

ANSI A190.1-2012

AMERICAN NATIONAL STANDARD

Standard for Wood Products – Structural Glued Laminated Timber

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AMERICAN NATIONAL STANDARD

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Standard for Wood Products – Structural Glued Laminated Timber

APA – The Engineered Wood Association

Approved January 23, 2013
American National Standards Institute

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FOREWORD (This Foreword is not a part of American National Standard ANSI A190.1-2012)

This Standard is a revision of American National Standard ANSI/AITC A190.1-2007. It contains requirements for the manufacture and quality control of structural glued laminated timber. See History of Project, for further information.

Development of consensus for this Standard was accomplished by the *Procedures for Development of American Institute of Timber Construction Consensus Standards*, approved January 23, 2013 by the American National Standards Institute (ANSI).

Since January 1, 2013, APA – The Engineered Wood Association has assumed the Secretariat responsibilities for this Standard and re-designated it as ANSI A190.1-2012. The maintenance of this Standard follow the *Operating Procedures for Development of Consensus Standards of APA – The Engineered Wood Association*, approved by ANSI.

Inquiries or suggestions for improvement of this standard are welcome and should be directed to APA – The Engineered Wood Association at 7011 South 19th Street, Tacoma, WA 98466, www.apawood.org.

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STRUCTURAL GLUED LAMINATED TIMBER

This Standard, which was initiated by the American Institute of Timber Construction (AITC), has been developed under the provisions of the American National Standards Institute (ANSI) as a revision of American National Standard, *Structural Glued Laminated Timber* (ANSI/AITC A190.1-2007). See History of Project, for further information.

1. SCOPE

The purposes of this Standard are (1) to establish nationally recognized requirements for the production, inspection, testing and certification of structural glued laminated timber, and (2) to provide material suppliers, producers, distributors and users with a basis for common understanding of the characteristics of this product.

This Standard describes minimum requirements for the production of structural glued laminated timber, including size tolerances, grade combinations, lumber, adhesives, appearance grades, and manufacture. It also describes the required quality control system for the laminator including: plant qualification, daily quality control, the functions of an accredited inspection agency, and product marking.

These requirements are intended to permit the use of any suitable method of manufacture which will produce a product equal to or superior in quality and performance to that specified, provided such method is approved in accordance with the requirements of this Standard.

2. REFERENCED PUBLICATIONS

Referenced publications shall be considered part of this Standard. Later issues of a publication shall be adopted as part of this Standard only if the Technical Review Board referred to in Section 15 determines that the publication is applicable and consistent with the intent and requirements of this Standard.

3. GENERAL REQUIREMENTS

Structural glued laminated timber represented as conforming to this Standard shall meet all of the requirements specified herein, subject to the minor variations described in 3.1.

Components used to manufacture the structural glued laminated timber shall meet the requirements of Sections 5, 6, and 7. Manufacturing shall conform to the requirements in Sections 8, 9, 10, and 11 and the plant's procedures manual. All production shall be inspected and tested in accordance with Section 12. Products meeting the requirements of this Standard shall be marked in accordance with Section 13. The plant shall be subject to regular periodic auditing by an accredited inspection agency as defined in Section 14.

3.1 Minor Variations

A member conforms to this Standard where minor variations of a limited extent in non-critical locations exist, or where structural damage or defects have been repaired and, in the judgment of a qualified person, the member is structurally adequate for the use intended. The identity of the member and the nature of the minor variation shall be documented. A qualified person is one who is familiar with the job specifications and applicable design requirements and has first hand knowledge of the manufacturing process.

3.2 Grade Combinations

Grade combinations and their corresponding design values shall be developed in accordance with ASTM D3737 or shall be obtained by performance testing and analysis in accordance with recognized standards. Grade combinations shall be approved by the accredited inspection agency. Alternate grades of lumber are permitted to be used to replace standard laminating grades in grade combinations developed in accordance with ASTM D3737 provided that the alternate grades are qualified in accordance with AITC 407.

3.3 Quality System

The principal responsibilities for assuring conformance to this Standard are placed on the manufacturer's continuing quality control of the production operations and periodic audit thereof by an accredited inspection agency. This quality control system includes:

- (a) A check of each step of the production process,
- (b) Physical tests on samples representing finished production, and
- (c) A visual inspection of the finished production.
- (d) Periodic auditing by an accredited inspection agency as defined in Section 14.

4. TOLERANCES

The size and shape of the laminated timber shall be as agreed upon between buyer and seller.

4.1 Tolerance for Dimensions

The dimensional tolerances permitted at the time of manufacture shall be as follows:

Width – Plus or minus 1/16 in. (2 mm).

Depth – Plus 1/8 in. (3 mm) per ft (305 mm) of depth. Minus 3/16 in. (5 mm) or 1/16 in. (2 mm) per ft of depth, whichever is larger.

Length – Up to 20 ft (6.1 m), plus or minus 1/16 in. (2 mm). Over 20 ft (6.1 m), plus or minus 1/16 in. (2 mm) per 20 ft (6.1 m) of length or fraction thereof.

4.2 Tolerance for Camber or Straightness

Tolerances for camber are applicable at the time of manufacture without allowance for dead load deflection. Up to 20 ft (6.1 m), the tolerance is plus or minus 1/4 in. (6 mm). Over 20 ft (6.1 m) the tolerance shall increase 1/8 in. (3 mm) per each additional 20 ft (6.1 m) or fraction thereof, but not to exceed 3/4 in. (19 mm).

The tolerances are intended for use with straight or slightly cambered members and are not applicable to curved members such as arches.

4.3 Tolerance for Squareness of Cross Section

The tolerance for squareness shall be within plus or minus 1/8 in. (3 mm) per ft (305 mm) of specified depth unless a specially shaped section is specified. Squareness shall be measured by placing one leg of a square across a top and/or bottom face and measuring the offset from the other leg of the square to the member at the opposite face of the beam.

4.4 Tolerances for Other Measurements

Tolerances for measurements not addressed in Sections 4.1, 4.2, and 4.3 shall be as agreed upon between buyer and seller.

5. LUMBER FOR LAMINATING

5.1 Species

For purposes of this Standard, softwood and hardwood species shall be approved for use in structural glued laminated timber if stress indices and knot distributions are established as described in ASTM D3737, or if other proposed criteria are determined to be in conformance with this Standard by the Technical Review Board.

5.2 Moisture Content

The moisture content of lumber shall not exceed 16% at the time of bonding. An exception applies when it is known that the equilibrium moisture content of the laminated timber in use will be 16% or more: the moisture content of laminations at the time of bonding shall not exceed 20%. Both end jointing and face bonding procedures for lumber with moisture content above 16% shall be approved by an accredited inspection agency.

The moisture content of a piece of lumber shall be taken as the average moisture content throughout the cross sections measured and along the length of the piece.

All moisture meters used for lumber segregation shall be calibrated according to ASTM D4444.

5.3 Sawn Lumber Grading

Sawn lumber is permitted to be visually graded, mechanically graded, or proof graded. All lumber shall be identified by grade prior to bonding. Lumber for multiple piece laminations (laminations consisting of 2 or more pieces of lumber across the width) shall be graded as individual pieces of lumber except for manufactured lumber as described in Section 5.4.

5.3.1 Visually Graded Lumber

Lumber shall be graded according to standard grading rules approved by the Board of Review of the American Lumber Standard Committee (ALS), or written special laminating grading rules. Such grades of lumber shall be modified, as necessary, to comply with additional requirements set forth in the laminating specifications for the species.

5.3.2 Mechanically Graded Lumber

Mechanically graded lumber shall be graded according to standard grading rules approved by the Board of Review of the American Lumber Standard Committee or special rules determined to be in conformance with this Standard by the Technical Review Board. E-rated, machine stress rated (MSR) and machine evaluated lumber (MEL) are three commercial designations of mechanically graded lumber. Such grades shall be modified, as necessary, according to additional requirements set forth in the laminating specifications for the species.

5.3.3 Proof Graded Lumber

Proof testing shall be qualified under the supervision of an accredited inspection agency. Such proof graded lumber shall be subjected to quality control based on full size tension tests as set forth in AITC 406. Proof grading shall be limited to individual pieces of lumber without end joints.

5.3.4 Grading of Lumber to be Ripped

Lumber to be ripped shall be graded so that resulting pieces conform to all applicable grade requirements including knot size, slope of grain, and density or rate of growth.

- (a) Mechanically Graded Lumber – When mechanically graded lumber is ripped, it shall be regraded using the grade-determining mechanical or physical property and applicable visual requirements. Regrading requirements for mechanically graded lumber are permitted to be waived if the modulus of elasticity and tensile strength performance of the ripped pieces are monitored by quality control procedures approved by an accredited inspection agency.
- (b) Proof Graded Lumber – Proof graded lumber shall be proof tested after ripping to the requirements established for the ripped size. Regrading requirements for proof graded lumber are permitted to be waived if the modulus of elasticity and tensile strength performance of the ripped pieces are monitored by quality control procedures approved by an accredited inspection agency.
- (c) Ripping After End Jointing – Ripping is permitted on laminations after end jointing and on completed members after bonding. Ripping shall be according to procedures approved by an accredited inspection agency.

