of the Discolorations in Aircraft Veneers: Yellow Birch.* Forest Products Laboratory Report No. 1377, 7 pp., illus.

(2–6) Hartley, Carl, and Scheffer, T. C.
1943. *Recommended Practice for Controlling Sap Stain in Aircraft Yellow-Poplar Lumber.* Forest Products Laboratory Report No. 1378, 3 pp., illus.

(2–7) Hepting, George H., Roth, Elmer R., and Luxford, R. F.
1942. *The Significance of the Discolorations in Aircraft Veneers: Yellow-Poplar.* Forest Products Laboratory Report No. 1375, 8 pp., illus.

(2–8) Scheffer, Theodore C.
1936. *Progressive Effects of Polyporus Versicolor on the Physical and Chemical Properties of Red Gum Sapwood.* U. S. Dept. Agr. Tech. Bul. 527, 46 pp., illus.

(2–9) ———, and Hansbrough, John R.
1942. *The Significance of the Discolorations in Aircraft Veneers: Sweetgum.* Forest Products Laboratory Report No. 1376, 8 pp., illus.

(2–10) ———, and Lindgren, Ralph M.
1940. *Stains of Sapwood and Sapwood Products and their control.* U. S. Dept. Agr. Tech. Bul. 714, 124 pp., illus.

(2–11) ———, Wilson, T. R. C., Luxford, R. F., and Hartley, Carl.
1941. *The Effect of Certain Heart Rot Fungi on the Specific Gravity and Strength of Sitka Spruce and Douglas-Fir.* U. S. Dept. Agr. Tech. Bul. 779, 24 pp., illus.

2.4. Requirements for Wood in Specific Parts

2.40 General. The amount of perfect lumber of any species in the larger sizes used in aircraft is limited, but greatly increased quantities of suitable material may be obtained by the judicious utilization of smaller sizes through the modern technique of spliced and laminated construction, and by a proper understanding of so-called blemishes and defects as related to strength. The influence of certain blemishes or imperfections is frequently overemphasized, causing unnecessary rejection of suitable material. Furthermore, since the effects of defects depend not only on their character and size, but also on their location in the piece and on the kind and magnitude of stress to which the piece is subjected, it is both possible and practical to admit some defects and to so effect their limitation and placement in finished

parts that they do not reduce the strength. The tolerance limitations for blemishes and defects set forth herein are so established as to provide maximum utilization of material without sacrifice of strength. This requires limitation of defects according to the character of the member and the position of the defects in it, and furthermore requires considerable detail in describing the permissible size and location of the defects. The requirements apply in general to parts made from any species of wood, although the several types of defects for which restrictions are provided do not occur in all species and some defects other than those mentioned are found in some species. Admissibility of such defects must be judged on the basis of their equivalence to those permitted. In this connection careful attention should be given to the discussion of defects and their effects as presented in section 2.3.

2.400. *Definition of "Lamination."* A lamination may consist of a single piece or of two or more pieces edge glued to form the required width or depth. Edge glue lines in adjacent laminations should be staggered not less than the thickness of the thicker lamination (fig. 2–109).

2.401. *Requirements for annual ring direction.* Requirements for the use of flat-grained or edge-grained material are based on consideration of the stability of dimension and shape and are not specified because of any difference in strength. Edge-grained lumber shrinks and swells less in width than does flat-grained lumber. Consequently, change in the vertical dimension of a spar with changes in moisture content during manufacture and assembly, as well as in service, is minimized by making its vertical face edge-grained. Furthermore, edge-grained material is less subject to cupping and warping than is flat-grained. In general, the use of flat-grained and edge-grained laminations in the same assembly should be avoided.

2.402. *Definitions of "Edge-grained" and "Flat-grained."* An edge-grained board, part, or lamination is defined as one in which the anual rings make an angle of 45° or more with the wider surfaces; a flat-grained board, part, or lamination is defined as one in which the anuual rings make an angle of less than 45° with the wider surfaces. Edge-grained and flat-grained faces or surfaces are similarly defined.

2.41. Requirements Generally Applicable to All Wood Parts. The requirements given herein as being generally applicable to all wood parts should be considered to be in addition to the requirements for specific parts given in later sections unless, in such sections, specific exception is made.

