AMERICAN NATIONAL STANDARD

ANSI 405-2023

Standard for Adhesives for Use in Structural Glued Laminated Timber

Approved American National Standard

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Standard for Adhesives for Use in Structural Glued Laminated Timber

APA – The Engineered Wood Association

Approved January 19, 2023
American National Standards Institute

FOREWORD **(This Foreword is not a part of American National Standard ANSI 405-2023)**

This Standard is a revision of ANSI 405-2018. It contains minimum requirements to evaluate adhesives for use in structural glued laminated timber.

The development of this consensus American National Standard was achieved by following the *Operating Procedures for Development of Consensus Standards of APA – The Engineered Wood Association*, approved by the American National Standards Institute (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 405-2023 Standard for Adhesives for Use in Structural Glued Laminated Timber

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 ANSI 405-2018, *Standard for Adhesives for Use in Structural Glued Laminated Timber*. See History of Standard in Appendix X2, for further information.

1. SCOPE

This Standard provides minimum requirements to evaluate adhesives for use in structural glued laminated timber (glulam). Adequacy of the adhesive is established by meeting or exceeding the criteria outlined in Section 4.

Alternative tests shall not be permitted to substitute for the tests prescribed in this Standard. Although the test methods specified in this Standard are primarily intended for evaluation of face bond adhesives, the minimum test requirements noted shall be used for evaluation of end joint adhesives by adapting the required face bond specimens to conform to the required end joint adhesive curing conditions.

Adhesives approved for use in glulam under AITC 405-92 or ANSI/AITC A190.1-2002 are beyond the scope of this Standard. It is the responsibility of the accredited inspection agencies, as defined in ANSI A190.1, to establish policies regarding the continued use of adhesives previously approved for use under those standards.

The notes and appendices 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.

1.1 Minor Changes in Formulation

Previously approved adhesives with minor changes in formulation shall meet the requirements of ASTM D2559 and shall pass the in-plant qualification. The remaining requirements of this Standard shall be permitted to be waived if the following documentation is signed by an authorized agent and provided to the laminator's accredited inspection agency by the adhesive manufacturer:

1. Request for approval of the modified adhesive
2. Description of reason for the changes in formulation
3. Statement that changes to the adhesive are minor and will not change the performance as measured by the screening tests in this Standard.

1.2 Validating Test Results

All testing shall be performed or witnessed by a laboratory accredited as a competent testing laboratory in accordance with ISO/IEC 17025 general requirements. Test results shall be submitted by the adhesive manufacturer to the accredited inspection agency.

1.3 Mixing and Curing Conditions

The mixing and curing conditions for samples made with the proposed adhesive shall be representative of the conditions recommended by the adhesive manufacturer for in-plant use. Where a variety of conditions will be recommended, the adhesive manufacturer shall provide evidence, in the form of test data or rational analysis, to attest that the adhesive will perform acceptably under all recommended mixing and curing conditions.

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

ANSI/AITC A190.1-2002, American National Standard for Wood Products – Structural Glued Laminated Timber

ANSI/AWC NDS-18, National Design Specification for Wood Construction

ANSI/UL 263-2022, Fire Tests of Building Construction and Materials

ASTM D905-08(2021), Standard Test Method for Strength Properties of Adhesive Bonds in Shear by Compression Loading

ASTM D1151-00(2022), Standard Practice for Effect of Moisture and Temperature on Adhesive Bonds

ASTM D1183-03(2019), Standard Practices for Resistance of Adhesives to Cyclic Laboratory Aging Conditions

ASTM D2559-12a(2018), Standard Specification for Adhesives for Bonded Structural Wood Products for Use under Exterior Exposure Conditions

ASTM D3434-00(2018), Standard Test Method for Multiple-Cycle Accelerated Aging Test (Automatic Boil Test) for Exterior Wet Use Wood Adhesives

ASTM D4442-20, Standard Test Method for Direct Moisture Content Measurement of Wood and Wood-Based Materials

ASTM D5266-13(2020), Standard Practice for Estimating the Percentage of Wood Failure in Adhesive Bonded Joints