5.4 Manufactured Lumber

Manufactured lumber consists of 2 or more pieces bonded together and qualified in accordance with the requirements set forth in AITC 401. Multiple piece laminations which have been edge bonded are not considered to be manufactured lumber provided they are graded as separate pieces as set forth in Section 5.3.

5.5 Structural Composite Lumber (SCL)

SCL shall be as defined in ASTM D5456 and shall meet the requirements of AITC 402.

6. LAMINATIONS

6.1 Bonding Surfaces

All bonding surfaces including face, edge and end joints shall be smooth and, except for minor local variations, shall be free of raised grain, torn grain, skip, burns, glazing or other deviations from the plane of the surface that might interfere with the contact of sound wood fibers in the mating surfaces. All bonding surfaces shall be free from dust, foreign matter, and exudation which are detrimental to satisfactory bonding.

6.2 Wane

For dry-service conditions, wane up to 1/6 the width at each edge of interior laminations is permitted in certain grade combinations. Wane is permitted to be used in wet-service conditions only where moisture accumulation in the wane areas will not occur. For multiple piece laminations (across the width), wane shall not be permitted in the edge joints, whether bonded or not.

6.3 Lamination Thickness

Laminations shall not exceed 2 in. (51 mm) in net thickness unless a gap-filling adhesive is used for face and edge bonds. Exception: A non-gap-filling adhesive shall be permitted to be used to bond laminations thicker than 2 in. (51 mm) where the laminator's process is qualified and approved by the accredited inspection agency.

6.4 Dimensional Tolerances

At the time of bonding, variations in thickness across the width of a lamination shall not exceed plus or minus 0.008 in. (0.2 mm). The variation in thickness along the length of an individual piece of lumber or the lamination shall not exceed plus or minus 0.012 in. (0.3 mm). The thickness variation shall occur randomly across the width and along the length such that the cumulative effect does not contribute to side-to-side depth variations greater than that allowed in Sections 4.1 and 4.3. Warp and cup shall not be so great that they will not be straightened out by pressure in bonding.

6.4.1 Thickness Tolerances for Laminating with Gap-Filling Adhesives

Where gap-filling adhesives which meet the requirements of Section 7.2 are used, all requirements of Section 6.4 apply except that variations in thickness of laminations are permitted to exceed the limitations specified in Section 6.4 but the maximum bond line thickness shall not exceed 1/16 in. (2 mm).

7. ADHESIVES

Adhesives shall conform to the requirements of ANSI 405.

7.1 Labeling

Each container of adhesive shall be identified with the name of the manufacturer, the name and/or designation of the adhesive, the adhesive manufacturer's lot number and the expiration date after which the adhesive shall not be used.

Labels on each container, with all required information shall be made visible and obvious to the observer. Expired adhesive shall not be used unless recertified in writing by the adhesive manufacturer and the new expiration date is displayed in an obvious place.

7.2 Gap-Filling Adhesives

Gap filling adhesives shall meet all requirements when tested with a bond line thickness of 1/16 in. (2 mm). Shims shall be used to ensure that the required bond line thickness is maintained during specimen preparation.

8. WOOD INSERTS

Wood inserts are permitted to be used to meet appearance grade requirements. The moisture content of inserts shall be in accordance with Section 5.2. Adhesives and the method for attaching inserts shall provide durability characteristics appropriate for the end use.

8.1 Maximum Insert Depth

- (a) Insert depth shall be limited to 1/2 in. (13 mm) for laminations less than nominal 6 in. nominal (140 mm) in width, and 3/4 in. (19 mm) for laminations 6 in. nominal (140 mm) or wider except for the outer 5% of the depth within the tension zone of bending members.
- (b) The depth for inserts located in the outer 5% of the depth of a bending member within the tension zone shall be limited to 1/4 in. (6 mm) for laminations less than 6 in. nominal (140 mm) in width and shall be limited to 3/8 in. (10 mm) for laminations 6 in. nominal (140 mm) and wider.

When for a specific known loading of a member, engineering calculations are used to determine the zones in the tension portion of bending members which will be loaded to less than 50% of the design strength in bending, the depth of the insert is permitted to be that given in (a).

Inserts used in the tension portion of bending members shall be tapered at each end with a slope not steeper than 1:16.

9. FACE AND EDGE JOINTS

The selection and preparation of lumber, laminations, and adhesives shall be in accordance with Sections 5, 6, and 7.

9.1 Adhesive Mixing and Application

Mixing of the adhesive, the interval between mixing and spreading, spreading, assembly time, assembly pressure, temperature and curing time of the adhesive shall be based on recommendations of the adhesive manufacturer with subsequent qualification and daily quality control by the laminator.

Proportions for each adhesive mix shall be determined by weight. Liquids are permitted to be measured by volume only after the containers have been calibrated on a weight basis. Automatic adhesive mixing equipment is permitted to be used provided appropriate mix proportions can be maintained within limits prescribed by the adhesive manufacturer. The mix ratio shall be verified a minimum of once daily by procedures described in AITC Test T122.

The adhesive, whether mixed prior to application or applied separately shall be applied uniformly to wood surfaces in an amount adequate to meet the performance requirements of this Standard. Determination of the adhesive spread rate shall be made in accordance with AITC Test T102. No adhesive shall be used after expiration of its storage or pot life, as determined by the adhesive manufacturer.

Lumber surface temperature at the time of bonding may be critical to achieving satisfactory adhesive bonds. Adjustments in assembly time, quantity of adhesive spread and curing conditions shall be made depending upon the lumber temperature and ambient temperature. The adequacy of adjustments shall be demonstrated by shear strength and bond durability tests conducted on bonds manufactured at the lowest and highest temperatures at which laminating takes place.

The temperature of the adhesive mix and other variables as required by the adhesive manufacturer shall be measured with sufficient frequency to assure that the working life of the adhesive is not exceeded.

9.2 Face Joint Assembly and Bonding

Face joints shall have pressure applied uniformly starting at any point, but progressing continuously outward toward the ends or along the length of the member. Assembly pressure at the bond line shall be according to the adhesive manufacturer's recommendations. Caul boards or plates shall be used, if necessary, to prevent localized crushing of the outer laminations.

Pressure shall be maintained for a sufficient period of time so as to ensure close contact between laminations and not over-stress bond lines during development of bond strength. Pressures shall be checked prior to substantial cure and adjustments made as required.

The use of mechanical fasteners such as nails, screws, etc., to secure laminations in lieu of clamping pressure shall not be permitted.

9.3 Edge Joint Assembly and Bonding

Edge joint bonding shall not be required unless specified by the designer. When edge joint bonding is required, edge joints shall be tested in the same manner as face joints and the same requirements for wood failure and shear strength shall apply. A gap filling adhesive shall be used to bond edge joints, unless the maximum net width of pieces being bonded is less than or equal to 2 in. (51 mm).

When edge joints are not pre-bonded, they shall be staggered laterally in adjacent laminations by at least the net thickness of the lamination, but not less than 1 in. Where edge joints are pre-bonded in accordance with the requirements of Section 9.2, they need not be staggered laterally.

Where multiple-piece laminations are not edge bonded, it is intended that the edges of the pieces be reasonably close to each other. Edge spacing in top and bottom laminations is permitted to be up to 1/4 in. (6 mm) for the full length with an occasional 3/8 in. (10 mm) gap permitted. Edge spacing in interior laminations shall not exceed 3/8 in. (10 mm) for nominal widths of 10 in. (235 mm) and less, 1/2 in. (13 mm) for 12 in. nominal (286 mm) widths and 5/8 in. (16 mm) for 14 in. nominal (337 mm) widths. For widths wider than 14 in. nominal (337 mm), the allowable opening shall be proportional to the opening allowed for a nominal width of 14 in. (337 mm). Measurements of openings shall be cumulative across multiple-piece laminations containing 3 or more pieces.

Unbonded edge joints shall not be permitted in face laminations of members used in wet service conditions where moisture is likely to accumulate in the unbonded joint.

9.4 Curing Schedules

The laminator's procedures and quality control manual shall include certified bonding procedures for each adhesive formulation used. A separate procedure shall be established for each combination of adhesive, species and treatment. The procedures shall include time-temperature relationships.

10. END JOINTS

End joints shall be bonded in accordance with the requirements for face joint bonding with appropriate modifications to the adhesive spreading, assembly times, application of pressure and curing times for the methods used.

End joints shall be qualified in accordance with Section 12.1.3.

10.1 Assembly and Bonding

End joints shall be pre-bonded or assembled and bonded integrally with the face joint operation. Where end joints are bonded integrally with the face joint bonding of laminations, they must be positively maintained in alignment while the face joint bond is accomplished. Positioning and alignment methods shall permit measurement of tolerances with gauges. End joints for the production of curved members shall be pre-bonded unless the assembled thickness tolerance of the end joint area and alignment can be maintained by other methods.

