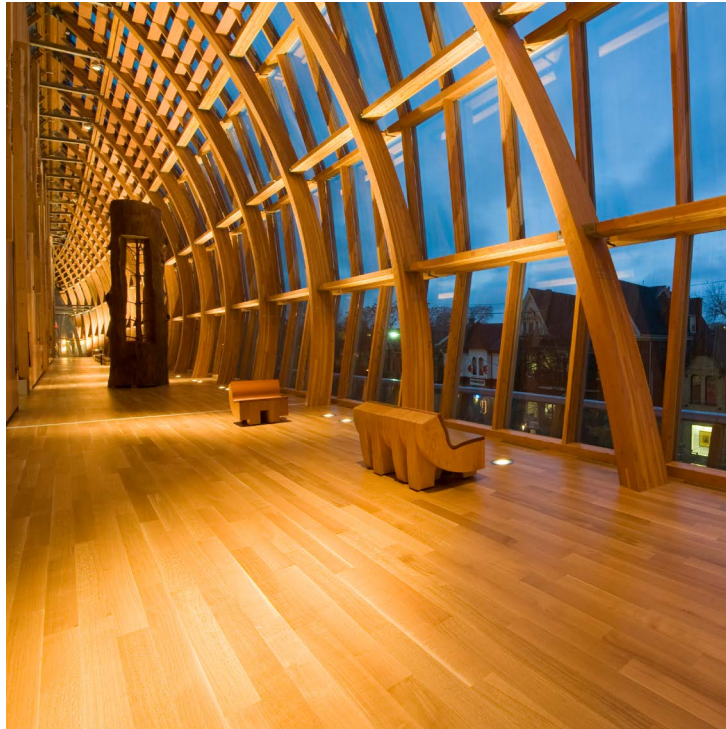


AMERICAN NATIONAL STANDARD

ANSI A190.1-2022

Product Standard for Structural Glued Laminated Timber



AMERICAN NATIONAL STANDARD

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Product Standard for Structural Glued Laminated Timber

APA – The Engineered Wood Association

Approved February 17, 2022
American National Standards Institute

FOREWORD (This Foreword is not a Part of American National Standard ANSI A190.1-2022)

This Standard, which was initiated by APA – The Engineered Wood Association, has been developed under the provisions of the American National Standards Institute (ANSI) as a revision of American National Standard, *Standard for Wood Products – Structural Glued Laminated Timber* (ANSI A190.1-2017). See History of Project in Appendix X1, for further information.

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. The maintenance of this Standard follows 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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ANSI A190.1-2022 Product Standard for Structural Glued Laminated Timber

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 (glulam), 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 glulam, including size tolerances, grade combinations, lumber, adhesives, appearance classifications, 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.

The notes and appendix included in this Standard are non-mandatory. This Standard incorporates the U.S. customary units as well as the International System of Units (SI). The values given in the U.S. customary units are the standard and the SI values given in parentheses are for information only. In case of a dispute on size measurements, the U.S. customary method of measurement shall take precedence.

2. REFERENCED DOCUMENTS

This Standard incorporates dated references. Subsequent amendments or revisions to these references apply to this Standard only when incorporated into this Standard by amendments or revisions.

2.1 U.S. Standards

ANSI 117-2020, Standard Specification for Structural Glued Laminated Timber of Softwood Species

ANSI 405-2018, Adhesives for Use in Structural Glued Laminated Timber

ANSI/AWC NDS-2018, National Design Specification for Wood Construction

ASTM D2555-17a, Standard Practice for Establishing Clear Wood Strength Values

ASTM D3737-18e1, Standard Practice for Establishing Allowable Properties for Structural Glued Laminated Timber (Glulam)

ASTM D4444-13(2018), Standard Method for Laboratory Standardization and Calibration of Hand-Held Moisture Meters

ASTM D5456-21e1, Standard Specification for Evaluation of Structural Composite Lumber Products

ASTM D7341-21, Standard Practice for Establishing Characteristic Values for Flexural Properties of Structural Glued Laminated Timber by Full-Scale Testing

2.2 Other Standards

AITC Test T102-2007, Adhesive Spread Measurement

AITC Test T103-2007, Calibration of Plant Pressure System: Bolts or Screw Type Jacks

AITC Test T104-2007, Calibration of Torque Wrenches

AITC Test T105-2007, Diagnostic Tests for Finger Joint Quality

AITC Test T107-2007, Shear Test

AITC Test T110-2007, Cyclic Delamination Test

AITC Test T115-2007, Machining Test for End Joints

AITC Test T116-2007, Modulus of Elasticity for E-Rated Lumber by Static Loading

AITC Test T118-2007, Bending Proof Loading for End Joints

AITC Test T119-2007, Full Size End Joint Tension Test

AITC Test T121-2007, Tension Proof Loading for End Joints

AITC Test T122-2007, Mix Ratio Check for Automatic Adhesive Mixing Machines

AITC Test T123-2007, 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

3. TERMINOLOGY

3.1 Definitions

See the referenced documents for definitions of terms used in this Standard.

3.2 Terms Specific to This Standard

Accredited Inspection Agency—an agency meeting the following requirements:

- a. has trained personnel to verify that the grading, measuring, species, construction, bonding, workmanship, and other characteristics of the products as determined by inspection in compliance with all applicable requirements specified in this Standard,
- b. has written procedures to be followed by its personnel in performance of the inspection,
- c. has no financial interest in, or is not financially dependent upon, any single company manufacturing the product being inspected,
- d. is not owned, operated, or controlled by any such company, and
- e. is accredited by a recognized accreditation body under ISO/IEC 17020

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

Assembly Time, Closed—the time interval between the assembling of adhesive-coated surface and the application of heat/or pressure to set the adhesive

Assembly Time, Open—the time interval between adhesive application to the laminations or end joints and assembly of the adhesive joints

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

Block-gluing—the process for bonding glulam components into a block-glued glulam using a gap-filling adhesive

Bond Line—the layer of adhesive which attaches two laminations or end joints

Camber—a small amount of curvature built into a glulam to offset anticipated deflection or to facilitate roof drainage

Certificate of Conformance—a certificate issued by an approved agency certifying that the product is in conformance to a standard or standards

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

Curved Members—glulam members which are designed and manufactured 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 and marked as required in Section 14.2

Note 1: Prismatic glulam manufactured in accordance with a layup combination provided in ANSI 117 and marked in accordance with Section 14.1 are not considered as Custom Members, regardless of the glulam size.