2.410. *Slope of grain.*

2.4100. *Requirements.* In general the slope of grain in any part with respect to the longitudinal axis of the part should be not steeper than 1 in 15. In tapered members subject to nonuniformly distributed tensile stress the slope of grain should be measured with respect to the center line of the face at which the tensile stress is greatest. The slope of grain within the middle half of the depth of solid or laminated spars may be permitted to be as steep as 1 in 10.

2.4101. *Local deviations of grain slope.* It is obvious that local deviations of grain involving slopes steeper than those permitted will sometimes be permissible. It is difficult to set up definite requirements for permissible local grain deviations which will be valid or applicable to all cases, since the type, magnitude, and location of such deviations vary greatly. Hence, it is essential that inspectors use a certain amount of discretion and judgment relative to material having local grain slopes slightly steeper than the specified values.

A general requirement for solid or laminated spars is that no grain deviation steeper than the specified value of 1 in 15 should be permitted in an outer eighth of the depth of the spar. In an adjacent eighth deviations involving steeper slopes such as a wave in a few growth layers are unlikely to be harmful. Local grain slope deviations in excess of those specified will be permitted in spar flanges only in the inner one-fourth of the flange depth. This applies to both solid flanges, and horizontally or vertically laminated flanges.

2.4102. *Combinations of grain slope.* When a piece has diagonal as well as spiral grain, the effective grain slope will be steeper than either of the two slopes considered individually. This combined slope may be determined as outlined in section 2.3022. References to slope of grain relate to the combined or effective slope and are not to be construed as pertaining to only one or the other of the two types. Spiral grain is difficult to detect, and for this reason much closer inspection is needed than for the detection of diagonal grain. It may be noted (see table 2–11) that for a permissible grain slope of 1 in 15 no consideration need be given to the combined slope when neither

the diagonal nor spiral grain has a slope steeper than 1 in 21.

2.4103. *Permissible deviations from slope of grain requirements.* In the interest of conserving material, the aircraft manufacturer may desire to relax the requirement on slope of grain for those portions of members where stresses are low. Requests for such deviations should be submitted to the procuring or certificating agency for approval. Consideration of such requests by the appropriate agency will be based on revised margins of safety prepared by the aircraft manufacturer in accordance with the appropriate correction factors contained in ANC Bulletin 18a, Design of Wood Aircraft Structures.

2.411. *Scarf joints.*

2.4110. *Requirements.* The following requirements apply to all scarf joints in solid or laminated aircraft parts:

(1) The slope of scarf should be not steeper than 1 in 15 unless the aircraft manufacturer obtains specific deviations from the procuring or certificating agency on the basis of adequate margins of safety.

(2) The direction of scarf should be related to the direction of grain slope as specified in section 2.4111.

(3) In laminated members the longitudinal distance between the nearest tips of scarfs in adjacent laminations should be not less than 10 times the thickness of the thicker lamination (fig. 2–104).

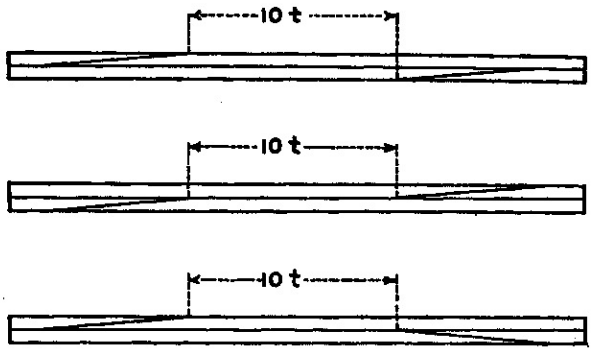

Figure 2–104. Minimum permissible longitudinal separation of scarf joints in adjacent laminations.

2.4111. *Effect of sloping grain on scarf joints.* The proportion of end grain appearing on a scarfed surface may be greatly increased if the material to be spliced is somewhat cross-grained, and the scarf is made "across" rather than in the general direction of the grain. Since end-grain gluing is more difficult (and results in weaker joints) than side-grain gluing, it follows that where cross grain within the specified acceptable limits is present, all scarf cuts must be made in the general direction of the grain slope (fig. 5–67).

2.4112. *Recommendations in addition to requirements.* It is recommended that, in addition to the specific requirements of the succeeding sections, (1) the number of scarf joints be limited as much as possible, (2) the location be limited to the particular portions of a member where margins of safety are most adequate and stress concentrations are not serious, and (3) special care be exercised to employ good technique in all phases of the preparation, gluing, and pressing operations. It is particularly important that these recommendations be followed in the case of solid spars and flanges and those having few laminations.