10.2 Joint Thickness Tolerance

For plane scarf joints, the thickness tolerance in end joint areas at the time of face joint bonding shall be within plus 0.020 in. (0.5 mm) to minus 0.005 in. (0.1 mm) of the thickness of the lumber being end jointed. For finger joints, a thickness tolerance of plus 1/32 in. (0.8 mm) is allowed in the assembled thickness. The thickness of exposed tips of plane scarf joints or finger joints which occur across the full width of the face of the lamination shall not exceed 1/32 in. (0.8 mm).

10.3 Knots In or Near End Joints

Knots or knotholes in plane scarf joints shall be limited to those permitted for the lumber grade. In no case shall they exceed 1/4 the nominal width of the piece in laminations occupying the outer 10% on each side of bending members.

Finger joints shall not contain knots except that an occasional occurrence of a single pin knot, not to exceed 3/8 in. (10 mm) diameter, is permitted in finger joints in the outer 10% of depth on the tension side of bending members. An occasional single knot up to 1/2 in. (13 mm) diameter is permitted in joints in the remainder of bending members and in uniform-grade members.

In bending members, knots exceeding 3/8 in. (10 mm) diameter shall not be permitted within 2 knot diameters or 6 in. (152 mm), whichever is less, of finger joints in the inner and outer tension zones (in no case less than 10% of the depth of bending members), nor shall knots over 1/2 in. (13 mm) diameter occur within one knot diameter of finger joints in the balance of the laminations.

In uniform-grade members, knots larger than 3/4 in. (19 mm) shall not be permitted within one knot diameter of finger joints.

Measurement of knot diameter for spacing near end joints shall be parallel to the longitudinal axis of the piece of lumber. The distance of knots from finger joints shall be measured from the edge of the knot nearest the joint to the closest part of the joint.

10.4 Spacing of End Joints in Adjacent Laminations

Spacing between finger joints in adjacent laminations shall be determined by measuring the distance between the closest parts of joints in adjacent laminations measured in a direction parallel to the longitudinal axis.

The spacing of scarf joints shall be determined by measuring the distance between tips along the face joint bond of adjacent laminations. Furthermore, a plane at a right angle to the axis of a member that intersects one plane scarf joint in a lamination shall not intersect any part of another plane scarf joint in an adjacent lamination.

For multiple-piece laminations, an end joint shall be considered in the same manner as a lamination consisting of a single piece when end joints in the pieces of the lamination are within 6 in. (152 mm) of each other. If only one piece of a multiple-piece lamination has an end joint within a 6 in. (152 mm) cross section, and an end joint occurs in one piece of an adjacent lamination closer than 6 in. (152 mm), this combination shall be considered on the same basis as a single piece lamination provided the combined width of the 2 end joints does not exceed the width of the lamination.

In those areas of members consisting of multiple-piece laminations where specific joint spacing is required, the sum of the widths of the end joints of multiple-piece lamination in any 2 laminations in any 6 in. (152 mm) of length shall not exceed the width of a single lamination; nor shall more than 3 end joints in adjacent laminations closer together than 6 in. (152 mm) appear on either side of members in this area.

Concentrations of end joints shall be avoided. In addition, end joints shall be dispersed as follows:

- (a) The minimum spacing of end joints in adjacent laminations in the tension zone of bending members for the outer 1/8 of the depth of the member plus one lamination shall be 6 in. (152 mm). This spacing applies over the central 75% along the length of the zone stressed in tension. There are no minimum spacing requirements for the remaining portion of the tension zone.

Where engineering calculations are used to determine zones in the tension portions of bending members which are loaded to less than 50% of the design value in bending, the minimum spacing requirements shall not apply to these zones.

- (b) When end joints are proof loaded in accordance with either AITC Test T118 or T121, there are no requirements for minimum spacing of end joints.
- (c) When the outer lamination on the tension side of a member is repaired by the procedures described in AITC 403, the repair shall be made in such a manner that no end joint in the outer lamination or the next inner lamination occurs within 6 in. (152 mm) on either side of the repair tip(s).
- (d) No specific end joint spacing is required in arches.

10.5 Spacing of End Joints Within the Same Lamination

- (a) End joints within the same lamination shall be spaced a minimum of 6 ft (1.8 m) apart in the outer 10% of the total depth of bending members on the tension side. An occasional occurrence of two end joints less than 6 ft (1.8 m) apart along lamination lengths shall be permitted. In the remainder of bending members, end joint spacing within the same lamination shall be permitted to be less than 6 ft.
- (b) Requirements for spacing of end joints within the same lamination shall not apply provided the full length of the lamination is proof loaded in tension by AITC Test T121, and the laminations are resurfaced after end jointing to the tolerances set forth in Section 6.4.

10.6 End Joints Used for Repair

Laminating repair procedures using end joints which are integrally bonded in the repair process shall be evaluated by an accredited inspection agency using the same test criteria and manufacturing tolerances that are applicable to production end joints. The procedure for testing and evaluation in AITC 403 shall be followed.

If structural repairs using end joints are made to laminations containing end joints that have been previously proof loaded, the member containing the repaired lamination shall not be marked as a member containing proof loaded end joints.

11. APPEARANCE GRADES

Glued laminated timber shall be finished to a Framing, Industrial, Architectural or Premium grade unless otherwise agreed upon by buyer and seller.

11.1 Framing Appearance Grade

11.1.1 Lamination Characteristics

Laminations are permitted to possess the natural growth characteristics of the lumber grade.

11.1.2 Void Repair

Voids appearing on the edge of laminations need not be filled. Loose knots and open knot holes in the wide face of laminations exposed to view need not be filled. Gaps in edge joints appearing on the wide face of laminations exposed to view need not be filled.

11.1.3 Wane

Pencil wane is permitted in all combinations and is not limited in length, subject to the provisions in Section 11.1.4. The frequency of occurrence of pencil wane shall not exceed one in ten pieces of lumber used. Occasional wane approximately one foot (305 mm) in length and not exceeding the permissible depth of a low lamination shall be permitted in all combinations without regard to the cumulative effects indicated in Section 11.1.4. Wane permitted in specific laminating combinations up to 1/6 the lumber width on each side is not limited in length.

11.1.4 Surfacing

Members are required to be surfaced “hit or miss” on two sides only to match conventional framing lumber sizes. The following appearance requirements apply only to these two sides. Misses, low laminations, and pencil wane are permitted on a cumulative basis. The cumulative depth of misses, low laminations, and wane shall not exceed 10% of the width of the member at any bond line, except for combinations which permit more wane and have design values reduced accordingly. The maximum area of low laminations shall not exceed 25% of the surface area of a side.

11.2 Industrial Appearance Grade

11.2.1 Lamination Characteristics

Laminations are permitted to possess the natural growth characteristics of the lumber grade.

11.2.2 Void Repair

Voids appearing on the edge of laminations need not be filled. Loose knots and open knot holes in the wide face of laminations exposed to view need not be filled. Gaps in edge joints appearing on the wide face of laminations exposed to view need not be filled.

11.2.3 Wane

Pencil wane is permitted in all combinations, and is not limited in length, subject to the provisions of Section 11.2.4. The frequency of occurrence of pencil wane shall not exceed one in ten pieces of lumber used. Occasional wane approximately one foot (305 mm) in length and not exceeding the permissible depth of a low lamination shall be permitted in all combinations without regard to the cumulative effects indicated in Section 11.2.4. Wane permitted in specific laminating combinations up to 1/6 the lumber width on each side is not limited in length.

11.2.4 Surfacing

Members are required to be surfaced on two sides only. The following appearance requirements apply only to these two sides. Occasional misses, low laminations, and pencil wane are permitted on a cumulative basis. The cumulative depth of the misses, low laminations, and wane shall not exceed 10% of the width of the member at any bond line, except for combinations which permit more wane and have shear design values reduced accordingly. The maximum area of low laminations shall not exceed 5% of the surface area of a side, and no more than two low laminations shall be adjacent to one another.

11.3 Architectural Appearance Grade

11.3.1 Lamination Characteristics

The wide face of laminations exposed to view shall be free of loose knots. Otherwise, laminations are permitted to possess the natural growth characteristics of the lumber grade.

11.3.2 Void Repair

In exposed surfaces, voids measuring over 3/4 in. (19 mm) long shall be filled by the manufacturer with a wood-tone colored filler that reasonably blends with the final product or with wood inserts selected for similarity to the grain and color of the adjacent wood. Exception: A void (not repaired) is permitted to be longer than 3/4 in. (19 mm) if its area does not exceed 1/2 in². (3.23 cm²). Open knot holes on the wide face of laminations exposed to view shall be filled.

11.3.2.1 Pencil Wane

All occurrences of pencil wane shall be repaired, regardless of length. Pencil wane shall be permitted to be repaired using filler up to a maximum length of 8 in. (203 mm). For pencil wane longer than 8 in. (203 mm), wood inserts shall be used for repairs.

11.3.2.2 Edge Joints

Voids greater than 1/16 in. (2 mm) wide in edge joints appearing on the wide face of laminations exposed to view shall be filled with wood-tone colored filler that reasonably blends with the final product.

11.3.3 Surfacing

Exposed faces shall be surfaced smooth. Misses, wane, and low laminations shall not be permitted. Occasional repaired pencil wane shall be permitted subject to the restrictions of Section 11.3.2.1.