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

Glulam—see structural glued laminated timber

Glulam, Add-on—a glulam manufactured by adding one or more individual laminations to a pre-fabricated glulam in accordance with the layup requirements of the finished glulam (see Section 7.3.2)

Glulam, Block-glued—a glulam with solid rectangular cross-section comprised of 2 or more glulam components bonded together using a gap-filling adhesive and a layup required for the finished glulam (see Section 7.3.4)

Glulam, Re-glued—a glulam manufactured by gluing together 2 glulam components that were pre-pressed in the same process using a gap-filling adhesive and a layup required for the finished glulam (see Section 7.3.3)

Note 2: A large glulam may exceed the planer size even though it can be accommodated by the beam press. When manufacturing such a large glulam, the re-gluing process intentionally leave an unglued (dry) face joint between top and bottom sections of the glulam so that each part can be planed individually and re-glued to the final finished size. Re-glued glulam is typically used to manufacture a deeper finished glulam. Re-glued glulam is primarily different from block-glued glulam in that the components for the former are usually tight-fit from the initial pressing operation, while the components for the latter may not be as tight-fit. Re-gluing is permitted for 1 face joint and may be applicable to prismatic or curved members, but block-gluing is limited to prismatic members only. Re-glued glulam is limited to re-gluing of 2 glulam components due to the need to maintain the tight-fit between those 2 glulam components.

Glulam Component—a glulam manufactured for block-gluing or re-gluing into a larger finished glulam

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—wood strips used for non-structural repairs in the sides of glulam

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—a 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 of lumber or SCL that have been tapered to form sloping plane surfaces and, 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 glulam; (adj) pertaining to the process of manufacturing glulam

Lamination—a single layer of wood material extending the full width and full length of the finished glulam 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 and marked as required in Section 14.1

Note 3: California Building Code requires glulam used by the Department of Health Care Access and Information (HCAI, formerly the Office of Statewide Health Planning and Development or OSHPD) to be continuously inspected except for non-custom glulam members of 5-1/2 inches (140 mm) in maximum width, 18 inches (457 mm) in maximum depth and 32 feet (9.8 m) clear span in maximum length.

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 5% tolerance limit with 75% confidence from end joint qualification by 1.67

Reference Design Values—design value used in the U.S. based on normal duration of load, dry-service conditions, and reference temperatures up to 100°F (38°C) for Allowable Stress Design (ASD)

Note 4. Load and Resistance Factor Design (LRFD) values may be converted from the ASD reference design values in accordance with the National Design Specification for Wood Construction (NDS).

Re-gluing—the process for bonding glulam components into a re-glued glulam using a gap-filling adhesive

Ripping—the process of sawing any width lumber to develop narrower lumber

Sample—a group of specimens collected for testing

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

Structural Composite Lumber (SCL)—an engineered wood product that is intended for structural use and bonded with adhesives, and meeting the definition and requirements of ASTM D5456

Structural Glued Laminated Timber (Glulam)—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 composed 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

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

4. GENERAL REQUIREMENTS

Glulam represented as conforming to this Standard shall meet all of the requirements specified herein, subject to the minor variations described in Section 4.1.

Basic elements used to manufacture the glulam shall meet the requirements of Sections 6, 7 and 8. Manufacturing shall conform to the requirements in Sections 9, 10, 11 and 12, and the plant's procedures manual. All production shall be inspected and tested in accordance with Section 13. Products meeting the requirements of this Standard shall be marked in accordance with Section 14. The plant shall be subject to regular periodic auditing by an accredited inspection agency as defined in Section 3.

4.1 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.

4.2 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 ASTM D7341 for flexural properties. Grade combinations shall be approved by an accredited inspection agency except that the grade combinations and their corresponding design values provided in ANSI 117 shall be permitted for use in conjunction with this Standard. Alternate grades of lumber are permitted to be used to replace standard laminating grades in grade combinations developed in accordance with ASTM D3737 or ASTM D7341, provided that the alternate grades are qualified in accordance with AITC 407.

4.2.1 Fire-Resistance-Rated Glulam

Custom or non-custom members manufactured to provide a one-hour fire rating shall be manufactured to the specified layout except that a core lamination shall be removed, the tension zone moved inward, and the equivalent of one additional nominal 2-in. (38-mm) thickness outer tension lamination added. Members manufactured to provide a two-hour fire rating shall be manufactured to the specified layout except that two core laminations shall be removed, the tension zone moved inward, and the equivalent of 2 additional nominal 2-in. (38-mm) thickness outer tension laminations added. Fire-resistance-rated glulam shall be marked in accordance with Section 14.3.

4.3 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,
- c. A visual inspection of the finished production, and
- d. Periodic auditing by an accredited inspection agency as defined in Section 3.

5. TOLERANCES

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

5.1 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.

5.2 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.

5.3 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.

5.4 Tolerances for Other Measurements

Tolerances for measurements not addressed in Sections 5.1, 5.2, and 5.3 shall be as agreed upon between buyer and seller.