2.412. *Moisture content.* Each piece of lumber at the time of fabrication shall have been dried to an average moisture content not less than 8 percent and not greater than 12 percent by careful air drying, by kiln drying in accordance with the latest issue of Specification AN–W–2, "Wood; Method for Kiln Drying," or by a combination of air-drying and kiln-drying processes. The spread in moisture content among laminations in the same assembly should not exceed 2 percent at the time of assembly. Also, laminations should be dried to such a moisture content that the water added with the glue will not raise the moisture content above 12 percent (table 5–11).

Regardless of the method of drying, the requirements of paragraph G–3 of AN–W–2 relative to freedom from case-hardening stresses, uniformity of moisture content, etc., should be observed.

2.413. *Rings per inch.* The number of annual rings in any 1 inch measured in a radial direction on either end section of a lamination or of a part should not be less than required by the Army-Navy aeronautical specification for the species (table 2–14). If the radial dimension of the piece is less than 1 inch, there should be at least a proportionate number of rings.

2.414. *Specific gravity.* The specific gravity of any piece or part, based on weight and volume when oven dry, should be within the limits given in the Army-Navy aeronautical specification for the particular species of wood (table 2–14). Methods for determining specific gravity are discussed in section 2.20. Some of the AN speci-

Table 2–14. Limits of Specific Gravity and Rings per Inch in Current AN Specifications

Species	AN specification number	Allowable values		
		Specific gravity		Rings per inch
		Minimum	Maximum	Minimum number
Cedar, Port Orford (*Chamaecyparis lawsoniana*)	AN–C–72a	0. 40		8
Fir, Douglas-(*Pseudotsuga taxifolia*):				
Class N	AN–F–7a	. 45		8
Class L	AN–F–7a	. 38	0. 47	6
Fir, noble (*Abies nobilis*)	AN–F–6a	. 36		6
Hemlock, western (*Tsuga heterophylla*)	AN–H–4a	. 40		6
Pine, eastern white (*Pinus strobus*)	AN–P–16	. 34		6
Pine, sugar (*Pinus lambertiana*)	AN–P–19	. 34		7
Pine, western white (*Pinus monticola*)	AN–P–18	. 38		6
Poplar, yellow-(*Liriodendron tulipifera*)	AN–P–17b	. 38		6
Spruce, red (*Picea rubra*)	AN–S–6a	. 36		6
Spruce, Sitka (*Picea sitchensis*)				
Spruce, white (*Picea canadensis*)				

fications list limiting values of weight per cubic foot, and these may be used in lieu of the specified values of specific gravity.

2.415. *Sapwood.* Bright sapwood should not be considered a defect. Aircraft parts should conform to current AN specifications with respect to the permissibility of sap-stained material.

2.416. *Indented rings.* Indented rings or "bear scratches" should not be considered defects.

2.417. *Decay and stain.* All parts shall be free from rot, dote, red heart, purple heart,[5] heart stain, or other form of decay. Care should be exercised to avoid mistaking for decay some of the distinctive shades of color that occur in sound material of various species.

2.418. *Shakes, splits, or compression failures.* All parts should be free from shakes, splits, or compression failures.

2.419. *Surfacing of laminations.* Laminations should be smoothly surfaced and free from dirt or grease on the surface to be glued. Those that include scarf or edge joints, or both, should be surfaced subsequent to the formation and gluing of such joints. (See also conditioning of glued stock, sec. 5.28).

2.4190. *Compression wood.* Compression wood of such a character that "cross breaks" (sec. 2.306) are present should not be permitted in any part.

[5] A purplish color and other colorations are often natural and inherent in yellow-poplar and if the wood is sound these are acceptable.

2.42 Requirements for Wood Spars and Spar Flanges.

2.420. *General.* The requirements stated for spar flanges relate specifically to a one-part flange as in a typical box spar with two shear webs. When the flange is divided into two or more parts as in a spar of I-, multiple I-, or multiple box-section the requirements stated apply to each such part.

"Vertical" and "horizontal" as used in expressing the requirements for spars and spar flanges refer respectively to vertical and chordwise directions in a wing spar. "Depth" and "width" likewise refer respectively to the vertical and chordwise dimensions of a wing spar or a flange of a wing spar. These terms are to be appropriately interpreted when considering a spar that is otherwise positioned.