11.3.4 Eased Corners

The corners of the member exposed to view in the final structure shall be eased with a minimum radius of 1/8 in. (3 mm) or equivalent chamfer.

11.4 Premium Appearance Grade

11.4.1 Lamination Characteristics

Laminations shall be selected to minimize loose knots, unsound knots, knotholes, pencil wane, bark inclusions, and voids that will be visible after final surfacing of the member. On the wide face of laminations exposed to view in the finished member, knots shall be limited to 20% of the net face width of the lamination, and not over two maximum size knots or their equivalent shall occur in a 6 ft (1.83 m) length. Otherwise, laminations are permitted to possess the natural growth characteristics of the lumber grade.

11.4.2 Void Repair

In exposed surfaces, voids measuring over 3/4 in. (19 mm) in length shall be filled by the manufacturer with wood-tone colored filler that reasonably blends with the final product or with clear wood inserts selected for similarity to the grain and color of the adjacent wood. Exception: A void (not repaired) is permitted to be longer than 3/4 in. (19 mm) if its area does not exceed 1/2 in². (3.23 cm²).

Occasional occurrences of voids due to loose knots, unsound knots, knotholes, etc., which were not detected during the grading process, shall be permitted subject to the repair requirements of the preceding paragraph.

11.4.2.1 Pencil Wane

All occurrences of pencil wane shall be repaired regardless of length. Pencil wane shall be permitted to be repaired using filler up to a maximum length of 8 in. (203 mm). For pencil wane longer than 8 in. (203 mm), wood inserts shall be used for repairs.

11.4.2.2 Edge Joints

Voids greater than 1/16 in. (2 mm) wide in edge joints appearing on the wide face of laminations exposed to view shall be filled with wood-tone colored filler that reasonably blends with the final product.

11.4.3 Surfacing

Exposed faces shall be surfaced smooth. Misses, wane, and low laminations are not permitted. Occasional repaired pencil wane shall be permitted subject to the restrictions of Section 11.4.2.1.

11.4.4 Eased Corners

The corners of the member exposed to view in the final structure shall be eased with a minimum radius of 1/8 in. (3 mm) or equivalent chamfer.

12. QUALITY CONTROL SYSTEM

The quality control system of the laminator shall be established, implemented, and maintained by the laminator and shall be subject to approval by an accredited inspection agency.

At a minimum the quality control system shall include:

- (a) Plant and process qualification, including qualification tests as required in Section 12.1 and verification of such qualification by an accredited inspection agency.
- (b) Adhesive lot testing as required in Section 12.2.
- (c) Daily quality control as required in Section 12.3, consisting of:
 1. A continuous detailed check of each step of the process at production checkpoints including in-line tests.
 2. Physical tests of representative samples.
 3. Visual inspection of finished production.
- (d) Regular audits by an accredited inspection agency (see Section 12.4).
- (e) Plant manuals (see Section 12.5).
- (f) Quality control records (see Section 12.6).

12.1 Plant and Process Qualification

All processes affecting the quality of structural glued laminated timber or the evaluation quality shall be qualified by test and approved by the accredited inspection agency prior to production. The following is required for plant qualification:

- (a) Bonding qualification described in Section 12.1.1.
- (b) Face and edge joint qualification described in Section 12.1.2.
- (c) End joint qualification described in Section 12.1.3.
- (d) Qualification of special materials used by the plant such as alternate lumber grades (AITC 407), structural composite lumber (AITC 402), and manufactured lumber (AITC 401).
- (e) Qualification of special processes used by the plant such as proof-grading lumber (AITC 406), lamination repairs (AITC 403), and radial reinforcement (AITC 404).
- (f) Physical tests used by the plant for daily quality control shown in Section 12.1.5.
- (g) Current calibration of test equipment and production gauges.

A summary of the tests for qualification is shown in Table 1.

Test Performed On	Minimum Number of Samples	Minimum Number of Specimens per Sample	AITC Test Number and Type of Test	Requirements or Limitations for	References Within this Standard
Face and Edge Joints	2 beams ^(a,b) – 1 open assembly 1 closed assembly	10 total bond lines for each assembly	T107 Shear	Strength and Wood Failure	12.1.1 12.1.2
	2 beams ^(a,b) – 1 open assembly 1 closed assembly	3 sample blocks from each assembly	T110 Cyclic Delamination	Bond Line Openings	12.1.1 12.1.2
End Joints	1 ^(a)	30	T119 Tension	Strength and Wood Failure	12.1.1 12.1.3
	1 ^(a,c)	5	T110 Cyclic Delamination	Bond Line Openings	12.1.1 12.1.3
The following tests are required in addition to the above requirements when these processes and/or materials are used in the plant.					
Proof Loaded End Joints	2	30	T118 Bending or T121 Tension	Strength	12.1.3.3
End Joints for Repair	10 Repairs	2	T119 (Modified) Tension	Strength and Wood Failure	12.1.3 12.1.3.4
	1 ^(d)	5	Beam Test		AITC 403
Manufactured Lumber	1	102	T123 Tensile Properties	Strength	AITC 401
SCL	Per Applicable Requirements in ASTM D5456 and AITC 402	Per Applicable Requirements in ASTM D5456 and AITC 402	T123 Tension Plus Referenced ASTM Tests T107, T110	Strength	ASTM D5456 AITC 402
			T116	SCL/SCL plus SCL/Wood Long Span E	AITC 402
Radially Reinforced Curved Members	1	10			AITC 404
Proof Graded Lumber	1	102	T123 Tensile Properties	Strength	AITC 406
			T116	Long Span E	AITC 406
<p>(a) For each adhesive-species-treatment combination used (SCL is considered a separate species for testing requirements).</p> <p>(b) When edge joint bonding is a structural requirement.</p> <p>(c) End joints are permitted in specimens used for face joint bonding.</p> <p>(d) End joint repair procedures must be verified for adequacy by supplemental full scale beam tests in addition to AITC Test T119.</p>					

12.1.1 Bonding Qualification

Each combination of adhesive, species grouping, and treatment used for face, edge or end joint bonding shall be qualified for use prior to production in accordance with applicable provisions of this Section. Samples to be used for in-plant qualification shall be prepared using representative product manufacturing processes.

12.1.1.1 Basic Species Groupings

For qualification purposes, the species or species groups within the following groupings need not be qualified separately.

Group 1 – Douglas Fir Larch*

Group 2 – Southern Pine

Group 3 – Hem-Fir, Mountain Hemlock, Douglas Fir South, Sitka Spruce

Group 4 – Softwood Species including Englemann Spruce, Lodgepole Pine, Ponderosa Pine, Spruce-Pine-Fir and other Western Species.

Group 5 – California Redwood

Group 6 – Alaska Cedar, Port-Orford Cedar

Group 7 – Red Oak, White Oak

*Larch shall require separate qualification for face bonding because of galactan content if deemed necessary by the accredited inspection agency.

12.1.1.2 Species group modifications for qualification:

- (a) Where a plant has qualified adhesives for a face joint bond on Group 1 species, a separate qualification is not required on Groups 3, 4 and 5.
- (b) Where end joints of both Douglas Fir-Larch and Hem-Fir have been separately qualified, it is not necessary to qualify the combined species, provided the end joint cure cycle used is controlled by the more restrictive requirement.
- (c) Where end joints have been qualified for Group 1 species for the Qualification Stress Levels (QSLs) of 2400 psi (16.6 MPa) or higher, a separate qualification is not required for Group 3 species for QSLs of 2000 psi or less. Where end joints have been qualified for Group 1 and 2 species, a separate qualification for Group 4 species is not required for QSLs of 2000 psi (13.8 MPa) or less.

Where qualification of end joints for a Group 3, 4, 5 or 6 species is required, and the plant has been previously qualified for the wider widths of Group 1 or 2 species, using the same configuration and jointing procedures, AITC Test T119 needs to be performed on the nominal 6 in. (140 mm) width only. However, wider widths shall not be exempted from the continuous daily quality control tests.

12.1.2 Face and Edge Joint Qualification

- (a) Face and edge joints shall be prepared meeting the requirements of Section 9 and the plant's procedures and quality manuals. Where gap-filling adhesives are to be evaluated, test specimens shall be cut from samples specially made by using shims or by a similar method to maintain a bond line thickness equivalent to the maximum bond line thickness to be approved.
- (b) A minimum of 10 bondlines from each of two beams shall be tested using AITC Test T107. The average shear strength of the sample shall equal or exceed 90% of the average clear wood shear strength parallel to grain as determined from ASTM D2555. Where species groups are used, the procedures for assigning values for groups given in ASTM D2555 shall be used. The shear value for 12% moisture content shall be used for moisture contents of 12% or less. The average wood failure of the sheared or broken surfaces of all specimens to be evaluated for qualification or lot verification testing of adhesives shall equal or exceed 80% for adhesives used with softwoods and non-dense hardwoods, or shall equal or exceed 60% for adhesives used with dense hardwoods.
- (c) A minimum of three cyclic delamination specimens shall be prepared and tested in accordance with AITC Test T110. After one complete cycle, softwoods shall have no more than 5% delamination and hardwoods shall have no more than 8% delamination.