6. LUMBER FOR LAMINATING

6.1 Species

For purposes of this Standard, softwood and hardwood species shall be approved for use in glulam if stress indices and knot distributions are established as described in ASTM D3737, the wood species comply with requirements for layups or combinations developed in accordance with ASTM D7341, or other proposed criteria are determined to be in conformance with this Standard by the Technical Review Board.

6.2 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 glulam 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.

6.3 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 6.4.

6.3.1 Visually Graded Lumber

Lumber shall be graded according to standard grading rules approved by the Board of Review of the American Lumber Standard Committee (ALSC) 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.

6.3.2 Mechanically Graded Lumber

Mechanically graded lumber shall be graded according to standard grading rules approved by the Board of Review of the ALSC 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.

6.3.3 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.

6.3.4 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.

6.4 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 6.3.

6.5 Structural Composite Lumber (SCL)

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

7. LAMINATIONS

7.1 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. For species requiring resurfacing before gluing, the lapse time between resurfacing and gluing shall not exceed 24 hours unless a longer lapse time is qualified and documented in the Plant Manual.

7.2 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.

7.3 Lamination Thickness

7.3.1 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 an accredited inspection agency.

7.3.2 Add-on Glulam

7.3.2.1 A gap-filling adhesive shall not be required for bonding add-on laminations not exceeding 2 in. (51 mm) in net thickness.

7.3.2.2 Add-on glulam shall be manufactured with add-on laminations of the same nominal thickness as the laminations used in the original glulam. For each add-on glulam, the bonding surfaces of laminations shall meet the surfacing requirements specified in Sections 7.1.

7.3.2.3 Add-on glulam shall meet the layup requirements for the layup combination of the finished glulam.

7.3.3 Block-Glued Glulam

7.3.3.1 Block-glued glulam shall be manufactured using a gap-filling adhesive. Block-gluing of 2 or more glulam components shall be permitted. The glulam components shall be limited to prismatic straight glulam.

7.3.3.2 Each glulam component shall comply with this Standard. For each block-glued glulam, the bonding surfaces of glulam components shall meet the surfacing requirements specified in Sections 7.1. End jointing of glulam components shall not be permitted.

7.3.3.3 Block-glued glulam shall meet the requirements for the layup combination of the finished glulam.

7.3.4 Re-Glued Glulam

7.3.4.1 Re-glued glulam shall be manufactured using a gap-filling adhesive. Re-gluing shall be limited to 2 glulam components (i.e., 1 dry glue bond).

7.3.4.2 Re-gluing of re-glued glulam shall be completed within 72 hours after the glulam components are manufactured unless a longer lapsed time is specifically qualified, approved by an accredited inspection agency, and documented in the Plant Manual.

7.3.4.3 Each glulam component shall comply with this Standard. For each re-glued glulam, the bonding surfaces of glulam components shall meet the surfacing requirements specified in Sections 7.1. End jointing of glulam components shall not be permitted.

7.3.4.4 Re-glued glulam shall meet the layup requirements for the layup combination of the finished glulam.

7.4 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 5.1 and 5.3. Warp and cup shall not be so great that they will not be straightened out by pressure in bonding.

7.4.1 Thickness Tolerances for Laminating with Gap-Filling Adhesives

Where gap-filling adhesives which meet the requirements of Section 8.2 are used, all requirements of Section 7.4 apply except that variations in thickness of laminations are permitted to exceed the limitations specified in Section 7.4 but the maximum bond line thickness shall not exceed 1/16 in. (2 mm).

8. ADHESIVES

Adhesives required by this Standard shall conform to the requirements of ANSI 405.

8.1 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.

8.2 Gap-Filling Adhesives

Gap-filling adhesives shall meet all requirements of ANSI 405 and this Standard 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. Gap-filling adhesives shall be used for block-glued and re-glued glulam in accordance with Sections 7.3.3 and 7.3.4, respectively.

9. WOOD INSERTS

Wood inserts are permitted to be used to meet appearance classification requirements. The moisture content of inserts shall be in accordance with Section 6.2. Adhesives and the method for attaching inserts shall provide durability characteristics appropriate for the end use.

9.1 Maximum Insert Depth

- a. Insert depth shall be limited to 1/2 in. (13 mm) for laminations less than 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.

10. FACE AND EDGE JOINTS

The selection and preparation of lumber, laminations, and adhesives shall be in accordance with Sections 6, 7, and 8. Glulam components for block-glued and re-glued glulam shall meet all requirements of this Standard before block-gluing or re-gluing into the finished glulam.

10.1 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 is 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.

10.2 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.

10.3 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 the 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 10.2, 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.

10.4 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.

11. END JOINTS

End joints shall be bonded in accordance with the requirements for face joint bonding with appropriate modifications to the adhesive spreading, assembly time, application of pressure and curing time for the methods used. End jointing glulam shall not be permitted.

End joints shall be qualified in accordance with Section 13.1.3.

11.1 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.

11.2 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).

11.3 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.

11.4 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 3 or more 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.

11.5 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 (1.8 m).
- 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.

11.6 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.

12. APPEARANCE CLASSIFICATIONS

Glulam shall be finished to a Framing, Framing-L, Industrial, Industrial-L, Architectural or Premium classification unless otherwise agreed upon by buyer and seller.

12.1 Framing Appearance Classification

12.1.1 Lamination Characteristics

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

12.1.2 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.

12.1.3 Wane

Pencil wane is permitted in all combinations and is not limited in length, subject to the provisions in Section 12.1.4. 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 12.1.4. Wane permitted in specific laminating combinations up to 1/6 the lumber width on each side is not limited in length.

12.1.4 Surfacing

Members are required to be surfaced 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.

12.2 Framing-L Appearance Classification

This appearance classification is the same as the Framing appearance classification except that the “L” indicates that SCL has been used for the outer laminations. All other characteristics remain the same as those listed for the Framing appearance classification.