2.4200. *Straightness.* In measuring the deviation from straightness, a member should be so supported that it is not deflected by its own weight.

2.42000. *Spars.* The maximum deviation from straightness of a finished spar, prior to its assembly into the structure, should not exceed the following limits:

Maximum deviation $=\left(\frac{L}{100}\right)^2/4h$ inches in the beamwise (vertical) direction.

Maximum deviation $=\left(\frac{L}{100}\right)^2/2h$ inches in the chordwise (horizontal) direction

where

L=length in inches over which the bowing occurs.

h=dimension in inches of the member in the direction of bow.

2.42001. *Spar flanges.* The maximum deviation from straightness of a finished solid or laminated spar flange, prior to being glued to the spar webs should not exceed $(L/100)^2/2h$ in either the beamwise or chordwise direction.

2.42002. *Graph for allowable bowing.* The straightness requirements for a spar or spar flange are readily determined from figure 2–105. Example, for a spar length of 16 feet (192 inches), the allowable beamwise bow for a spar 1 inch deep is read from the lower curve as 0.93 inch and if a spar of this length is 5½ inches deep the allowable bow is $0.93 \div 5\frac{1}{2} = 0.17$.

2.4201. *Knots.* Knots are to be measured on the surfaces on which they appear. In the subsequent detailed limitations of knots in solid spars or spar flanges and in laminations for spars or spar flanges "size" means the distance between lines enclosing the knot and parallel to the edges of the face on which the knot appears and "diameter" is the minimum distance between parallel lines (in any direction) enclosing the knot (fig. 2–106). When the same knot shows on opposite faces of a piece (spar, spar flange, or lamination), the average of the measurements on the two faces should be taken as the size or diameter and this average shall be included but once in the sum of the sizes or diameters within a specified length or area.

In addition to the limitations stated no knot shall exceed one-half inch in size or diameter. Knots less than one-sixteenth inch in size or diameter should be disregarded in applying limitations of individual knots but should be included in limitations of the sums of sizes or diameters. When two or more knots are close together forming a cluster around which the grain is deflected as a unit, the cluster shall be subject to the same limitations as individual knots.

2.4202. *Compression wood.* On an edge or on an outer quarter of the vertical face of a solid or a horizontally laminated spar or on any surface of a solid spar flange, compression wood should

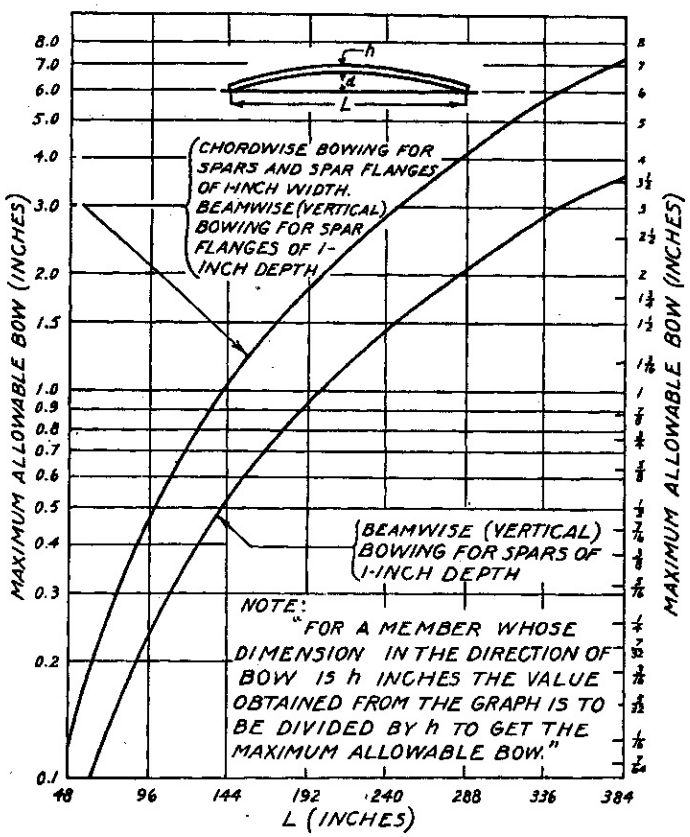

Figure 2–105. Straightness requirements for spars and spar flanges.