12.1.3 End Joint Qualification

- (a) Full-size end joint specimens shall be prepared meeting the requirements of Section 10 and the plant's procedures and quality manuals. Qualification of end joints in any width qualifies all narrower widths. Where both nominal 1 in. (19 mm) and nominal 2 in. (38 mm) thick lumber are used in production, each shall be qualified separately where the joint geometry is judged to be significantly different by the accredited inspection agency.
- (b) A minimum of 30 specimens shall be tested in tension using AITC Test T119. Average wood failure of all specimens tested shall equal or exceed 80% for softwoods or non-dense hardwoods, or 60% for dense hardwoods. The average strength and the 5% tolerance limit on strength with 75% confidence shall be determined. The strength value at the 5% tolerance limit with 75% confidence divided by 1.67 shall be the QSL for the process.
- (c) A minimum of 5 specimens shall be tested for durability using AITC Test T110. After one complete cycle, softwoods shall have no more than 5% delamination and hardwoods shall have no more than 8% delamination.

12.1.3.1 Minimum QSL

- (a) Multiple Grade Members – The QSL shall meet or exceed the reference bending design value provided that the outer fiber stresses determined by a transformed section analysis using the average modulus of elasticity for each grade do not exceed the design stress by more than 10%. Where the outer fiber stress determined by the transformed section analysis exceeds the design value by more than 10%, the QSL shall meet or exceed 90% of the outer fiber stress determined by transformed section analysis. The QSL shall also meet or exceed 1.25 times the reference tension design value.
- (b) Uniform-grade Members – For uniform-grade layups and other layups with calculated outer fiber stresses less than 10% greater than the reference bending design value, the QSL shall meet or exceed 90% of the outer fiber stress as determined by transformed section analysis. The QSL shall also meet or exceed 1.25 times the reference tension design value.

The required strength is applicable to nominal 2x6 (38 mm x 140 mm) lumber. For other widths in nominal 2 in. (38 mm) thick lumber, the required strengths are permitted to be multiplied by the factors listed in Table 2.

TABLE 2

STRENGTH ADJUSTMENT FACTORS FOR LUMBER LARGER THAN 2x6 USED IN AITC TEST T119

Size	All Species Except Southern Pine	Southern Pine
2 x 8 (38 mm x 184 mm)	0.95	0.98
2 x 10 (38 mm x 235 mm)	0.90	0.95
2 x 12 (38 mm x 286 mm)	0.85	0.93

12.1.3.2 QSL for Inner Laminations of Bending Members

End joints with lower QSLs than those required for outer tension zone laminations are permitted in inner tension and compression zones of bending members provided:

- (a) The edges of each lamination shall be clearly marked to identify the strength level until beam surfacing unless the end joint configuration is such that the end joint with the lower QSL is readily distinguishable from the end joint with the higher QSL used in outer laminations when viewed from the edge of the laminations.
- (b) The end joint with the lower QSL shall be qualified for the maximum stress level for which it is used.
- (c) The end joint with the lower QSL shall not be used in the outer tension zone nor in the outer 10% of the depth on the tension side, whichever is greater.
- (d) End joints with QSL levels less than 75% of the QSL of the outer tension zone shall not be used in the outer compression zone of bending members.
- (e) The required strength level for the lower strength end joint shall be determined by straight-line interpolation from the outer tension lamination to the mid-depth of the member. For this procedure, the stress at the outer tension lamination shall be the 1.67 times the reference bending stress for the beam combination, and the stress at the mid-depth of the member shall be taken as zero.

12.1.3.3 Proof Loaded End Joints Qualification

When proof loaded end joints are to be used, such end joints shall be qualified by AITC Test T118 for bending proof loading; or by AITC Test T121 for tension proof loading.

12.1.3.4 End Joints Used in Lamination Repair

End joints used in lamination repairs shall be qualified by testing in accordance with the procedures given in AITC 403.

12.1.4 Other Qualification Tests

All inspection and test procedures required in Section 12.2 for daily quality control shall be performed as a part of the qualification procedure.

12.2 Adhesive Lot Testing

Each new lot of adhesive previously qualified under Section 12.1.1 shall be tested for strength, wood failure, and durability prior to shipment of the members manufactured with this lot. Samples for this testing shall be made-up separately prior to use of the adhesive in production or taken from the first production run. Tests shall be made on specimens which have been manufactured from the species to be used in the production of glued laminated timber and using the same adhesive curing procedures. Testing of a new lot of adhesives for face joint bonding will satisfy the requirements for edge joint bonding using the same adhesive.

Where gap-filling adhesives are to be evaluated, test specimens shall be cut from samples specially made by using shims or by a similar method to maintain a bond line thickness equivalent to the maximum bond line thickness to be approved.

12.2.1 Face Joint Bonding: Strength and Wood Failure

Shear tests shall be performed on each new lot of adhesives in accordance with AITC Test T107. The average shear strength of the sample shall equal or exceed 90% of the average clear wood shear strength parallel to grain as determined from ASTM D2555. Where species groups are used, the procedures for assigning values for groups given in ASTM D2555 shall be used. The shear value for 12% moisture content shall be used for moisture contents of 12% or less. The average wood failure of the sheared or broken surfaces of all specimens to be evaluated for qualification or lot verification testing of adhesives shall equal or exceed 80% for adhesives used with softwoods and non-dense hardwoods, or shall equal or exceed 60% for adhesives used with dense hardwoods.

12.2.2 End Joint Bonding: Strength and Wood Failure

End joint specimens shall be prepared using the same adhesive curing procedures used in production. End joint adhesives shall be evaluated for strength and wood failure according to AITC Test T119. A minimum of 4 end joints shall be tested for adhesive lot testing. Average wood failure of all specimens tested shall equal or exceed 80% for softwoods or non-dense hardwoods, or 60% for dense hardwoods. Average strength required of all the specimens tested shall be as determined by the qualification test required in Section 12.1.3.

12.2.3 Durability of Adhesive Bonds: Face and End Joint Bonding

Face and end joint bond durability shall be tested in accordance with AITC Test T110 on each new lot of adhesive. After one complete cycle, softwoods shall have no more than 5% delamination and hardwoods shall have no more than 8% delamination. Face and end joint test specimens shall be prepared using the same adhesive curing procedures used in production.

12.3 Daily Quality Control

For the purposes of quality control, an 8-hour work shift or portion thereof shall constitute one day. Daily testing requirements shall apply to each work shift or portion thereof. Daily quality control shall include in-line assessments, off-line tests of representative specimens, and inspection of finished production.

12.3.1 In-Line Assessments

In-line assessments shall be conducted at production checkpoints identified in the plant's quality manual. Assessments shall include, but not be limited to, the measurement of moisture content; evaluation of surfacing quality; measurement of temperature; observation of end joint, edge joint, face joint bonding processes; tests of adhesive mix ratios; measurement and observation of adhesive spread; and monitoring of assembly time, pressure and curing conditions.

12.3.2 Off-line Tests

Strength and durability of face joints, edge joints and end joints shall be monitored daily by off-line tests of representative specimens. Machining and fitment of end joints shall also be conducted as part of daily quality control. A summary of daily quality control tests is shown in Table 3.

Test Performed on:	Minimum Number of Specimens per Sample per Sampling Period	AITC Test Number and Type of Test	Requirements or Limitations for	References Within this Standard
Face and Edge Joints ^(a, b)	10	T107 Shear	Strength and Wood Failure	12.3.4
	1	T110 Cyclic Delamination	Bond Line Openings	12.3.6
End Joints ^(a, c, f)	2	T119 Tension	Strength and Wood Failure	12.3.5
	Varies ^(d)	T105 ^(e)		12.3.5
	1	T110 Cyclic Delamination	Bond Line Openings	12.3.6
The following tests are required in addition to the above requirements when these processes and/or materials are used in the plant.				
Proof Loaded End Joints	All joints tested in production.	T118 Bending -or- T121 Tension	Strength	12.3.5.3
End Joints for Repair	1 -or- 5 -or- 10 Plus 1	T119 Tension -or- T106 Tension -or- T107 Shear	Strength and Wood Failure	AITC 403 12.3.6
	1	T110 Cyclic Delamination	Bond Line Openings	AITC 403 5.6.2.10
Manufactured Lumber	Varies ^(d)	T123 Tensile Properties	Strength	AITC 401
SCL	Per Applicable Test	T107, T110	Strength and Wood Failure	AITC 402
		T116	Long Span E	AITC 402
Radially Reinforced Curved Members	Per Manufacturer's Procedures and QC Manual			AITC 404
Proof Graded Lumber	Varies ^(d)	T116	Long Span E	AITC 406
	Varies ^(d)	T123 Tensile Properties	Strength	AITC 406

(a) For each adhesive-species-treatment combination used (SCL is considered a separate species for testing requirements).
 (b) Where edge joint bonding is a structural requirement.
 (c) In outer tension zone(s). When no outer tension laminations are produced during sampling period, make test end joints from outer tension zone material.
 (d) Sample size varies with quality control requirements per each laminator's qualification.
 (e) AITC Test T115 should be used for plane scarf joints and integrally bonded end joints.
 (f) End joints are permitted in specimens used for face joint bonding.