12.3 Industrial Appearance Classification

12.3.1 Lamination Characteristics

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

12.3.2 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.

12.2.3 Wane

Pencil wane is permitted in all combinations and is not limited in length, subject to the provisions of Section 12.3.4. 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 12.3.4. Wane permitted in specific laminating combinations up to 1/6 the lumber width on each side is not limited in length.

12.3.4 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.

12.4 Industrial-L Appearance Classification

This appearance classification is the same as the Industrial appearance classification except that the “L” indicates that SCL has been used for the outer laminations. All other characteristics remain the same as those listed for the Industrial appearance classification.

12.5 Architectural Appearance Classification

12.5.1 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. SCL shall not be used for any laminations of this appearance classification.

12.5.2 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.

12.5.2.1 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.

12.5.2.2 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.

12.5.3 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 12.5.2.1.

12.5.4 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.

12.6 Premium Appearance Classification

12.6.1 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 (1.8 m) length. Otherwise, laminations are permitted to possess the natural growth characteristics of the lumber grade. SCL shall not be used for any laminations of this appearance classification.

12.6.2 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.

12.6.2.1 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.

12.6.2.2 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.

12.6.3 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 12.6.2.1.

12.6.4 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.

13. 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 13.1 and verification of such qualification by an accredited inspection agency.
- b. Adhesive lot testing as required in Section 13.2.
- c. Daily quality control as required in Section 13.3, 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 13.4).
- e. Plant manuals (see Section 13.5).
- f. Quality control records (see Section 13.6).

13.1 Plant and Process Qualification

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

- a. Bonding qualification described in Section 13.1.1.
- b. Face and edge joint qualification described in Section 13.1.2.
- c. End joint qualification described in Section 13.1.3.
- d. Qualification of special materials used by the plant such as alternate lumber grades in accordance with AITC 407, SCL in accordance with AITC 402 or ASTM D5456, and manufactured lumber in accordance with AITC 401.
- e. Qualification of special processes used by the plant such as proof-grading lumber in accordance with AITC 406, lamination repairs in accordance with AITC 403, and radial reinforcement in accordance with AITC 404.
- f. Physical tests used by the plant for daily quality control shown in Section 13.1.5.
- g. Current calibration of test equipment and production gauges.

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

TABLE 1

SUMMARY OF QUALIFICATION TESTS

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 ^c	2 beams ^{a,b} – 1 open assembly 1 closed assembly	10 total bond lines for each assembly	T107 Shear	Strength and Wood Failure	13.1.1 13.1.2
	2 beams ^{a,b} – 1 open assembly 1 closed assembly	3 sample blocks from each assembly	T110 Cyclic Delamination	Bond Line Openings	13.1.1 13.1.2
End Joints	1 ^a	30	T119 Tension	Strength and Wood Failure	13.1.1 13.1.3
	1 ^a	5	T110 Cyclic Delamination	Bond Line Openings	13.1.1 13.1.3
<i>The following tests are required in addition to the above requirements when these processes and/or materials are used in the plant.</i>					
Proof Loaded End Joints	2	30	T118 Bending or T121 Tension	Strength	13.1.3.3
End Joints for Repair	10 Repairs	2	T119 (Modified) Tension	Strength and Wood Failure	13.1.3 13.1.3.4
	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 SCL/SCL plus SCL/Wood	ASTM D5456 AITC 402
			T116	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
Block-Glued (Edge or Face) or Re-Glued Glulam (Face only)	2 beams ^e – 1 open assembly 1 closed assembly	9 specimens for secondary glue bonds for each assembly	T107 Shear	Strength and Wood Failure	13.1.2.1, 13.1.2.2 or 13.1.2.3
	2 beams ^e – 1 open assembly 1 closed assembly	3 specimens for secondary glue bonds for each assembly	T110 Cyclic Delamination	Bond Line Openings	13.1.2.1, 13.1.2.2 or 13.1.2.3

a. For each adhesive-species-treatment combination used (SCL is considered a separate species for testing requirements).

b. When edge joint bonding is a structural requirement.

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

d. End joint repair procedures must be verified for adequacy by supplemental full-scale beam tests in addition to AITC Test T119.

e. See sampling requirements specified in 13.1.2.1, 13.1.2.2 or 13.1.2.3, as applicable.

13.1.1 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.

13.1.1.1 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 an accredited inspection agency.

13.1.1.2 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 (16.5 MPa) or higher, a separate qualification is not required for Group 3 species for QSLs of 2000 psi (13.8 MPa) 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.

13.1.2 Face and Edge Joint Qualification

- a. Face and edge joints shall be prepared meeting the requirements of Section 10 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 bond lines from each of two beams shall be tested using AITC Test T107. The average shear strength of all specimens from each beam 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. Alternatively, the average shear strength of all specimens from each beam shall equal or exceed the value provided in Table 2. 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 from each beam 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 from each specimen.