ASTM D7247-17, Standard Test Method for Evaluating the Shear Strength of Adhesive Bonds in Laminated Wood Products at Elevated Temperatures

ASTM E119-20, Standard Test Methods for Fire Tests of Building Construction and Materials

2.2 Other Standards and Documents

AITC Test T107-2007, Shear Test

AITC 405-92, Standard for Adhesives for Use in Structural Glued Laminated Timber

CAN/ULC S101-14, Standard Methods of Fire Endurance Tests of Building Construction and Materials

CSA O86-19, Engineering Design in Wood

CSA O112.9-21, Evaluation of Adhesives for Structural Wood Products (Exterior Exposure)

CSA O122-16, Structural Glued-Laminated Timber

CSA O177-06(R2020), Qualification Code for Manufacturers of Structural Glued-Laminated Timber

ISO/IEC 17025-2017, General Requirements for the Competence of Testing and Calibration Laboratories

USDA 2021 Wood Handbook – Wood as an Engineering Material

3. REQUIRED TESTS

The screening tests described herein shall be performed and the results submitted to the accredited inspection agency for approval prior to the in-plant qualification.

3.1 Screening Tests

For the purposes of the screening tests under Sections 3.1.1, 3.1.2, and 3.1.5, species within the groupings defined in ANSI A190.1 need not be approved separately. Treated lumber shall be considered separately under Sections 3.1.1, 3.1.2, and 3.1.5. For the screening tests under Sections 3.1.3, 3.1.4, 3.1.6, 3.1.7, and 3.1.8 either Douglas fir-Larch or Southern Pine shall be used. The wood used to make all test specimens shall be as required by ASTM D2559 or as required in the specific test standard.

3.1.1 ASTM D2559

This test shall be performed in its entirety under all conditions described therein.

3.1.2 ASTM D1151

For the purposes of this test, a sample shall consist of ten (10) specimens. Two (2) samples (20 specimens) of the adhesive-bonded and two (2) samples (20 specimens) of a solid wood control shall be used. The wood for the control shall be of the same species and density as that used to test the adhesive.

All specimens are permitted to be the size and shape described in ASTM D905; however, modified specimens are permitted to be used. Total specimen thickness is permitted to be reduced to 1.25 inches (32 mm). If the modified specimen size is used, all specimens (solid and bonded) shall have the thinner dimension. The specimens shall be tested in shear according to the procedures outlined in ASTM D905 or AITC Test T107. A minimum of one (1) sample (10 specimens) of each of the bonded and solid wood specimens shall be conditioned to each of the exposures listed below.

One (1) sample of each of the adhesive-bonded and the solid wood control specimens shall be tested immediately following preconditioning. The other samples shall be conditioned to Test Exposure Number 3 (see Table 1 of ASTM D1151). For the purposes of this Standard, the following exception shall be permitted: temperatures shall be held ± 9°F (5°C) for one (1) hour and tested immediately.

The results shall be compared directly to the solid wood control.

3.1.3 ASTM D7247

For the purposes of this test, a sample shall consist of ten (10) specimens. One (1) sample (10 specimens) of the bonded and one (1) sample of matched solid wood control shall be used. The test temperature and heat exposure duration for specimens tested at elevated temperature (Section 7.2 of ASTM D7247) shall meet the requirements of Items 1, 2, 3, and 4 below.

1. The solid wood control specimen and both pieces of the bonded specimen shall be prepared from the same commercial species group of Douglas fir-Larch or Southern Pine. The adhesive formulation used in the test shall be the same as the adhesive formulation used in the production process.
2. For the bonded specimens, the minimum target bondline temperature shall be 428°F (220°C). For the matched solid wood control specimens, the minimum target temperature at the shear plane shall be 428°F (220°C).
3. The minimum target temperatures of Item 2 shall be maintained for a minimum of 10 minutes or until achieving a residual strength ratio for the solid wood control specimens of 30% ± 10%, whichever is longer.
4. Block shear testing shall be conducted immediately after removal from the oven such that the specimen bondline or shear plane temperature does not drop more than 9°F (5°C) after leaving the oven and prior to failure. This provision is satisfied when the time interval from the removal of the specimen from the oven to the failure of the block shear specimen does not exceed 60 seconds for each specimen tested and the room temperature of the test laboratory at the time of testing is not less than 60°F (15.5°C).