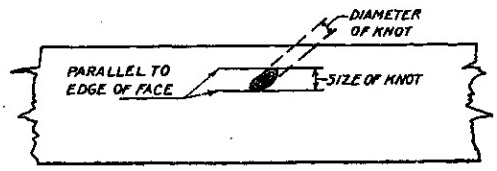

Figure 2–106. "Size" and "diameter" of knot.

not be permitted in streaks wider than one-fourth inch and the aggregate width of compression wood on any of these surfaces should not exceed one-sixth the thickness of the spar, or one-sixth the depth of the spar flange, whichever is the less.

In vertically laminated spars compression wood should not be permitted in streaks wider than one-fourth inch on an outer quarter of the depth of a lamination and the aggregate width of compression wood in such an outer quarter, or on an edge of the spar, should not exceed one-sixth the thickness of the spar.

In the laminations of a spar flange, compression wood should not be permitted in streaks wider than one-fourth inch and the aggregate width of compression wood on the face of a lamination, or on any surface of the flange, should not exceed one-sixth the least dimension of the flange.

Within the middle half of the depth of a solid spar or of a lamination in a vertically laminated spar compression wood should not be permitted in streaks wider than one-half inch and the aggregate width of compression wood should not exceed one-tenth the depth of the spar or lamination.

2.4203. *Dihedral.* Dihedral in horizontally laminated spars or spar flanges may be produced by bending the assembly immediately after the glue is spread. The minimum radius of curvature to which any lamination is bent should be not less than 500 times the thickness of that lamination.

2.421. *Requirements for solid spars.*

2.4210. *Definition.* A solid spar is a spar whose cross section is composed of a single piece of wood.

2.4211. *Annual ring direction* (fig. 2–107). The spar should be edge-grained over not less than two-thirds the depth of both vertical faces.

2.4212. *Knots* (see also sec. 2.4201). Within either outer quarter of the spar depth, the size of a knot (on the edge or on either vertical face) should not exceed $\frac{1}{16}$ W (W=the width of the spar); the sum of the sizes of all knots (on the edge and in the adjacent quarters of the vertical faces) within any length equal to $5W$ should not exceed $\frac{1}{8}$ W and the sum within any length equal to W should not exceed $\frac{1}{16}$ W.

Within the middle half of the spar depth the diameter of a knot should not exceed $\frac{1}{2}$ W and the sum of the diameters of all knots on one face within a length equal to 5 W should not exceed $\frac{1}{2}$ W.

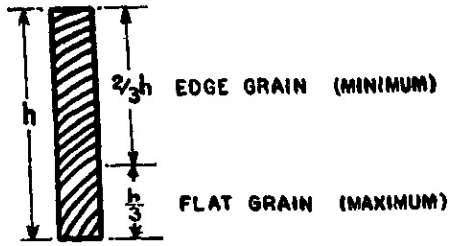

Figure 2–107. Annual ring direction requirements for solid spars.

2.4213. *Pitch or bark pockets.* A pitch or bark pocket should be not deeper than $\frac{1}{8}$ W; not wider than $\frac{1}{4}$ inch or $\frac{1}{8}$ W, whichever is the lesser; and not longer than 2 inches or four times its distance from a corner of the spar, whichever is the lesser.

The distance, measured in any direction, between two pockets on the same face of the spar should be not less than six times the length of the shorter pocket and for pockets in the same growth layer this distance should be not less than six times the length of the longer pocket.

2.422. *Requirements for horizontal laminated spars.*

2.4220. *Definition.* A horizontally laminated spar is a spar in which the cross section is made up of two or more laminations glued together and in which the principal glue planes are horizontal. In spars that taper in depth, laminations should be parallel to the edge at which the tensile stress is greatest.

Because of difficulties, waste, and duplication involved in the gluing, pressing, and finishing of an assembly whose depth in the direction of the gluing pressure is several times as great as its thickness (as, for example, in a spar 5 inches deep by 1 inch thick), horizontally laminated spars should preferably be made up in multiple thickness for subsequent resawing and finishing, rather than singly.

2.4221. *Annual ring direction* (fig. 2–108). Laminations should be edge-grained on those faces which will be vertical in the finished spar.