TABLE 2

REQUIRED SHEAR STRENGTH OF ADHESIVE JOINTS

Species or Species Group ^a	Required Average Shear Strength at Moisture Content of					
	12% or Below		14%		16%	
	psi	MPa	psi	MPa	psi	MPa
Alaska Cedar	1020	7.0	980	6.8	930	6.4
California Redwood ^b	850	5.9	820	5.7	790	5.4
Douglas Fir	1020	7.0	980	6.8	940	6.5
Douglas Fir South	1360	9.4	1270	8.8	1180	8.1
Eastern Spruce	1080	7.4	1010	7.0	950	6.5
Hem-Fir	1040	7.2	980	6.8	930	6.4
Lodgepole Pine	790	5.4	760	5.2	730	5.0
Port-Orford Cedar	1230	8.5	1140	7.9	1060	7.3
Red Oak	1600	11.0	1500	10.3	1420	9.8
Softwood Species ^c	790	5.4	760	5.2	730	5.0
Southern Pine	1250	8.6	1150	7.9	1040	7.2
Sugar Maple	2100	14.5	1950	13.4	1820	12.5
Western Hemlock	1160	8.0	1110	7.7	1050	7.2
Western Larch	1220	8.4	1160	8.0	1100	7.6
White Oak	1800	12.4	1680	11.6	1560	10.8

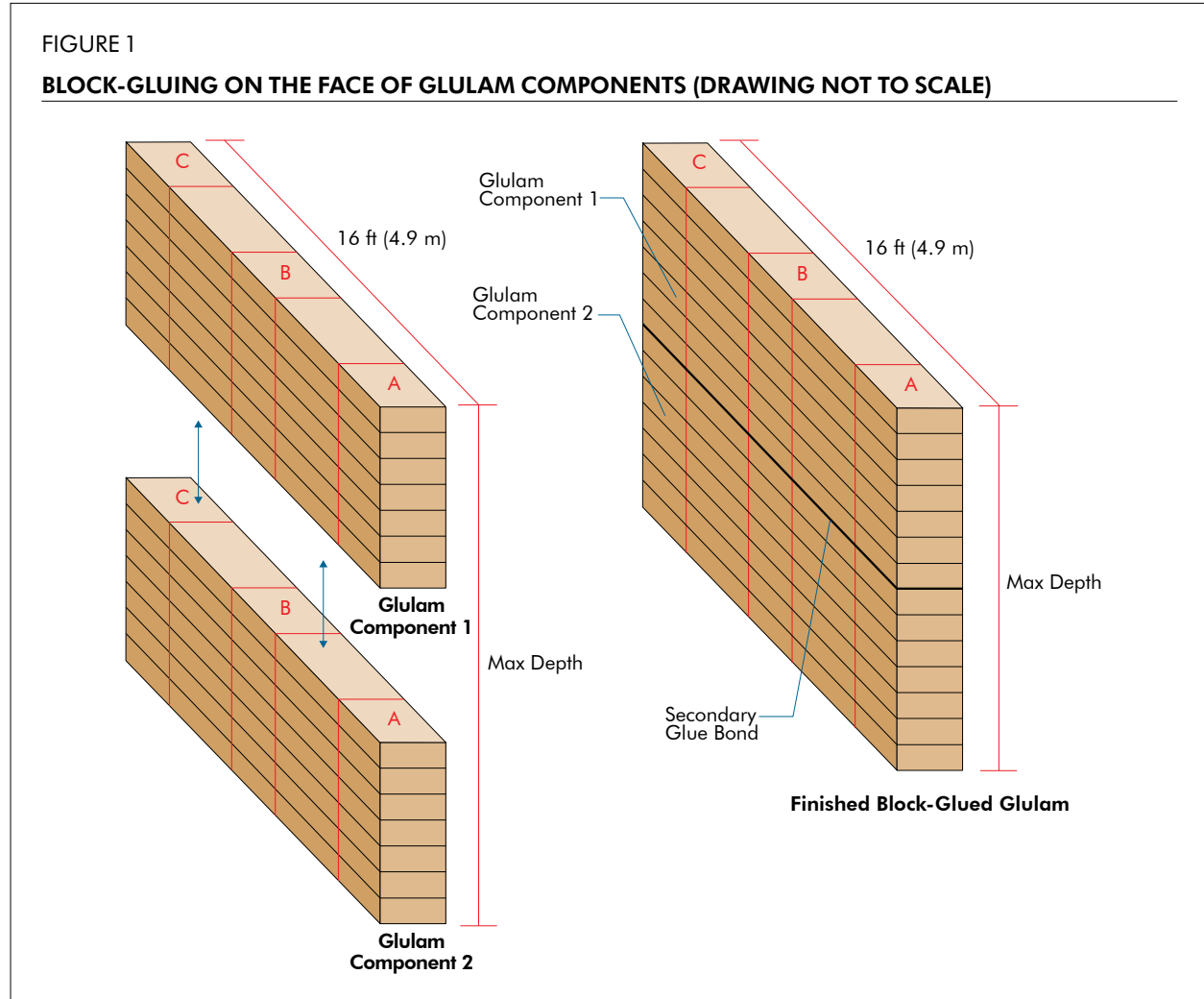
a. For other species or species groups, the value shall be based on 90% of the shear strength parallel to grain as determined from the data and procedures presented in ASTM D2555 or Wood Handbook.

b. Average shear for old growth and new growth California Redwood.

c. Based on the species with the lowest shear strength included in Softwood Species (Lodgepole Pine).

13.1.2.1 Face Joint Qualification for Block-Glued Glulam

Face joints used for the face bond qualification of block-glued glulam shall be obtained from a minimum of 2 finished block-glued glulams (test beams), 1 open assembly and 1 closed assembly, as shown in Figure 1.