For adhesives tested in accordance with the conditions listed above, the residual shear strength ratio for the bonded specimens, as calculated in accordance with ASTM D7247, shall be equal to or higher than the lower bound of the 95% confidence interval on the mean residual shear strength ratio for the solid wood control specimens.

3.1.4 CSA O112.9 – Section 4.10.2 Creep Resistance

This test shall be performed in its entirety for exposure B_2 only.

Note 1: In accordance with Section 3.1, the specimens are limited to either Douglas fir-Larch or Southern Pine for the completion of this test, which may or may not coincide with the species outlined in CSA O112.9.

3.1.5 ASTM D1183

For the purposes of this test, a sample shall consist of ten (10) specimens. One (1) sample (10 specimens) of the bonded specimens and one (1) sample (10 specimens) of a solid wood control shall be used. The wood for the control shall be of the same species and density as that used to test the adhesive.

All specimens are permitted to be the size and shape described in ASTM D905, however modified specimens are permitted to be used. Total specimen thickness is permitted to be reduced to 1.25 inches (32 mm). If the modified specimen size is used, all specimens shall have the thinner dimension.

One (1) sample (10 specimens) from each of the bonded and solid wood samples shall be conditioned through one cycle of Test Condition Designation "D" in Table 1 of ASTM D1183 including all four (4) of the conditions described therein. The specimens shall be tested in shear according to the procedures outlined in ASTM D905 (or AITC Test T107).

The results shall be compared directly to the solid wood control.

3.1.6 Durability

Either test identified in this Section shall be permitted to be used for durability testing.

3.1.6.1 ASTM D3434

This test shall be performed in its entirety with the exception that the test shall not be required to run for more than 800 cycles. No phenol-resorcinol-formaldehyde control specimens shall be required.

3.1.6.2 CSA O112.9 – Section 5.5 Block Shear Test and Percent Wood Failure Assessment (Boil-Dry-Freeze Test)

This test shall be performed in its entirety with the exception that treatments outlined in Sections 5.5.3.2 and 5.5.3.3 of that standard need not be tested.

Note 2: In accordance with Section 3.1, the specimens are limited to either Douglas fir-Larch or Southern Pine for the completion of this test.

3.1.7 CSA O177 – Section A.2 Small-Scale Flame Test

This test shall be performed in its entirety.

Note 3: In accordance with Section 3.1, the specimens are limited to either Douglas fir-Larch or Southern Pine for the completion of this test.

3.1.8 ASTM E119, ANSI/UL 263, or CAN/ULC S101

This test shall be conducted in accordance with ASTM E119, ANSI/UL 263, or CAN/ULC S101 using a glulam member as a loadbearing beam under the conditions specified in this section. See Commentary X1.3.1.8 for more information.

3.1.8.1 Specimen

The glulam beam shall be 6-3/4 inches (171 mm) in net width by 13-1/2 inches (343 mm) in net depth (9 lams of 1-1/2 inches or 38.1 mm each) manufactured with the 24F-V4/DF layup with the exception that a core lamination (L3/DF) shall be replaced by an additional 302 tension lamination at the bottom of the beam. The glulam length exposed to fire shall be at least 12 feet (3.7 m), depending on the furnace size in the

accredited fire test laboratory. The glulam moisture content at the time of fire testing shall not exceed 15% for all measurements determined in accordance with ASTM D4442 or using a hand-held moisture meter calibrated for the wood species at the mid-depth of the glulam beam at approximately 1/3, 1/2, and 2/3 of the beam length.

3.1.8.2 End Joint and Face Joint

The glulam beam shall be manufactured with the adhesive(s) intended for qualification of the face bonds or end joints, or both in accordance with the adhesive manufacturer's specifications. Regardless of the adhesive that will be used for end jointing, an end joint shall be located at the bottom tension lamination within 1 foot of the center of the span. End joint proof-loading is permitted. The glulam beam manufacturing shall be witnessed by an accredited inspection agency as defined in ANSI A190.1.