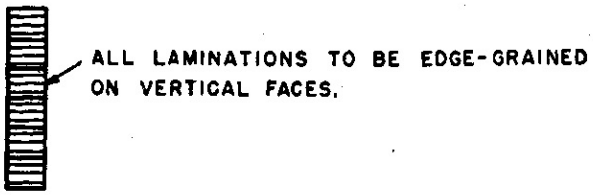

Figure 2–108. Annual ring direction requirements for horizontally laminated spars.

2.4222. *Knots* (see also sec. 2.4201). Within either outer quarter of the spar depth, the size of a knot in a lamination whose vertical dimension is greater than one-eighth the spar depth should not exceed $\frac{1}{16}$ W, the sum of the sizes within a length of the lamination equal to 5 W should not exceed $\frac{1}{8}$ W, and the sum within a length equal to W should not exceed $\frac{1}{16}$ W.

Within either outer quarter of the spar depth the size of a knot in a lamination whose vertical dimension is one-eighth the spar depth or less should not exceed $\frac{1}{10}$ W, the sum of the sizes of all knots within a length of the lamination equal to 5 W should not exceed $\frac{1}{5}$ W, and the sum in a length equal to W should not exceed $\frac{1}{10}$ W.

Within the middle half of the spar depth, the diameter of a knot in any lamination should not exceed $\frac{1}{2}$ W and the sum of the diameters of all knots in a length of the lamination equal to W should not exceed $\frac{1}{2}$ W.

2.4223. *Pitch or bark pockets.* A pitch or bark pocket in any lamination should be not deeper than $\frac{1}{8}$ W or one-half the vertical dimension of the lamination, whichever is the lesser; not wider than $\frac{1}{4}$ inch or $\frac{1}{8}$ W, whichever is the lesser, and not longer than 2 inches with the further requirement that a pocket on a face of the spar should be not longer than four times its distance from a corner of the spar. The distance, measured in any direction, between two pockets on the same face of the spar should be not less than six times the length of the shorter pocket and for pockets in the same growth layer, this distance should be not less than six times the length of the longer pocket.

2.423. *Requirements for vertically laminated spars.*

2.4230. *Definitions* (fig. 2–109). A vertically laminated spar is a spar whose cross section is made up of two or more laminations and in which the principal glue lines are vertical.

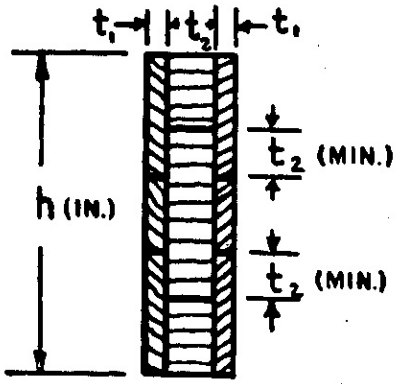

Figure 2–109. Acceptable practice for building up vertical laminations.

2.4231. *Annual ring direction* (fig. 2–110). Face laminations should be edge-grained on their vertical faces. In spars consisting of four or more laminations, flat-grained laminations may be used in pairs provided the individuals of each pair are located and oriented symmetrically with respect to the vertical central plane of the spar and provided the total thickness of flat-grained laminations does not exceed 50 percent of the spar thickness. Single piece laminations (namely, laminations without edge joints) that are flat-grained in one-third or less of their width may be used as edge-grained laminations provided they are symmetrically located and oriented in pairs.

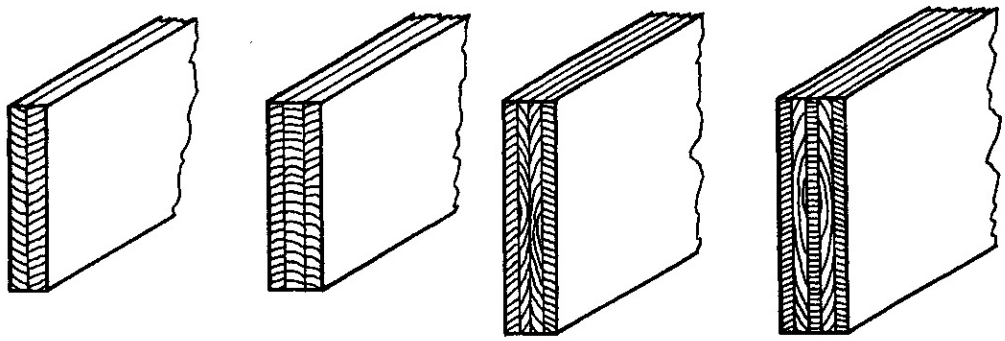

Figure 2–110. Lamination arrangement and permissible combinations of edge-grained and flat-grained laminations in vertically laminated spars. Spars to be symmetrical about vertical central plane.