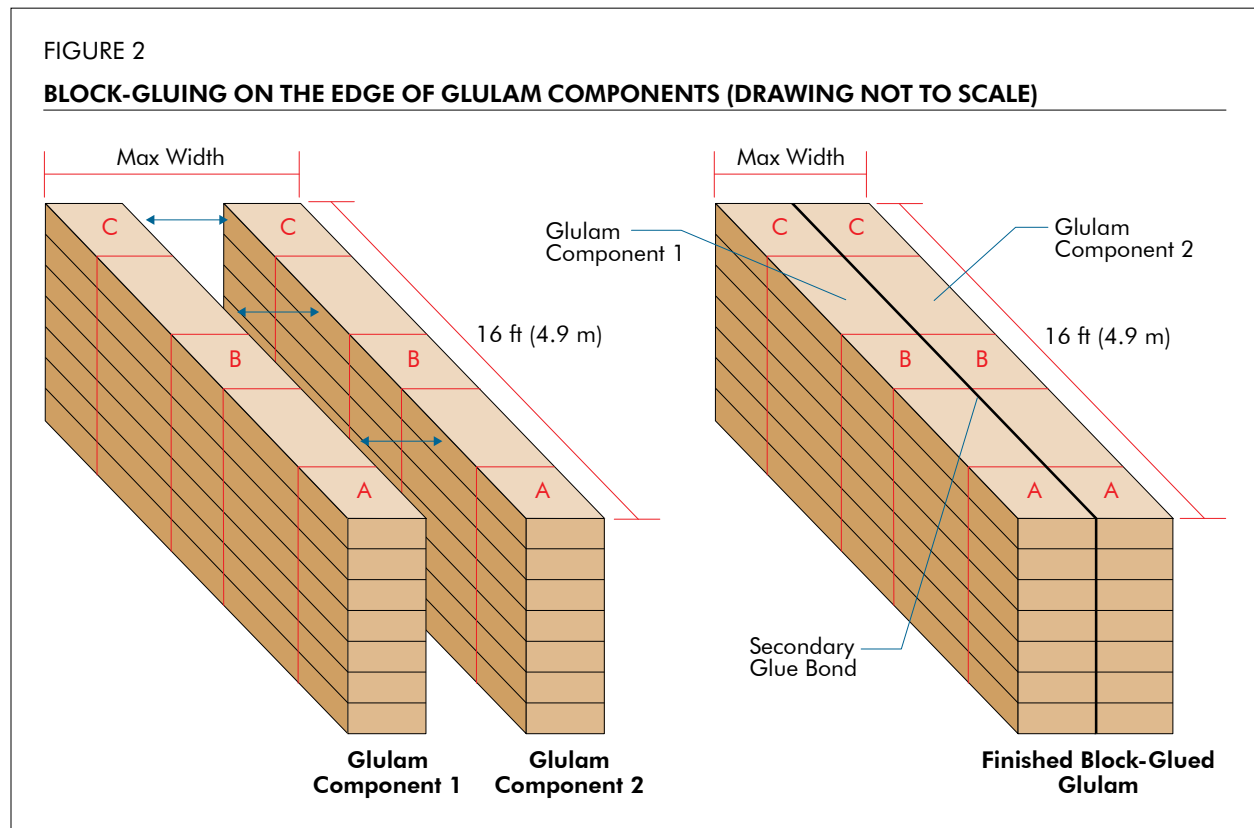
Face bonding of block-glued glulam shall be qualified as follows:

1. Each test beam (finished block-glued glulam), as shown in Figure 1, shall be manufactured with the maximum depth intended for qualification with the secondary glue bond placed at mid-depth of the finished beam. Each test beam shall be at least 16 feet (4.9 m) in length.
2. Three sections (A, B and C in Figure 1) shall be sampled from both ends and the center of each test beam to prepare the specimens for AITC Tests T107 and T110.

3. For AITC Test T107, 3 shear specimens shall be prepared from each section (A, B or C in Figure 1) with the secondary glue bond in the shear plane. The average shear strength and average wood failure of the secondary glue bond obtained from all 9 specimens in each test beam shall meet the requirements specified in Section 13.1.2(b).
4. For AITC Test T110, a specimen of 8 or more laminations in depth with the secondary glue bond located in the center of the specimen depth shall be prepared from each section (A, B or C in Figure 1). Cyclic delamination of each specimen on the secondary glue bond shall meet the requirements specified in Section 13.1.2(c).
5. All qualified manufacturing details shall be documented and included in the Plant Manual in accordance with Section 13.5.

13.1.2.2 Edge Joint Qualification for Block-Glued Glulam

Edge joints used for the edge bond qualification of block-glued glulam shall be obtained from a minimum of 2 finished block-glued glulams (test beams), 1 open assembly and 1 closed assembly, as shown in Figure 2.



Edge bonding of block-glued glulam shall be qualified as follows:

1. Each test beam (finished block-glued glulam), as shown in Figure 2, shall be manufactured with the maximum width intended for qualification with the secondary glue bond placed at mid-width of the finished beam. Each test beam shall be at least 16 feet (4.9 m) in length.
2. Three sections (A, B and C in Figure 2) shall be sampled from both ends and the center of each test beam to prepare the specimens for AITC Tests T107 and T110.
3. For AITC Test T107, 3 shear specimens shall be prepared from each section (A, B or C in Figure 2) with the secondary glue bond in the shear plane. The average shear strength and average wood failure of the secondary glue bond obtained from all 9 specimens in each test beam shall meet the requirements specified in Section 13.1.2(b).
4. For AITC Test T110, a specimen of 6 or more laminations in depth with the secondary glue bond located in the center of the specimen width shall be prepared from each section (A, B or C in Figure 2). Cyclic delamination of each specimen on the secondary glue bond shall meet the requirements specified in Section 13.1.2(c).
5. All qualified manufacturing details shall be documented and included in the Plant Manual in accordance with Section 13.5.

13.1.2.3 Face Joint Qualification for Re-Glued Glulam

Face joints used for the face bond qualification of re-glued glulam shall be obtained from a minimum of 2 finished re-glued glulams (test beams), 1 open assembly and 1 closed assembly, as shown in Figure 1. Face bonding of re-glued glulam shall be qualified in accordance with Section 13.1.2.1 with the following exceptions:

- a. Radius of the glulam components shall represent the smallest radius intended for re-gluing, and
- b. A minimum of 72 hours shall be lapsed after the glulam components are manufactured before re-gluing unless a longer lapsed time is intended to be qualified.