3.1.8.3 Specimen Installation

The beam shall be installed in a test furnace such that, throughout the fire test, the beam is exposed to fire on three sides, with the tension face toward the furnace fire. The beam shall be supported at the ends and unrestrained against thermal expansion in accordance with ASTM E119, ANSI/UL 263, or CAN/ULC S101. Provision shall be made to prevent twisting of the beam at the ends and to provide continuous lateral restraint on the compression edge of the beam for the entire test duration while the method of lateral restraint shall not carry any of the load through load-sharing or composite action. The beam shall be covered on top by slabs made of steel, concrete, or another non-combustible material. The slabs shall not be fastened to the glulam beam. Where insulation is used to protect the slabs against the furnace fire, the insulation at the boundary between the glulam beam and the slabs shall cover the sides of the beam for no more than 3/4 inch (19 mm), measured vertically from the top of the beam.

3.1.8.4 Loading

The fire test shall be conducted with a superimposed load and exposed to a fire that follows the standard time-temperature curve of ASTM E119, ANSI/UL 263, or CAN/ULC S101. Throughout the fire test, a uniformly distributed load or series of concentrated loads shall be applied to the top of the beam and positioned symmetrically along the center of the beam. The use of a single-point loading is not permitted. The specimen shall be subjected to a superimposed load that produces a maximum moment of 41,010 lbf-ft (55.5 kN-m).

3.1.8.5 Alternative Methods

Other Douglas fir-Larch or Southern Pine glulam layups shall be permitted for use for the fire test provided that the allowable bending stress of the glulam is not less than 2,400 psi (16.5 MPa) and the specimen dimension is not less than that specified in Section 3.1.8.1. In this case, the superimposed load shall be determined in accordance with Chapter 16 of the National Design Specification for Wood Construction (NDS) or Annex B of CSA O86. See Commentary X1.3.1.8 for additional information.

Note 4: In accordance with Section 3.1, the specimen is limited to either Douglas fir-Larch or Southern Pine.

3.2 In-Plant Qualification

Once the required screening tests have been passed and the data submitted and approved, the adhesive shall pass an in-plant qualification as described in ANSI A190.1 prior to being used in the manufacture of glulam.

4. PASS/FAIL CRITERIA

4.1 ASTM D2559

Pass/fail criteria shall be as outlined within that specification.

4.2 ASTM D1151

The average strength of bonded specimens shall equal or exceed 90% of the average strength of the solid wood control at every condition.

The average wood failure of bonded specimens according to ASTM D5266 shall equal or exceed 75% at every condition.

4.3 ASTM D7247

The residual shear strength ratio for the bonded specimens, as calculated in accordance with ASTM D7247, shall be equal to or higher than the lower 95% confidence interval on the mean residual shear strength ratio for the solid wood control specimens.

4.4 CSA O112.9 – Section 4.10.2 Creep Resistance

Pass/fail criteria shall be as outlined within that specification.

4.5 ASTM D1183

The average strength of bonded specimens shall equal or exceed 90% of the average strength of the solid wood control.

The average wood failure of bonded specimens according to ASTM D5266 shall equal or exceed 75%.

4.6 Durability

4.6.1 ASTM D3434

Dry average strength shall equal or exceed the values listed in Table 1 or ASTM D2559.

TABLE 1

REQUIRED AVERAGE SHEAR STRENGTH OF ADHESIVE JOINTS IN LAMINATED CONSTRUCTIONS OF DIFFERENT SPECIES AT VARIOUS MOISTURE CONTENTS

	Required Average Shear Strength (psi) at Moisture Content of		
Species	**12% or less**	**Up to 14%**	**Up to 16%**
Douglas fir	1,020	980	940
Larch, Western	1,220	1,160	1,100
Pine, Southern	1,250	1,150	1,040

Strength retention and wood failure shall be recorded at each stage of the test. The retained strength shall be plotted on a graph as a function of the number of cycles. The shape of the curve shall exhibit a logarithmic degradation trend. The strength of the adhesive after 800 cycles shall equal or exceed 500 psi (3.45 MPa) and shall not be less than 2/3 of the strength retained after 200 cycles.