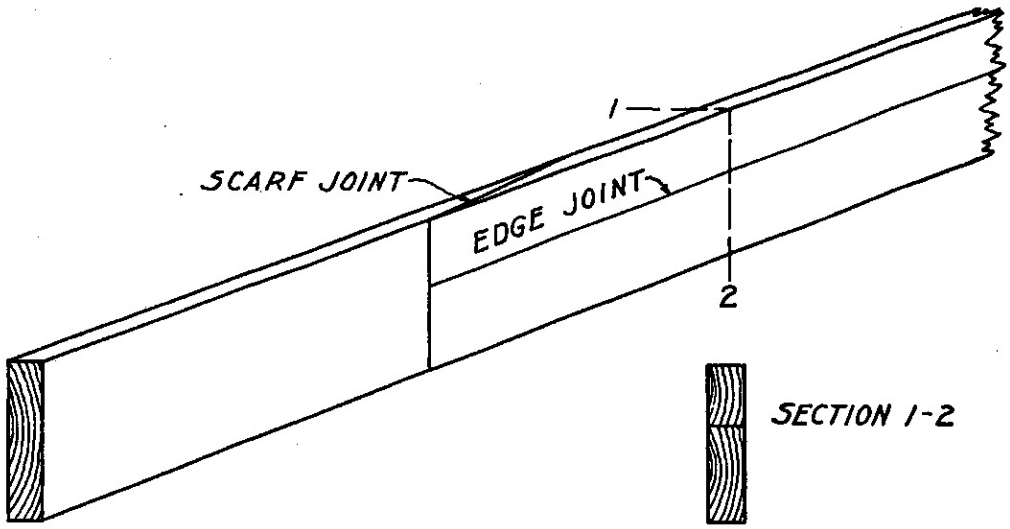

Figure 2–111. Orientation of growth layers in built-up lamination.

Laminations that are equidistant from the vertical central plane of the spar should be of the same thickness as well as of the same character with respect to being edge-grained or flat-grained. For the required symmetry all pieces edge or scarf jointed together to form a flat-grained lamination must be oriented with the annual rings facing the same way (fig. 2–111).

2.4232. *Knots* (see also sec. 2.4201). Within either outer quarter of the spar depth the size of a knot (on the edge or on either vertical face) in a lamination should not exceed $\frac{1}{16}$ W with the further limitation that the size of a knot on the narrow face of a lamination should not exceed one-fourth the width of that face. The sum of the sizes of all knots in a lamination within a length equal to 5 W should not exceed $\frac{1}{8}$ W and within any length equal to W the sum should not exceed $\frac{1}{16}$ W.

Within the middle half of the spar depth, the diameter of a knot in a lamination should not exceed $\frac{1}{2}$ W and the sum of the diameters of all knots in a lamination within a length equal to 5 W should not exceed W.

2.4233. *Pitch or bark pockets.* A pitch or bark pocket in any lamination should be not deeper than $\frac{1}{8}$ W or one-half the thickness of the lamination, whichever is the lesser; not wider than one-fourth inch or $\frac{1}{8}$ W, whichever is the lesser, and not longer than 2 inches with the further requirement that a pocket on a face of the spar should be not longer than four times its distance from a corner of the spar.

The distance, measured in any direction, between two pockets on the same face of the spar should be not less than six times the length of the shorter pocket and for pockets in the same growth layer this distance should be not less than six times the length of the longer pocket.

2.424. *Requirements for solid spar flanges.*

2.4240. *Definition.* A solid spar flange is a spar flange whose cross section consists of a single piece of wood.

2.4241 *Annual ring direction.* Solid spar flanges may be either edge-grained or flat-grained on their horizontal faces (sec. 2.401).

2.4242. *Knots* (see also sec. 2.4021). On any face of a solid spar flange, the size of a knot should not exceed $\frac{1}{16}$ W (W=the width of the face on which the knot appears); the sum of the sizes of all knots within any length equal to 5 W should not exceed $\frac{1}{8}$ W; and the sum in a length equal to W should not exceed $\frac{1}{16}$ W.