Where manufactured lumber and sawn lumber of the same species are used during the same shift, daily quality control tests for face, edge and end joint bonding need to be run only on the material which has controlling test values as determined during qualification.

12.3.3 Sampling

Face, edge and end joint bonding for each combination of species, type of adhesive and treatment used during the work shift shall be represented by this sampling. Where bonded concurrently, species, within a group, as indicated by Section 12.1.1.1, can be grouped together and the test of one species can apply to all species in this group for a given sampling period. The sampling of species from day-to-day should be approximately in proportion to the volume of production of each species used in the plant.

12.3.4 Face and Edge Joints

A minimum of one sample shall be taken from every 50,000 board feet (83 m³), or portion thereof, which is bonded during each work shift.

Samples shall be representative of production members made under production conditions. Where possible, samples shall be cut from the ends of production members.

For face and edge joints, 10 or more bond lines shall be tested. Where a sampled cross section contains more than 10 bond lines, all bond lines shall be tested. If production members contain less than 10 bond lines, a minimum of 2 cross sections shall be sampled and all bond lines in each sampled cross section shall be tested.

12.3.4.1 Tests for Face Joint Bonding

Shear tests on bond lines between laminations shall be conducted in accordance with AITC Test T107. The shear strengths of all specimens to be evaluated shall be averaged and this average shall equal or exceed 90% of the average clear wood shear strength parallel to grain as determined from ASTM D2555.

The wood failure on the sheared or broken surfaces of all specimens to be evaluated shall be averaged and this average shall equal or exceed 70% for adhesives used with softwoods and non-dense hardwoods and 50% for adhesives used for dense hardwoods.

12.3.4.2 Tests for Edge Joint Bonding

Where edge joint bonding is a structural requirement, shear tests shall be conducted as for face joint bonding with appropriate modification of width depending upon the thickness of the lamination. The criteria specified in Section 12.3.4.1 shall be met.

12.3.5 End Joints

A lot size shall be established by the laminator and approved by the accredited inspection agency. The number of end joints to be tested by AITC Test T119 shall be based on the production of end joints for the outer tension zone of bending members (a minimum of 10% of depth) and for the full depth of uniform-grade members. The number of end joints to be tested shall be a minimum of 1 end joint per 200 of these joints, but no less than 2 end joints per lot, shift, or every 50,000 board feet (83 m³) or portion thereof of production.

Where no end joints are produced for the outer tension zone in a bending member, a minimum of two specimens per lot, shift, or every 50,000 board feet (83 m³), or portion thereof, shall be tested.

The end joints tested shall be made using lumber meeting the requirements for the highest grade of lumber required in the outer 5% of depth on the tension side of a bending member for the combination used to determine the QSL.

In addition, a minimum of one end joint shall be tested by AITC Test T105:

- (a) At the beginning of each shift.
- (b) Following any major change in end joint production variables, including the curing sequence.
- (c) Following a change of end joint cutter heads.

AITC Test T115 is permitted to be substituted for AITC Test T105 where plain scarf joints and integrally bonded end joints are used. The selection of test specimens and evaluation of test results from all samples shall be in accordance with procedures approved by an accredited inspection agency.

12.3.5.1 Separate Production Lines

The requirements for testing of end joints shall be applicable to each end joint production process or separate end joint fabrication line.

12.3.5.2 Tests for End Joint Bonding

End joints shall be tested daily for strength and wood failure in accordance with AITC Test T119. The criteria for wood failure shall be as specified in Section 12.3.4.1 for face joint bonding. Strength quality control requirements shall be based on lot sampling. Lot quality control shall be monitored with a continuous quality control program. Statistical Process Control (SPC) limits for lot sample average strength shall be established to maintain the required end joint strength.

12.3.5.3 Tests for Proof Loaded End Joints

Where proof loaded end joints are used, all of the daily production line checks and daily tests required for end joints shall be performed. In addition all quality control procedures set forth in AITC Test T118 or T121, whichever is applicable shall be followed.

12.3.5.4 Tests for End Joints Used in Lamination Repair

Where end joints are used in the repair of laminations, daily quality control and tests set forth in AITC 403 shall be performed.

12.3.6 Tests for Integrity of Adhesive Bonds

Cyclic delamination tests made in accordance with AITC Test T110 shall be conducted on samples from face joints and end joints, and on edge joints where edge joint bonding is used.

End joints are permitted in the specimens used for face joint bonding.

Where the lamination repair procedure is used, a cyclic delamination sample is to be made in combination with each required strength test sample.

Delamination after one complete cycle shall not exceed 5% for softwoods and 8% for hardwoods. If delamination exceeds these values after one cycle, a second cycle shall be performed on the same specimens, in which case the delamination shall not exceed 10%.

12.3.7 Inspection of Finished Production

All production shall be inspected for conformance to the requirements of this Standard as to:

- (a) Dimensions (width, depth and length).
- (b) Shape, including camber and squareness of cross section.
- (c) Type, quality and location of structural bond lines.
- (d) Appearance grade.
- (e) Lumber species and placement of grades.
- (f) Moisture content.
- (g) Adhesive type – If adhesive appears to have the wrong color, the type must be ascertained from records or determined by suitable test if records do not correspond with the visual observation.
- (h) Bond line – If bond line thicknesses do not fall within the range of 0.006 in. (0.2 mm) plus or minus 0.004 in. (0.1 mm) (except gap-filling adhesives which are permitted to have a greater bond line thickness), investigation of the production procedures shall be made to assure conformance with this Standard. Infrequent occurrences of separations of bond lines shall be limited (in the judgment of a qualified inspector), to no greater than the lamination characteristics permitted at the bond line. Any separation of bond lines shall require investigation of records and production procedures, and may require additional physical tests. Probes, increment borings or other means shall be used to evaluate the degree of separations.
- (i) Application of the appropriate marks.

12.4 Audit by an Accredited Inspection Agency

All products conforming to this Standard shall be manufactured in facilities that are subject to periodic, unannounced audits by an accredited inspection agency. All processes and records relevant to the production of such products shall be subject to audit.

12.5 Plant Manuals

Production procedures and the plant quality control system shall be fully described in the plant's procedures manual and quality control manual. Production check points, physical testing and visual inspection procedures shall be included in the quality control manual. Manuals shall be kept up to date by the manufacturing facility. These manuals shall have the approval of the accredited inspection agency and shall be reviewed periodically by that agency.

12.6 Quality Control Records

Records of quality control procedures shall be maintained by the laminator. The following records shall be kept by the laminator for a minimum of 5 years.

- (a) Qualification test results.
- (b) Daily tests on finished production, including shear tests, cyclic delamination tests and end joint strength tests.

- (c) Production line test results – daily check sheet listing each phase of production to be checked. Items shall be initialed as having been checked with comments indicating compliance. When noncompliance is found, the action and correction of the procedure shall be noted.
- (d) Documentation of any engineering analysis performed in accordance with Section 3.1.

13. MARKING

Structural glued laminated timber represented to comply with this Standard shall be distinctively marked.

13.1 Non-Custom Members

Non-custom members shall be marked with the following:

- (a) Identification of this Standard, **ANSI A190.1**
- (b) Identification of the accredited inspection agency (see Section 14)
- (c) Identification of the laminating plant
- (d) The species or species group of lumber in the timber
- (e) The applicable laminating specification and combination symbol. (Where design values for shear (F_v) compression perpendicular to grain ($F_{c\perp}$) and bending (F_b) are other than the published design values for a combination, these design values must be included in the mark.)
- (f) Appearance grade denoted by **FRAM** – Framing, **IND** – Industrial, **ARCH** – Architectural, and **PREM** – Premium
- (g) **PROOF LOADED END JOINTS** if the member has the required laminations proof loaded
- (h) A lot number or job identification number as a means to trace the member back to the production and quality control records at the manufacturing facility
- (i) Alternate Tension Laminations – Where alternate tension laminations are used, a mark shall be added to the member to identify the alternate face lamination grade used (e.g., C14-24).

13.1.1 Frequency of Marking

Non-custom and other required marks in this Section shall be placed on non-custom members at intervals of 8 ft (2.4 m) or less in order that each piece cut from a longer piece will have at least one each of the required marks.

13.2 Custom Members

For members laminated to meet specific job specifications (custom members) the marking need consist of only items (a), (b), (c) and (i) in Section 13.1. Custom-made timbers shall bear at least one mark containing the required identification. When long members shipped to a job are to be cut later into several members for use in the structure, the frequency of marking required for non-custom members shall be followed.

13.3 Fire-Resistance Ratings

Custom or non-custom members manufactured to provide a one-hour fire rating shall be manufactured to the specified layup except that a core lamination shall be removed, the tension zone moved inward, and the equivalent of one additional nominal 2 in. thickness outer tension lamination added. These members are permitted to be marked with a **1-HOUR FIRE RATING** designation.

Members manufactured to provide a two-hour fire rating shall be manufactured to the specified layup except that two core laminations shall be removed, the tension zone moved inward, and the equivalent of two additional nominal 2 in. thickness outer tension laminations added. These members are permitted to be marked with a **2-HOUR FIRE RATING** designation.