Exception: The strength retention requirement after 800 cycles shall be permitted to be reduced to 400 psi (2.76 MPa) if the average wood failure of the specimens exceeds 75%. In no case, however, shall the strength after 800 cycles be less than 2/3 of the strength retained after 200 cycles.

4.6.2 CSA O112.9 – Boil-Dry-Freeze Test

Pass/fail criteria shall be as outlined within that specification.

4.7 CSA O177 – Section A.2 Small-Scale Flame Test

Pass/fail criteria shall be as outlined within that standard.

4.8 ASTM E119, ANSI/UL 263, or CAN/ULC S101

The fire-resistance rating when tested in accordance with Sections 3.1.8.1 through 3.1.8.4 shall be 60 minutes minimum. The maximum total deflection and maximum rate of deflection, as measured for the loadbearing beam unrestrained against thermal expansion in accordance with ASTM E119, ANSI/UL 263, or CAN/ULC S101 are not applicable for the purpose of this Standard. When alternative methods are used in accordance with Section 3.1.8.5, the fire-resistance rating shall meet the minimum fire duration calculated in accordance with NDS or CSA O86 and approved by the accredited inspection agency.

Note 5: Commentary X1.3.1.8 provides deemed-to-comply glulam sizes and minimum fire duration for glulams manufactured in both the U.S. and Canada.

5. REPORTING

The results of all screening tests shall be summarized in a single report with supporting test data appended for reference.

5.1 Submission of Data

All data for all testing as required in this Standard shall be submitted to the laminator's accredited inspection agency by the adhesive manufacturer at the time of application for certification.

APPENDIX X1. COMMENTARY (Non-Mandatory Information)

X1.1 Scope

This Standard was developed by the glulam industry to establish a consistent and reasonable performance level for adhesives used in glulam. Historically, satisfactory performance has been maintained by prescriptively limiting the types of adhesives permitted for this use and allowing the marketplace to "weed out" poor performers. Alternative adhesive types were permitted only after extensive testing and comparisons to control specimens bonded with phenol-resorcinol-formaldehyde (PRF) adhesives.

Changes in adhesive technology and knowledge have created a need to define measurable performance requirements for adhesives used in glulam. Principles of fair and equitable competition dictate that these performance-based requirements be applicable to all adhesives, regardless of type. Therefore, all new adhesives proposed for use in glulam are required to meet the criteria defined in this Standard.

Note 6: The commentary provided in this Appendix refers to the section number contained in the body of this Standard, following "X1." For example, Commentary X1.1.2 refers to Section 1.2 of this Standard. As some sections in this Standard do not require commentary, the Commentary section numbers in this Appendix X1 may not be consecutive.

X1.1.1 Minor Changes in Formulation

The intent of this provision is to allow the accredited inspection agency to reduce testing requirements when minor changes are made to an approved adhesive. The results of the ASTM D2559 tests and the documentation required for submittal to the accredited inspection agency provide evidence that the adhesive changes are minor.

X1.1.2 Validating Test Results

The intent of this Section is to ensure that tests of adhesives are performed in a competent manner producing consistent results.

X1.1.3 Mixing and Curing Conditions

Many variables affect the curing and subsequent performance of structural adhesives. One adhesive may perform well when cured at room temperature, but may perform poorly when cured using radio frequency (RF) curing techniques. Another adhesive may be very sensitive to the moisture content of the lumber or some other variable.

While it is impossible to test every possible combination of variables, the adhesive manufacturer should perform sufficient testing to ensure reliable performance of the adhesive under all application and curing conditions recommended by the manufacturer. It is the responsibility of the adhesive manufacturer to demonstrate that the adhesive is suitable for use under the recommended conditions. This may be accomplished by testing multiple sets of specimens to "bracket" the expected performance of the adhesive or by testing specimens cured under the known limiting conditions.

X1.3 Required Tests

The screening tests are typically conducted by the adhesive manufacturer, and the in-plant qualification is conducted by the laminator under the supervision of the accredited inspection agency.