13.1.3 End Joint Qualification

- a. Full-size end joint specimens shall be prepared meeting the requirements of Section 11 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 an 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 from each specimen.

13.1.3.1 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 3.

Note 5: For example, when 2x8 end joints are manufactured with 302-24 Douglas fir tension lamination for qualification, the required tension test value at 5% tolerance limit with 75% confidence, when the end joints are tension-tested at its full width of 2x8, is the requirement for a 2x6 end joint of 4,000 psi (27.6 MPa) times the strength adjustment factor of 0.95 provided in Table 3, or 3,800 psi (26.2 MPa). See Section 13.1.3.5 if each end joint is split into 2 pieces of 2x4 for tension testing.

TABLE 3
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

13.1.3.2 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.

13.1.3.3 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.

13.1.3.4 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.

13.1.3.5 Split End Joints

If the end joint is larger than 2x6 (38 mm x 140 mm) and is split into 2 equal-width pieces prior to tension testing to accommodate small-capacity tension test machines, the average of those 2 split pieces shall be multiplied by the correction factors listed in Table 4 when compared to the required tensile strength.

TABLE 4

CORRECTION FACTORS FOR TENSION TEST RESULTS OBTAINED FROM SPLIT END JOINTS

Size	Correction Factor to Adjust to Nominal 2x6 (38 mm x 140 mm)		Correction Factor to Adjust to the Width Before Splitting	
	All Species Except Southern Pine	Southern Pine	All Species Except Southern Pine	Southern Pine
Split 2 x 8 (38 mm x 184 mm)	0.95	0.99	0.90	0.97
Split 2 x 10 (38 mm x 235 mm)	0.97	0.99	0.87	0.94
Split 2 x 12 (38 mm x 286 mm)	1.00	1.00	0.85	0.93

Note 6: For example, when 2x8 end joints are manufactured with 302-24 Douglas fir tension lamination for qualification but the tension test machine at the manufacturing facility does not have the capacity to break the end joints in full width, each 2x8 end joint may be split into 2 pieces of 2x4. The average tension value obtained from both 2x4 split end joints for each 2x8 end joint should be adjusted by the correction factor of 0.90 provided in Table 4 to represent the tensile strength of the parent 2x8 end joint. The adjusted tension test value for all 2x8 end joints at 5% tolerance limit with 75% confidence is compared to the 2x8 end joint tension requirement of 3,800 psi (26.2 MPa) in accordance with Note 5.

Alternatively, the average tension value obtained from both 2x4 split end joints for each 2x8 end joint may be adjusted by the correction factor of 0.95 provided in Table 4 to represent the tensile strength of a standard 2x6 end joint. However, the adjusted tension value test value for the standard 2x6 end joints at 5th percentile with 75% confidence should be compared to the 2x6 end joint tension requirement of 4,000 psi (27.6 MPa).

13.1.4 Other Qualification Tests

All inspection and test procedures required in Section 13.2 for daily quality control shall be performed as a part of the qualification procedure.

13.2 Adhesive Lot Testing

Each new lot of adhesive previously qualified under Section 13.1.1 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 glulam 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.

13.2.1 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 all specimens from each beam 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 from each beam 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.

13.2.2 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 13.1.3.

13.2.3 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 from each specimen. Face and end joint test specimens shall be prepared using the same adhesive curing procedures used in production.

13.3 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.

13.3.1 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.

13.3.2 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. The secondary glue bond for block-glued and re-glued glulam shall be subject to off-line tests. A summary of daily quality control tests is shown in Table 5.

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.

TABLE 5

SUMMARY OF OFF-LINE TESTS – FOR DAILY REQUIREMENTS

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,f}	10	T107 Shear	Strength and Wood Failure	13.3.4
	1	T110 Cyclic Delamination	Bond Line Openings	13.3.6
End Joints ^{a,c}	2	T119 Tension	Strength and Wood Failure	13.3.5
	Varies ^d	T105 ^e		13.3.5
	1	T110 Cyclic Delamination	Bond Line Openings	13.3.6
<i>The following tests are required in addition to the above requirements when these processes and/or materials are used in the plant.</i>				
Proof Loaded End Joints	All joints tested in production.	T118 Bending or T121 Tension	Strength	13.3.5.3
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 13.3.5.4
	1	T110 Cyclic Delamination	Bond Line Openings	AITC 403 13.3.6
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
		T123 Tensile Properties	Strength	AITC 406
Block-Glued (Edge or Face) or Re-Glued Glulam (Face only) ^g	6 specimens with a secondary glue bond from each sampled member	T107 Shear	Strength and Wood Failure	13.3.4
	2 specimens with a secondary glue bond from each sampled member	T110 Cyclic Delamination	Bond Line Openings	13.3.6

- 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.
- g. See sampling requirements specified in 13.3.4 or 13.3.6, respectively, as applicable.

13.3.3 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 13.1.1.1, 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.

13.3.4 Face and Edge Joints

- a. A minimum of one sample shall be taken from every 50,000 board feet (118 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.

- b. For the secondary glue bond of block-glued and re-glued glulam, a section shall be taken from each end of every 3 or less production members. Samples shall be representative of production glulams made under production conditions during each work shift. Three shear specimens shall be prepared from each section in accordance with Section 13.1.2.1 or 13.1.2.2, as applicable, for block-glued glulam or Section 13.1.2.3 for re-glued glulam.

13.3.4.1 Tests for Face Joint Bonding

- a. 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. Alternatively, the shear strengths of all specimens to be evaluated shall be averaged and this average shall equal or exceed the value provided in Table 2.

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.

- b. For block-glued or re-glued glulam, shear tests on the secondary glue bond shall be conducted in accordance with AITC Test T107. The average shear strength and wood failure of all specimens on the secondary glue bond, as obtained from each sampled production member, shall meet the requirements specified in Section 13.3.4.1(a).