2.4243. *Pitch or bark pockets.* A pitch or bark pocket should be not deeper than one-eighth the dimension of the flange in the direction of the depth of the pocket; not wider than one-fourth inch or one-eighth the dimension of the flange in the direction of the width of the pocket, whichever is the lesser; and not longer than four times its distance from a corner of the flange. The distance, measured in any direction, between two pockets on the same face of the flange should be not less than six times the length of the shorter pocket and for pockets in the same growth layer this distance should be not less than six times the length of the longer pocket.

2.425. *Requirements for laminated spar flanges.*

2.4250. *Definition.* A laminated spar flange is a flange whose cross section is made up of two or more laminations glued together.

Flanges may be either horizontally or vertically laminated. In horizontally laminated flanges that taper in depth, laminations should be parallel to the face at which the tensile stress is greatest.

2.4251. *Annual ring direction.* Laminated spar flanges may be either edge-grained or flat-grained on their horizontal faces (sec. 2.401).

2.4252. *Knots* (see also sec. 2.4201). On any face of a lamination whose cross section exceeds one-third the cross section of the flange, the size of a knot should not exceed $\frac{1}{16}$ W (W=the width of the corresponding face of the flange).

On any face of a lamination whose cross section does not exceed one-third the cross section of the flange, the size of a knot shall not exceed $\frac{1}{10}$ W except that the size of a knot on the narrow face of a lamination should not exceed one-fourth the width of that face. (Knots less than one-sixteenth inch in size are to be disregarded in accordance with sec. 2.4201.)

The sum of the sizes of all knots on any face of a lamination in a length equal to the width of that face should not exceed the size of the largest knot permitted on that face, and the sum of the sizes in a length equal to five times the width of the face should not exceed twice the size of the largest single knot permitted.

2.4253. *Pitch or bark pockets.* A pitch or bark pocket in any lamination should be not deeper than one-eighth the dimension of the flange in the direction of the depth of the pocket or one-half the thickness of the lamination, whichever is the lesser; not wider than one-fourth inch or one-eighth the dimension of the flange in the direction of the width of the pocket, whichever is the lesser; and not longer than four times its distance from a corner of the flange. On any face of the flange, the distance, measured in any direction, between two pockets should be not less than six times the length of the shorter pocket, and for pockets in the same growth layer this distance should be not less than six times the length of the longer pocket.

2.426. *Requirements for stressed parts of small cross section as compared to their length, such as cap strips, verticals, and diagonals of ribs; skin-stiffeners; longerons; etc.*

2.4260. *General.* All such parts into which nails are to be driven should be free of knots or other defects which interfere with nailing or are likely to cause splitting in nailing.

2.4261. *Annual ring direction.* Those faces of cap strips, verticals, and diagonals of trussed ribs that are parallel to the plane of the rib should preferably be edge-grained.

2.4262. *Knots.* Knots may be permitted in the middle half of the width of a flat-sawed face, provided the diameter of any one knot does not exceed one-eighth the width of the face, and provided such knots do not cause deviations of grain in the outer quarters steeper than the allowable value.

2.4263. *Pitch or bark pockets.* No pitch or bark pockets should be permitted in members that are less than 1 inch in either cross-sectional dimension. Pitch or bark pockets may be permitted in an edge-grained face (if it is wider than 1 inch), provided their dimensions do not exceed a depth of one-eighth the dimension of the piece parallel to the depth of the pocket; a width of one-eighth the width of the face on which they appear; and a length not greater than 2 inches, or four times the distance of the pocket from the edge of the piece, whichever is the less.

The distance, measured in any direction, between two pockets should be not less than six times the length of the shorter pocket, except that where they are in the same line, the distance between pockets should be not less than six times the length of the longer pocket.

2.4264. *Compression wood.* No compression wood should be permitted in parts which are less than 1 inch in either cross-sectional dimension. In larger parts, compression wood may be permitted in streaks not wider than one-twentieth the width of the face and aggregating not more than one-tenth the width of the face on which they appear.

2.427. *Requirements for curved laminated members, such as fuselage rings, door frames, and wing-tip bows.*

2.4270. *Annual ring direction.* Material for curved parts should preferably be flat-grained on the faces, which will be curved after gluing in order to minimize changes in curvature with moisture-content changes.

2.4271. *Knots.* Material for this use shall be free of knots of such size as would interfere with bending to the required curvature or with good contact between laminations.

2.4272. *Compression wood.* Material for such use should be free from compression wood.