X1.3.1 Screening Tests

ANSI A190.1 groups species with similar bonding and strength characteristics for in-plant qualification of an adhesive. These same groups are acceptable for the screening tests.

For the tests in Sections 3.1.3, 3.1.4, 3.1.6, and 3.1.7, either Douglas fir-Larch or Southern Pine specimens are permitted to be used. Either of these species is suitable to demonstrate the durability of the adhesive under the accelerated aging tests. Further durability testing on other species is not necessary as the purpose is to test the adhesive, not the substrate nor the durability of the species of wood.

X1.3.1.2 ASTM D1151

The modified specimen thickness accommodates the use of one-inch (nominal) thickness lumber planed to a thickness of 5/8 inch (16 mm) for the bonded specimens. Using the modified specimen thickness, side-matched specimens of bonded and solid wood can be obtained from a single piece of 2 x 6 dimension lumber.

X1.3.1.3 ASTM D7247

The intent of Section 3.1.3 is that all specimens are held at the target temperature for the same period of time. Subsequently, it is necessary to determine the required time through preliminary testing of samples of solid-sawn specimens.

X1.3.1.4 CSA O112.9 – Section 4.10.2 Creep Resistance

For the purposes of this screening test, species used shall conform to the species groupings as outlined in ANSI A190.1, which may or may not coincide with those outlined in CSA O112.9.

The intent of CSA O112.9 condition B_2 creep test was to simulate temperatures that framing members in a fire-protected assembly could be exposed to at some point during a standard fire test to determine the fire resistance rating. Glulam member may be exposed to longer fire events than protected framing members. Despite the basis of the test being different (protected framing members vs. glulam), the ANSI 405 Committee felt the test condition (in addition to the battery of other tests required by ANSI 405) satisfies the high temperature creep requirements for adhesives for use in glulam.

X1.3.1.5 ASTM D1183

See Section X1.3.1.2.

X1.3.1.6 Durability

X1.3.1.6.1 ASTM D3434

The automatic boil test in ASTM D3434 has demonstrated its usefulness as a predictor of durability. This test has been a requirement for adhesives qualified under ANSI 405 since its inception. Traditionally, this test has been run for 800 cycles with comparison made to PRF control specimens. Careful inspection of data available from several sources has led to the establishment of performance-based criteria, eliminating the need for a PRF control.

X1.3.1.6.2 CSA O112.9 – Boil-Dry-Freeze Test

While the automatic boil test in ASTM D3434 is considered an excellent test, limited accessibility of test equipment makes an alternative test desirable. Limited data suggest that the CSA O112.9 Boil-Dry-Freeze test provides a useful alternative to ASTM D3434.

For the durability tests outlined in Section 3.1.6, Douglas fir-Larch or Southern Pine are the only two species allowed to be used, though both species need not be used.

X1.3.1.7 CSA O177 – Section A.2 Small-Scale Flame Test

The intent of Section 3.1.7 is to qualify the adhesive to avoid delamination due to intensive heat, such as under fire exposure.

X1.3.1.8 ASTM E119, ANSI/UL 263, or CAN/ULC S101

The intent of Section 3.1.8 is to qualify a glulam beam manufactured with a new structural adhesive for fire performance. The specified glulam specimen when tested with the loading prescribed in Section 3.1.8.4 is expected to achieve a fire-resistance rating of 60 minutes. However, for the purpose of synchronization between glulams

manufactured in the U.S. and Canada, Table X1.1 provides deemed-to-comply glulam sizes and minimum fire duration for glulams manufactured in both the U.S. and Canada when designed in accordance with the NDS and CSA O86 fire provisions. Similar equivalency between the U.S. and Canadian glulams is also provided in CSA O177. When the test span is different from Table X1.1, the minimum applied bending moment during fire test and the minimum fire duration should be determined based on the NDS or CSA O86 accordingly.