13.4 Top Stamp Requirements

Prismatic members with unbalanced layups or camber shall be marked “TOP” with letters approximately 2 in. (51 mm) high. Custom members shall be stamped on the top at both ends. Non-custom members shall be stamped along the top at intervals set forth in Section 13.1.1.

13.5 Certification of Conformance

When a Certificate of Conformance is issued, all glued laminated timber covered by the certification must be appropriately marked with the mark of the accredited inspection agency.

13.6 Dual Manufacture

This Standard is applicable to glued laminated timber manufactured in a single plant, or partly in one plant and partly in another. When more than one plant is involved, each plant must be qualified under this Standard and the Certificate of Conformance shall so indicate. The mark placed on the member(s) shall be the mark of the last plant involved in the manufacturing process.

13.7 Marking Truss Members

When trusses are shipped, each assembly, subassembly, or separate part shall be marked.

13.8 Withdrawal of Marking

Marking and/or certification of the product shall be removed and certificates (if required) withdrawn if any one of the following conditions is met.

- (a) Physical tests, visual inspection, and review of production records indicate that a marked or certified product is not in conformance with the requirements of this Standard.
- (b) Investigation shows that the product does not conform to the requirements of the Standard.

14. ACCREDITED INSPECTION AGENCY

An accredited inspection agency:

- (a) Operates an inspection system which audits the quality control system of laminators.
- (b) Provides the facilities and the personnel to perform the audit and to verify the testing as described herein.
- (c) Determines the individual plant's ability to produce in accordance with this Standard.
- (d) Provides periodic audit of the plant's production operations and production quality to assure compliance with this Standard.
- (e) Enforces the proper use of the inspection agency quality marks and certificates.
- (f) Has no financial interest in, or is not financially dependent upon, any single company manufacturing any portion of the product being inspected or tested.
- (g) Is not owned, operated or controlled by any such company.
- (h) Provides an arbitration review board to arbitrate disputes between the agency and the laminator. Such a board shall include, but not be limited to, three persons:
 - 1. A recognized independent authority in the field of engineered timber construction to serve as chairman,
 - 2. At least one registered engineer knowledgeable in the design and use of structural glued laminated timber, and
 - 3. At least one person knowledgeable in glued laminated timber quality control and manufacturing.
- (i) Maintains or participates in a Technical Advisory Committee of laminator members and advisors for review of appropriate documents, procedures and applicable research and development.
- (j) Is accredited under ISO/IEC Standard 17020 as an Inspection Agency.

15. TECHNICAL REVIEW BOARD (TRB)

15.1 Scope

The Secretariat of this Standard, APA – The Engineered Wood Association, shall provide a Technical Review Board with the following functions:

- (a) Interpretation of this Standard,
- (b) Processing of appeals to the suitability of this Standard, and
- (c) Determination of the applicability and consistency of later issues of documents referenced in this Standard.

15.2 Membership

The Technical Review Board shall consist of five voting members. The representation of the Board members shall be as follows:

- (a) One member representing laminators receiving testing and inspection services from the Secretariat.
- (b) One member representing the majority of laminators that receive inspection and testing services from accredited agencies other than the Secretariat.
- (c) One qualified expert in the field of structural glued laminated timber representing an educational or research organization.
- (d) One qualified expert in the field of engineered timber construction who is a registered professional engineer or architect. This member shall not be an employee of any firm engaged in the manufacture of structural glued laminated timber or other engineered wood products, or of any firm that supplies raw materials, equipment, or services for the manufacture of such products.
- (e) One qualified expert in the field of engineered timber construction who is a registered professional engineer to serve as Chairman of the Technical Review Board. The Chairman shall not be an employee of any firm engaged in the manufacture of structural glued laminated timber or other engineered wood products, or of any firm that supplies raw materials, equipment, or services for the manufacture of such products.
- (f) A nonvoting secretary provided by the Secretariat.

15.2.1 Selection

The Secretariat shall conduct a selection process that ensures the criteria of Section 15.2 have been satisfied. Each accredited agency shall provide the TRB secretary with TAC membership lists for the purpose of requesting nominees and conducting elections of TRB members. Members shall be elected for two-year terms, except for the Chairman who shall be elected for a four-year term. Terms shall begin on May 1 and end on April 30.

- (a) The member representing Category 15.2 (a) shall be nominated and elected by the laminators whom he represents. This member shall be elected for a two-year term beginning in each even-numbered year.
- (b) The member representing Category 15.2 (b) shall be nominated and elected by the laminators whom he represents. This member shall be elected for a two-year term beginning in each odd-numbered year.
- (c) The member representing Category 15.2 (c) shall be nominated and elected by the Technical Advisory Committees of all accredited agencies. This member shall be elected for a two-year term beginning in each even-numbered year.

- (d) The member representing Category 15.2 (d) shall be nominated and elected by the Technical Advisory Committees of all accredited agencies. This member shall be elected for a two-year term beginning in each odd numbered year.
- (e) The Chairman of the Technical Review Board shall be nominated and elected by the Technical Advisory Committees of all accredited agencies. The Chairman shall be elected for a four-year term beginning in every other odd numbered year.
- (f) If a member resigns from the Board prior to the end of his term or becomes ineligible, a new member meeting the criteria shall be elected to the vacated position to serve for the remainder of the term.

15.3 Requests for Services

Requests for services of the Technical Review Board shall be made in writing to the secretary. A minimum of eight (8) copies of the request and any supporting data shall be provided to the secretary for distribution to the TRB members and for inclusion in the records.

15.4 Conduct of Meetings

- (a) Meeting Calls – The secretary of the Technical Review Board shall issue all meeting calls and notices. A minimum of 30 days' notice shall be given.
- (b) Acting Chairman – In the absence of the elected Chairman, the members of the Technical Review Board shall elect an Acting Chairman from among themselves for a specific meeting.
- (c) Quorum – A quorum must be present for a valid Technical Review Board vote. A quorum shall consist of the Chairman or Acting Chairman, at least one member from Category 15.2 (a) or (b), and at least one member from Category 15.2 (c) or (d).
- (d) Voting – Each member of the Technical Review Board shall have one vote except that (1) the secretary shall not vote; (2) the Chairman or Acting Chairman shall not vote except to break a tie; (3) members representing Category 15.2 (a) or (b) shall not vote on any matter which has been presented by their respective companies. A majority of those voting carries a motion provided a quorum is present. Letter ballots of the Technical Review Board shall be permitted.
- (e) Rules – The Chairman or Acting Chairman shall conduct all meetings under Robert's Rules of Order.
- (f) Hearings – The Technical Review Board is permitted to invite affected, interested or knowledgeable persons or firms to testify at hearings or to supply supplemental data or information. Hearings shall be open to all interested parties.
- (g) Deliberations – After the hearings, the Technical Review Board shall meet to discuss and deliberate on the case. Deliberations shall be closed to all except the TRB members and secretary. Representatives of accredited inspection agencies shall be permitted to observe the deliberations.
- (h) Challenge – When the TRB has reached a decision, the proponent for the hearing matter shall be permitted to challenge the TRB decision. Additional deliberation shall be at the discretion of the TRB Chairman.
- (i) Decisions – The decision of the Technical Review Board shall be binding and final.
- (j) Records and Reports – The secretary shall maintain a file of correspondence, meeting minutes, and other records of the Technical Review Board. Meeting minutes shall be made available to the public upon request. Proprietary information shall not be made available without express written consent of its owner.

15.5 Expenses

The expenses of the administration of the Technical Review Board shall be apportioned as follows:

- (a) Direct administrative expenses shall be borne by the Secretariat.
- (b) Meeting expenses shall be allocated to the party or parties requesting the convening of the Technical Review Board including:
 - 1. Transportation, food, and lodging expenses incurred by the Board members in conjunction with a meeting.
 - 2. An honorarium for the TRB Chairman or acting chairman for each day the board meets. The amount shall be as determined by the Secretariat.
 - 3. Rental of meeting rooms and audiovisual equipment necessary for the meeting.
 - 4. Food or beverages served at the meeting.

16. DEFINITIONS

Accredited Inspection Agency – an organization that provides third-party auditing of the laminating plant and conforms to Section 14 of this Standard.

Assembly Time – the interval of time between spreading of the adhesive on the laminations and application of final pressure to the entire assembly. Assembly time may be separated into open and closed assembly periods.

Bending Members – members manufactured with higher lamination grades near the surfaces than in the core.

Bond Line – the layer of adhesive which attaches two adherents.

Camber – a small amount of curvature built into a glued laminated timber to offset anticipated deflection or to facilitate roof drainage.

Curing Time – the period of time which an adhesive takes to attain a specified degree of cure.

Curved Members – members which are designed so that significant curvature remains after deflection due to service loads has taken place, such as curved beams and arches.

Custom Members – members that are manufactured to meet individual job specifications.

Delamination – the separation of layers in an assembly because of failure of the adhesive, either in the adhesive itself or at the interface between the adhesive and the lamination.

Dry-Service Conditions – environmental exposure conditions that result in a member moisture content of less than 16% in service.