13.3.4.2 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 13.3.4.1 shall be met.

13.3.5 End Joints

A lot size shall be established by the laminator and approved by an 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 (118 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 (118 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.

13.3.5.1 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.

13.3.5.2 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 13.3.4.1 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.

13.3.5.3 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.

13.3.5.4 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.

13.3.6 Tests for Integrity of Adhesive Bonds

- a. 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 for each specimen 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 specimen, in which case the delamination shall not exceed 10%.
- b. A cyclic delamination specimen shall be taken from each end of every 3 or less production members in accordance with Section 13.1.2.1 or 13.1.2.2, as applicable, for block-glued glulam or Section 13.1.2.3 for re-glued glulam. Samples shall be representative of production glulams made under production conditions during each work shift. Cyclic delamination tests shall be conducted in accordance with AITC Test T110. Delamination for each specimen on the secondary glue bond, as obtained from each sampled production member, shall meet the requirements specified in Section 13.3.6(a).

13.3.7 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 classification.
- 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 1/16 in. (2 mm) or less 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.

13.4 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.

13.5 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 an accredited inspection agency and shall be reviewed periodically by that agency.

13.6 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 4.1.

14. MARKING

Glulam represented to comply with this Standard shall be distinctively marked..

14.1 Non-Custom Members

Non-custom members shall be marked with the following:

- a. Identification of this Standard, **ANSI A190.1**
- b. Identification of an accredited inspection agency (see Section 3.2)
- c. Identification of the laminating plant
- d. The species or species group of lumber in the glulam
- 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 classification denoted by **FRAM** – Framing, **FRAM-L** – Framing-L, **IND** – Industrial, **IND-L** – Industrial-L, **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).

Non-custom members shall not be required to be marked as “Non-Custom.”

14.1.1 Frequency of Marking

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.

14.2 Custom Members

For members laminated to meet specific job specifications (custom members), the marking shall consist of only items (a), (b), (c), (h), and (i) in Section 14.1. Custom-made members 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. Custom members shall not be required to be marked as “Custom.”

Note 7: Custom members have less stringent marking requirements than non-custom members because the end use is usually known and the relevant information can be communicated in documentation for the specific job rather than relying on markings on the members. In addition, non-custom members are marked every 8 ft (2.4 m) to allow for cutting into shorter lengths prior to installation, where custom members are only required to be marked at one location.

14.3 Fire-Resistance Ratings

Fire-resistance-rated glulam members, when manufactured in accordance with Section 4.2.1, are permitted to be marked with a **1-HOUR FIRE RATING** or a **2-HOUR FIRE RATING** designation, as applicable.

14.4 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 14.1.1.

14.5 Certification of Conformance

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

14.6 Dual Manufacture

This Standard is applicable to glulam 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.

14.7 Marking Truss Members

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

14.8 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.

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 glulam 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 glulam 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 glulam 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 to be represented by this member. 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 to be represented by this member. 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 members of Categories 15.2 (c), 15.2 (d), and 15.2 (e) 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.

APPENDIX X1: 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 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.

In 2017, this Standard was revised as ANSI A190.1-2017 and approved by ANSI on January 24, 2017.

In 2022, this Standard was revised as ANSI A190.1-2022 and approved by ANSI on February 17, 2022 with the title change from Standard for Wood Products – Structural Glued Laminated Timber to Product Standard for Structural Glued Laminated Timber. Major changes to this Standard included the introduction of new qualification and quality assurance requirements for add-on, block-glued, and re-glued glulam, and the addition of correction factors for tension test results obtained from split end joints (see Table 4), which had been used by the glulam industry for years but had not been included in this Standard. In addition, the layup combinations provided in ANSI 117 were recognized in this Standard and the required average shear strengths for adhesive joints are tabulated (see Table 2). The format of this Standard was also updated by relocating the definition section to the front portion of this Standard for consistency with most national and international standards.

The names of ANSI A190.1 Committee members when this Standard is published are as follows. The current list of the committee membership is available from the Committee Secretariat upon request.

Name	Affiliation	Note
DeepaReddy Akula	Vinside Capital	
Linda Brown	Southern Pine Inspection Bureau	
Kevin Cheung	Western Wood Products Association	
Mark Clark	Hexion, Inc.	ExSub Member
David Conner	Timber Products Inspection, Inc.	
Brad Douglas	American Wood Council	
Julie Frappier	Nordic Structures	
Bill Gareis	Ashland Chemical	
William Gould	ICC-ES	
Jim Henjum	SmartLam N.A.	
Benjamin Herzog	University of Maine	
Levi Huffman	DR Johnson Wood Innovations	
Jessica Jennings	Georgia-Pacific Chemicals, LLC	
Henry Morris	Pacific Lumber Inspection Bureau	ExSub Member
Jeff Morrison	Rosboro LLC	Chair
Brent Olson	PFS TECO	
Steven Reiersen	Akzo Nobel Coatings, Inc.	
Andreas Rhude	Consultant	
Glen Robak	Weyerhaeuser	
Sheldon Shi	University of North Texas	
Jeffrey Stefani	Anthony Canfor	
Robert Taylor	Boise Cascade	
Leif Van Cott	Unalam	
Travis Van De Vliert	Western Archrib	
Chris Whelan	Henkel Corporation	
Tom Williamson	Timber Engineering, LLC	Vice-Chair
Clay Winje	Kalesnikoff Lumber	
B.J. Yeh	APA - The Engineered Wood Association	Secretariat
Larry Zhou	Universal Timber Structures Inc	

Inquiries or suggestions for improvement of this Standard should be directed to:

Secretariat, ANSI A190.1

APA – The Engineered Wood Association

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ANSI A190.1-2022 Product Standard for Structural Glued Laminated Timber

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