TABLE X1.1

DEEMED-TO-COMPLY GLULAM SIZES AND MINIMUM FIRE DURATION

Glulam Grade	Width x Depth	Minimum Applied Bending Moment During Fire Test, lbf-ft (kN·m)	Minimum Fire Duration, mins.
ANSI 24F-V4/DF[a]	6-3/4 in. x 13-1/2 in. (171 mm x 343 mm)	41,010 (55.6)[c]	60
		44,750 (60.7)[d]	51
CSA 24f-E Douglas fir-Larch[b]	6.9 in. x 13.5 in. (175 mm x 343 mm)	42,620 (57.8)[c]	61
		46,440 (63.0)[d]	52

a. For 24F-V4/DF of ANSI A190.1, the Allowable Stress Design allowable bending stress = 2,400 psi (16.5 MPa), and the Limit States Design specified bending strength = 4,365 psi (30.1 MPa).

b. For 24f-E Douglas fir-Larch of CSA O122, the Allowable Stress Design allowable bending stress = 2,444 psi (16.9 MPa), and the Limit States Design specified bending strength = 4,438 psi (30.6 MPa).

c. Applied bending moment calculated in accordance with NDS (allowable stress design), assuming a test span of 150 inches (3.81 m), compression edge to be restrained laterally for the entire test duration (C_L = 1.0), and 10-year load duration (C_D = 1.0).

d. Applied bending moment consists of the factored bending moment divided by 1.5 (principal-load factor for live loads). Factored bending moment calculated in accordance with CSA O86 (limit states design), assuming a test span of 150 inches (3.81 m), compression edge to be restrained laterally for the entire test duration (K_L = 1.0), and normal load duration (K_D = 1.0).