Eased Corner – slightly rounded surfacing of corner of member to remove sharp edge.

Equilibrium Moisture Content – a moisture content at which wood neither gains nor loses moisture to the surrounding air.

Five Percent Tolerance Limit with 75% Confidence – a statistical term describing the lower estimate bound of the fifth percentile that ensures that the population fifth percentile equals or exceeds the estimate 75% of the time.

Gap-Filling Adhesive – an adhesive that has the capability of filling voids of up to 1/16 in. (2 mm) between two mating surfaces.

Hardwood, Non-Dense – any hardwood having an average specific gravity of 0.42 or less when determined by oven-dry weight and green volume.

Inserts – wood strips used for non-structural repairs in the sides of glued laminated timber.

Joint, Edge – a joint formed by two pieces of lumber laid edge to edge to form a wider lamination or portion thereof.

Joint, End – a joint formed by joining pieces of lumber end to end with adhesives.

Joint, Face – an adhesive joint occurring between the wide faces of laminations.

Joint, Finger – an end joint made up of several meshing fingers of wood.

Joint, Scarf – an end joint formed by joining with adhesive the ends of 2 pieces that have been tapered to form sloping plane surfaces. In some cases, a step or hook is machined into the scarf to facilitate alignment of the 2 ends, in which case, the plane is discontinuous and the joint is known as a stepped or hooked scarf joint.

Laminating – (n) the process of manufacturing structural glued laminated timber; (adj) pertaining to the process of manufacturing structural timber.

Lamination – a single layer of wood material extending the full width and full length of the finished structural glued laminated timber member, composed of one or several pieces of lumber in width or length.

Lot – a definite quantity of product or material accumulated under conditions that are considered uniform for sampling purposes.

Lot, Adhesives – generally used by adhesive manufacturers to identify a batch of adhesive.

Manufactured Lumber – two or more pieces or strips of lumber structurally bonded to form a single piece of lumber.

Mechanically Graded Lumber – lumber graded using mechanical or physical evaluation, combined with visual grading.

Moisture Content – the amount of water contained in the wood, usually expressed as a percentage of the weight of oven-dry wood.

Multiple-Piece Lamination – a lamination which contains 2 or more pieces of lumber across the width of the lamination.

Non-custom Members – members that are not manufactured for an individual job specification.

Occasional – where there is provision within the scope of the applicable rule or standard that allows for random variation in production practices, a frequency of occurrence of not more than 5% (1 in 20) shall apply. When the term occasional applies to lumber grading, a frequency of occurrence of not more than 10% (1 in 10) shall apply.

Off-Line Tests – physical tests performed on representative specimens removed from production.

Pencil Wane – wane limited to 1/4 in. (6 mm) measured across the width of a lamination.

Pot Life – the period of time during which an adhesive, after mixing with catalyst, solvent or other compounding ingredients, remains suitable for use.

Production Check-Points – those locations in production where an individual production step has been completed and the process or material is checked for conformance to the requirements of this Standard.

Proof Graded Lumber – lumber that is graded for tensile strength by proof testing each piece in tension to eliminate low-strength pieces.

Proof Loading – application of a known load to a lamination, either tension or bending.

Qualification Stress Level (QSL) – the property established by dividing the end joint qualification lower 5th percentile strength with 75% confidence by 1.67.

Reference Design Values – design value based on normal duration of load, dry conditions, and temperatures less than 100°F (37.8°C). This value is based on the Allowable Stress Design (ASD). Load and Resistance Factor Design (LRFD) values require further conversion.

Ripping – the process of sawing any width lumber to develop narrower lumber.

Sample – a group of specimens collected for testing.

Structural Composite Lumber (SCL) – a composite of either wood veneer sheets or wood strand elements with wood fibers primarily oriented along the length of the member.

Structural Glued Laminated Timber – an engineered, stress rated product of a timber laminating plant comprising assemblies of specially selected and prepared wood laminations securely bonded together with adhesives. The grain of all laminations is approximately parallel longitudinally. The laminations may be comprised of pieces end joined to form any length, of pieces placed or bonded edge-to-edge to make wider ones or pieces bent to curved form during bonding.

Specimen – all or part of a sample that has been selected for testing.

Wet-Service Conditions – environmental exposure conditions that result in a member moisture content of 16% or greater in service.

Wood Failure – that portion of a bonded surface which in cyclic delamination or strength tests exhibits ruptured wood fiber as opposed to failure of the adhesive.

17. REFERENCED DOCUMENTS

From time to time, these referenced documents are updated and revised. Newer versions of these documents shall be used if they have been reviewed and determined to be applicable and consistent with this Standard by the Technical Review Board (see Section 15.1 (c)).

AITC 200-2009, Manufacturing Quality Control Systems Manual

AITC Test T102-2009, Adhesive Spread Measurement

AITC Test T103-2009, Calibration of Plant Pressure System: Bolts or Screw Type Jacks

AITC Test T104-2009, Calibration of Torque Wrenches

AITC Test T105-2009, Diagnostic Tests for Finger Joint Quality

AITC Test T106-2009, Strip Tension Test for End Joints Used in Lamination Repair

AITC Test T107-2009, Shear Test

AITC Test T110-2009, Cyclic Delamination Test

AITC Test T115-2009, Machining Test for End Joints

AITC Test T118-2009, Bending Proof Loading for End Joints

AITC Test T119-2009, Full Size End Joint Tension Test

AITC Test T121-2009, Tension Proof Loading for End Joints

AITC Test T122-2009, Mix Ratio Check for Automatic Adhesive Mixing Machines

AITC Test T123-2009, Sampling, Testing and Data Analysis to Determine Tensile Properties of Lumber

AITC 401-2005, Standard for Manufactured Lumber for Use in Structural Glued Laminated Timber

AITC 402-2005, Standard for Structural Composite Lumber (SCL) Used in Structural Glued Laminated Timber

AITC 403-2005, Standard for End Joints for Use in Lamination Repair

AITC 404-2005, Standard for Radially Reinforcing Curved Glued Laminated Timber Members to Resist Radial Tension

AITC 406-2005, Standard for Proof-Graded Lumber for Glued Laminated Timber

AITC 407-2005, Standard for Alternate Lumber Grades for Use in Structural Glued Laminated Timber

ANSI 405-2008, American National Standard for Adhesives for Use in Structural Glued Laminated Timber

ASTM D2555-06 Standard Methods for Establishing Clear Wood Strength Values

ASTM D3737-09 Standard Method for Establishing Stresses for Structural Glued-Laminated Timber (Glulam) Manufactured from Visually Graded Lumber

ASTM D4444-08 Standard Test Methods for Use and Calibration of Hand-Held Moisture Meters

ASTM D5456-10a Standard Specification for Evaluation of Structural Composite Lumber Products

HISTORY OF PROJECT (NON-MANDATORY INFORMATION)

Commercial Standard CS 253-63, Structural Glued Laminated Timber, was developed at the request of the American Institute of Timber Construction (AITC) and was published in 1963.

In 1970, AITC requested that the National Bureau of Standards initiate a revision of CS 253-63 under the Procedures for the Development of Voluntary Product Standards. A proposed revision was approved by the Standing Committee in June 1972. The recommended revision was then circulated for acceptance in July 1972. The response to this circulation indicated that certain changes to the Standard were necessary. A new proposal was approved by the Standing Committee in October 1972. The new recommended Standard was circulated for acceptance in January 1973. The response to this circulation indicated a consensus among producers, distributors and users, in accordance with the published procedures. This edition of the Standard was designated PS 56-73, Structural Glued Laminated Timber, and became effective on July 1, 1973.

This Standard was also processed through ANSI and was given the designation ANSI A190.1-1973. Amendment 1 to this Standard was developed in accordance with the Department of Commerce Procedures for the Development of Voluntary Product Standards and became effective on July 19, 1976. In 1982, AITC requested that this Standard be revised as American National Standard ANSI/AITC A190.1-1983.

The revision was accomplished under the ANSI canvass process and was approved by the ANSI Board of Standards Review on June 3, 1983.

In 1991, AITC requested this Standard be revised as American National Standard ANSI/AITC A190.1-1992. This revision was again accomplished under the ANSI canvass process and approved by the ANSI Board of Standards Review on March 16, 1992.

In 2002, AITC requested this Standard be revised as American National Standard ANSI/AITC A190.1-2002. This revision was again accomplished under the ANSI canvass process and approved by the ANSI Board of Standards Review on October 10, 2002.

In 2007, AITC requested this Standard be revised as American National Standard ANSI/AITC A190.1-2007. This revision was again accomplished under the ANSI canvass process and approved by the ANSI Board of Standards Review on April 30, 2007.

In 2012, AITC requested this Standard be revised as American National Standard ANSI/AITC A190.1-2012. This revision was again accomplished under the Procedures for Development of American Institute of Timber Construction Consensus Standards and approved by the ANSI Board of Standards Review on January 23, 2013.

On January 1, 2013, APA – The Engineered Wood Association assumed the Secretariat responsibilities for this Standard and re-designated it as ANSI A190.1-2012.

ANSI A190.1-2012 Standard for Wood Products – Structural Glued Laminated Timber

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