X1.4.6 Durability

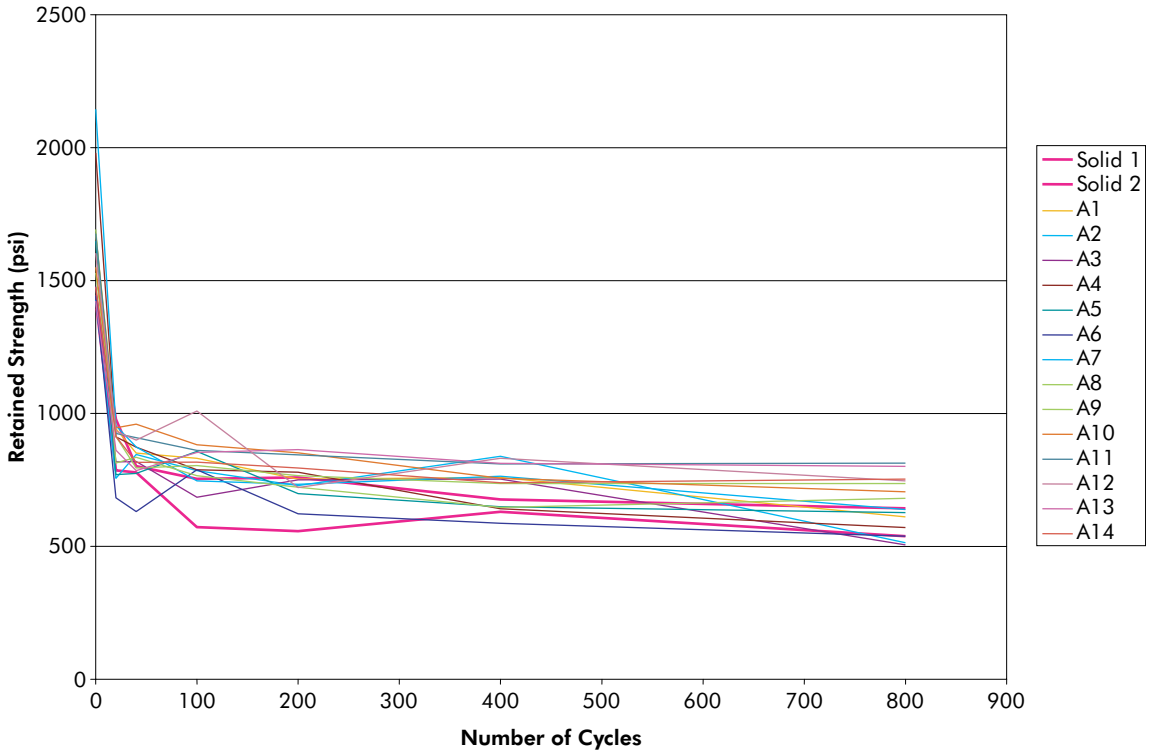
X1.4.6.1 ASTM D3434

The strength of solid wood specimens and specimens bonded with durable adhesives follow similar degradation trends when subjected to this test. Both follow a logarithmic degradation trend as cycles increase. Most of the strength loss occurs in the first 100 cycles of exposure, with the retained strength leveling off after about 100–200 cycles. Adhesives with insufficient durability will typically continue to lose strength rapidly, rather than "leveling off" like these adhesives. Figure X1.1 illustrates this trend using actual performance data for solid wood and several adhesives, including samples of PRF, melamine, polyurethane, and isocyanate adhesives from several manufacturers. Each of the adhesives shown meets the performance requirements of this test.

The retained strength requirements are permitted to be reduced according to the provisions of the *Exception* clause if accompanied by high percentages of wood failure. This provision was included to avoid penalizing good performing adhesives, because the wood degraded somewhat more than expected.

FIGURE X1.1

PERFORMANCE CURVES FOR DURABLE ADHESIVES



X1.5.1 Submission of Data

The laminator's accredited inspection agency will determine if an adhesive meets the requirements of this Standard and give or deny approval. The accredited inspection agency will inform the adhesive manufacturer of its decision with any reasons for disapproval. Either party may request a ruling of the Technical Review Board to resolve a dispute or disagreement.

APPENDIX X2: History of Standard (Non-Mandatory Information)

This Standard was initially published in 2005 by the American Institute of Timber Construction (AITC) as ANSI/AITC 405-2005 and subsequently revised in 2008 as ANSI/AITC 405-2008. On January 1, 2013, the responsibilities of the Secretariat for this Standard were transferred to APA – The Engineered Wood Association with a revised designation as ANSI 405-2008 after approval by the American National Standards Institute (ANSI). ANSI 405-2008 was revised as ANSI 405-2013, ANSI 405-2018, and ANSI 405-2023 subsequently.

In ANSI 405-2023, a full-scale fire test, which has been the glulam industry practice for years, was added to this Standard for the glulam adhesive approval (see Sections 3.1.8, 4.8, and X1.3.1.8).

The names of the ANSI Committee members when this version of the Standard was published are as shown below. The current list of the committee membership is available from the committee secretariat upon request.

Name	Affiliation	Note
DeepaReddy Akula	Vinside Capital	
Zhaozhen Bao	PFS TECO	
Joshua Bartlett	Franklin International	
Linda Brown	Southern Pine Inspection Bureau	
Tim Bruegman	Hexion, Inc.	
Kevin Cheung	Western Wood Products Association	
Vincent Chui	ICC Evaluation Service	
David Conner	Timber Products Inspection, Inc.	
Don DeVisser	Pacific Lumber Inspection Bureau	ExSub Member
Brad Douglas	American Wood Council	
Julie Frappier	Nordic Structures	
Bill Gareis	Bostik, Inc.	ExSub Member
Benjamin Herzog	University of Maine	
Levi Huffman	DR Johnson Wood Innovations	
Jessica Jennings	Bakelite Synthetics	
Erik Laughton	Kalesnikoff Mass Timber	
Dominique Lavoie	Boise Cascade	
Jeff Morrison	Rosboro LLC	Chair
Brent Olson	Mercer Mass Timber LLC	
Victor Pearson	American Laminators	
Steven Reierson	Akzo Nobel Adhesives, Inc.	
Glen Robak	Weyerhaeuser	
Sheldon Shi	University of North Texas	
Jeffrey Stefani	Canfor Southern Pine	
Leif Van Cott	Unalam	
Travis Van De Vliert	Western Archrib	
Chris Whelan	Henkel Corporation	
Tom Williamson	T.Williamson-Timber Engineering LLC	Vice-Chair
B.J. Yeh	APA – The Engineered Wood Association	Secretariat
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ANSI 405-2023
Standard for Adhesives for Use in Structural Glued Laminated Timbers

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